



Energy Savings and Impacts Scenario Tool (ESIST)

Version 1.1 User Manual

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Version Changes

This user manual describes version 1.1 of the ESIST model and the ESIST: Pilot Gas Version. Changes in version 1.1 include:

- New data reflecting the most recently available information on historical sales, utility revenue, energy efficiency, and electricity demand projections.
- Updates to historical emissions rates.
- Updates to energy burden analysis data.
- Updates to demographics data.
- Adjustments to the analysis period allowing for future scenarios from 2022-2040 (the previous version of ESIST analyzed 2021-2040).
- Other minor bug fixes and changes.

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Abbreviations

AAGR	annual average growth rate
ACEEE	American Council for an Energy-Efficient Economy
ACS	American Community Survey
AEO	Annual Energy Outlook
AVERT	Avoided Emissions and Generation Tool
CAGR	compound annual growth rate
CO₂	carbon dioxide
COBRA	Co-Benefits Risk Assessment tool
CRF	capital recovery factor
DSM	demand-side management
EE	energy efficiency
EERS	energy efficiency resource standard
ESIST	Energy Savings and Impacts Scenario Tool
eGRID	Emissions & Generation Resource Integrated Database
EIA	Energy Information Administration
EMM	Electricity Market Module
EPA	U.S. Environmental Protection Agency
GHG	greenhouse gas
GW	gigawatt
HVAC	heating, ventilation, and air-conditioning
IRP	integrated resource plan
ISO	independent system operator
kWh	kilowatt-hour

LBNL	Lawrence Berkeley National Laboratory or the Berkeley Lab
MW	Megawatt
MWh	megawatt-hour
NGO	nongovernmental organization
NO_x	nitrogen oxides
NYISO	New York Independent System Operator
PM_{2.5}	fine particulate matter
PUC	public utility commission
SEO	state energy office
SO₂	sulfur dioxide
T&D	transmission and distribution

1. Introduction

Energy efficiency, or EE, programs and policies are a proven and cost-effective strategy for helping to meet customer electricity demand and reducing generation that would otherwise occur at electric generating units. In the United States, all 50 states currently administer some type of energy efficiency program, while many states have mandated a certain level of savings through energy efficiency resource standard (EERS) policies.¹ Some states also have requirements for electricity suppliers to implement cost-effective energy efficiency. State and local governments also implement energy efficiency policies such as building energy stretch codes, building performance standards, building electrification, financing programs, energy efficiency plans targeting low-income and multifamily residents, and energy efficiency data sharing and transparency.

States and local governments often seek analytical tools to help inform their efforts to adopt new energy efficiency policies and programs, or to maintain or expand their existing activities. These activities help jurisdictions stay current with market trends, meet regulatory or legislative requirements, and ensure that customer-funded energy efficiency programs are cost-effective and meet customer needs.² Timely, reliable, and readily available information about the range of impacts of proposed energy efficiency programs and policies can help states, communities, and their stakeholders make informed choices. These impacts may include quantified electricity savings, spending requirements, emissions and health impacts, and equity impacts specific to low-income customers.

The benefits from state, local, and utility investments in energy efficiency are diverse. They include customer savings on electricity bills, as well as electricity system benefits such as stabilizing or reducing electric loads, improving electric supply reliability, and deferring or avoiding investment in costly new infrastructure. Other drivers include benefits such as reductions in criteria air pollutants and greenhouse gases (GHGs), improvements to public health, support for economic development, progress toward energy equity, and an increase in jobs. Quantitative estimates of these multiple benefits can support planning and investment decisions consistent with the jurisdiction's energy efficiency policy and program goals. Such estimates can also help demonstrate the value of energy efficiency to a broad spectrum of officials and stakeholders responsible for supporting a reliable electricity system, strong economy, and healthy environment.³

¹ See: ACEEE. "State Energy Efficiency Resource Standards (EERS)." (2019). See <https://www.aceee.org/sites/default/files/state-eers-0519.pdf> for more information.

² Throughout this document, "customer-funded energy efficiency" is used as to describe the types of energy efficiency programs that are administered by utilities or third-party organizations and that stakeholders are most likely to model in the Energy Savings and Impacts Scenario Tool. While these programs may be funded by a combination of electric rate charges, grants, and other sources of revenue, they typically exclude energy efficiency savings that result from mandated codes and standards.

³ For more information on quantitative estimates of these impacts, see EPA's 2018 edition of *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments*, available at <https://www.epa.gov/statelocalenergy/quantifying-multiple-benefits-energy-efficiency-and-renewable-energy-guide-state>.

About the Energy Savings and Impacts Scenario Tool and This Manual

The Energy Savings and Impacts Scenario Tool (ESIST) Version 1.1 is a customizable and transparent Excel-based planning tool for analyzing the energy savings and costs from customer-funded energy efficiency programs and their impacts on emissions, public health, and equity. ESIST enables users to develop, explore, and share energy efficiency scenarios between 2010 and 2040. ESIST users first select a study area based on states, utility types, specific utilities, or difference customer sectors within a utility.⁴ Users can adjust inputs, including electricity sales growth forecasts, energy efficiency savings goals, program budgets, savings expiration schedules, discount rates, and first-year costs.⁵ The tool allows users to compare levels of energy efficiency savings, annual costs, and levelized costs of saved energy. ESIST users can then estimate multiple benefits that could result from the energy efficiency scenario—including avoided emissions, public health benefits, peak demand impacts, and energy burden reductions—and review customer demographic data.

ESIST combines several publicly available and peer-reviewed data sets to support analyses that would otherwise be significantly more time-consuming and resource-intensive. It also provides users with the flexibility to rely on default values or to customize input assumptions, allowing policymakers, practitioners, and others to use ESIST as a comprehensive tool for generating scenarios and informing decision-making. ESIST can be used by itself or in tandem with other tools and analyses for further exploration of results.

To streamline and simplify analysis for users, ESIST integrates and aggregates publicly available datapoints on the electricity sector from the U.S. Energy Information Administration (EIA).⁶ These data include information on historical utility-level electricity sales, energy efficiency savings, number of customers served, and revenue, among other values.⁷ Users may apply ESIST to aggregate these data at different geographical resolutions, ranging from national- or state-level analysis to different customer sectors within specific utilities.

These historical data are then used to estimate future trajectories of electric customer-funded energy efficiency savings and associated costs using pre-loaded electricity demand projections from EIA's 2023 Annual Energy Outlook (AEO).⁸ Historical and projected trajectories of savings are then combined with data from other sources, including the Lawrence Berkeley National Laboratory

⁴ ESIST can model the United States as a whole, each of the 50 states, Washington, D.C., and Puerto Rico. Other territories are not currently available in ESIST.

⁵ Electricity sales growth forecasts should be inclusive of effects from electrification measures.

⁶ The primary source of savings and sales data is EIA's Form 861, available at <https://www.eia.gov/electricity/data/eia861/>, with the most recent data for 2021 downloaded in March 2023. Savings data reported in EIA is in the form of "adjusted gross savings," which account for realization rates and in-service rates, but not free ridership or spillover. For more information on these terms, see: Northeast Energy Efficiency Partnerships (NEEP). "Glossary of Terms Version 2.1." (July 2011). Available at https://neep.org/sites/default/files/resources/EMV_Glossary_Version_2.1.pdf.

⁷ The primary focus of ESIST is on electricity use and efficiency savings in the electric power sector. For more information on modeling energy efficiency impacts for direct fuel consumption, see *Appendix C: ESIST: Pilot Gas Version*.

⁸ AEO is an annual projection published by EIA, containing information on electricity sales, energy prices, emissions, and many other metrics through 2050. For more information, see <https://www.eia.gov/outlooks/aeo/>.

(the Berkeley Lab or LBNL) and the U.S. Environmental Protection Agency (EPA), to calculate additional energy efficiency impacts.

This manual is intended to help users understand and use ESIST. It introduces the stepwise input process—either by applying defaults or entering user-specified values—for generating results within ESIST. The manual also describes how users can identify and generate user-specified values and contextualize ESIST outputs.

If you have questions or need assistance using ESIST, please contact us at esist@epa.gov.

Potential Uses and Users

ESIST is intended to inform a wide range of potential uses. For example, ESIST can:

- Estimate the historical or future (2010–2040) electricity impacts of customer-funded energy efficiency programs and assess their contribution toward achieving existing, expanded, or new energy efficiency targets.
- Inform utility benefit-cost analyses by modeling benefits and costs in alternate energy efficiency scenarios.
- Generate different efficiency scenarios to facilitate stakeholder comparison and discussion of future costs and benefits, such as during integrated resource plan (IRP) processes.
- Aggregate the results from analyses across multiple utilities or program administrators to illustrate the combined effects of energy efficiency programs in a single state, or nationwide.
- Assess the multiple benefits of electric customer-funded energy efficiency in terms of emissions, public health, peak demand, or energy burden impacts.
- Evaluate the impacts of energy efficiency and monetary assistance on low-income household energy burdens and calculate the total annual program costs of reducing energy burdens for low-income customers.
- Review a set of demographic data describing the number of households in a utility service territory based on household income, including ownership status, race and ethnicity, and other criteria.
- Use electricity savings impacts from ESIST as an input to emission quantification tools, such as EPA’s AVOIDED EMISSIONS AND GENERATION TOOL (AVERT).⁹ While ESIST provides high-level information on long-term annual avoided emissions resulting from an energy efficiency program across an entire region, AVERT provides more granular data (both spatially and temporally) associated with savings from an energy efficiency program.
- Use electricity savings impacts from ESIST as an input to public health quantification tools, such as EPA’s CO-BENEFITS RISK ASSESSMENT (COBRA) tool.¹⁰ While ESIST provides high-level information on long-term monetized public health benefits across the entire country

⁹ More information on AVERT is available at <https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert>.

¹⁰ More information on COBRA is available at <https://www.epa.gov/cobra>.

resulting from an energy efficiency program, COBRA provides more granular data (both spatially and categorically) associated with emission reductions resulting from an energy efficiency program.

Some potential users of ESIST include:

- State agency officials examining the policy implications of changes to energy efficiency investments.
- Public utility commission staff evaluating the costs and benefits of proposed efficiency programs.
- Analysts and academics exploring different resource planning scenarios with varying levels of energy efficiency investment.
- Nongovernmental organizations (NGOs) assessing the energy burden impacts of efficiency programs targeted to reach low-income households.
- Air quality planners and public health officials seeking to quantify the emissions and public health benefits of efficiency programs.
- Utilities reviewing demographic data of households in their utility service territory to reach with energy efficiency programs.

See Appendix B for more information on potential use cases for ESIST.

Considerations for Applying ESIST

ESIST can support flexible and streamlined analysis of energy efficiency impacts, but users should take care to consider its limitations and determine whether pre-loaded default values or user-specified inputs are most appropriate for local circumstances and conditions. This section highlights some key issues to consider when using ESIST and provides guidelines for identifying solutions.

Default Values

Wherever possible, ESIST provides default values and explanatory text for a broad range of inputs and assumptions. These include, but are not limited to, sales projections, projected costs, avoided emissions rates, and public health impact factors. These default values allow users who do not have access to jurisdiction-specific or other information sources to generate results quickly and easily for energy efficiency costs, energy savings, and other key impacts. This simplifies use of ESIST and generates reasonable values that are specific to the geography of interest. When applying default values, users should take care to understand, assess, and appropriately adjust these default inputs, assumptions, and calculations.¹¹

Alternate Data Sources

Where locally preferred data sets exist, default values can be overwritten. Users may apply electricity demand futures from other sources, such as a local utility, independent system operator (ISO), state energy office (SEO), or public utility commission (PUC). ESIST allows users to choose

¹¹ Refer to the “Library” tab in ESIST Excel workbook for more detail on default input assumptions used in ESIST.

one of three methods to project energy savings, thereby providing users with flexibility for jurisdictions that may structure energy efficiency goals in different ways (e.g., annual incremental savings as a percent of sales, cumulative savings, energy efficiency budget levels). Users can input alternate values (e.g., costs of implementing energy efficiency, avoided emission rates) throughout most steps in ESIST.

Key Notes and Alerts

Throughout this manual, users should also observe “Key Notes” that highlight topics of special interest or that deserve additional explanation. These notes include:

- Reasonable projections for energy efficiency savings.
- Development of state-specific sales projections.
- Different cost perspectives (i.e., first-year versus levelized costs).
- Different program and measure portfolios (i.e., the types of measures or technology that the program seeks to encourage).
- Lifetime of the analysis (i.e., implications of short-term versus long-term results).
- Adjusting emissions rates and using ESIST data in AVERT.
- Assumptions related to low-income weatherization savings.
- Considerations for reducing energy burden.
- Retail versus wholesale savings.

ESIST also includes several “Alerts” to help users select parameters that are realistic or achievable in practice. For example, an alert is provided in cases where a level of annual incremental savings is specified that approaches or exceeds the maximum level regarded as achievable for most jurisdictions.

Limitations

ESIST is intended as a planning tool that balances complexity and relative ease of use. Users should be aware of its limitations and appropriate uses and describe these when discussing scenarios and communicating results with stakeholders. One important caveat is that ESIST provides information on costs and benefits for some *but not all* categories that are commonly assessed in benefit-cost testing of energy efficiency resources. For example, ESIST does not estimate values of avoided energy generation or capacity costs.

Jurisdictions vary in the types of costs and benefits that are included in their benefit-cost tests. While ESIST may be used to estimate some costs and benefits, users who are composing a comprehensive benefit-cost analysis of energy efficiency programs should consult with literature, such as the National Standard Practice Manual, for information on best practices for developing the benefits and costs of categories not calculated by ESIST.¹² Table 1 depicts the lists of benefits and

¹² NESP. *National Standard Practice Manual for Benefit-Cost Analysis of Distributed Energy Resources*. (August 2020). Available at https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/08/NSPM-DErs_08-24-2020.pdf.

costs that are described in this manual. Categories that can be estimated with ESIST are marked with an “√” and the rest are left blank. This table also describes the scope of these impacts, as they are calculated in ESIST. Note that ESIST only monetizes public health benefits; all other captured benefits in ESIST are quantified in some other way.

Additional detail on ESIST’s limitations—including data availability and sources, data applicability, time scale, geography, and level of detail—are discussed where applicable in the sections that follow. This manual also includes citations for all data sources and assumptions, considerations for applying default values, and suggested sources of alternate local data.

Table 1. Categories of costs and benefits described in the National Standard Practice Manual

Benefit and cost type	Category	Estimated in ESIST?	Scope of ESIST estimate
Societal	Resilience		
	GHG emissions	√	Regional changes in GHG emissions resulting from energy efficiency programs implemented in states or utility territories
	Other environmental	√	Regional changes in criteria pollutant emissions resulting from energy efficiency programs implemented in states or utility territories
	Economic and jobs		
	Public health	√	National public health benefits are calculated based on regional emission changes
	Low-income: society	√	Energy burden impacts help users estimate the level of investment in low-income programs needed to overcome energy burden disparities
	Energy security		
Host Customer	Host portion of DER costs	√	ESIST calculates participant costs of energy efficiency
	Interconnection fees		
	Risk		
	Reliability		
	Resilience		
	Tax incentives		
	Host customer non-energy impacts		
Generation	Low-income non-energy impacts		
	Energy generation		
	Capacity		
	Environmental compliance		
	RPS/CES compliance		
	Market price effects		
Ancillary services			

Benefit and cost type	Category	Estimated in ESIST?	Scope of ESIST estimate
Transmission	Transmission capacity		
	Transmission system losses	✓	Users can enter a transmission and distribution (T&D) loss value (in percent) to estimate the losses avoided by energy efficiency
Distribution	Distribution capacity		
	Distribution system losses	✓	Users can enter a T&D loss value (in percent) to estimate the losses avoided by energy efficiency
	Distribution operations and maintenance		
	Distribution voltage		
General	Financial incentives	✓	ESIST calculates utility costs of implementing energy efficiency, including financial incentives
	Program administration costs	✓	ESIST calculates utility costs of implementing energy efficiency, including administration costs
	Utility performance incentives	✓	ESIST calculates utility costs of implementing energy efficiency, including performance incentives
	Credit and collection costs		
	Risk		
	Reliability		
	Resilience		

Source: For more information on categories or definitions of terms used, see the National Standard Practice Manual, available at https://www.nationalenergyscreeningproject.org/wp-content/uploads/2020/08/NSPM-DERs_08-24-2020.pdf.

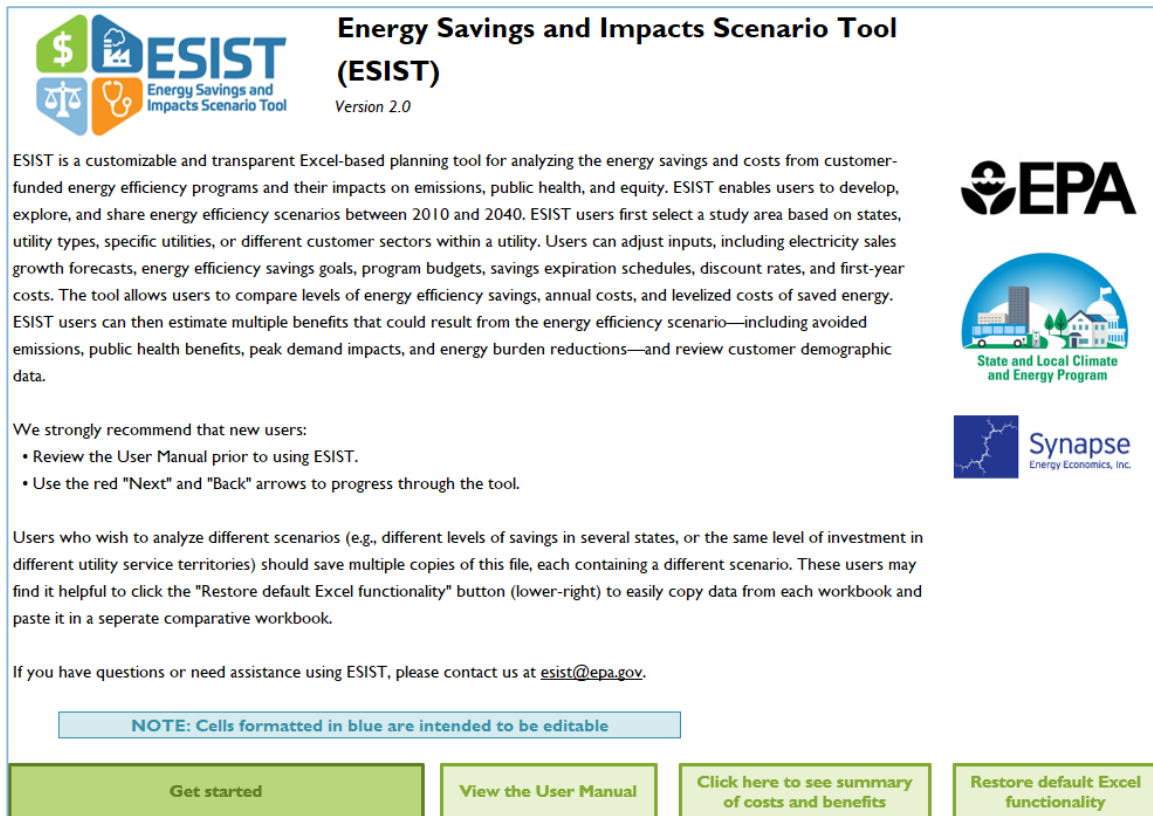
2. ESIST Overview

Upon opening ESIST, users see a “Welcome” screen that summarizes ESIST (see Figure 1). Users will encounter the following types of interactive buttons in ESIST:

- Red **Next** and **Back** buttons guide the user through the tool; most users will wish to rely on these buttons to follow ESIST’s suggested series of steps.
- Buttons with green text on a green field **contain links** that allow the user to advance through the tool to subsequent steps.
- Buttons with gray text on a gray **future steps** field indicate that the user has not yet reached; clicking red “Next” buttons allows the user to go to these steps.
- Buttons with yellow text on a yellow field may be clicked to **reset the current** to its default settings; users may wish to click these buttons on datasheets where they have previously entered user-specific information or otherwise altered the default value or formula.
- ESIST features cells with that indicate users can make changes to these cells without harming **blue text on a blue field** the tool’s functionality.

In general, all other cells should not be edited or altered in order to preserve ESIST’s functionality.

Figure 1. ESIST “Welcome” screen Get Started



Energy Savings and Impacts Scenario Tool (ESIST)
Version 2.0

ESIST is a customizable and transparent Excel-based planning tool for analyzing the energy savings and costs from customer-funded energy efficiency programs and their impacts on emissions, public health, and equity. ESIST enables users to develop, explore, and share energy efficiency scenarios between 2010 and 2040. ESIST users first select a study area based on states, utility types, specific utilities, or different customer sectors within a utility. Users can adjust inputs, including electricity sales growth forecasts, energy efficiency savings goals, program budgets, savings expiration schedules, discount rates, and first-year costs. The tool allows users to compare levels of energy efficiency savings, annual costs, and levelized costs of saved energy. ESIST users can then estimate multiple benefits that could result from the energy efficiency scenario—including avoided emissions, public health benefits, peak demand impacts, and energy burden reductions—and review customer demographic data.

We strongly recommend that new users:

- Review the User Manual prior to using ESIST.
- Use the red "Next" and "Back" arrows to progress through the tool.

Users who wish to analyze different scenarios (e.g., different levels of savings in several states, or the same level of investment in different utility service territories) should save multiple copies of this file, each containing a different scenario. These users may find it helpful to click the "Restore default Excel functionality" button (lower-right) to easily copy data from each workbook and paste it in a separate comparative workbook.

If you have questions or need assistance using ESIST, please contact us at esist@epa.gov.

NOTE: Cells formatted in blue are intended to be editable

Get started **View the User Manual** **Click here to see summary of costs and benefits** **Restore default Excel functionality**

This first datasheet also includes four buttons. First, “Get started” brings the user to the next step in ESIST. ESIST requires users to progress in sequence through the following seven steps, which are

briefly described here. In ESIST version 1.1, all costs and prices are displayed in 2021 dollars. Additional details on each of the steps are provided in the following sections.

1. **Set study area:** Users may set the study area to include:
 - a. Geographic areas, including the United States as a whole, each of the 50 states, Washington, D.C., or Puerto Rico.
 - b. Sectors, including residential, commercial, industrial, or all sectors.
 - c. Utility types, including investor-owned utilities, retail power marketers, cooperative utilities, municipal utilities, other types of utilities, or all utility types.
 - d. Specific utility service territories.
2. **Set baseline electricity sales:** Step 2 calculates a level of sales that serves as the baseline for quantifying and displaying the impacts of energy efficiency investments over time. By default, the historical baseline sales level has been adjusted to exclude the impacts of energy efficiency programs from the historical period of 2010–2021. This adjustment allows users to explicitly observe the impacts of energy efficiency, including historical impacts and future impacts from past programs, separately from electricity sales. Users can choose a growth rate that will apply to the default sales or input their own historical baseline sales. A selected growth rate then projects future sales from 2022–2040.
 - a. **Set target type:** ESIST allows users to choose from three different target types, including:
 - b. Annual Budget: Set up an energy efficiency trajectory based on potential program budget.
 - c. Annual Incremental Savings: Set up an energy efficiency trajectory based on the annual incremental savings to be implemented in each year, measured in megawatt-hour (MWh), or the annual incremental savings as a percent of previous-years' sales (in %).
 - d. Cumulative Savings: Set up an energy efficiency trajectory based on a future-year target for cumulative energy efficiency (in MWh or %).

Depending on the target type chosen, users progress through the next steps in the tool differently.

If Annual Budget is chosen:

1. **Set program cost assumptions:** Users set an estimated dollar-per-kilowatt-hour (kWh) cost for incremental energy efficiency measures.
2. **Set budget assumptions:** Users set annual budgets (measured in million dollars spent) for energy efficiency spending.

If Annual Incremental Savings is chosen:

1. **Set savings trajectory:** Users set an energy efficiency trajectory based on annual incremental savings (measured in MWh).
2. **Set program cost assumptions:** Users set an estimated dollar-per-kilowatt-hour (kWh) cost for incremental energy efficiency measures.

If Cumulative Savings is chosen:

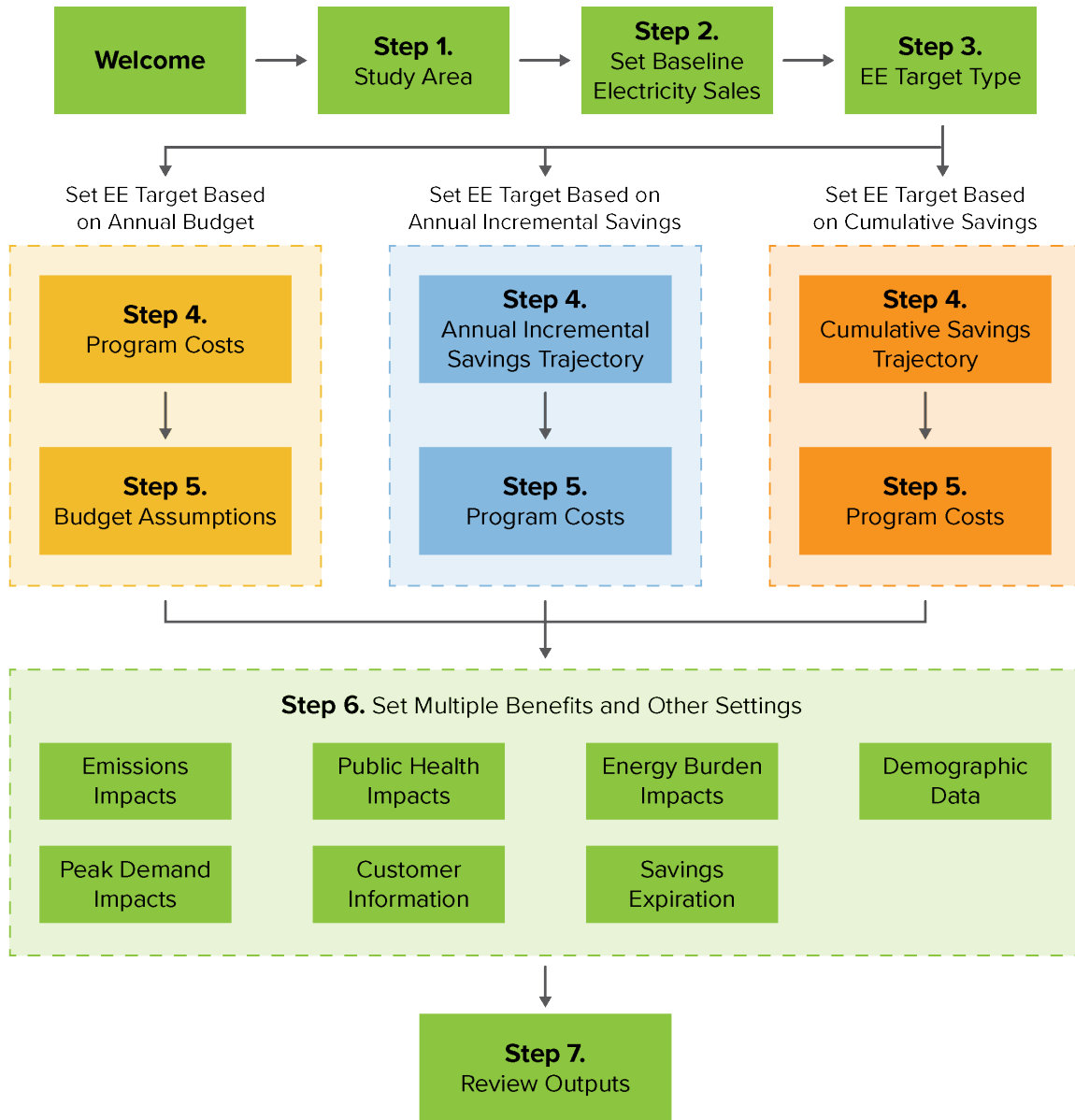
1. **Set savings trajectory:** Users set an energy efficiency trajectory based on a cumulative target for savings in some future year (measured in MWh).
2. **Set program cost assumptions:** Users set an estimated dollar-per-kilowatt-hour (kWh) cost for incremental energy efficiency measures.

Under all three target types, users have an option to progress to the final two steps:

1. **Set multiple benefits and other settings:** Users can choose whether to adjust or view the assumptions that affect emissions impacts, public health impacts, energy burden impacts, demographic data, peak demand impacts, customer information, and savings expiration.
2. **Review outputs:** Users may view outputs including sales, savings, costs, avoided emissions, public health impacts, energy burden impacts, and peak demand impacts. Users may then compare results to other geographies and other scenarios if desired.

Figure 2 provides a graphical representation of these steps.

Figure 2. ESIST steps



View User Manual

The second button, “View the User Manual” links the user to this document.

Summary of Costs and Benefits in ESIST

The third button, “Click here to see summary of costs and benefits” brings the user to a page showing the same information shown in Table 1.

Comparing Scenarios

The fourth button, “Restore default Excel functionality” resets the workbook to show typical Excel features that are otherwise hidden from view. When users first open the tool, Excel features such as the formula bar, column and row headings, and tab list are hidden from view to streamline the user interface. Users who wish to access the supporting datasheets, or users who wish to export datasheets to other standalone Excel workbooks, may wish to click this button. After clicking this button, users may click it again to re-hide these same features.

This may be a particularly useful feature for users looking to conduct analyses for various scenarios. For example, users may be interested in evaluating the costs, emissions, and public health impacts associated with a scenario that models an energy efficiency savings level of one percent annual incremental savings and a second scenario that doubles this level of savings. Other users may be interested in evaluating the impacts of savings in some, but not all, utilities within a state. Still other users may wish to evaluate each sector (residential, commercial, industrial) separately within the same utility.

In these cases, users may save new copies of ESIST, each named to reflect the energy efficiency parameters being chosen. In each saved copy, users may click the “Restore default Excel functionality” to easily jump between tabs of different workbooks saved with different ESIST scenarios and copy results to standalone workbooks for comparison. For example, users may then compare outputs from Step 7 or charts between the ESIST scenarios. With default Excel functionally restored, users can also export the results to a new workbook by right-clicking on the tab name (e.g., “S7_Outputs”), selecting “Move or Copy,” ticking the box labeled “Create a copy,” and moving the tab to a new workbook. Users can then press CTRL+A, CTRL+C, and CTRL+V to replace all linked formulas with static values. In this separate workbook, users can then perform any additional comparative analysis.

3. ESIST Step-by Step Instructions

The next seven sections of this manual provide details on each step in using ESIST. Following these sections, the three appendices provide additional detail on methodology and usage of ESIST:

- Appendix A: Data sources used in ESIST.
- Appendix B: Highlights several potential use cases of ESIST.
- Appendix C: Pilot Gas Version used for exploring impacts associated with reducing consumption of natural gas.

Step 1: Set Study Area

The first step with ESIST is setting the study area. The default options within ESIST allow users to define the area of interest in terms of geography (e.g., nationwide, statewide, or utility service territory), utility type, and customer sector. These options align with the geographic areas for which jurisdictions are most likely to explore setting savings targets. For example, each of the states that currently has an EERS sets its targets on a statewide or utility service territory basis. ESIST allows users to explore the implications of setting energy efficiency targets for different geographic areas, such as jurisdiction-wide or for one or more utility service territories.

First, users select either a single state (including all 50 states, the District of Columbia, and Puerto Rico) or the nation as a whole.

Second, users can select a customer sector within the chosen state or nation as a whole. Customer sectors are defined according to EIA, which divides savings and sales into residential, commercial, and industrial categories.¹³ Users may also select **Total** to analyze all three sectors together.

Third, users can select a utility type. Utility types are defined as cooperative, investor-owned, municipal, retail power marketer, and other.¹⁴ Users may also select **Total** to analyze all five utility types together.

Fourth, users can select a specific utility. This option is only available after they have specified a utility type (e.g., other than **Total**). Users can then choose from a list of utilities within that type and state.

¹³ EIA's Form 861 does not separately report data for the low-income residential sector. All data for low-income residential customers is included within the residential sector. ESIST users who are interested in analyzing detailed energy efficiency trajectories for the low-income residential sector should review the Energy Burden Impacts module described in in Step 6.

¹⁴ "Other" utilities include political subdivisions, third-party demand-side management administrators, federal entities, and other miscellaneous utility types. Some entities included in this data set have historical energy efficiency savings, but no historical sales. For guidance on which utilities are active in which territories, see <https://www.eei.org/about-eei/us-investor-owned-electric-companies> and <https://www.electric.coop/our-organization/nreca-member-directory>. Users may also wish to consult with the website for their public utilities commission (sometimes called a department of public utilities or public services commission) for more information on the types of utilities that exist within their state of interest.

After the study area is set, ESIST automatically loads all relevant historical data and default projections for the selected area.¹⁵

Depending on the geography you have selected, ESIST may not load all the savings and sales germane to your jurisdiction. In some parts of the country, energy efficiency is administered by third parties, whereas electricity continues to be sold by electric utilities. In these cases, if a user selects only the third-party demand-side management (DSM) administrator (denoted in the tool as “Other” utility type), ESIST will not load any relevant data on sales.¹⁶ Conversely, if a user selects only the utility, ESIST will not load any relevant data on savings. Users should take care to note whether their selected region contains any substantial third-party administrators. In these cases, users may be better served by setting their selected area to the entire state (thereby ensuring all sales and savings get pulled from ESIST’s data library), rather than selecting one utility or third-party administrator at a time. Table 2 lists states where there are substantial savings reported by a third-party administrator.

Table 2. States with substantial savings reported by a third-party DSM administrator

State	Name of third-party DSM administrator
DC	DC Sustainable Energy Utility
DE	Delaware Sustainable Energy Utility
HI	Hawaii Energy Efficiency Program
MA	Cape Light Compact
ME	Efficiency Maine Trust
NY	NYSERDA
OR	Energy Trust of Oregon
VT	Vermont Energy Investment Corporation
WI	Focus on Energy

Note: This is not an exhaustive list. Many states have other governmental or semi-governmental organizations that administer energy efficiency programs in all or part of the state.

Step 2: Set Baseline Electricity Sales

The next step within ESIST is to identify a baseline sales forecast for the user-defined study area. The purpose of this step is to determine a baseline against which incremental energy efficiency investments in future years can be applied.¹⁷

¹⁵ Due to the way dropdown selectors in Excel work, it is possible for a user to create non-existent geographies. For example, a user could select a fine level of geographic resolution (e.g., “City of Aspen”), then change earlier dropdowns such that an implausible selection is shown (e.g., the user changes the state from “CO” to “AK” where no City of Aspen exists). In these situations, ESIST will display zeros for savings and sales and will display an alert at the top of the page, since it will be unable to find any historical data that corresponds with the new, implausible selection. Users should take care to only create plausible combinations of geographies.

¹⁶ Users may also observe the presence of utilities titled as “Adjustment.” These rows reflect the sales associated with non-respondents to EIA’s Form 861.

¹⁷ For more information about developing a baseline from which to assess energy efficiency savings, see: EPA. *Including Energy Efficiency and Renewable Energy Policies in Electricity Demand Projections*. (2015). Available at <https://www.epa.gov/statelocalenergy/including-energy-efficiency-and-renewable-energy-policies-electricity-demand>.

ESIST Approach

The default baseline sales forecast in ESIST represents historical years without the impacts of historical energy efficiency (2010–2021) and forecasted electricity sales based on an annual electricity sales trajectory from EIA’s AEO.¹⁸ ESIST uses data from EIA to estimate the cumulative energy efficiency that was in place in the historical years.¹⁹ ESIST uses these data to adjust historical sales, resulting in a value that represents sales that would have occurred were there no historical energy efficiency implemented. This step is performed so that users can explicitly observe the impacts of existing energy efficiency programs, both on past year sales, and on future year sales. Without this step, there is a risk that users could double-count the impact of energy efficiency in ESIST. Equation 1 shows ESIST’s default equation for calculating baseline sales.

Equation 1. Demonstrative calculation of “baseline sales” for the year 2021

$$\begin{aligned}
 \text{Baseline sales}_{2019} &= \text{Reported sales}_{2021} + \text{Reported EE savings}_{2021} \\
 &+ \text{Reported savings}_{2020} + \text{Reported savings}_{2019} + \dots \\
 &+ \text{Reported savings}_{2011} - (\text{Expired savings}_{2020} \\
 &+ \text{Expired savings}_{2019} + \dots + \text{Expired savings}_{2011})
 \end{aligned}$$

To estimate sales for future years (i.e., 2022–2040), the adjusted baseline sales value from the most recent historical year (i.e., 2021) is multiplied by 1 plus the selected growth rate, as shown in Equation 2.

Equation 2. Demonstrative calculation of “baseline sales” for the year 2022

$$\text{Baseline sales}_{2022} = \text{Baseline sales}_{2021} \times (1 + \text{Selected growth rate})$$

The columns in Step 2 of the tool are as follows:

- The first column describes the information contained in each associated row.
 - There are three separate rows, each displaying information for annual sales growth, reported sales (i.e., a sales trajectory that includes the impacts of energy efficiency savings), and baseline sales (i.e., a sales trajectory that has had the user-defined impacts of past energy efficiency savings removed from past years).
- The second column details the unit measurement of the row (% or MWh).
- Columns 3–13 present the historical data.
- The 14th and subsequent columns (to the right on each sheet) present projected data for future years, based on the input assumptions chosen by the user.²⁰

¹⁸ Specifically, ESIST relies on data from AEO 2023’s Reference case.

¹⁹ This process also accounts for whether any historical measures have expired in past years, based on the savings expiration schedule defined in Step 6. Sales are tabulated from EIA 861, relying on data from “delivery” and “bundled” service providers, but not “energy” service providers. The quantity of electricity sold by these “energy” service providers is already captured in the “delivery” and “service” datapoints.

²⁰ Data are provided through 2040 for users who wish to assess the impact of energy efficiency over a long time horizon. This timeframe in ESIST is consistent with analyses such as EIA’s AEO and utility integrated resource

Alternatively, users may apply a historical baseline sales data set from their local utility, ISO, or another source.²¹ To override the default annual sales values and import external sales (in MWh), simply select the user input option and replace the default historical savings pre-populated by ESIST with user-defined values. Users are encouraged to take steps to understand and communicate whether and how historical energy efficiency program impacts are represented in user-specified baseline data sets. If the effects of historical energy efficiency programs are embedded in these values, users can consider making appropriate adjustments to their scenario to avoid double-counting incremental energy efficiency savings.

Future Baseline Sales Growth

The next decision users make in Step 2 is the level of growth in electricity sales over the future analysis time horizon. Users can choose annual or cumulative growth rates that apply to the most recent historical year (2021) within ESIST. The chosen growth rate forecasts annual baseline sales for all future years. ESIST's default option is the compound annual growth rate (CAGR) from EIA's AEO Reference case.

Users can select one of the following annual growth rate options by clicking on the blue dropdown:

- Compound Annual Growth Rate (CAGR)
- Annual Average Growth Rate (AAGR)
- Historical CAGR
- User Input (%)
- User Input (MWh)

Table 3 compares each of these growth rate options and indicates recommended uses. The details provided in this table and the next section are intended to help users understand the data sources and assumptions that affect the future growth of baseline electricity sales so they can make an informed choice within the tool. Note that growth rates from AEO (including CAGR and AAGR) are region-specific, based on the region selected by the user, but do not change based on selections to utility or sector.²²

Users should check whether their sales projections take into account sales increases from electrification. In situations where modeled energy efficiency programs contain electrification measures, the sales projection should not include sales increases related to these measures to avoid double-counting. In other cases, users may want their projections to account for sales increases related to electrification measures unlikely to be covered by energy efficiency programs (e.g., vehicle electrification).

plans that extend several decades into the future to inform electricity system planning and investment decisions. While extended planning horizons are necessary for these purposes, such values are inherently more uncertain than near-term projections. Users interested in analysis over the short term (e.g., within the range of a single energy efficiency measure's lifetime) can ignore years beyond the study period.

²¹ For more information on ISOs, see page 19.

²² See Figure 3 for more information on the regions modeled in AEO.

Table 3. Comparison of baseline electricity sales options

Baseline sales growth rate	Includes embedded effects of historical energy efficiency	Includes embedded effects of some future energy efficiency rebates	Includes embedded effects from building codes, lighting, and appliance standards	Type of average	Basis of growth rate	Recommended use
CAGR	Yes	Yes	Yes	CAGR	AEO Reference case	Best for capturing the long-term trends in electricity demand as modeled in the AEO when no other geographically specific data are available
AAGR	Yes	Yes	Yes	Year-on-year	AEO Reference case	Best for capturing the near-term, year-to-year variations in electricity demand as modeled in the AEO when no other geographically specific data are available
Historical CAGR	No	No	No	CAGR	Historical data from EIA Form 861	Best when future growth trends in baseline sales are assumed to not change substantially from the past
User Input (%)	Users should determine	Users should determine	Users should determine	N/A	Custom projection	Best when the user already possesses a geographically specific, year-on-year growth rate
User Input (MWh)	Users should determine	Users should determine	Users should determine	N/A	Custom projection	Best when the user already possesses a geographically specific annual MWh change in electricity sales

CAGR (Default)

CAGR applies a single compound annual growth rate to each future year. These values are from EIA’s AEO Reference case.²³ The annual growth rates are specific to the selected state’s associated electrical area, as modeled in AEO (see Figure 3). These electrical areas are also called Electricity Market Module (EMM) regions and are calculated using the formula shown in Equation 3. With this selection, a single unchanging growth rate is applied to every year in the

²³ Each year, EIA publishes a new version of the AEO, which contains projections of future energy use, prices, and emissions that generally account for existing, “on-the-books” policies. AEO contains a number of different modeled futures; ESIST uses the Reference case.

analysis. For example, for the United States as a whole, the default value is about one percent per year, applied in each future year. This selection is most useful if the user is less concerned with year-on-year variations in electricity sales and instead wishes to apply an average growth rate to the study period.

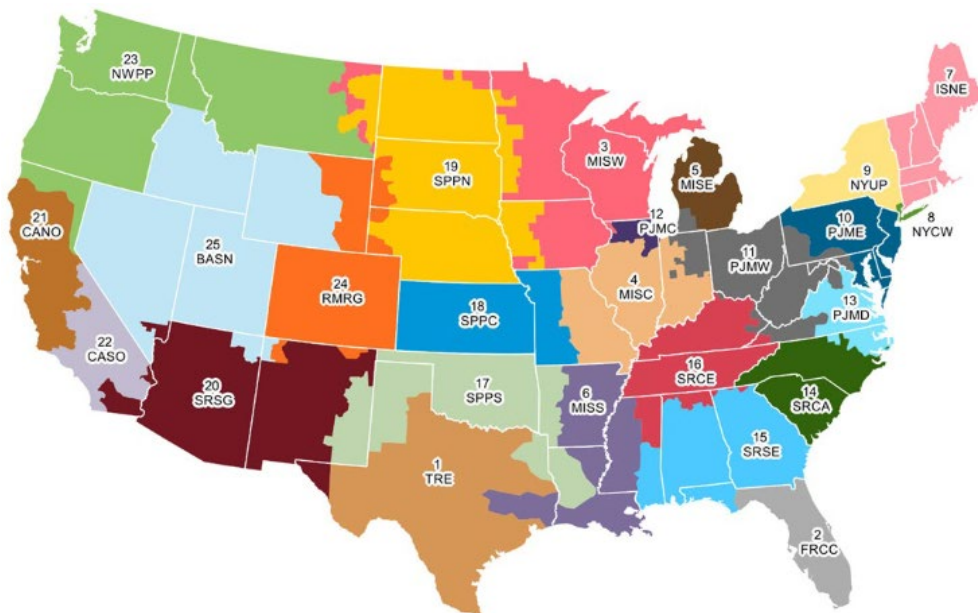
Equation 3. Equation for calculating CAGR in AEO

$$AEO\ CAGR = \left(\frac{\text{Last year electricity sales for census division}}{\text{First year electricity sales for census division}} \right)^{\left(\frac{1}{\text{Number of years}} \right)} - 1$$

AAGR

The **AAGR** selection applies a growth rate that is specific to each future year. This selection allows users to apply unique changes to sales in each year; in contrast, the CAGR applies a single average change in sales over the entire time period. The AEO annual growth rate is most useful if the user is attempting to capture the near-term, year-on-year variations in electricity sales modeled in the AEO.²⁴ These are best used when more geographically specific data (i.e., from a local ISO or utility) are not available.

Figure 3. Map of EMM regions modeled in AEO



Source: <https://www.eia.gov/outlooks/aeo/assumptions/pdf/electricity.pdf>

Note: This figure does not display Alaska, Hawaii, or Puerto Rico, which are assigned a default value equal to the national average.

²⁴ Series modeled in the AEO (including electricity sales) tend to observe larger variations in near-term years (i.e., through the next two to five years), as the AEO modeling takes into account near-term expectations for commodity price changes, power plant construction, and weather. Over the longer term (i.e., from the mid-2020s through 2040), there tends to be less dramatic year-to-year variation in modeled values.

Key Note—Allocating growth rates to states: AEO calculates sales projections for EMM regions that are not aligned with state borders. In AEO 2021, sales information is reported at the EMM region level. ESIST assigns sales projections to each state based on which EMM region that state is most located in. For example, Maine is in the “New England” census division; if Maine (or a constituent sector or utility) is selected, ESIST automatically applies the growth rates for that region to that state.

Historical CAGR

The **Historical CAGR** selection is a CAGR based on the adjusted baseline sales for the selected geography, calculated over the period from 2010–2021. This average is then applied to every future year in this analysis. This selection is useful if the future growth rate is not expected to change substantially from recent observed historical data. This may also be a good selection if users wish to investigate the incremental impacts of future codes or standards aimed at reducing energy consumption, as these future codes and standards by definition are not included in historical sales.

User Input (%)

User input (%) allows users to input their own annual sales growth rate (on a percent basis) in place of the default annual sales growth rates. Upon choosing this option, future values in the “Annual sales growth rate” cells are shown in blue and can be modified. Any positive or negative value can be entered in these cells.²⁵ This is a useful selection if users have access to sales growth rates (year-on-year or average) from an outside source. Users interested in identifying an alternative to ESIST default rates—either for comparison to the default values or to replace the defaults—are encouraged to consult one or more of the following:

- **Utility integrated resource plans (IRPs):** Many utilities across the country are required by statute or state regulators to submit an IRP detailing their plans for power plant construction, electricity procurement, environmental compliance, and related matters. Typically, these plans include one or more projections of electricity sales. Plans may be released yearly or on a multi-year schedule.
- **ISOs:** ISOs frequently release their own projections of electricity sales, separate or in addition to any sales projections made by utilities that are a constituent of the ISO’s geographical region. These sales forecasts may be developed for the ISO as a whole or for more discrete constituent regions within the ISO, such as individual states or specific electricity control areas.²⁶
- **Other sources:** Users may also choose to rely on sales forecasts developed by organizations other than EIA. These sales forecasts may be modified or adjusted versions of forecasts found in utility IRPs or ISO studies, or they may have been independently developed by state agencies, NGOs, or other entities.

²⁵ Note that in cells formatted to be percentages, if a user enters “.2” Excel may interpret this entry as “20 percent.” If a user intends for “.2” to instead represent “0.2 percent,” then he or she should enter “0.2” in the cell.

²⁶ Two examples of ISO-developed sales projections include ISO New England’s CELT forecast (available at <https://www.iso-ne.com/system-planning/system-plans-studies/celt>) and New York ISO’s Gold Book (available at <https://www.nyiso.com/gold-book-resources>).

User Input (MWh)

The **User input (MWh)** selection functions similarly to the **User input (%)** selection, except with a different format. This option allows users to input their own annual sales (in MWh format) in place of the default annual sales. After making this selection, the future values in the “Baseline sales” row are shown in blue and can be modified. Users can enter any positive value in these cells. Once the sales are entered, ESIST will automatically show the user an implied annual sales growth rate. As in the **User input (%)** selection, this is a useful selection if users have specific sales numbers from an outside source such as an IRP or ISO, as described above.

Embedded Savings

Being clear on which energy efficiency program impacts are embedded in a baseline sales forecast may be important to avoid double-counting and properly account for energy efficiency targets set in Step 2. The term “embedded” is used to describe the energy efficiency savings that are included in a baseline electricity sales forecast. Depending on what source is used for an electricity sales forecast, embedded savings may be explicitly described, or may be accounted for in some way that is difficult to discern. For example, both ISO New England and New York Independent System Operator (NYISO) publish forecasts of electricity consumption each year that clearly identify the amount of energy efficiency that is assumed in an expected or baseline future.²⁷ Meanwhile, AEO 2023 does not explicitly note the quantity of energy efficiency modeled in its Reference case.²⁸ As a result, the default selections in ESIST (which are based on AEO 2023) do not explicitly remove embedded savings from the baseline sales forecast for future years.

In situations where users are relying on an outside source for baseline electricity sales, users should assess how their data source addresses the following items to avoid double-counting:

²⁷ For information on ISO New England’s 2021 forecast, see https://www.iso-ne.com/static-assets/documents/2021/04/forecast_data_2021.xlsx. For information on NYISO’s 2021 forecast, see <https://www.nyiso.com/documents/20142/2226333/2021-Gold-Book-Final-Public.pdf/b08606d7-db88-c04b-b260-ab35c300ed64?t=1619631804748>.

²⁸ In 2018, EIA released a white paper (see: Fickling and Jarzomski. *Modeling the Effects of Historical and Projected Energy Efficiency Incentives*. [2018]. Presented at 2018 ACEEE Summer Study on Energy Efficiency in Buildings. Available at <https://www.aceee.org/files/proceedings/2018/index.html#/paper/event-data/p275>) where it outlined the methods used in AEO 2018 to model the impacts of ratepayer-funded energy efficiency. EIA modeled two scenarios: one in which future energy efficiency rebates are implemented (as in the AEO 2018 Reference case), and one in which these future energy efficiency rebates are not implemented. In AEO 2018, EIA modeled just one component of energy efficiency savings—energy efficiency rebates. It did not project savings from other energy efficiency strategies such as low-interest loans, behavioral programs, and market transformation activities. This paper illustrated that the modeled savings in the AEO is relatively small; between 2020–2050, the cumulative annual impact of customer-funded energy efficiency rebates is estimated to range from 0.2 to 0.4 percent of sales, suggesting very small annual incremental impacts in any one year. In emailed communication dated September 2020, EIA described that their methodology has not changed substantially, but that they do not plan to regularly release updates to this analysis. Our understanding is that this has not changed with the most recent AEO release used in ESIST, AEO 2023. For these reasons, we have assumed that embedded energy efficiency savings in the AEO projection are zero. Likewise, we observe that EIA has not materially updated assumptions related to electrification, as the nationwide 2022-2040 CAGR for electricity sales has not varied substantially in any of the nine AEO Reference cases released since AEO 2015 (with the CAGR for AEO 2023 of 0.60 percent compared to CAGRs as low as 0.51 percent in AEO 2017 to a high of 0.77 percent in AEO 2016, and an average across all nine AEO studies of 0.65 percent). Users interested in modeling the impacts of energy efficiency in the context of ambitious levels of electrification may want to rely on other, region-specific load forecasts as inputs to ESIST rather than projections from AEO.

1. Savings from historical energy efficiency programs funded by utility customers.
2. Savings from some future energy efficiency rebates that lower the costs to customers of certain energy-efficient equipment.
3. Savings from existing building energy codes, as well as existing federal appliance and lighting efficiency standards.
4. Savings from future changes to building energy codes, as well as federal appliance and lighting standards that are scheduled to take effect during the forecast period.

In many situations, it is possible or even likely that the source being used does not address any of these four points.²⁹ In these cases, users should be careful to caveat that their analysis may over-estimate savings. Users may want to perform sensitivity analyses to determine the impacts of potentially overcounting these savings.

Step 3: Set Target Type

Many states, local governments, and utilities around the country set energy efficiency targets to ensure they achieve expected savings levels and associated policy objectives. Common policy objectives include saving homeowners and businesses money, ensuring a robust electricity grid, and achieving air quality and health benefits, among other benefits.³⁰ Jurisdictions typically set energy efficiency targets in terms of a quantity of annual incremental savings or cumulative savings, or an annual budget level. ESIST supports each of these prevailing approaches to setting targets.

After setting a study area and developing a projection for baseline sales, users must then set an energy efficiency target type that serves as the basis for modeling savings and cost trajectories. Users may select one of the three target types described below. Users may wish to make a selection that most closely aligns with the locally preferred approach and available data from sources such as energy efficiency plans, energy efficiency potential studies, or state and local energy policies. In addition, tools such as the State and Local Planning for Energy (SLOPE) Platform, can be used to reference energy efficiency potential by sector and state.³¹

Annual Budget

In this approach, users set annual budgets for energy efficiency spending (in constant dollars) and inputs for energy efficiency costs (in dollars-per-kWh). The tool will calculate the savings trajectory based on these parameters. This target type is likely to be most relevant for jurisdictions that are analyzing the impacts of year-on-year changes in energy efficiency budgets.

²⁹ The NYISO and ISO New England examples described earlier tend to be outliers on this issue.

³⁰ For more information on quantitative estimates of these impacts, see EPA's 2018 edition of *Quantifying the Multiple Benefits of Energy Efficiency and Renewable Energy: A Guide for State and Local Governments*, available at <https://www.epa.gov/statelocalenergy/quantifying-multiple-benefits-energy-efficiency-and-renewable-energy-guide-state>.

³¹ For more information on SLOPE, see <https://maps.nrel.gov/slope/>.

Example: An energy efficiency plan filed with a PUC by a utility or third-party program administrator has been capped at \$40 million annually. Following state policy directives encouraging further investment in energy efficiency, the SEO staff and NGOs, in addition to other stakeholders, may wish to model the savings that accrue from raising the budget allowed for energy efficiency programs.

Annual Incremental Savings

In this approach, users set a trajectory for annual incremental savings. This is also sometimes referred to as “first year savings” because the target quantifies the savings from new measures in the first year the measures are installed. Users can create a trajectory by entering in an annual quantity (measured in MWh) or a percent (measured in annual MWh saved divided by the previous year’s baseline sales). This target type is likely to be most relevant for jurisdictions that are interested in analyzing the impacts of year-on-year changes in savings.

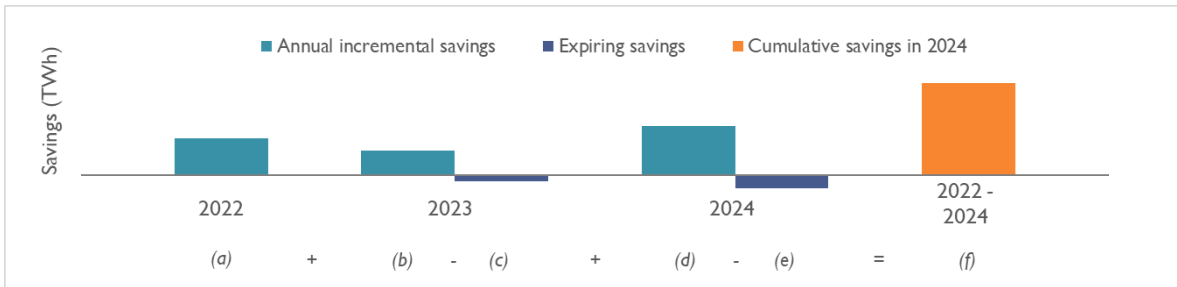
Example: An energy efficiency plan filed with a PUC by a utility or third-party program administrator may include a savings target of 1.0 percent per year (measured as a percent of total electricity sales) in 2022 and 2023. PUC staff, utilities, and others can use ESIST to examine a scenario where this target is maintained through 2040. In a jurisdiction where air quality is an issue, stakeholders may also compare criteria pollutant emissions under the baseline scenario (e.g., 1.0 percent savings per year) to another scenario where pollution limits are met (e.g., where the utility ramps up to a savings target of 2.5 percent in 2025 and maintains this higher target through 2040).

Cumulative Savings

Users set a cumulative savings target to achieve for some future year. Cumulative savings differ from annual incremental savings (see Figure 4). Annual incremental savings are the new first-year savings from measures that are installed in any one year. Cumulative savings are the sum total of new and persisting savings in a given year, net of expired savings.³²

³² We note that other organizations may use different terms for these definitions. For example, the American Council for an Energy-Efficient Economy (ACEEE) uses the term “annual total savings” in place of what we consider cumulative savings, and uses the term “cumulative savings” to refer to what would be a multi-year sum of what we consider cumulative savings (see, for example, page 9 of Gold, R. and Nowak, S. Energy Efficiency Over Time: Measuring and Valuing Lifetime Energy Savings in Policy and Planning. ACEEE. (February 2019). Available at <https://www.aceee.org/sites/default/files/publications/researchreports/u1902.pdf>). Other jurisdictions may use other terms or may apply these terms to other definitions.

Figure 4. Annual incremental savings versus cumulative savings



This target may be a cumulative quantity (measured in MWh) or a percent (measured in cumulative MWh saved divided by the previous year’s baseline sales). This target type is likely to be most relevant for jurisdictions that are revisiting existing energy efficiency goals or considering new energy efficiency goals that are established on a cumulative level of savings achieved in some future year.

Example: A state may have a goal to reduce GHG emissions by 90 percent by 2050. An energy efficiency potential study may identify a cumulative achievable savings potential of 25 percent in 2030. In assembling a multi-sector plan for how to achieve the state’s GHG reduction goal, the SEO staff, NGOs, and other stakeholders may wish to model the reductions attained by ramping up energy efficiency programs to the 25 percent level.

Next, ESIST leads users through two steps (Steps 4 and 5) to set a savings or budget, and a cost trajectory. These steps are presented in a different order depending on the target type selected in Step 3. Under the annual and cumulative savings target types, users first set a savings trajectory and then a cost trajectory. Under the annual budget target types, this is reversed, and users first set a cost trajectory and then a budget trajectory. The next section breaks out the discussion of setting a budget or savings trajectory by the three target types listed above.

Steps 4 and 5: Annual Budget

Under the annual budget target type, users establish a budget or spending level for energy efficiency in each modeled year. First, users set an expected program cost for energy efficiency, measured in terms of dollars-per-kWh. Second, users set an annual budget, measured in dollars. ESIST then calculates annual incremental savings, measured in MWh.

Step 4: Set Program Cost Assumptions

In this step, users have four choices for setting the cost of energy efficiency, measured in dollars-per-kWh:

- Constant
- Historical
- User Input

Within ESIST, “costs” are defined as total program costs—i.e., the cost to the utility and program participants to implement an energy efficiency program. These total costs are distinct from “net costs,” which account for energy efficiency benefits (such as in the context of an energy efficiency program cost-effectiveness evaluation). Program costs are a key metric of interest to state and local governments, utilities, and other stakeholders. These outputs have implications for the overall magnitude of the target that the jurisdiction sets, how rapidly the jurisdiction wishes to ramp up the full target level, and whether the ramp up is constant or varies over time.

The following sections discuss each of the above choices in more detail.

Constant

When **Constant** is selected, ESIST loads a default cost of saved energy for the first year of the energy efficiency program.³³ This first-year cost of saved energy is calculated by dividing the total program cost by the annual incremental savings (i.e., achieved in the first year). For a default cost, ESIST relies on a 2020 Berkeley Lab study that finds a national, savings-weighted average levelized utility cost of \$0.026 per kWh (in 2018 dollars).³⁴ Under the **Constant** setting, ESIST assumes that this cost (or another cost chosen by the user) remains flat for future years. For the historical years, ESIST reports actual historical cost data unique to the geography chosen. Users may also update the utility share of costs input to more accurately represent the allocation in their jurisdiction. The utility share of costs indicates how much of the total cost per kWh is allocated to utilities versus the costs born exclusively by energy efficiency program participants.³⁵

The 2018 Berkeley Lab study also describes energy efficiency costs for different states and different sectors. Users have the option to rely on national-level data, state-specific data, sector-specific data, or both state- and sector-specific data.³⁶

³³ The first-year cost of saved energy reflects the fact that funds collected via electricity rates from customers are typically spent in the same year they are collected. The levelized cost of saved energy spreads the initial cost over the expected lifetime of the efficiency measures, enabling comparisons between energy efficiency measures and other traditional energy resources.

³⁴ See: Lawrence Berkeley National Laboratory. "Still the One: Efficiency Remains a Cost-Effective Electricity Resource." (2021). Available at <https://eta.lbl.gov/publications/still-one-efficiency-remains-cost>. Values reported in this document have been modified to reflect changes in dollar years (using data on inflation from the U.S. Federal Reserve), splits in utility/participant spending, and a conversion from levelized costs to first-year spending (based on ESIST's assumptions on dollar years and capital recovery factors, developed using data from this Berkeley Lab study).

³⁵ As a default, ESIST assumes a utility/participant split of 54%/46%, based on analysis in: Lawrence Berkeley National Laboratory. "The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015." (2018). Available at https://eta-publications.lbl.gov/sites/default/files/cose_final_report_20200429.pdf.

³⁶ We rely on Berkeley Lab (2021) for utility cost data for all sectors together, individual sectors, and geographic regions. We rely on Berkeley Lab (2018) for data on the utility share of cost input, and for information on state-specific costs. We note that depending on the selected geography, users may observe a discontinuity between historical costs of saved energy and the costs projected for future years from Berkeley Lab. This may be due to inconsistencies in selected geography. For example, a discontinuity may appear if the user has selected a specific utility, but chooses to base future costs on state-level estimates from Berkeley Lab. The discontinuity may instead be due to differences in how these two sets of numbers are calculated. This is because historical costs represent the utility-reported costs in any one year, while the Berkeley Lab estimates are calculated with information from a number of years.

Users may also update the discount rate, which is applied to calculate the levelized cost of saved energy.³⁷ Discount rates can be used to value future-year costs (or savings) by being combined with a measure lifetime to calculate a “capital recover factor,” which can then be used to convert first-year costs of saved energy into levelized costs. All else being equal, higher discount rates result in higher levelized costs of saved energy, while lower discount rates lead to lower levelized costs of saved energy. ESIST automatically converts first-year costs to levelized costs using the discount rates chosen by the user.

Key Note—First-year versus levelized costs: To facilitate “apples-to-apples” comparisons between energy efficiency and other energy resources, the first-year cost of saved energy can be reframed as the levelized cost of saved energy (i.e., amortized cost). This spreads the initial cost over the expected lifetime of the efficiency measures. ESIST does this by multiplying the costs by a capital recovery factor (CRF):

$$1. \text{ Levelized Cost of Saved Energy} = \text{CRF} * \text{Total Costs} / \text{Annual Savings}$$

The CRF is defined by a standard amortization formula:

$$2. \text{ CRF} = r * (1 + r)^n / [(1 + r)^n - 1]$$

This second equation highlights the dependence of the levelized cost of saved energy on r , the discount rate, and n , the estimated lifetime of the measure in years.

Historical

When users select **Historical**, the “First-year cost of saved energy” row uses the reported cost for the selected geography in 2021 for all future years. Historical first-year costs of saved energy are provided for all past years. These values are provided as a reference point, enabling users to view and compare trends over time. The calculation of historical costs uses total savings and energy efficiency expenditure data from EIA Form 861.³⁸

User Input

When users select **User input**, the “First-year cost of saved energy” row turns blue for future years, allowing users to overwrite the cost of saved energy in every year of the study period. Because of the variability in the types of costs used by different jurisdictions, ESIST presents costs from several perspectives. ESIST automatically converts this first-year total cost into first-year utility

³⁷ Discount rates commonly used in federal government decision-making related to energy efficiency include both three percent and seven percent (see https://www.reginfo.gov/public/jsp/Utilities/circular-a-4_regulatory-impact-analysis-a-primer.pdf). Seven percent represents the average cost of capital investments by corporations and other entities, while three percent represents the societal discount rate based on the rate the average saver uses to discount future consumption. The National Standard Practice Manual (available at https://nationalefficiencyscreening.org/wp-content/uploads/2017/05/NSPM_May-2017_final.pdf) recommends using a discount rate in the range of 0–3 percent for most purposes related to energy efficiency. For these reasons, ESIST uses three percent as a default value.

³⁸ For years before 2013, EIA includes a category of expenditures called indirect costs that are shared between energy efficiency and load management programs. To determine the magnitude of indirect costs to include, ESIST calculates the fraction of total savings from the combined energy efficiency and load management that was achieved through energy efficiency by each utility for each sector. ESIST then includes these fractions of the indirect costs in the total cost of energy efficiency for each utility and sector.

costs using the utility share of costs chosen by users. ESIST then converts first-year utility costs to utility leveled costs using the discount rates chosen by the user.

Step 5: Set Budget Assumptions

After setting the cost of energy efficiency (measured in dollars-per-kWh), users next set the program cost or budget (measured in dollars). Users have three options within this selection:

- Constant Budget
- Percent Change
- User Input

The following sections discuss each of the choices in more detail.

Constant Budget

When users select **Constant budget** ESIST assumes that the annual program budget observed in 2021 is extended at the same level in each future year. Users may overwrite this annual program budget with any number greater than or equal to 0. This option is most useful for users who wish to analyze an unchanging level of expenditures in each year of the study period.

Percent Change

When users select **Percent change**, ESIST applies an annual year-on-year percent change in program budgets, beginning with 2022 and continuing through 2040. This option is most useful for users who wish to analyze a budget that grows or shrinks over time.

User Input

When users select **User input**, all values in the “Annual Program Admin. Budget (2020 \$ Million)” row turn blue, indicating that the user may overwrite numbers in all future years. Users may overwrite this annual program budget with any number greater than or equal to zero. This option is most useful for users who wish to analyze a changing level of budgets throughout the study period.

These budget inputs are then used to calculate a savings trajectory. ESIST also uses this information to calculate the total energy efficiency expenditures (i.e., inclusive of both utility and participant costs), as well as the implied level of annual incremental savings (measured in both MWh and savings as a percent of previous-year sales).

Key Note—Reasonably achievable savings levels (annual budget): As with the annual and cumulative savings target types, if users set an annual utility budget trajectory that implies annual incremental savings greater than three percent in any given year, ESIST prompts the user to closely examine this value. It is possible that some jurisdictions may achieve or exceed three percent annual incremental savings for a limited set of years, although literature review indicates that this level represents the high end of the achievable annual incremental savings range.

Steps 4 and 5: Annual Incremental Savings

Under the annual incremental savings target type, users establish an expected level of savings for energy efficiency for each modeled year. Annual incremental savings are the new savings from

energy efficiency expenditures in a given year and are sometimes referred to as “first-year savings.”

First, users set an expected level of annual incremental or first-year savings, measured in terms of MWh. Second, users set an expected program cost for energy efficiency, measured in terms of dollars-per-kWh. The model then calculates annual costs measured in dollars.

Step 4: Set Savings Trajectory

In ESIST, annual incremental savings can be framed in two ways: (1) in MWh or (2) in MWh as a percentage of the previous years’ MWh sales. Users should note that ESIST provides historical data on savings for 2011–2021. (2010 is considered the baseline year, and energy efficiency savings are not provided for this year.)

Under the “Savings Trend” dropdown, users can select from three options: Increase to Goal (the default), User Input (savings as a % of sales), and User Input (MWh savings).

- Selecting **Increase to goal** (the default option) allows users to input an “Annual Savings Goal (% of sales)” in percentage terms and a target year to start the increase. Users also enter a “ramp rate,” which is the percentage that sales increase in each year. Utilities that are implementing increasing levels of energy efficiency typically only gradually increase energy efficiency; it is rare for utilities to change from having no energy efficiency programs in one year to being a leading energy efficiency utility in the following year.

***Example:** Users can set a target savings level of 2.5 percent per year, a starting year of 2022, and a ramp rate of 0.2 percent. In this example, the selected area will begin increasing savings in the year 2022 at a level of 0.2 percentage points above recent historical levels, and will continue to increase by 0.2 percentage points in each year until a level of 2.5 percent is reached at some point in the future.¹ After the goal is reached, the goal will be maintained for the remaining years of the analysis period.*

- With the **User input (savings as a % of sales)** option, future values in the “Annual incremental savings” row turn blue, indicating to users that they can edit values for all future years. These cells accept any value greater than or equal to zero percent.
- **User input (MWh savings)** allows users to edit annual incremental savings in MWh terms instead. If this option is chosen, future values in the “Annual incremental savings” row turn blue, indicating to users that they can edit values for all future years. These cells accept any value greater than or equal to 0 MWh.

Key Note—Reasonably achievable energy efficiency savings levels (annual incremental savings): As with the annual budget and cumulative savings target type, if users set an annual incremental savings trajectory that implies annual incremental savings greater than three percent in any given year, ESIST suggests that this value be re-examined. It is possible that some jurisdictions may achieve or exceed three percent annual incremental savings for a limited set of years, although literature review indicates that this level represents the high end of the achievable annual incremental savings range.

Step 5: Set Program Cost Assumptions

In this step, users have the same options to set program costs, measured in dollars-per-kWh, as are available in the Annual Budget target type (see page 23):

- Historical (default)
- Constant
- Savings-Dependent
- User Input

A description of the Savings-Dependent selection follows. For more information on Historical, Constant, and User Input selections, see page 23.

Savings-Dependent

When users select **Savings-dependent**, ESIST prompts the user to adjust a specified first-year cost of energy efficiency by three different adjustment factors that are each associated with a level of savings achieved. For example, a user may specify a first-year cost of energy efficiency of \$0.50 per kWh. They may then specify a level of savings of 0.5 percent, and a cost adjustment factor of zero percent. ESIST would interpret this to mean that costs would remain unadjusted (e.g., \$0.50 per kWh) up until a level of annual incremental savings of 0.5 percent were achieved. The user would then enter a second tier of adjustments: perhaps a threshold of one percent annual incremental savings and a cost adjustment factor of -10 percent. ESIST would then decrease the specified cost by 10 percent (creating a new cost of \$0.45 per kWh) for all years where savings are greater than 0.5 percent but less than one percent. Users may specify three different cost adjustment thresholds.

This approach is most useful in situations where users anticipate costs to vary according to program level. For example, users may assume that costs decrease as programs get larger (e.g., as a result of economies of scale) or that costs increase as programs move through the energy efficiency supply curve (e.g., as a result of lower cost opportunities being realized before higher cost opportunities).

Step 4 and 5: Cumulative Savings

Under the cumulative savings target type, users establish a cumulative level of energy efficiency savings for some future modeled year. Cumulative savings are the sum total of new and persisting savings in a given year, net of expired savings.

First, users set an expected level of cumulative savings in some future year, measured in terms of MWh, which ESIST then transforms into first-year or annual incremental savings also measured in terms of MWh. Second, users set an expected program cost for energy efficiency, measured in terms of dollars-per-kWh. The model then calculates annual costs measured in dollars.

Step 4: Set Savings Trajectory

In ESIST, cumulative savings can also be framed in two ways: (1) in MWh or (2) the MWh as a percentage of the baseline MWh sales in some future year. For user reference, ESIST provides historical data on savings for 2011–2021 (2010 is considered a baseline year).

Under the “Savings Trend” dropdown, users can select from three options: Increase to Goal (the default), User Input (savings as a % of sales), or User Input (MWh savings).

- Selecting **Increase to Goal** (the default option) allows users to input a “Cumulative Savings Goal (% of sales),” a year in which this goal needs to be achieved, and a year in which the ramp begins. This option is intended for users who wish to analyze a target level of cumulative savings, but are not necessarily interested in year-on-year changes in savings. For example, a user may choose to analyze a scenario in which savings reach 20 percent by 2030, on a cumulative basis. In this case, ESIST increases the cumulative savings level beginning in the user-specified year (e.g., 2022). Savings levels from 2022–2029 are then interpolated based on the 2030 goal and the level of savings modeled in 2020.³⁹ After the goal is reached in 2030, the cumulative savings will be held constant at this level for all future years.
- With the **User input (savings as a % of sales)** option, the “cumulative savings (% of sales)” row turns blue, illustrating to users that they may input values for cumulative savings (measured in savings as a percent of baseline sales) in each year for all future years. Users may enter any value greater than zero percent. This option is intended for users seeking to customize cumulative savings (on a percentage basis) in each year of the study period.
- With the **User input (MWh savings)** option, the “cumulative savings (MWh savings)” row turns blue, illustrating to users that they may input values for cumulative savings (measured in MWh) in each year for all future years. Users may enter any value greater than 0 MWh. This option is intended for users wishing to customize cumulative savings (on a MWh basis) in each year of the study period.

Key Note—Reasonably achievable energy efficiency savings levels (cumulative savings): As with the annual budget and annual incremental savings target type, if users set a cumulative savings trajectory that implies annual incremental savings greater than three percent in any given year, ESIST suggests that this value be re-examined. It is possible that some jurisdictions may achieve or exceed three percent annual incremental savings for a limited set of years, although literature review indicates that this level represents the high end of the achievable annual incremental savings range.

Step 5: Set Program Cost Assumptions

In this step, users have the same options to set program costs (measured in dollars-per-MWh) as are available in the Annual Incremental Savings target type (see page 28):

- Historical (default)
- Constant
- Savings-dependent
- User input

³⁹ Under this option, ESIST maintains savings at historical levels 2021 through the year before the “year to start ramp.” Savings are maintained at the target level in the “target year,” as well as in all following years.

Step 6: Set Multiple Benefits and Other Settings

State and local governments and utilities that are exploring options for setting new, expanded, or revised energy efficiency targets are typically motivated by numerous objectives. Key objectives include energy savings and costs (as described above), as well as multiple other priorities. These priorities may be formally specified in legislation or regulation, or they may be indicated in the platforms and agendas of governors, mayors, or their agencies' leadership. These objectives for energy efficiency investments may include avoiding emissions, improving public health, advancing energy equity, and achieving peak demand savings and associated grid reliability effects. ESIST supports quantification of these impacts and facilitates analyzing savings expiration for energy efficiency measures, customer demographic data, and other utility customer information. Users are encouraged to carefully review the assumptions, data sources, and default values within the tool for appropriate use in their jurisdiction.

After setting savings and first-year costs of saved energy, users can then adjust assumptions in the six modules described in Figure 5. Outputs from Steps 1–5 are automatically passed through to each of the modules within Step 6. These data are combined with the default assumptions within these modules to generate the results in Step 7: Review Outputs. For all assumptions within Set Multiple Benefits and Other Settings, if the user does not view or modify any information, ESIST automatically applies default values.

While ESIST automatically calculates results from the assumptions within Set Multiple Benefits and Other Settings, users may wish to adjust the default values in these modules. Changes to some of the assumptions may impact the level of savings and total costs (e.g., modifying the trajectory of savings expirations can impact annual incremental savings or levelized costs).

Figure 5. ESIST interface for setting multiple benefits and other settings

Step 6. Set Multiple Benefits and Other Settings

Set other inputs for the modules described below. If these modules are not edited, default values will be used.
Note that some modules may contain detailed results, rather than inputs that are meant to be edited by the user.

Emissions Impacts	Estimate impacts on greenhouse gas and criteria pollutant emissions, and estimate losses to transmission and distribution (T&D).
Public Health Impacts	Examine impacts on outdoor air quality and public health. This sheet is informational only; there are no inputs to edit.
Energy Burden Impacts	Analyze energy burden and investment in energy efficiency, bill assistance, and other programs for low-income customers.
Demographic Data	Examine demographic data for households in the selected service territory. This sheet is informational only; there are no inputs to edit.
Peak Demand Impacts	Set up the expected relationship between annual electricity sales and peak demand, and annual incremental savings and peak avoided MW.
Customer Information	Examine historical information on number of customers, average rates, and average per-customer consumption. This sheet is informational only; there are no inputs to edit.
Savings Expiration	Determine the schedule on which savings from energy efficiency measures expire.

Emissions Impacts

ESIST calculates avoided emissions (i.e., the pollutants that would otherwise be emitted in the absence of energy efficiency programs) associated with carbon dioxide (CO₂), fine particulate

matter (PM_{2.5}), sulfur dioxide (SO₂), and nitrogen oxides (NO_x). ESIST calculates avoided emissions at the regional level; it multiplies savings (which occur in a state or service territory from the user-generated energy efficiency scenario) by emission rates that describe the estimated regional change in emissions resulting from energy efficiency savings installed in a single state or utility.

Default Assumptions

To estimate avoided emissions, ESIST relies on avoided emission rates data from three sources. The data source used differs depending on the geography the user has selected, and the time period the user is examining:

- If users have selected the United States as a whole, or a state or utility service territory within the contiguous United States:
 - Data from EPA's AVERT model is used for historical emission rates.⁴⁰ AVERT calculates avoided emissions for 14 different regions of the country; each state (or utility service territory) is assigned to a single AVERT region and utilizes the avoided emissions rates associated with that region.⁴¹ See Figure 6 for a map of the AVERT regions.
 - Data from the Integrated Planning Model (IPM) is used for marginal emission rates in 2040. IPM is a capacity expansion and dispatch model that EPA routinely uses to examine future changes to the electric power system. It models projections of the electric power sector in the contiguous United States through 2050, with individual power plants and load quantities mapped to 67 power regions.⁴² In

⁴⁰ More information on AVERT is available at <https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert>.

⁴¹ Avoided emissions rates are calculated for each AVERT region, assuming that an energy efficiency portfolio reduces regional fossil demand the same amount in all hours of the year. The assumed AVERT emission rates are calculated by examining marginal emission rates in scenarios where fossil fuel load is decreased by 0.5 percent, roughly equivalent to recent observed levels of annual incremental energy efficiency savings at the national level. These emissions rates are in line with the emissions rates described in EPA's "Emission Factors from AVERT" fact sheet (most recent version available at <https://www.epa.gov/avert/avoided-emission-factors-generated-avert>). Note that emissions rates resulting from higher levels of energy efficiency penetration (including one percent and five percent) were also examined, although little variation was found in terms of typical emissions rates. Note also that these are gross emissions rates (i.e., they have not been increased to reflect T&D losses). The values for the United States as a whole are calculated using a weighted average based on sales. Emissions rates assumed for 2010–2016 were calculated using AVERT version 2.3; emission rates assumed for 2017–2021 were calculated using AVERT version 3.0 and version 4.0.

⁴² Avoided emissions rates were calculated using IPM by running two scenarios: a base case and a scenario with 10 percent reduction in demand in each modeled year. For each region, pollutant, and year, we calculated the change in emissions between the two scenarios and divided that quantity by the change in generation to calculate marginal emission rates in the modeled scenario. See U.S. EPA. "Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model." (January 2020). Available at <https://www.epa.gov/power-sector> for more information. We observe that marginal emission rates from these IPM runs resemble marginal emission rates calculated by EIA's 2023 Annual Energy Outlook (see <https://www.eia.gov/outlooks/aeo/>). When compared to the National Renewable Energy Laboratory's 2022 Standard Scenarios (see <https://www.nrel.gov/analysis/standard-scenarios.html>) the marginal emission rates from IPM are higher. These differences can be attributed to impacts from the Inflation Reduction Act (IRA), other differing trends in renewable costs, and differing assumptions related to electrification and load.

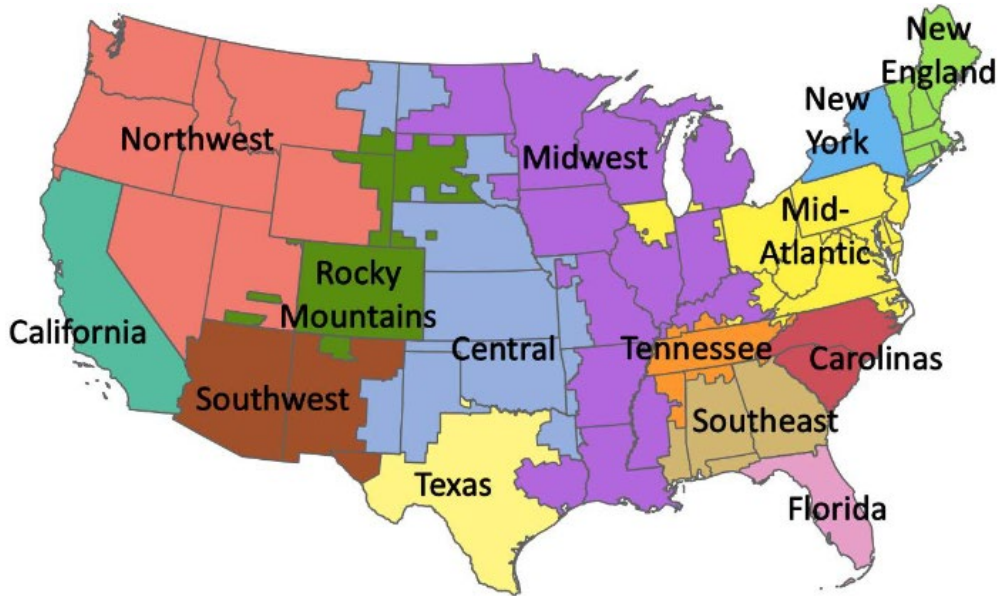
ESIST, we relied on data for 2040. These regions are aggregated to AVERT regions and assigned to the geography selected by the user.

- For 2021–2039, the emission rates are linearly interpolated between the AVERT and IPM modeled values.
- Users can enter annual emission rates more specific to the region or year they are interested in modeling, if those rates are available. Note that the benefit-per-ton values ESIST uses to calculate public health impacts are linked to AVERT regions. Users should take care to ensure that all user-input emission rates are consistent with the topology used in ESIST when estimating public health impacts for a scenario. See the following Public Health Impacts section for more information.⁴³
- If users have selected a non-contiguous state or territory (i.e., Alaska, Hawaii, and Puerto Rico):
 - ESIST displays information on non-baseload emission rates from EPA’s Emissions & Generation Resource Integrated Database (**eGRID**) database for 2021.⁴⁴ These data are displayed for all years between 2010–2040. Users in these states and territories are encouraged to utilize more regionally and temporally specific emission rates if they are available.

⁴³ If users have questions on how to ensure topological consistency for user-inputted emission rates, please contact EPA at esist@epa.gov.

⁴⁴ Non-baseload emission rates are used because these are the eGRID emission rates that are most frequently compared to AVERT or other marginal emission rate sources. For example, see the Greenhouse Gas Emissions Technical Reference documentation for EPA’s Energy Star Portfolio Manager (available at <https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf>) or: Diem A., and Quiroz, C. *How to use eGRID for Carbon Footprinting Electricity Purchases in Greenhouse Gas Emission Inventories*. (July 2012). Available at <https://www3.epa.gov/ttnchie1/conference/ei20/session3/adiem.pdf>.

Figure 6. Map of AVERT regions



Source: Figure 3 of the AVERT User Manual, version 4.0. Available at <https://www.epa.gov/system/files/documents/2023-01/avert-user-manual-v4.0.pdf>

ESIST provides default emission rates for CO₂, PM_{2.5}, SO₂, and NO_x. For all pollutants, ESIST provides emission rates at an annual level (i.e., annual tons emitted per total annual MWh). For NO_x, we also provide emission rates for the ozone season.⁴⁵

Future marginal emission rates in ESIST are best used as screening-level estimates of regional avoided emissions due to energy efficiency programs. There is substantial uncertainty in future marginal emission rates. Marginal emission rates can vary widely depending on assumptions that change quickly year-to-year (e.g., costs of renewable resources, information on planned conventional resource retirements). They also vary based on the local information available (e.g., a utility may have more granular, up-to-date data on resource costs or retirement dates), and the scenario being considered (e.g., a state energy office may be considering two different scenarios: one with high amounts of renewables and one without, each of which would have different marginal emission rates). As a result, the ESIST default future emission rates utilize a simple linear trend connecting present-day values with modeled values in 2040.

Users looking to assess the range of uncertainty in the default emission rates can examine different sets of emission impacts. With the **User input** setting, users could apply either the 2021 or 2040 emission rates over the entire study period (for example). Users can then compare this with the results calculated using the **Default** setting for emission rates to evaluate a low, medium, and high estimates of emission rates over the study period. Because public health impacts (see page 35)

⁴⁵ We note that these ozone season emission rates are used to calculate public health benefits related to avoided ozone (see the *Public Health Analysis* section below). Total avoided NO_x for the ozone season should not be added total annual avoided NO_x as this will result in some double-counting of NO_x emissions. However, benefit-per-ton values used in ESIST do not double-count the impact of NO_x emission rates for the purposes of ozone and particulate matter benefits.

are directly linked to the assumed emission rates, this sensitivity analysis may be of special interest to users focused on those impacts.

ESIST also analyzes the effect that the transmission and distribution (T&D) loss factor has on emission impacts. This loss factor refers to the amount of electricity that is lost in the form of heat as it travels from electricity generating units through the transmission and distribution wires to homes and businesses. Modeled EIA data for 2010–2021 indicate that on a national basis, the T&D loss factor is about seven percent.⁴⁶ Effectively, this means that for every 1 MWh of energy efficiency installed at the retail level, 1.07 MWh of generation at the wholesale level (i.e., the power plant level) are displaced.⁴⁷ The adjustment allows users to fully account for additional emissions benefits from avoided inefficiencies on the grid, in addition to avoided electricity used at the retail level. ESIST displays the avoided annual generation, as well as the avoided generation for the ozone season of May 1 through September 30 (for the purposes of calculating ozone-related benefits).

Other Data Sources

Users can also adjust avoided emissions factors using their own data sets if they prefer information from organizations such as a regional planning organization, state department of environmental quality, or from other modeling platforms that project emissions and emission rates. Importantly, ESIST uses benefit-per-ton values to calculate public health impacts that are linked to AVERT regions (see the following section on Public Health Impacts for more information). If users input their own emission rates, users should take care to choose a topology that is aligned with the AVERT topology used in ESIST. Otherwise, it is likely that the public health impacts reported by ESIST will not align with the user-selected emission rates. To submit questions on how to ensure topological consistency for user-inputted emission rates, please contact EPA at esist@epa.gov.

Similarly, users can adjust T&D loss factors if they have specific information from regional utilities, ISOs, or regional transmission organizations. Adjusting these factors allows users to calculate avoided emissions—i.e., the pollutants that would otherwise be emitted in the absence of energy efficiency programs.

Users may wish to use EPA’s AVERT model to calculate emission rates for specific energy efficiency measures or portfolios.⁴⁸ AVERT allows users to set up 8,760 hourly demand reduction profiles and examine their impact on one of 14 regions throughout the United States. AVERT leverages statistical analysis of generation and emissions data from a recent historical year to allows users to estimate changes in generation and pollutants (including SO₂, NO_x, primary PM_{2.5},

Key Note—Using ESIST data in AVERT: An alternate use of ESIST is to develop a trajectory for annual energy efficiency savings and analyze these savings in AVERT. With this approach, users can manually input the MWh savings outputs from ESIST into AVERT to generate additional data on avoided emissions (including locations of decreased emissions, as well as hourly emissions profiles associated with that specific region’s power plants) for a year in the recent past or near future.

⁴⁶ All T&D loss factors are calculated using modeled data from EIA’s AEO, with the latest year referencing AEO 2023. These are the same T&D loss factors used in the AVERT model.

⁴⁷ Generally, 1 MWh of energy efficiency installed at the retail level displaces a quantity of wholesale generation equal to retail MWh / (1 – T&D loss factor).

⁴⁸ For more information, see <https://www.epa.gov/avert>.

volatile organic compounds, and NH₃) at specific power plants throughout the country. Unlike ESIST, AVERT allows users to examine more detailed emission impacts (from both a spatial and temporal perspective), but is limited to analysis for a year in the recent past or near future (i.e., within the next 5 years). It also includes mapping and emissions analysis functionality not present in ESIST.

Procedure for Making Changes in ESIST

Avoided emissions factors can be adjusted by selecting **User input**. This turns avoided emissions values for all future years blue, indicating that users may overwrite these values. These cells accept any “lb per MWh” value; positive numbers are associated with emissions decreases, whereas negative numbers (if entered) are associated with emissions increases. In addition, if **Default** is selected, users are encouraged to enter their own avoided emissions rates for all future years, either for each year individually, or for all future years together under the selection cell.

To adjust the T&D factor input, users select **User input** instead of the default **EIA** option. Selecting this option turns all values for future years blue, indicating that they can be overwritten. Users may enter any value between zero percent and 15 percent.⁴⁹

Key Note—Changing emissions rates: Users that expect their modeled electricity system to become cleaner over time (e.g., through retirements of higher-emitting plants or through the addition of low- or zero-emitting plants) should note that the avoided emissions resulting from energy efficiency will decrease over this period. Like all values in ESIST, users can replace default values with their own values if available. For example, users may choose to replace the default avoided emissions rates with avoided emissions rates produced by an electric sector dispatch and capacity expansion model, which itself models the change in resource mix over time, leading to different avoided emissions rates than what exists today.

Public Health Impacts

The ESIST Public Health Impacts module estimates the dollar value of avoided air pollution–related health impacts associated with reducing electricity demand.⁵⁰ Increased levels of energy efficiency lower electricity demand, lowering the amount of electricity produced and pollutants emitted by power plants. Improved air quality benefits human health in the form of avoided cases of premature death, hospital visits, cases of aggravated asthma, and other adverse outcomes. These outcomes can be “monetized” by estimating the dollar value that society places on avoiding these effects. These estimated dollar values may in turn be used to calculate a “benefit-per-ton” metric, which expresses the total economic value of the health benefits of reducing emissions on a per-ton basis.

⁴⁹ Data from AEO suggests average nationwide T&D losses are on the order of seven percent. Different regions may have different loss rates, with some higher and others lower. We observe that in the 2018–2019 Puerto Rico Integrated Resource Plan (Prepared for Puerto Rico Electric Power Authority, published June 2019, and available at <https://energija.pr.gov/wp-content/uploads/sites/7/2019/06/2-IRP2019-Main-Report-REV2-06072019.pdf>), expected losses were 12 percent (see Table 3-11). ESIST rounds up and assumes a maximum T&D loss value of 15 percent for anywhere in the United States based on this value.

⁵⁰ All public health impacts estimated in ESIST are related to outdoor air quality impacts. Other public health impacts related to indoor air quality may be substantial for certain populations but are not estimated in ESIST. For more information on this topic see <https://www.epa.gov/indoor-air-quality-iaq>.

ESIST calculates health impacts at the national level; it multiplies the emission impacts (which occur at a regional level and result from savings changes at a state or utility level) by standard benefit-per-ton factors. These factors describe the national health benefits resulting from regional changes to emissions.

The section below summarizes the methodology used for calculating effects from air pollution and how these effects are quantified and monetized. This section simplifies an inherently complex procedure. Readers interested in learning more about the adverse health effects associated with poor air quality and the procedure for quantifying and monetizing these impacts may refer to other resources, including EPA Technical Support Documents and the peer-reviewed literature.⁵¹

Default Assumptions

ESIST estimates the dollar benefits of reducing ground-level ozone and PM_{2.5} precursor emissions from power plants located throughout the United States. The benefit per ton reflects the value of avoided cases of PM_{2.5} and ozone-related premature death and illnesses. Benefits include reductions of premature mortality, hospital admissions, cases of new onset asthma, and other adverse outcomes.⁵²

Calculated values are based on previously conducted air quality modeling simulations paired with the environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE). First, air quality simulations were conducted to characterize the relationship between emissions and ozone or PM_{2.5} changes. The modeling tracked the impacts of state-level power plant NO_x emissions to national changes in summertime ozone and the impacts of state-level power plant NO_x, SO₂, and primary particulate matter (PM) emissions to national changes in annual average PM_{2.5}.⁵³ Second, BenMAP-CE was used to quantify and monetize the benefits of improved air quality.⁵⁴ Finally, after estimating the dollar value for each scenario, the estimated benefits were

⁵¹ U.S. EPA. *Technical Support Document Estimating the Benefit per Ton of Reducing Directly-Emitted PM_{2.5}, PM_{2.5} Precursors and Ozone Precursors from 21 Sectors*; Research Triangle Park, NC, November 2021. https://www.epa.gov/system/files/documents/2021-10/source-apportionment-tsd-oct-2021_0.pdf; U.S. EPA. Technical Support Document (TSD) for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS Estimating PM 2.5-and Ozone-Attributable Health Benefits; Research Triangle Park, NC, 2021.; Fann, N.; Baker, K. R.; Fulcher, C. M. *Characterizing the PM_{2.5}-Related Health Benefits of Emission Reductions for 17 Industrial, Area and Mobile Emission Sectors across the U.S.* (2012). Environment International, 49, 141–151. Available at <https://doi.org/10.1016/j.envint.2012.08.017>; Wolfe, P.; Davidson, K.; Fulcher, C.; Fann, N.; Zawacki, M.; Baker, K. R. *Monetized Health Benefits Attributable to Mobile Source Emission Reductions Across the United States in 2025.* (2019). Science of The Total Environment, 650, 2490–2498. Available at <https://doi.org/10.1016/J.SCITOTENV.2018.09.273>; Sacks, J. D.; Lloyd, J. M.; Zhu, Y.; Anderton, J.; Jang, C. J.; Hubbell, B.; Fann, N. *The Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE): A Tool to Estimate the Health and Economic Benefits of Reducing Air Pollution.* (2018). Environmental Modelling & Software, 104. Available at <https://doi.org/10.1016/j.envsoft.2018.02.009>.

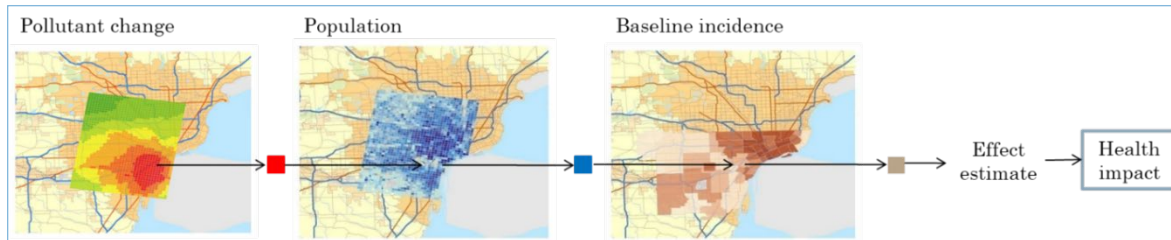
⁵² Note that other public health benefits may exist but are unquantified. For a complete list of the public health benefits accounted for in ESIST, see: EPA. *Integrated Science Assessment for Particulate Matter (Final Report)*. (2019). Research Triangle Park, North Carolina; and EPA. *Integrated Science Assessment of Ozone and Related Photochemical Oxidants (Final Report)*. (2020). Research Triangle Park, North Carolina.

⁵³ U.S. EPA. *Regulatory Impact Analysis for the Repeal of the Clean Power Plan, and the Emission Guidelines for Greenhouse Gas Emissions from Existing Electric Utility Generating Units*. Research Triangle Park, NC, 2019. EPA-452/R-19-003

⁵⁴ U.S. EPA. *Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP-CE)*. (2018). Research Triangle Park, North Carolina.

then divided by the number of tons of precursor emissions reduced. PM_{2.5} precursors include NO_x, SO₂, primary PM_{2.5} and the precursor for ozone is ozone-season NO_x. Benefits and emissions associated with particular power plants were calculated by state and for the nation as a whole. These were then allocated to the 14 AVERT regions to create a topology consistent with ESIST's avoided emission rates.⁵⁵ A high-level illustration of how emissions are translated into public health benefits is shown in Figure 7.

Figure 7. Illustration of how pollutant changes are translated into public health impacts



ESIST then multiplies the change in total precursor emissions against the health benefit-per-ton values (measured in terms of dollars per short ton of avoided emissions) to yield the total estimated health benefits associated with reducing emissions from each pollutant. Benefits are categorized into (a) those linked to reduced PM emissions and (b) those linked to reduced ozone emissions. The “Total” row represents the total monetized benefits related to both PM and ozone.

To simplify the presentation of results in ESIST, we present values calculated at a three percent discount rate, short-term (i.e., day-to-day) exposure to ozone (rather than long-term, or the cumulative exposure over the course of a year), and “low” impacts related to PM_{2.5} (which correspond to a wider range of ages assumed to be impacted by PM rather than the “high” impacts also calculated). These assumptions are relatively conservative. For these last two variables in particular, which use relatively conservative default assumptions, different assumptions would likely produce larger health impacts.⁵⁶

Other Data Sources

Should users wish to calculate public health impacts using other data sources, they may wish to export the avoided emissions calculated by ESIST to an alternative model, such as EPA’s COBRA model and the BenMAP-CE model.⁵⁷ Users may observe differences in total public health benefits due to differences in model assumptions and methodologies. COBRA allows users to calculate the public health impacts related to reductions in PM_{2.5} emissions (including emissions from related pollutants such as SO₂, NO_x, and primary PM_{2.5}). Unlike ESIST, COBRA allows users to calculate public health impacts related to emission changes in other sectors than the electric power sector and allows users a finer degree of control over where emission changes are taking place (i.e., at the county level). It also includes mapping functionality not present in ESIST.

⁵⁵ Emissions and benefits were allocated to AVERT regions based on the quantity of emissions modeled from power plants in each AVERT region.

⁵⁶ For more information on the distinctions between these different settings, see the BenMAP-CE user manual at <https://www.epa.gov/benmap/benmap-ce-manual-and-appendices>.

⁵⁷ For more information, see <https://www.epa.gov/cobra>.

Procedure for Making Changes in ESIST

We do not recommend that users use alternate values for benefits per ton in ESIST, as the current values have been calculated to be as consistent as possible with other parameters calculated in ESIST.

Energy Burden Impacts

The Energy Burden Impacts module in ESIST models the impact of low-income energy efficiency and monetary assistance programs on household energy and electricity burdens.⁵⁸ Specifically, users can estimate the level of investment required to reduce the disparity between low-income households' electricity burden (the proportion of income spent on electricity) and the electricity burden of non-low-income households.⁵⁹ Nationwide, low-income households spend a greater share of their income on electricity than higher-income households, producing disparities in energy and electricity burdens.⁶⁰ Users can observe disparities between low-income and non-low-income households in their selected geography, and model energy efficiency and monetary assistance programs that help close the gap in electricity burden between low-income and non-low-income households. Users may use this module to examine goals for energy efficiency programs targeted to reach low-income households.

The Energy Burden Impacts module is not functional when the user has chosen a sector other than Residential in Step 1.⁶¹ If the user has selected the Residential sector, they have two options: (a) model low-income savings as a component part of the Residential sector (i.e., within Steps 2 through 5) or (b) model low-income savings separately from the residential sector in the Energy Burden Impacts module. If a user is following approach (a), they should not use the Energy Burden Impacts module to model additional low-income savings. Instead, they should model Residential savings as if low-income savings were included in a broader pool of energy efficiency savings installed at all residences. If a user is following approach (b), they should assume that the savings modeled in the Energy Burden Impacts module are distinct from the savings modeled elsewhere in the analysis. Note that emissions impacts and public health impacts are calculated solely based on the savings modeled in Steps 2 through 5 and that any savings modeled in the Energy Burden Impacts module do not produce additional emissions or public health impacts. In addition, note that all savings modeled in the Energy Burden Impacts module are assumed to be additional to any existing savings from low-income energy efficiency programs in the user-specified geography.

Default Assumptions

ESIST primarily relies on energy burden data from the U.S. Department of Energy's Low-Income Energy Affordability Data (LEAD) Tool.⁶² The LEAD Tool was created to help states, communities,

⁵⁸ In this module, low-income households are defined to be any household below 200 percent of the Federal Poverty Level.

⁵⁹ "Energy burden" refers to the sum of a household's expenditures on energy (i.e., electricity as well as natural gas, oil, and/or gasoline) divided by its income. "Electricity burden" refers to a household's expenditures on electricity alone, divided by household income.

⁶⁰ ACEEE. *How High Are Household Energy Burdens? An Assessment of National and Metropolitan Energy Burdens Across the United States*. (2020). Available at <https://www.aceee.org/energy-burden>.

⁶¹ We note that the Energy Burden Impacts module is also available in the ESIST: Pilot Gas Version. See *Appendix C: ESIST: Pilot Gas Version* for more information.

⁶² For more on the LEAD tool, see <https://www.energy.gov/scep/slsc/lead-tool>.

and other stakeholders create better energy strategies and programs by improving their understanding of low-income housing and energy characteristics. Data in the LEAD Tool come from the U.S. Census Bureau's American Community Survey 2020 Public Use Microdata Samples. More information on how low-income energy efficiency programs are reported in this data set, and how these programs may be subject to some double-counting, can be found in the Other Data Sources section on page 42.

County-level income and energy expenditure data from the LEAD tool have been compiled into a library table in ESIST. ESIST automatically selects the appropriate counties relevant to the user-specified geography. For example, if a user selects a single state, it will retrieve all the LEAD data for all the counties in that state. If a user selects a single utility, then ESIST will retrieve data for all the counties in which that utility serves at least one customer.⁶³ ESIST will then load data from LEAD on the number of households, average energy burden, average electricity burden, and average income. Data are provided both for low-income households (defined in ESIST as any household below 200 percent of Federal Poverty Level) and all other households defined as non-low-income.⁶⁴

This module also relies on a number of parameters specified from the user or calculated elsewhere in ESIST. All the following values are specified in the **User inputs** section, except for the “Low-income program cost multiplier,” which is specified in the **Scenario calculations and outputs** section.

These include:

- **Electricity burden target:** This is the target electricity burden envisioned for low-income households. This value must be less than or equal to the current low-income electricity burden (as calculated by ESIST) and must be greater than zero percent. Based on this input, ESIST will then calculate the electricity cost reduction needed at average low-income households to meet this new electricity burden. Each year, this reduction is applied to the number of households specified by the user (see following bullets for more information). The default assumption in ESIST is set equal to the selected region’s current electricity burden for low-income households.
- **Year to begin program:** This is the first year that the low-income program scenario (as envisioned in the Energy Burden Impacts module) would be deployed. Users may enter any value for all future years. The default value is set to 2022.
- **% of households to reach annually:** This is the number of new households the program scenario will reach each year. The default value is set to 10 percent. In effect, this assumes that each year, 10 percent of all low-income households in the area being analyzed have their electricity burdens adjusted to the parameter entered in **Electricity**

⁶³ This matching is done using data from EIA Form 861. Utility-specific data on the number of customers or kWh sales on a county-by-county basis are not available. Note that there are situations in which the vast majority of a utility’s customers are in County X, but a small minority of customers exist in County Y. ESIST will report household income and energy expenditure data from both counties, as if the utility served an equal number of customers in both counties. Users should cross-reference other data sources for information on which counties are most representative of the service territory relevant to their interest.

⁶⁴ For detail on the poverty guidelines as defined by Health and Human Services, see <https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines>.

burden target. With an assumption of 10 percent of households per year, a 2022 starting year, and the default low-income measure expiration (described below), by 2040, the program scenario will have been deployed to almost 90 percent households in the selected geography. Not all programs may be able to reach 90 percent of customers over time. Traditional energy efficiency programs may not successfully reach some customers due to issues regarding language, rental status, health and safety barriers, and interest in participation, among other reasons. To reach shares approaching 100 percent, programs targeting low-income households would have to be designed to overcome these barriers.

- **Measure expiration:** This parameter allows users to select a measure expiration trend to apply to energy efficiency savings modeled in the Energy Burden Impacts module. The default setting assumes that energy savings from efficiency measures expire consistent with how savings have been observed to expire from past low-income energy efficiency programs. Users may also choose a “Linked” option, which links the measure expiration trend to the one specified by users in the “Savings Expiration” module (which includes further options—including user inputs—beyond the default low-income trend). See the *Savings Expiration* section on page 49 for more information.
- **Monthly monetary assistance per household:** This parameter provides an option for users to model monetary pay assistance to low-income households. Users can specify any value greater than or equal to \$0. The default value is set to \$0 per household per month. The user is encouraged to look into the data for their specific geography and identify a suitable value.⁶⁵ This input is called “monetary assistance” because it can be used to model any form of low-income monetary assistance, including bill pay, reduced customer rates, or direct rebates. It can also be used to model bill assistance from outside the utility (e.g., the Low Income Home Energy Assistance Program or LIHEAP). This value is applied to all low-income households for every year in the analysis, including and following the “year to begin.” It is not customized to apply to only a percentage of households receiving assistance. Therefore, users should set this parameter equal to the *average amount of monetary assistance across all low-income households*. For example, if 50 percent of low-income households are expected to receive monetary assistance of \$20 per month and all other low-income households are expected to get no monetary assistance, the user should enter a value of \$10.
- **Low-income program cost multiplier:** This parameter specifies the difference in the cost of saved energy for programs delivered to low-income customers, relative to the cost of delivering these programs to non-low-income residential customers. These cost differences may be due to the type of programs that are offered to low-income customers, versus non-low-income residential customers (e.g., whole-home improvements). The default value, provided by Berkeley Lab in its study *Still the One: Efficiency Remains a Cost-Effective Electricity Resource*, is 337 percent, indicating that the cost of electricity savings in low-income households is about 3.4 times greater than in non-low-income households.⁶⁶

⁶⁵ For more information on possible values to use, see the LIHEAP Data Warehouse at <https://liheappm.acf.hhs.gov/datawarehouse/>.

⁶⁶ For more information on this data set, see <https://emp.lbl.gov/cost-saving-electricity-through-energy-efficiency>.

With this information, ESIST then calculates the gross annual electricity cost reduction needed to overcome the electricity burden gap observed between low-income households and non-low-income households (see Equation 4). ESIST also calculates the net annual electricity cost reduction, after taking any monetary assistance into account (see Equation 5). Third, in the **Scenario calculations and outputs** section, ESIST estimates the cost to administer these programs, calculated by multiplying the number of households in a jurisdiction by the share of households planned to be reached each year and the user-specified cost to administer energy efficiency in low-income households. Finally, in the **Energy burden outputs** section, ESIST estimates the impact that the program has on the average low-income customer’s electricity burden and energy burden over time. This last section also estimates the electricity burden for a household participating in the first year of the program. Typically, these households will have the target electricity burden value in the first year of the program. Then, over time, this electricity burden will increase as energy savings from efficiency measures expire.

Equation 4. Estimation of gross annual electricity cost reduction

$$\begin{aligned} & \text{Gross annual electricity cost reduction} \\ &= (\text{Average Electricity Burden}_{LI \text{ Households}} \\ & \quad - \text{Target Electricity Burden}_{LI \text{ Households}}) \\ & \quad \times \text{Average Household Income}_{LI \text{ Households}} \end{aligned}$$

Equation 5. Estimation of net annual electricity cost reduction

$$\begin{aligned} & \text{Net annual electricity cost reduction} \\ &= \text{Gross annual electricity cost reduction} \\ & \quad - (\text{Monthly Monetary Assistance} \times 12 \text{ months}) \end{aligned}$$

Other Functionality

The Energy Burden Impacts module contains a number of other calculations that give the user additional insight into how investments in energy efficiency could impact energy burden:

- In the **User inputs** section, users may choose to “Assess programs that reduce gas use.” This is a useful option for users interested in the impacts of low-income weatherization programs or other programs that reduce consumption of fossil fuels in addition to electricity.⁶⁷ If users select this option, they will be prompted to enter or modify defaults for gas therm savings per kWh savings (i.e., the number of therm savings that are expected in a weatherization program, divided by the number of kWh savings expected from the same program) and retail gas rate (in dollars per therm).⁶⁸ A new section will appear at the bottom of the page titled **Scenario calculations: Gas savings**. This section uses EIA and LEAD data to perform analogous calculations related to gas savings and program costs.
- The **Scenario assumptions** section includes two subsections. It is hidden by default, but users may view additional rows by clicking the “+” icon on the left side of the screen.

⁶⁷ In ESIST, weatherization measures are those that provide both electricity savings (in kWh) and gas savings (in therms). This includes measures like insulation, pipe wrap, and deep energy retrofits. These are in contrast to measures that provide electricity savings only (or primarily), such as lighting and refrigeration measures.

⁶⁸ See Key Note on low-income weatherization assumptions for more information on the default assumptions used.

- The **Household calculations** section describes background calculations related to electricity burden.
- The **Other assumptions** section describes background data used for calculating electricity burden for both low-income customers and non-low-income customers.

Key Note—Low-income weatherization assumptions: If users wish to assess programs that reduce gas use in addition to electricity consumption, ESIST provides users with two key default assumptions.

The first, therms saved per kWh saved, refers to the quantity of gas savings that users can expect alongside electricity savings in a low-income weatherization program. The default—0.23 therms saved per kWh saved—is calculated based on a simple average of values observed in recent low-income weatherization programs in Colorado, Maryland, Massachusetts, Minnesota, Idaho, and Washington. This value varies widely across states in programs: it is as low as 0.03 therms saved per kWh saved in recent low-income weatherization programs in Maryland, and is as high as 0.83 therms saved per kWh saved in recent programs in Minnesota. These datapoints may differ in terms of program scope, reporting requirements, or other aspects. Users should use data specific to their selected geography wherever possible.

The second key assumption is the residential rate for natural gas (measured in dollars per therm). Data for this assumption are based on information from the 2019 edition of EIA's Natural Gas Annual report (available at <https://www.eia.gov/naturalgas/annual/>). Users should take note (a) if they have more locally specific data and (b) whether they expect this value to vary substantially over time.

For more information on gas energy efficiency savings, see *Appendix C: ESIST: Pilot Gas Version* at the end of this document.

Other Data Sources

ESIST contains limited historical data on existing low-income energy efficiency programs. Data on energy consumption and energy savings reported by EIA and DOE typically report impacts from low-income energy efficiency programs as contained within the same data columns as residential programs. As a result, it is not usually possible to identify the impact of low-income energy efficiency programs in isolation, or to identify where and how the impacts from these programs may overlap with the savings modeled in the Energy Burden Impacts module. In general, users should think of the savings modeled in the Energy Burden Impacts module as being additive, incremental, or separate from any existing low-income energy efficiency programs in the selected jurisdiction.

Users can adjust the user input values and annual targets related to program spending and participation by referring to specific utility program filings or other resources. ACEEE's state-by-state database, *Guidelines for Low-Income Energy Efficiency Programs*, also lists existing requirements for state and utility support of low-income energy efficiency programs that can assist users in understanding current program offerings.⁶⁹ In addition, the Urban Energy Justice Lab's *Energy Efficiency Equity Baseline Map* provides a comparative framework to examine the equity of utilities' investments into low-income energy efficiency programs.⁷⁰ The tool estimates equitable utility investment proportionate to the low-income population in the service territory and as a percentage of the total residential energy efficiency investment portfolio. Users may also wish to

⁶⁹ See <https://database.aceee.org/state/guidelines-low-income-programs>.

⁷⁰ See <https://umich.maps.arcgis.com/apps/Cascade/index.html?appid=28f6792ea2134ffba888413e70647c0c>.

consult with data sources such as University of Michigan's *Energy Equity Project Report*, which provides a standardized framework for measuring energy equity, and LBNL's upcoming *Distributional Equity Analysis* resource, set for release late 2023.⁷¹ This resource will provide a practical, how-to guide on designing and implementing distributional equity analyses for energy efficiency programs.

Key Note—Considerations for reducing energy burden: Policymakers have a number of strategies to tackle high energy burdens for low-income households. In ESIST, energy burdens can be reduced through energy efficiency savings and through a combination of bill pay assistance, rate reduction, and direct payments. Beyond ratepayer funds, policymakers can also leverage additional tools such as financing and partnerships with private entities and other state and local governments to reduce household spending on energy. It is important to note that ESIST does not account for other strategies to reduce energy burden, such as policies that reduce income disparities for low-income populations.

Procedure for Making Changes in ESIST

Users may use this module to examine energy efficiency programs targeted to reach low-income households and to understand the level of investment in energy efficiency and monetary assistance needed to overcome gaps in energy burden. As described above, users may make changes to their program parameters (e.g., year to begin, monetary assistance, percent of households to target annually) and unique features (e.g., low-income rate, low-income usage, cost of energy efficiency for low-income customers) and examine how the resulting trajectories compare with their input goals (e.g., annual spending, participation, low-income energy efficiency spending as a percentage of residential energy efficiency spending).

Demographic Data

Users can use the Demographic Data module in ESIST to view relevant data related to the demographic makeup of households in their selected geography. Unlike most other modules in ESIST, the Demographic Data module does not include inputs or interactive choices by the user.

Default Assumptions

As a default, the Demographic Data module relies on data from 2021 American Community Survey (ACS) 5-Year Estimates.⁷² Data are shown for the geography selected. For example, if a user selects "US Total" as a geography, demographic data will be shown for the entire United States. If a user selects a single state, demographic data will be shown for that state. If a user selects an electric utility, ESIST will use data from EIA Form 861 to identify all the counties (or county-

⁷¹ See https://energyequityproject.com/wp-content/uploads/2022/08/220174_EEP_Report_8302022.pdf and <https://emp.lbl.gov/publications/distributional-equity-analysis>.

⁷² U.S. Census Bureau. *American Community Survey, 2021 American Community Survey 5-Year Estimates*. Available at https://www2.census.gov/programs-surveys/acs/summary_file/2021/sequence-based-SF/data/5_year_by_state/

equivalents) in which that utility provides electric service to customers.⁷³ Demographic data will then be shown for that set of counties.

Information included in the Demographic Data module include data in the following categories:

- **Ownership status:** ESIST sums the number of households that are occupied by either owners or renters.
- **Race and ethnicity:** ESIST sums the number of households where the householder (i.e., the respondent to ACS) identifies as a particular race and ethnicity (i.e., American Indian or Alaska Native alone, Asian alone, Black alone, Hispanic, Native Hawaiian or Pacific Islander alone, White alone, and some other race or more than one race). Note that householders may select both Hispanic and an ACS race option.
- **Structure type:** ESIST sums the number of households that are single-family, multi-family, or some other housing type (e.g., mobile home, boat, RV).
- **Primary heating fuel type:** ESIST sums the number of households that rely on natural gas, electricity, or some other fuel as the primary means for heating. The number of households without heating is also displayed.
- **Household age:** ESIST sums the number of households that were built in 1979 or earlier, and the number of households that were built after 1979.⁷⁴
- **Housing size:** ESIST sums the number of households where the structure has fewer than four bedrooms, and the number of households where the structure has four or more bedrooms.
- **Household language:** ESIST sums the number of households according to language proficiency. Data are shown for (a) households where English is the primary language, (b) households where English is not the primary language but where there is English proficiency, (c) households where Spanish is the primary language and where there is limited English proficiency, and (d) households where some language other than English or Spanish is the primary language and where there is limited English proficiency.

Wherever possible, we display information from the ACS on low-income customers and non-low-income customers separately.⁷⁵ These data are displayed both in absolute terms (i.e., number of households) and in percentage terms (i.e., share of households that are low-income, relative to the total number of households in the relevant metric). In categories where absolute number of

⁷³ In practice, this means that if a utility serves 99 percent of its customers in County X and one percent of its customers in County Y, ESIST will include full data from both counties. This is also true in cases where multiple electric utilities may serve customers in a single county.

⁷⁴ 1979 represents a useful break point for several reasons: lead paint was banned in 1978 (although it is rare in houses built after 1959); the U.S. Department of Housing and Urban Development implemented codes for manufactured mobile homes in 1976; spray foam began to gain wide usage in the early 1980s, changing the type of insulation found in homes after this era; general awareness of harmful asbestos impacts took place in this era, leading to its gradual phase-out for new building construction material around this time period; and the oil crisis occurred in 1973–80, which sparked general shifts in thinking about energy consumption.

⁷⁵ As in the Energy Burden Impacts module, the definition of “low-income” on this page refers to customers with household incomes below 200 percent of the Federal Poverty Level. “Non-low-income” are all other customers. Because FPL varies according to household size, we calculate this threshold for each county separately based on average household size reported for that county.

households by income data are unavailable, we instead rely on data from LEAD to describe the shares of households that are low-income or not. Two categories—housing size and household language proficiency—do not have any available data related to income levels.

Other Data Sources

Demographic data included in ESIST is intended to describe a general portrayal of the demographics of households within the selected geography. Displayed data were chosen because of the expected relevance and usefulness to ESIST users interested in analysis of energy efficiency impacts on low-income or environmental justice communities. However, users may wish to consult other data sources for more detailed information about the demographics in their region of interest, particularly with respect to energy efficiency program implementation (rather than high-level planning).

For example, all demographic data in ESIST come from either the ACS or the LEAD tool.⁷⁶ Data displayed on the Demographic Data module represent just a subset of the detailed information available in either of these two sources. Users may wish to investigate data in these sources further for more information on the demographics of their selected geography.

Users may also wish to confer with EPA's EJSCREEN tool.⁷⁷ This tool allows users to access high-resolution demographic and environmental information on a specified location. A key feature of EJSCREEN is the environmental justice indices, which combine the environmental and demographic information in the tool. EJSCREEN includes 11 environmental indicators, six demographic indicators, and 11 corresponding environmental justice indexes at a detailed level of mapping not present in ESIST.

Procedure for Making Changes in ESIST

Unlike most other pages in ESIST, the Demographic Data module does not include inputs or interactive choices required by the user. Users can look to the *Other Data Sources* section (above) for more information on potential additional analyses.

Peak Demand Impacts

While most of the calculations in ESIST concern annual MWh savings, estimating the demand impact of energy efficiency can be a key analytic question in jurisdictions. Electricity demand is the amount of electricity required by the electrical grid at any moment in time—also sometimes referred to as load. This demand is measured in megawatts (MW) and must be met instantaneously by an equivalent amount of MWs of generating resources (referred to as “generating capacity” or “capacity”). “Peak system demand” refers to the largest quantity of MW demand that a system experiences over the course of one period of time, typically a day, season, or year. This is often also referred to as “peak load”.

For an electric grid, peak system demand may establish how many power plants the grid needs to provide reliable electric service. Energy efficiency can be added to the grid and help decrease the peak system demand, thereby deferring or even avoiding investment in new generating capacity.

⁷⁶ See: U.S. Census Bureau. *American Community Survey, 2021 American Community Survey 5-Year Estimates*. Available at https://www2.census.gov/programs-surveys/acs/summary_file/2021/sequence-based-SF/data/5_year_by_state/; LEAD tool, available at <https://www.energy.gov/scep/slsc/lead-tool>.

⁷⁷ For more information on EJSCREEN, see <https://www.epa.gov/ejscreen>.

Policymakers implementing energy efficiency may wish to know both a portfolio's "peak savings," which refer to the largest instantaneous MW quantity of energy efficiency savings observed in any hour for a given portfolio, and the "coincident savings," which refer to the MW quantity of energy efficiency savings observed in the same hour as peak system demand. Depending on the region, the hour when peak system demand occurs may be in the summer or the winter. Peak demand in a summer season is usually during the hottest day of the year when air conditioner use is highest for the season. Peak demand in the winter season often occurs during periods when it is especially cold, and electric heaters are turned high. ESIST is able to model any type of peak demand (for more on ESIST's default settings, see the following section "Default Assumptions").

Users may be interested in knowing an energy efficiency portfolio's peak savings or coincident savings for a variety of reasons outside of ESIST. For example, a user may be interested in knowing the impacts their energy efficiency program has on peak system demand for resource planning purposes; or industrial customers may wish to learn about the impact that coincident savings could have on the demand charge component of their electric bill.

Default Assumptions

In ESIST, users first estimate peak system demand and then estimate peak savings. Users have two choices for estimating peak system demand:

- Enter peak system demand values manually by selecting **MW input**.
- Estimate peak system demand values using a ratio of peak system demand to annual electricity sales by selecting the **Ratio** option. If users choose the **Ratio** option, they have two further choices. They can either:
 - Enter in their own ratio by selecting **User input**.
 - Or they can use ESIST's default setting by selecting **EIA**. These default values reflect data reported for the user-selected geography to EIA Form 861.

Next, users estimate peak savings. As with estimating peak system demand, users can choose to:

- Enter peak savings values manually by selecting **MW input**.
- Estimate peak savings using a ratio of peak savings to annual incremental savings by selecting **Ratio**. As with peak system demand, if users choose this second option, they have two choices:
 - Enter in their own ratio by selecting **User input**.
 - Use ESIST's default setting by selecting **EIA**. These default values reflect data reported for the user-selected geography to EIA Form 861. EIA does not report whether peak savings occur during winter or summer, or whether the peaks are coincident. ESIST assumes that savings are coincident with the higher of the two

Key Note—Retail versus wholesale savings: In ESIST, all peak values are entered as "retail" values. Here, "retail" values refer to the quantity of energy measured at the customer meter for which customers are charged retail rates, rather than the quantity of energy measured at the wholesale level, which is sometimes called "at the generator" energy. Quantities of energy measured at the wholesale level are larger than retail values, as they have not been adjusted to exclude transmission and distribution losses.

seasonal system peaks. Users may wish to consult local data to ensure the default peak savings assumptions are accurate.

Other Data Sources

Users may wish to consult other sources for data on both peak system demand and peak savings. For example, utility IRPs or state energy plans may include projections for future peak system demand, which users may either enter into ESIST (as MW values) or transform into their own MW-per-MWh ratios. Since the MW-per-MWh ratio may vary with the mix of energy efficiency measures being deployed in a given state, users may wish to consult their state or utility's technical reference manual or planning documents for this factor.

Procedure for Making Changes in ESIST

Users may use this module to estimate the amount of capacity potentially avoidable by investing in energy efficiency. ESIST translates peak savings values into avoided expenditures on conventional generating resources and reduced costs for electricity customers. As indicated above, users may change both peak system demand and peak savings by selecting either a **Ratio** approach or a **MW input** approach. If users choose a MW Input approach, they may simply enter in MW quantities for peak system demand or peak savings. If users choose a Ratio approach, they may use ESIST default (**EIA**) values to estimate peak system demand from annual electricity sales and peak savings from annual incremental savings using two different MW-per-MWh ratios, or they may enter in their own ratio (**User input**).

Customer Information

ESIST's customer information module allows users to examine historical data on number of customers, utility revenue, electricity rates, and average annual usage. Unlike most other modules in ESIST, the Customer Information module does not include inputs or interactive choices by the user.

Default Assumptions

As a default, the Customer Information module relies on data from EIA's Form 861 data set. Historical data are shown for the following parameters:

- **Customer count:** This is the number of customers in the selected jurisdiction. A "customer" roughly corresponds to a household or a business. As with historical sales shown in ESIST, this only includes customers reported under "bundled" and "delivery" service providers in EIA 861, and not "energy" service providers. Customers associated with "energy" service providers are already counted under the reported "bundled" and "delivery" data points.
- **Total utility revenue:** This is the total amount of revenue (measured in million dollars) collected by the utility from ratepayers. This includes revenue collected by all entities listed in EIA 861, including "energy" service providers as well as those reported under "bundled" and "delivery" service providers. Unlike electricity sales (see below), revenue associated with "energy" service providers is not already counted within the "bundled" and "delivery" data points and must be counted across all three service providers to arrive at the grand total utility revenue.

- **Sales after energy efficiency:** This is the total amount of electricity sales reported by the utility. As with other historical sales shown in ESIST, this only includes sales reported under “bundled” and “delivery” service providers in EIA 861, and not “energy” service providers. Sales associated with “energy” service providers are already counted under the reported “bundled” and “delivery” data points.
- **Average rates:** ESIST estimates historical average rates (measured in cents per kWh) for each historical year from by dividing total utility expenditures by the total number of retail sales associated with the selected geographic area from EIA Form 861 (see Equation 6).

Equation 6. Calculating average electricity rates

$$\text{Average electricity rate} = \frac{\text{Total utility revenue}}{\text{Sales after EE}}$$

- **Year-on-year change in rates:** ESIST estimates the annual average change in rate by using the formula in Equation 6.

Equation 7. Calculating year-on-year change in rates

$$\text{Year on Year change in rates} = \frac{\text{Average electricity rate}_{\text{Year } N}}{\text{Average electricity rate}_{\text{Year } N-1}} - 1$$

- **Average annual usage:** ESIST estimates the annual average usage (measured in kWh per year) for any one customer with the formula in Equation 6. In reality, customer usage varies. Customers with smaller homes, newer homes, fewer people per household, more moderate climates, lower incomes, and more dependence on fossil fuels for heating tend to use less electricity than customers in the same utility service territory with opposite characteristics.⁷⁸

Equation 8. Calculating average annual usage

$$\text{Average annual usage} = \frac{\text{Sales after EE}}{\text{Customer count}}$$

Generally, rates and usage data calculated in ESIST are likely to be most useful for the residential sector, and less useful for the commercial, industrial, or all (“Total”) sectors.⁷⁹ Even for the residential sector, ESIST simplifies rates by calculating all rates in dollar-per-kWh terms (most residential rates have at least some fixed dollar-per-month component). Non-residential bill and rate structures are typically even more different from residential bill and rate structures, and may include more complex rate types or other types of charges not often present in residential rates. They also tend to vary considerably from utility to utility, and they may in some cases even be

⁷⁸ See EIA’s Residential Energy Consumption Survey at <https://www.eia.gov/consumption/residential/data/2015/> for more information on how electricity consumption varies by household characteristic.

⁷⁹ In ESIST, the “residential” sector includes all residential customers, including low-income customers. This is because data reported to EIA (the basis for much of ESIST’s calculations) do not differentiate between low-income customers and other types of residential customers. In reality, low-income customers may have different usage patterns or rate structures than other residential customers. Users interested in assessing how rate and bill impacts differ across different residential customers should consult with more locally specific data if they are available.

facility specific. Usage varies widely across customers as well. However, usage patterns among residential customers are often more similar than usage patterns between residential, commercial, and industrial customers, or even between two different commercial or industrial customers (e.g., the likely differences in electricity usage at a corner market compared to a big-box store).

For these reasons, users should take caution when referencing these data if they selected a sector other than residential. We note that even for the residential sector, these numbers should be relied on for high-level estimates only and may not be detailed enough for users interested in program-level (rather than portfolio-level) impacts.

Other Data Sources

Users may wish to consult utility filings or IRPs for more detailed information on historical rates and usage, or information on projected future rates. Note that this information is typically only available for several years into the future (i.e., one to three years beyond the present day).

Procedure for Making Changes in ESIST

Unlike most other modules in ESIST, the Customer Information module does not include inputs or interactive choices required by the user. Users can look to the *Other Data Sources* section for more information on potential additional analyses.

Savings Expiration

Users can view and adjust assumptions regarding savings expiration. This refers to the concept that, like all equipment, energy efficiency measures age (i.e., they have a “measure life”) and eventually fail and cease to produce electricity savings.⁸⁰ ESIST applies the chosen savings expiration schedules to all program years. For example, measures installed in 2020 will expire along the same schedule as measures that are installed in 2025.

Default Assumptions

Users have six options for **measure life trends**, including: **LBNL default**, **LBNL manual**, **Simple**, **Average**, **Average after delay**, and **User input**.

- The **LBNL default** selection is an empirical estimate of the share of the savings and spending in an electric energy efficiency portfolio that expire each year after investment. The analysis draws from Berkeley Lab’s *Cost of Saved Energy* database, which tracks program spending, savings, and lifetimes for customer-funded energy efficiency programs that operated between 2009 and 2019.⁸¹ The spending, savings, and lifetimes provided are those claimed by utilities in energy efficiency program filings. To focus on recent program design and equipment efficiency, Berkeley Lab drew on data from programs that operated between 2014 and 2019.⁸² For each reported program lifetime from one to 30 years,

⁸⁰ Expiring measures may be replaced with measures from a customer-funded energy efficiency program or by a customer on their own. See the following section on “non-program replacement” for more on how to model expiring measures in ESIST.

⁸¹ See <https://emp.lbl.gov/projects/what-it-costs-save-energy> for more information. A technical brief describing the lifetime assumptions used in ESIST is available at <https://emp.lbl.gov/publications/energy-efficiency-lifetimes-how>.

⁸² The database includes more than 7,500 program years of data for the years 2014–2019 from investor-owned utilities, third party administrators (e.g., Efficiency Vermont), and state administrators (e.g., NYSERDA). Not all

Berkeley Lab calculated its share of reported savings and spending relative to all reported program savings and spending.⁸³ Berkeley Lab provided these shares for a total portfolio and also by program sector: Residential, Commercial & Industrial, Low-Income, and Cross-Cutting (i.e., programs that are not specific to either of the other sectors). Under the “LBNL Default” selection, ESIST will automatically select the measure expiration schedule that is linked to the selected sector.

Users should be aware that efficiency standards and program designs will likely evolve over the time frame of their analysis. Berkeley Lab’s values are drawn from claimed impacts in the recent past and do not account for these potential changes. Utilities or program administrators also make different assumptions about savings and lifetimes. The data presented are national, and do not reflect any location-specific factors that might affect measure lifetimes. There is no guarantee that these lifetimes and savings distributions over time will be realized in specific field settings.

Berkeley Lab also calculated typical lifetimes for common program types, which are summarized in Table 4. Note that these lifetimes are program-level averages, as reported by utilities or program administrators, and reflect a mix of individual measure lifetimes in a given program. The values, therefore, are not integers (e.g., 10 years), as may be expected for a single measure. Program average measure lifetimes vary both across and within measure categories because of differences in installed measures and engineering estimates of measure lifetimes. These lifetimes may be useful for users seeking to model specific programs, rather than typical portfolios.⁸⁴

Table 4. Measure lifetimes of different program categories, according to Berkeley Lab’s Cost of Saved Energy database

Sector	Program Category	25th Percentile	50th Percentile (Median)	75th Percentile
Commercial & Industrial	Commercial–MUSH (Municipal/University/Schools/Hospitals)	9.6	11.8	14.0
	Commercial & Industrial Custom	12.0	14.2	15.8
	Small Commercial Prescriptive	10.6	12.1	13.1
	Commercial Lighting	9.1	12.8	15.3
Residential	Residential Lighting	7.9	10.0	13.8
	Residential HVAC (Heating, Ventilation, and Air Conditioning)	11.0	14.9	18.0
	Whole Home Retrofit	11.2	14.2	16.5
	Residential Behavioral	1.0	1.0	2.0
Low-Income	Low-income	9.3	13.4	16.4

utilities and program administrators report lifetimes, so the final sample size for this analysis was about 2,900 program years from 32 states and 71 utilities and program administrators.

⁸³ In rare cases, utilities and program administrators will report lifetimes beyond 30 years. Berkeley Lab excludes these lifetimes as they do not correspond with prevailing estimates of efficiency measure lifetimes.

⁸⁴ For more detail on the definitions of these program categories, please refer to Berkeley Lab’s energy efficiency program typology at <https://emp.lbl.gov/publications/energy-efficiency-program-typology>.

- Under the **LBNL manual** selection, users may select a specific sector from among those described in Table 4. Users may select All Programs, Commercial & Industrial, Residential, Low-Income, and Residential and Low-Income. This setting is intended for users who wish to rely on the Berkeley Lab data but exercise a greater degree of control on what values are used.
- Under the **Simple** selection, measures expire entirely as of a specified year. This setting is intended for users interested in modeling the portfolio of savings as if it “turns off” in a single future year. Users must set a “measure life” that tells ESIST when this should occur. For example, if users input “10” for a measure life, 100 percent of savings will expire in the 10th year after installation. Users may enter any measure life greater than zero years and less than 100 years.
- Under the **Average** selection, users set an average measure life. The default is 11.0 years, based on the weighted average measure life observed in the EIA Form 861 data. This setting is intended for users interested in analyzing a savings portfolio composed of a static measure mix and therefore stable measure-life assumptions over time. Users may enter any measure life greater than zero years and less than 50 years. In ESIST, the “average” measure life refers to the length of time that it takes the average measure within the portfolio to expire. Mathematically, this implies that the number of years necessary for all measures in the portfolio to be completely expired is two times the measure life. Under this selection, savings expire in equal quantities, as calculated in Equation 9.

Equation 9. Annual fraction of expired savings

$$\begin{aligned} \text{Annual fraction of expired savings} \\ = 100 \text{ percent} / (\text{Average measure life} \times 2) \end{aligned}$$

- Under the **Average after delay** selection, users set an average measure life and a delay parameter. Under this selection, savings will persist at their full amount through the number of delay years. After the delay, savings will begin to expire according to the methodology described for the Average selection, above. This setting is intended for users interested in analyzing a savings portfolio where savings are expected to persist at or near 100 percent levels for some time, before decaying.
- Under the **User input** selection, the row labeled “% of measures expiring each year” turns blue, indicating to users that they may overwrite values in these cells. This setting is intended for users who wish to customize the savings expiration in each year of the study period. Users may enter any value between zero and 100 percent. A value of 100 percent implies that all measures will expire in a given year, while a value of zero indicates that no measures expire in that year. These values may vary widely depending on the type of energy efficiency measure or portfolio; users should confer with state or utility technical reference manuals or energy efficiency plans for more information.

Users may also specify a percentage for **Non-program replacement**. This describes the percentage of measures that are replaced by customers on their own, rather than through customer-funded energy efficiency programs. Some customers may wish to replace expiring measures with a similar—or better—measure without participating in an energy efficiency program. There are different reasons why a user may want to model this phenomenon: federal or state

standards for lighting, appliances, or building codes may change; reductions in technology costs may drop faster than expected; or customer preferences may change. To represent how the user foresees customers replacing energy efficiency in the tool, users may enter any value from zero to 100 percent in the “Non-program replacement” cell of ESIST. ESIST uses a default value of zero percent, effectively assuming that all measures are only replaced through energy efficiency programs.

Other Data Sources

Users may wish to consult energy efficiency lifetimes present in their state or utility’s technical reference manual or planning documents. Note that lifetimes vary by energy efficiency measure (e.g., an efficient lightbulb does not typically have the same measure life as an efficient motor), and a portfolio comprises many measures installed in each year.

Procedure for Making Changes in ESIST

Users may select either **Simple** or **User input** to change the measure expiration from the default assumption. Users should select **Simple** if they have a generic lifetime for the entire portfolio. They should select **User input** if they have specific information about how much of the portfolio savings are estimated to expire in each future year. Users should enter their new information in the blue highlighted cells that appear.

Step 7: Review Outputs

Reviewing Outputs

After progressing through the core part of ESIST and making any desired changes to the optional assumptions, the user may review outputs. These are categorized and organized on a single page. ESIST organizes outputs in the following categories:

- Sales and Savings
- Costs
- Emissions Impacts
- Public Health Impacts
- Energy Burden Impacts
- Wholesale Peak Impacts

These output categories in ESIST provide a comprehensive set of the outputs likely to be most useful to most users’ analyses.

Charts

Each section on the outputs sheet features a green button stating “Click here to view charts.” Each one of these links brings users to a separate section on a charts sheet. Each section on the charts sheet includes a relevant set of charts (see Figure 8 for an example). Table 5 provides a list of each chart type, along with a brief description. Note that all charts are time-series charts, displaying continuous values from 2010–2040.

Figure 8. Example of figure on ESIST’s “Charts” page

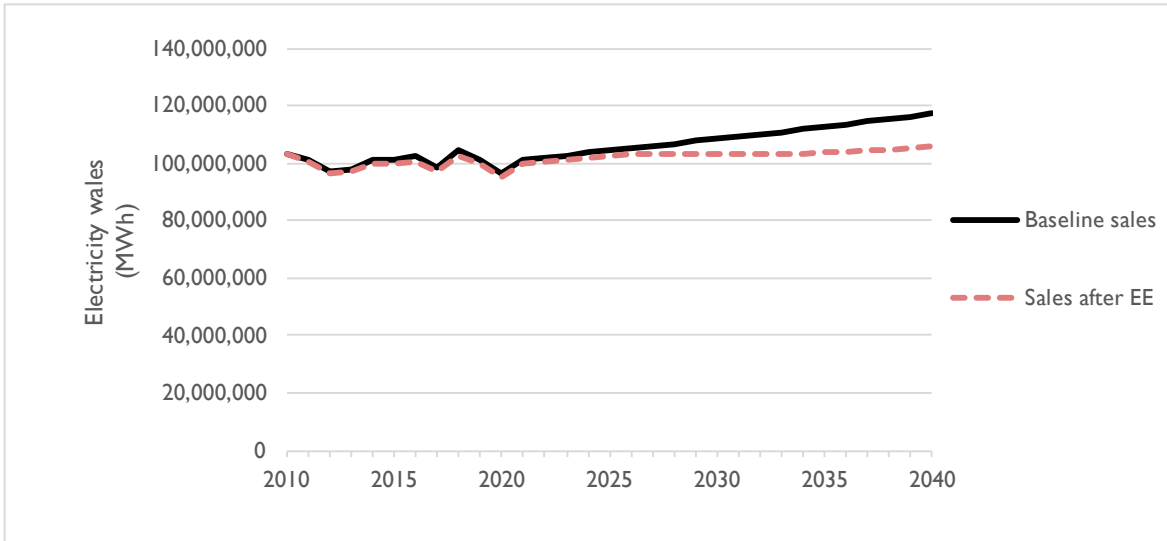


Table 5. List of charts in ESIST

Section	Chart Name	Description
Savings and Sales	Figure 1. Electricity Sales Before and after Energy Efficiency (EE)	Electricity sales trajectories, both before and after the cumulative impacts of energy efficiency.
	Figure 2. Incremental Savings	Annual incremental energy efficiency, displayed in terms of MWh.
	Figure 3. Cumulative Savings	Cumulative energy efficiency, displayed in terms of MWh.
Costs	Figure 4. Annual Costs	Annual first-year costs of energy efficiency; values are displayed both for the utility cost and the participant cost.
	Figure 5. Annual Utility First-Year Cost	Annual first-year unit cost of energy efficiency to utilities, measured in cents per kWh.
Emissions Impacts	Figure 6. Avoided CO ₂ Emissions	Avoided CO ₂ emissions. Displayed below this figure is the total avoided CO ₂ emissions from 2010–2040.
	Figure 7. Avoided PM _{2.5} Emissions	Avoided PM ₂ emissions. Displayed below this figure is the total avoided PM ₂ emissions from 2010–2040.
	Figure 8. Avoided SO ₂ Emissions	Avoided SO ₂ emissions. Displayed below this figure is the total avoided SO ₂ emissions from 2010–2040.
	Figure 9. Avoided NO _x Emissions	Avoided NO _x emissions. Displayed below this figure is the total avoided NO _x emissions from 2010–2040.

Section	Chart Name	Description
Public Health Impacts	Figure 10. Public Health impacts	Annual monetized public health benefits; values are displayed both for the PM benefits and ozone benefits. Below this figure is shown the cumulative total health benefits.
	Figure 11. Cumulative Low-Income Savings, Compared to Residential	Cumulative savings (in MWh) calculated for low-income customers in the Energy Burden Impacts module, compared to cumulative savings for residential customers (calculated in the main body of the tool).
Energy Burden Impacts	Figure 12. Low-Income and Residential EE Spending	Annual spending (in million dollars) calculated for low-income customers in the Energy Burden Impacts module, compared to annual spending for residential customers (calculated in the main body of the tool). A separate series is shown for total spending from both low-income energy efficiency programs and low-income monetary assistance.
	Figure 13. Low-Income EE Program Spending Relative to Residential	Annual spending (in %) calculated for low-income customers in the Energy Burden Impacts module divided by annual spending for residential customers (calculated in the main body of the tool).
	Figure 14. Low-Income Participation	Annual low-income households (in %) calculated in the Energy Burden Impacts module.
	Figure 15. Low-Income Electricity Burden and Energy Burden	Electricity burden (%) is equal to the spending on electricity for average low-income households, divided by typical low-income household income. Energy burden (%) is equal to the spending on all household energy for average low-income households, divided by typical low-income household income. Point values are also shown for electricity burden and energy burden for non-low-income customers.
Wholesale Peak Impacts	Figure 16. Wholesale Peak Demand and Avoided Peak	Peak demand trajectories, both before and after the cumulative impacts of energy efficiency.
	Figure 17. Cumulative Wholesale Peak Savings	Cumulative impacts of energy efficiency, displayed in terms of peak MW.

Appendix A: Data Sources

All data sources and equations can be found referenced throughout the user manual and ESIST workbook's "Library" worksheet tab. The Library tab within ESIST contains information on electricity sales, T&D losses, savings expiration trajectories, emissions factors, inflation factors, topologies, and resource costs.

The primary data source for electricity sales, energy efficiency savings, peak demand, and other utility-specific data is EIA Form 861, data set vintages 2010–2021.⁸⁵ EIA Form 861 is an annually produced set of Excel workbooks that provides utility-reported data on sales, savings, peak demand, customer counts, utility revenue, and balancing authorities, among other data points.

Data on projected electricity sales growth rates, fuel prices, and plant operating costs are retrieved from the 2023 edition of EIA's AEO.⁸⁶ AEO provides modeled projections of domestic energy markets through the middle of the 21st century, incorporating assumptions regarding macroeconomic growth, world oil prices, technological progress, and currently implemented energy policies.

Data on the first-year cost of saved energy are from two analyses by Berkeley Lab.⁸⁷

Default data on measure expiration are from Berkeley Lab's Cost of Saved Energy database, which tracks program spending, savings, and lifetimes for customer-funded energy efficiency programs that operated between 2009–2020.⁸⁸

Default data on historical emissions rates and T&D losses are from EPA's AVERT.⁸⁹ AVERT calculates avoided emissions for 14 different regions of the country.⁹⁰ Each state (or utility in a state) is assigned to an AVERT region and uses the avoided emissions rates associated with the region.⁹¹

Default data on future emission rates are estimated using the IPM power sector model.⁹²

⁸⁵ EIA Form 861 is available at <https://www.eia.gov/electricity/data/eia861/>.

⁸⁶ AEO 2023 is available at <https://www.eia.gov/outlooks/aeo/>.

⁸⁷ Lawrence Berkeley National Laboratory (LBNL). "The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015." (2018). Available at https://eta-publications.lbl.gov/sites/default/files/cose_final_report_20200429.pdf and Lawrence Berkeley National Laboratory (LBNL). "Still the One: Efficiency Remains a Cost-Effective Electricity Resource." (2021). Available at <https://eta.lbl.gov/publications/still-one-efficiency-remains-cost>.

⁸⁸ See <https://emp.lbl.gov/projects/what-it-costs-save-energy> for more information.

⁸⁹ More information on AVERT is available at <https://www.epa.gov/avert>.

⁹⁰ Note that older versions of AVERT (version 2.3 and earlier) use a 10-region topology. These earlier data are used as a basis for emission rates in ESIST for 2010–2016. The 14-region topology from AVERT version 3.0 and newer is used for 2017–2021.

⁹¹ For the default values in ESIST, avoided emissions rates are calculated in AVERT assuming a 0.5 percent reduction in load for baseload energy efficiency. Note that these are gross emissions rates (i.e., they have not been increased to reflect T&D losses). The values for the United States as a whole are calculated using a weighted average based on sales.

⁹² U.S. EPA. "Documentation for EPA's Power Sector Modeling Platform v6 Using the Integrated Planning Model." (January 2020). Available at www.epa.gov/airmarkets.

Default data on energy burden are from Department of Energy's LEAD Tool.⁹³ The LEAD Tool was created to help states, communities, and other stakeholders create better energy strategies and programs by improving their understanding of low-income housing and energy characteristics. Data in the LEAD Tool come from the U.S. Census Bureau's American Community Survey 2018 Public Use Microdata Samples.

All data related to demographics are from the U.S. Census Bureau.⁹⁴

Data on annual inflation are retrieved from the Federal Reserve Bank of St. Louis.⁹⁵

Key data sources for the health impacts module of ESIST include:

- U.S. EPA. *Technical Support Document Estimating the Benefit per Ton of Reducing Directly-Emitted PM_{2.5}, PM_{2.5} Precursors and Ozone Precursors from 21 Sectors*; Research Triangle Park, NC, November 2021.
https://www.epa.gov/system/files/documents/2021-10/source-apportionment-tsd-oct-2021_0.pdf.
- U.S. EPA. *Technical Support Document (TSD) for the Final Revised Cross-State Air Pollution Rule Update for the 2008 Ozone Season NAAQS Estimating PM_{2.5}-and Ozone-Attributable Health Benefits. (2021)*. Research Triangle Park, NC, 2021.
- Fann, N.; Baker, K. R.; Fulcher, C. M. *Characterizing the PM_{2.5}-Related Health Benefits of Emission Reductions for 17 Industrial, Area and Mobile Emission Sectors across the U.S. (2012)*. *Environment International*, 49, 141–151. Available at <https://doi.org/10.1016/j.envint.2012.08.017>.
- Wolfe, P.; Davidson, K.; Fulcher, C.; Fann, N.; Zawacki, M.; Baker, K. R. *Monetized Health Benefits Attributable to Mobile Source Emission Reductions across the United States in 2025. (2019)*. *Science of The Total Environment*, 650, 2490–2498. Available at <https://doi.org/10.1016/J.SCITOTENV.2018.09.273>.
- Sacks, J. D.; Lloyd, J. M.; Zhu, Y.; Anderton, J.; Jang, C. J.; Hubbell, B.; Fann, N. *The Environmental Benefits Mapping and Analysis Program—Community Edition (BenMAP–CE): A Tool to Estimate the Health and Economic Benefits of Reducing Air Pollution. (2018)*. *Environmental Modelling & Software*, 104. Available at <https://doi.org/10.1016/j.envsoft.2018.02.009>.

⁹³ For more on the LEAD tool, see <https://www.energy.gov/scep/slsc/lead-tool>.

⁹⁴ U.S. Census Bureau. *American Community Survey, 2021 American Community Survey 5-Year Estimates*. Available at https://www2.census.gov/programs-surveys/acs/summary_file/2021/sequence-based-SF/data/5_year_by_state/

⁹⁵ Available at <https://fred.stlouisfed.org/series/GDPCTPI/downloaddata>.

Appendix B: ESIST Use Cases

The following three “use cases” provide illustrative examples of how different users may apply ESIST in practice. These examples are not exhaustive or intended to limit ESIST’s potential applications. Potential users of ESIST include:

- Energy office staff and NGOs.
- State air regulators.
- PUCs, PUC staff, investor-owned utilities, municipal utilities, or utility cooperatives.

In all cases, users should take care to understand, assess, and make appropriate adjustments to default assumptions and calculations, consistent with local requirements, circumstances, and expectations. In addition, these users are likely to incorporate local utility-specific data and use state-specific target types or methodologies for calculating savings and associated costs. Note that specific caveats and other appropriate usage information can be found in “Key Notes” text boxes throughout this document.

Illustrative Use Case 1: Establish and Support Energy Efficiency Targets

Users and user goals: These users are interested in advancing energy efficiency programs as a strategy for reducing electricity demand and achieving energy efficiency savings targets such as EERS policies.⁹⁶ These users may also be interested in evaluating the ability of energy efficiency programs to meet objectives related to low-income customers or environmental justice communities. These users may include state energy officials, NGOs, and other electricity sector stakeholders. Applicable energy efficiency targets might be established in regulation or law, or alternatively framed within a state- or local-level energy plan or a utility IRP. ESIST can help users explore different scenarios for achieving EERS policies or other energy efficiency targets (e.g., sustaining current levels of savings, doubling current levels of savings, halving current levels of savings) and understand the impacts of these savings on future electricity sales.

In addition, these users may be interested in understanding how the portfolio of existing and new energy efficiency programs contribute to related state goals (e.g., air quality improvements, customer cost impacts). The modules in Step 6 of ESIST quantify metrics of interest, allowing users to quickly explore the potential range of scenarios. Users can assess demographics and programs that can help better target savings to reach underserved communities. For users with expertise in applying advanced sector tools (e.g., capacity expansion models, production dispatch models, air quality and health impact models), ESIST may serve as a source of key input values for sales trajectories and program costs.

⁹⁶ Every U.S. state currently administers some type of demand-side energy efficiency program, while about half have adopted a statewide EERS policy and others require utilities to deliver all cost-effective energy efficiency. The resulting energy efficiency savings for homeowners, businesses, and other electricity customers can serve as an “electricity system resource” on par with power plant generation that states, utilities, and electricity system planners can use to achieve various objectives. These EERS policies may include achieving annual energy efficiency savings equal to a specified percentage of total electricity sales, or meeting forecasted electricity demand over a defined geographic area (i.e., a utility service territory) within a specified timeframe.

Approach: Users can leverage ESIST to examine scenarios and explore varying levels of energy efficiency implementation and savings. For example, an ESIST user may closely examine specific utilities or utility types within their jurisdiction, as well as create different savings goals for municipal and investor-owned utilities. Users may also develop different savings goals for the residential, commercial, and industrial sectors, or evaluate impacts on electricity and energy burdens for programs targeted to reach low-income customers. Users examining a proposed change to an existing target, such as an EERS policy, start by entering the existing energy efficiency savings requirements. If savings as a percent of sales is appropriate, the user enters appropriate values for the duration of the study period (e.g., one percent of sales for 2022–2024). The next step is to save this Excel workbook, open a new version of ESIST, and then run ESIST again with the proposed change, allowing the user to compare the savings and cost impacts of the existing and proposed energy efficiency trajectories (see page 12 for more information on performing scenario analysis in ESIST). Regardless of the scenario evaluated in ESIST, users are encouraged to confirm that historical savings data used in the tool were reported correctly to EIA (e.g., savings reported by a utility in the state match the EIA values within a reasonable margin).

Outputs of interest: The outputs of interest for these users may include energy savings, costs, emissions, energy burden impacts, and demographic data. In a state energy plan, for example, the governor may be particularly interested in energy burden impacts and costs to customers. ESIST can be used to estimate the energy burden impacts associated with implemented programs targeted to reach low-income customers, and it can be used to contextualize savings and costs relative to recent historical consumption, utility revenue, and electricity rates. These outputs can be used to explain to the public the importance of energy efficiency programs. With ESIST, a wide range of outputs can be analyzed and reported together in one place, which can facilitate transparent evaluation and stakeholder discussion.

Illustrative Use Case 2: Establish or Review the Role of Energy Efficiency in Pollution Reduction Plans

Users and user goals: Energy efficiency can reduce criteria pollutant emissions and improve public health by avoiding generation at fossil fuel-fired power plants. State and local air quality officials, who are required to plan for and implement measures to meet federal air quality standards, can use ESIST to help evaluate opportunities for energy efficiency policies to reduce emissions, create public health benefits, and meet federal regulatory obligations under the Clean Air Act. For example, ESIST could be used to help a state seek compliance credit for efficiency-related emission reductions in a state implementation plan for the National Ambient Air Quality Standards. ESIST energy savings outputs may also be used in conjunction with other models to translate emissions reductions into public health improvements.

Approach: Beginning with inputs that describe utility energy efficiency policies, ESIST estimates the impact of those policies on reducing generation within the region. The tool then combines those results with default data from EPA sources to estimate related reductions in criteria pollutant emissions from power plants and the impact of those emission reductions on public health. Because ESIST can evaluate energy efficiency scenarios over a wide range of years, the tool can quickly determine screening level estimates of long-term emissions and public health impacts for a range of scenarios. ESIST's energy savings outputs can also be exported to other modeling tools to refine and explore air quality and public health benefits estimates.

Outputs of interest: The avoided emissions outputs of ESIST provide a screening level estimate of the emissions reductions that the energy savings from utility efficiency programs can provide. More precise and locational emissions estimates, which can be used to seek compliance credit to meet the National Ambient Air Quality Standards and other obligations under the Clean Air Act, may be obtained by integrating ESIST's MWh outputs into AVERT (or another emissions model). These emissions reductions can be analyzed either within ESIST to estimate public health impacts or can be used in another model (e.g., COBRA) for further analysis.

Illustrative Use Case 3: Establish or Review Energy Efficiency Plans

Users and user goals: These users are compiling or reviewing electric energy efficiency plans filed with PUCs by utility or third-party program administrators. These users may include PUCs, PUC staff, utilities and municipal utilities, or cooperatives, as well as other stakeholders.

In addition to evaluating the benefit-cost ratios of specific energy efficiency plans, stakeholders who review and comment on these plans often provide perspective on the broader energy planning landscape in a state. These users may be interested in the costs and benefits of alternate energy efficiency scenarios and how these scenarios compare to current and historical efforts. These users may also be interested in how energy efficiency plans meet various objectives related to low-income customers, such as customers served, share of funding dedicated to low-income customers, or energy burden impacts.

Approach: Using ESIST, users can compare a single utility's proposed energy efficiency plan with that utility's own historical energy efficiency savings. Users can also compare the proposed energy efficiency plan to planned or historical energy efficiency savings for other utilities in other states. Users can customize ESIST inputs by replacing its default assumptions with other sources of data as available from utility filings or through discovery. This customization allows the modeled scenarios to more accurately reflect local characteristics and programs. Customized values may include utility-specific values on baseline sales projections, estimated first-year costs of energy efficiency, peak savings, or utility-specific plans for low-income programs.

Outputs and scenarios generated from ESIST can facilitate discussion among members of collaborative organizations, and between stakeholders and utility commissions. Users can save multiple copies of ESIST and share impacts by distributing outputs to stakeholders. Scenarios can be developed and shared—with clearly documented input assumptions and parameters—within a single, transparent, well-documented Excel workbook.

Outputs of interest: Users engaged in the evaluation of an energy efficiency plan may be most interested in costs, savings, and electricity sales. ESIST may also serve as a useful platform for generating multiple benefits, including avoided emissions and energy burden impacts. Because ESIST outputs are aggregated across two sheets (graphically and in tabular format), they can be readily shared or displayed in presentations, reports, or testimony.

Appendix C: ESIST: Pilot Gas Version

ESIST focuses primarily on energy use and energy efficiency savings in the electricity sector. EPA is issuing a standalone pilot version of ESIST focused on natural gas consumption in the residential and commercial sectors to allow users to estimate natural gas savings from energy efficiency or other gas-saving measures. The methodology and functionality of this model is largely identical to the electricity-focused ESIST. The below sections highlight some of the major differences in sources used and calculations performed.

As with the electricity-focused ESIST, users of the ESIST: Pilot Gas Version 1.1 should be aware of the effects of electrification measures on gas consumption. For example, gas consumption projections made in light of ambitious electrification policies are likely to be lower than gas consumption projections made without these policies.

Default Data Sources

The pilot gas version of ESIST relies on the following data sources for default data:

- **Historical natural gas consumption:** Data on historical consumption of natural gas have been obtained from EIA Form 176.⁹⁷ This data set is updated each year and contains detailed, sector-specific natural gas consumption data for thousands of utilities across the United States. For the purposes of the pilot gas version of ESIST, we have retrieved “sales” and “transport” data for all utilities in the residential and commercial sectors.⁹⁸
- **Historical gas energy efficiency savings, spending, and measure lifetimes:** Data on historical gas energy efficiency savings, spending, and measure lifetimes were provided to EPA from Berkeley Lab. These data were compiled by Berkeley Lab through its *Cost of Saved Energy Database* and span the years 2012–2017.⁹⁹ We note the following about this data set:
 - **Definitions:** Reported savings are 'ex-ante' and for the most part, found in regulatory filings.¹⁰⁰ For some utilities and program administrators, evaluation results and net-to-gross ratios are used to arrive at an 'ex-ante' number. Reported utility spending includes the cost of administering, marketing, and evaluating programs, as well as incentives to customers. It excludes program participant costs and any performance incentives achieved through the implementation of the efficiency portfolio. The program

⁹⁷ For more information, see

<https://www.eia.gov/naturalgas/nqgs/#?report=RP1&year1=&year2=&company=&sortBy=&items=>.

⁹⁸ In EIA Form 176, “sales” refer to the quantity of gas that is sold directly to an end user. “Transported” gas is gas that is indirectly sold to the end user via some third party. Other sectors in EIA Form 176 not included in the pilot gas version of ESIST include the industrial, electric power, and vehicle sectors.

⁹⁹ For more information on this data set, see Berkeley Lab’s May 2020 report *Cost of Saving Natural Gas Through Efficiency Programs Funded by Utility Customers: 2012–2017*, available at https://eta-publications.lbl.gov/sites/default/files/cose_natural_gas_final_report_20200513.pdf.

¹⁰⁰ “Ex ante” savings are projected savings, rather than evaluated savings. As in the electric ESIST, some of the selectable organizations in the pilot gas version of ESIST have reported historical savings and spending, but no reported historical gas consumption.

average measure lifetime is the savings-weighted average of program lifetimes in each utility or program administrator's portfolio for a given year.

- **Data coverage:** This data collection does not include all investor-owned utilities with gas efficiency programs in the United States. Instead, this data collection covers 50 investor-owned utilities and two third-party administrators in 21 states for the period 2012–2017. Depending on the year, these program administrators account for 50–70 percent of national gas efficiency spending (relative to the Consortium for Energy Efficiency's estimates of national spending). In instances where utilities report data for some years but not others (e.g., data is reported for 2012–2016 but not 2017), the pilot gas version of ESIST automatically extends the last existing data point through the modeled historical period. This applies to periods where Berkeley Lab has compiled data (e.g., 2012–2017), as well as other years the pilot gas version of ESIST treats as the past (such as 2018–2021). For the utilities that have no reported savings, the pilot gas version of ESIST does not apply any “gap filling” step; users modeling geographies with no reported savings or spending should take care to ensure that these values are truly zero, rather than non-zero and not collected by Berkeley Lab.
- **Projected gas consumption:** As in the electricity-focused version of ESIST, future projections of natural gas consumption are based on data from AEO 2023.
- **Utility cost of energy efficiency:** As a default, the pilot gas version ESIST provides first-year utility cost of energy efficiency data for the U.S. as a whole and for four regions (Midwest, Northeast, South, and West) from Berkeley Lab's 2020 paper *Cost of Saving Natural Gas Through Efficiency Programs Funded by Utility Customers: 2012–2017*.¹⁰¹
- **Utility share of energy efficiency costs:** No data on the split of costs between utilities and program participants are currently available for gas energy efficiency measures. As a result, the pilot gas version of ESIST uses the same default used in the electricity-focused ESIST (a derivation of data from Berkeley Lab's 2018 paper *The Cost of Saving Electricity Through Energy Efficiency Programs Funded by Utility Customers: 2009–2015*).¹⁰²
- **Emissions impacts:** Data on emission factors associated with natural gas consumption are based on information in EPA's AP-42 and the 2017 National Emissions Inventory.¹⁰³ Users may wish to use the COBRA model to assess public health impacts related to emission reductions from lower gas consumption.¹⁰⁴
- **Energy burden impacts:** Users may assess energy burden impacts similar to that described above in Step 6 (see page 38). Energy burden calculations are performed on the basis of expenditures on natural gas, relative to household income. As in the electricity-focused ESIST, this analysis is performed for the residential sector only (although other

¹⁰¹ For more information, see https://eta-publications.lbl.gov/sites/default/files/cose_natural_gas_final_report_20200513.pdf.

¹⁰² For more information, see https://eta-publications.lbl.gov/sites/default/files/cose_final_report_20200429.pdf.

¹⁰³ See <https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf> (Table 1.4-2) and <https://www.epa.gov/air-emissions-inventories/2017-national-emissions-inventory-nei-technical-support-document-tsd>.

¹⁰⁴ For more information, see <https://www.epa.gov/cobra>.

parts of the tool combine commercial and residential data, the Energy Burden Impacts module pulls data for residential customers only).

- **Customer information:** Users may examine historical customer information similar to that described in Step 6 (see page 47). Because of data availability, information is presented for the residential sector only.
- **Savings expiration:** No data on measure expiration are currently available for gas energy efficiency measures. As a result, the pilot gas version of ESIST uses the same default used in the electricity-focused ESIST (a derivation of data from Berkeley Lab).¹⁰⁵

Functionality Limited or Excluded in ESIST: Pilot Gas Version 1.1

The following paragraphs describe the functionality that is present in the electricity-focused version of ESIST but is excluded from the pilot gas version.

- **Study area:** Users may currently model the U.S. as a whole, individual states, or individual utilities. The pilot gas version of ESIST is not yet able to model groups of utilities or sectors within utilities.
- **Other settings:** In the pilot gas version ESIST, users can modify parameters relating to measure expiration and emissions. Modules that are not currently included in the pilot gas version of ESIST include Peak Demand Impacts, Public Health Impacts, and Demographic Data. These modules are not included due to current gaps in data.
- **Outputs:** Broadly speaking, the pilot gas version has the same outputs as the electricity-focused ESIST, except for the outputs related to the modules excluded from the pilot gas version of ESIST: public health impacts and wholesale peak impacts. Otherwise, outputs on energy sales and savings, costs, emissions, and energy burden impacts are shown in the same format or an analogous format to the electricity-focused ESIST.

¹⁰⁵ See <https://emp.lbl.gov/publications/energy-efficiency-lifetimes-how> for more information.