LEAP

Long-range Energy Alternatives Planning System

User Guide for LEAP 2005

May 2005

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Download the latest version of LEAP from http://forums.seib.org/leap

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1 Introduction

The Long-range Energy Alternatives Planning system (LEAP) is a scenario-based energy-environment modeling tool. Its scenarios are based on comprehensive accounting of how energy is consumed, converted and produced in a given region or economy under a range of alternative assumptions on population, economic development, technology, price and so on. With its flexible data structures, LEAP allows for analysis as rich in technological specification and end-use detail as the user chooses.

With LEAP, the user can go beyond simple accounting to build sophisticated simulations and data structures. Unlike macroeconomic models, LEAP does not attempt to estimate the impact of energy policies on employment or GDP, although such models can be run in conjunction with LEAP. Similarly, LEAP does not automatically generate optimum or market-equilibrium scenarios, although it can be used to identify least-cost scenarios. Important advantages of LEAP are its flexibility and ease-of-use, which allow decision makers to move rapidly from policy ideas to policy analysis without having to resort to more complex models.

LEAP serves several purposes: as a database, it provides a comprehensive system for maintaining energy information; as a forecasting tool, it enables the user to make projections of energy supply and demand over a long-term planning horizon; as a policy analysis tool, it simulates and assesses the effects - physical, economic, and environmental - of alternative energy programs, investments, and actions.

You can use LEAP to project the energy supply and demand situation in order to glimpse future patterns, identify potential problems, and assess the likely impacts of energy policies. LEAP can assist you to examine a wide variety of projects, programs, technologies and other energy initiatives, and arrive at strategies that best address environmental and energy problems.

2 Getting Started

These help files contain comprehensive information on using LEAP. To get started, we suggest you familiarize yourself with some of the major concepts:

- **Help:** Use the Help menu to get access to LEAP's on-line documentation (help is organized using an index, a table of contents and can also be searched). In addition, **you can press the F1 function key** to get context-sensitive help anywhere in LEAP. Pressing **F1** will give you a page of help relevant to the screen you are working on.

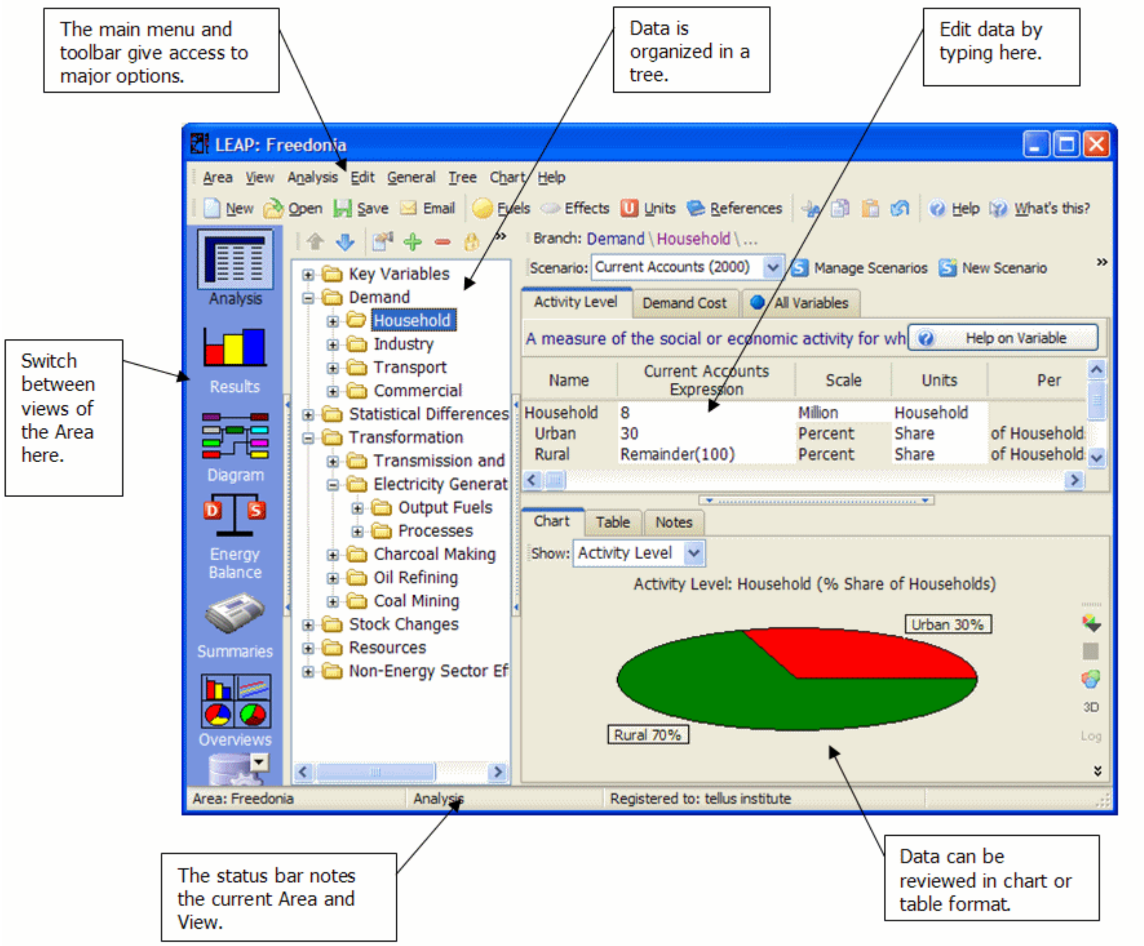
- **Views:** LEAP is structured as eight different "views" onto an energy system or "Area". These views are listed as graphical icons on the View Bar, normally located on the left of the screen.

- **Types of Analysis:** You can conduct a variety of analyses of energy systems using LEAP, including Demand Analysis, Transformation Analysis, Resource Analysis, and Environmental Analysis. All of these analyses can be combined together in LEAP to conduct Integrated Energy Planning (IEP) and greenhouse gas mitigation analyses, both of which rely upon conducting integrated social cost-benefit analysis. LEAP also optionally lets you create inventories and scenarios for Non-Energy Related Effects.

- **Data Structures:** The main Demand, Transformation and Resource data structures in a LEAP area are organized using a hierarchical tree. Different types of branches in the tree are represented as different icons (pictures). The types of data entered at each branch depend on the type of branch, its position in the tree (for example whether it is a Demand or Transformation branch), and the properties () you set for that branch. In addition to the tree, a number of cross-cutting supporting databases are also employed including the Fuels, Effects, Units and References databases.

- **Scenario analysis** is at the heart of using LEAP. Scenarios are self-consistent story-lines of how a future energy system might evolve over time in a particular demographic and socio-economic setting and under a particular set of policy conditions.

- **User Interface:** The main screen of the LEAP system consists of the View Bar on the left of the screen, a main menu and main toolbar at the top providing access to the most important functions of the program, and a status bar a the bottom of the screen showing the current area name, current view, licensing information and other status information. The layout of the rest of the screen will depend on which view is selected. NB: This documentation assumes you are familiar with using Windows-based programs.



- **Technology Database:** LEAP includes TED: the Technology and Environmental Database. TED provides extensive information describing the technical characteristics, costs and environmental impacts of a wide range of energy technologies. The quantitative data in TED is supplemented by qualitative Information Pages that review the availability, appropriateness, cost-effectiveness and key environmental issues of a wide range of energy technologies.

- **Additional Information** is available on the hardware and software requirements of LEAP, and on obtaining technical support. Please refer to the LEAP web site for information on how to license the full version of LEAP.

3 Basic Concepts

3.1 Expressions

LEAP borrows an approach made popular in spreadsheets: the ability for users to enter data and construct models using mathematical expressions. Expressions are standard mathematical formulae used to specify the values of variables in LEAP's Analysis View. In Current Accounts an expression defines the base year value for a given variable at a branch, while in scenarios, the expression defines how that variable changes over time (from one year after the base year to the end of the study period). Expressions can range from simple numeric values to complex mathematical formulae. Each formula can optionally reference LEAP's many built-in functions, as well as referencing the values of other branches and variables entered elsewhere in the LEAP analysis. Expressions can even create dynamic links to the values stored in an external Microsoft Excel spreadsheet.

LEAP provides a number of ways of editing expressions. The most common are:

- Typing directly into the expression field in one of the data entry tables in LEAP's Analysis View.
- Selecting one of the commonly used functions: Interpolation (), Growth (), End-Year (), or Remainder using the pop-up selection box attached to each expression field.
- Using the Time-Series Wizard: a tool for easily entering time-series functions (Interpolation, Step, Smooth functions, and forecasting functions)
- Using the Expression Builder tool (): a general purpose tool for creating expressions by dragging-and-dropping functions and LEAP and TED data and result variables.

3.1.1 Color Coding of Scenario Expressions

When editing scenario data in LEAP's Analysis View, expressions are color coded to show which expressions have been entered explicitly in the current scenario, and which are inherited from a parent scenario (including from data specified for Current Accounts). Blue text indicates a value entered explicitly in the current scenario, while black text indicates an inherited value. In addition, when expressions are inherited between regions expressions are shown with purple text.

- Use the **Show Scenario Branches** option (Main Menu: Tree: Show Scenario Branches) to list and optionally jump to any of the branches entered explicitly in the current scenario (i.e. those colored blue).
- To reset an expression back to its inherited default, highlight the expression and press **Delete**, or right-click and select the **Reset to Inherited () option.**

- For more information on scenario expressions, refer to scenarios.

3.1.2 Referencing Variables and Constants in Expressions

- **Data Variables:** In an expression, the values of other branches/variables are referenced by typing the branch name followed by a colon followed by the variable name. For example, the value of the activity level variable in the Demand\Households branch would be referenced by typing "**Demand\Households:Activity Level**". Note: Expressions are not case-sensitive. You can enter variable and function names in any combination of upper and lower-case letters. When you have finished entering the formula, LEAP will put the names in a standard format: capitalizing the function names. When referencing branches that are immediate siblings or parents of the current branch, you need only specify the last part of the branch name (e.g. cooking). When referencing more distant branches, include the full path name (e.g. Demand\Households\Urban\Cooking). When referencing a different variable at the same branch, you need not enter a branch name. Similarly, when referencing the same variable at a different branch you need not enter the variable name. In fact, if you do enter this additional information, LEAP will strip-it-out when you submit the expression.

- **Fuel Variables:** A further type of variable you can reference in expressions is fuel variables. These are the various chemical and physical characteristics of the fuel associated with a branch. Examples include the carbon, sulfur, and moisture content of the fuel, and its net heating value. Notice that only branches in which fuels are consumed or produced have valid fuel variables. These fuel variables reflect the data defined in the Fuels screen.

- **Constants:** Constants, including your own user-defined constants, can also be included in expressions. A default set of constants are included that define various molecular weight constants. These are primarily useful in defining emission factors. For example, a CO2 emission factor might be a function of the carbon content of the fuel, the fraction of the fuel oxidized, and the molecular weights of carbon and carbon dioxide.

- **TED Variables:** TED Branches and variables can also be referenced in expressions. The syntax is similar to that used for referencing LEAP variables (i.e. branch:variable), expect that a special function TED() needs to be wrapped around the reference. Referencing TED data allows you to selectively use items of data stored in the TED database in your calculations.

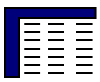
  Tip: Using the Expression Builder tool is the easiest way to create expressions that references other branches and variables.

3.1.3 Expression Elaboration

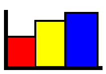
Expression Elaboration is a small panel that automatically pops-up under the main data entry table in Analysis View to elaborate on the meaning of complex expressions: ones that refer to other branches and variables. *Expression Elaboration* is useful for helping you to understand and explain your analyses WITHOUT continually having to navigate from branch to branch in the tree.

4 Views

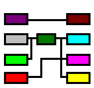
LEAP is structured as a set of eight different "views" of an energy system. These views are listed as graphical icons on the "View Bar", normally located on the left of the screen. Click an icon in the View Bar to select one of the views. In some cases, the system may need to calculate scenarios before the view is displayed. If you are working on a low resolution screen, we suggest that you hide the View Bar to make more space on the screen. Click the "hotspot" on the right of the View Bar, or use the menu option **View: View Bar** to do this. Thereafter, you will need to use the **View** menu to select the different views.



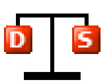
The Analysis View is the place where you create your data structures, models and assumptions in LEAP. In the Analysis view, the screen is divided into three panes. On the left, a hierarchical tree is used to create and organize data structures under four major categories Key Variables, Demand, Transformation and Resources. The tree is also used to select the data to be edited, which is shown on the right of the screen. For example, clicking on the "Electricity Generation" tree branch on the left of the screen, will display the data for that module on the right of the screen. On the top-right of the screen, a data entry table is used to edit data and create modeling relationships. The information you enter here is displayed graphically in the bottom-right pane.



The Results View displays results in detail for all parts of the energy system. It can be used to create a wide variety of charts and tables covering each aspect of the energy system: demand, transformation, resources, costs, and environmental loadings. Reports can be viewed for one or more scenarios and can be customized in a wide variety of ways. You can also use the "Favorites" option to bookmark the most useful charts for your analysis.

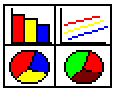


The Diagram View displays a "Reference Energy System" diagram showing the main energy flows in your system from resource extraction, through the conversion and transport of fuels, through to final energy demand. Using the diagram view you can zoom in to examine the processes within each Transformation module and their input and output fuels. As you edit Transformation data structures in the diagram view (e.g., adding or deleting modules, processes and fuels), the diagram view will automatically be updated.



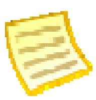
The Energy Balance View displays the results of your calculations as a standard energy balance table or chart. Energy balances can be viewed for any calculated scenario and any years in your analysis. Energy balances can also be customized to reflect different energy units.

The Summaries View: The summaries view is a general purpose tool with which you can create your own customized tabular reports. Reports can include any data variable or results value as well as your own commented subheadings. This view is also used to access the special cost-benefit summary report, which summarizes the costs and benefits of scenarios compared to a chosen baseline scenario.



The Overviews View is used to group together "Favorite" charts created earlier in the Results view. With Overviews, you get a birds-eye view of different important aspects of the energy system, such as costs, environmental impacts, and resource requirements. You can create multiple named Overviews, each of which can display up to 10 different Favorites.

TED: The Technology and Environmental Database provides extensive information describing the technical characteristics, costs and environmental impacts of a wide range of energy technologies available internationally or in particular developing country regions. The database includes information on existing technologies, current best practices and next generation devices. The first version of TED includes data on approximately one thousand technologies, referencing reports by dozens of institutions such as the Intergovernmental Panel on Climate Change , the U.S. Department of Energy, and the International Energy Agency, as well as data specific to energy technologies found in developing countries. In addition to its quantitative data, TED also includes qualitative information pages that review the availability, appropriateness, cost-effectiveness and key environmental issues for a wide range of energy technologies. TED's core database can be edited or supplemented by a user's own data.



The Notes View is a simple word processing tool with which you can enter documentation and references for each branch of the tree. To edit the notes, either type directly into the Notes Window, or select **Edit** to display a larger window with additional word-processing features. Notes can include formatting (bold, underline, fonts, etc.) and can also include standard Windows "objects" such as spreadsheets. Use the **Print** and **Print All** buttons ( ) to print one or all of the notes or the **Word** buttons ( ) to export one or all of the notes to Microsoft Word.

4.1 Analysis View

The **Analysis View** is used to:

- **Create the data structures for your area.** This is done primarily by editing the Tree shown on the left of the view, which is organized into four major categories of information: Key Variables, Demand, Transformation and Resources.

- **Create and manage alternative scenarios:** using the Manage Scenarios screen.

- **Enter the data, assumptions and modeling relationships for each scenario:** using the data entry tables on the right-hand side of the screen.

4.1.1.1 Top Pane

The data entry tables on the top-right of the Analysis View are used to enter expressions that define the Current Accounts (base year) values of variables and the future values of each variable for a given scenario. Depending on which tree branches you click on the left of the screen, different data entry tables will be listed as tabs on the top of the data entry table. For example, when editing demand sectors you will see tabs giving access to "Activity Levels" and "Costs", while at the lowest levels of the tree you will also see tabs for "Energy Intensities" and "Environment" data. Select a table by clicking on the tab. In general, the rows of each data entry table correspond to the tree branches immediately below the one you clicked on in the tree. For example, if you clicked on the Transformation branch, you will see information about all of the **modules** in your Transformation analysis. Similarly, if you click on the demand branch for the household sector, the rows of the data entry table will show information about household subsectors (e.g. urban, rural, depending on the structure you develop). Note though, that when editing Demand activity levels, LEAP also shows you a series of indented rows, which also shows you the activity levels in higher level branches.

Each data entry table is color coded to show you which fields can and cannot be edited be edited. Fields with a white background can be edited, while fields with a gray background cannot. Color coding is also used to show you which expressions have been entered explicitly in the current scenario, and which are inherited either from a parent scenario or from the data specified for current accounts. Blue text indicates a value entered explicitly in the current scenario, while black text indicates an inherited value (or data entered in Current accounts). Red text indicates an error.

The columns of information shown in most data entry tables are broadly similar. You will normally see the following columns:

- **Name:** the name of the tree branch being edited. This name cannot be edited in the data entry table. If you want to change it, either click on that name in the tree, or right-click on the row and edit that row.

- **Current Accounts Value (column header shows year):** Only when editing scenarios, the data entry table will contain an additional column showing the value entered for each branch in the Current Account year. Where appropriate, the foot of the column will show the total sum of all neighboring current account values. Notice that, this column shows numeric values: whereas you may have entered Current Accounts data as either a simple number or an expression.

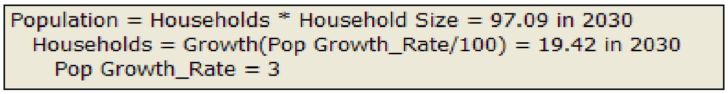
- **Expression:** LEAP borrows an approach made popular in spreadsheets: the ability for users to enter data and models in the form of mathematical expressions. In Current Accounts an expression defines the base year value for a given branch and variable, while in scenarios, the expression defines how that variable changes over time (from one year after the base year to the end of the study period). Expressions can range from simple numeric values to complex mathematical formulae. For more information, refer to Expressions and Examples of Expressions

- **Scale** and **Units:** In many tables, columns are provided for specifying the units of the data you are entering. For some variables, units consist of both a numerator and a denominator unit. Note that in most Transformation data screens, units are not chosen for each branch, but are chosen for a whole group of neighboring processes and output fuels. For these tables, scale and units selection boxes are shown in a panel immediately above the data entry table. Units and scaling factors can only be edited when editing Current Accounts data, since the settings apply across all scenarios. It is important to note that the units you choose for data entry do not have to be the same as the units in which you report your results. LEAP will handle unit conversion calculations for you. Most data can be entered in a choice of units, and LEAP provides a wide range of standard units for energy, power, mass, volume and monetary data. You can also add your own units using the General: Units option. This is most useful when specifying monetary data in different currency units. When entering energy simple numeric data in the demand energy intensity tables and switching energy units, LEAP will offer to automatically convert data from one unit to another. To avoid entering very large or very small numbers, most LEAP tables include a column in which you can choose scaling factor. Typically you will leave this blank, but you can also choose a factor such as "Thousand", "Million" or "Billion".

  Note that some data entry table have additional columns. For example, demand energy intensity branches also require that you select the fuel associated with a demand device.

4.1.1.2 Expression Elaboration

Expression Elaboration is a small panel that automatically pops-up under the main data entry table in Analysis View to elaborate on the meaning of complex expressions: ones that refer to other branches and variables. *Expression Elaboration* is useful for helping you to understand and explain your analyses without continually having to navigate from branch to branch in the tree.



4.1.1.3 "Breadcrumb" Navigation Bar

A web-like "breadcrumb" toolbar shown in the Analysis, Results and Notes views shows you which branch is currently selected in the tree and lets you navigate to other branches without having to use the tree.

4.1.1.4 Analysis Toolbar

Immediately above the data entry tables is a toolbar containing a selection box and the Manage Scenarios button. Use the selection box to select the data you want to edit in the data entry tables. Select between Current Accounts and any of the Scenarios in an area. Click on Manage Scenarios to create, delete or change the inheritance relationships of scenarios.

4.1.1.5 Bottom Pane

The bottom pane of the analysis view displays the data you entered in the top pane as either a chart or a table. These let you quickly examine the values generated by the expressions you have entered above. The chart and table toolbars on the right of the pane gives access to a range of options for formatting charts and tables (e.g. picking chart type and stacking options, colors, 3D effects, grids, number of decimal places, etc.) and for printing and copying charts and tables, exporting tables to Microsoft Excel, and exporting charts to Microsoft PowerPoint.

The bottom pane also gives access to a notes screen: a word processing tool in which you can enter documentation and references for each branch of the tree. To edit the notes, right-click and select **Edit** to display the notes in a larger window, which includes a basic set of word processing controls. Notes can include formatting (bold, underline, fonts, etc.) and can also include standard Windows "objects" such as spreadsheets. The notes view is linked to the References database, providing a centralized facility for referencing your data and assumptions. To edit the list of References, use the **New** ( ), **Add** ( )and **Delete** ( ) buttons to link to the References database.

4.1.2 Analysis View Toolbar

The Analysis View toolbar provides tools for working with the data entry screens of the Analysis View:

The **Region Selection Box** lets you choose a region to edit. This selection box is only displayed if your area has more than one region.

The **Scenario Selection Box** lets you choose either the Current Accounts data or one of the scenarios you have created for editing.

Manage Scenarios is used to create, delete, organize and set the properties of the scenarios in an Area.

Create Scenario is used to quickly edit or create a new scenario by reviewing its Key Parameters. This button is only displayed if you have created a Scenario Template for the area, describing the list of key parameters in scenarios.

Expression Builder is a general purpose tool that helps you construct LEAP's expressions by dragging and dropping functions and LEAP and TED Branches/Variables into an editing box.

The Time-Series Wizard is a tool that helps you construct the various time-series expressions supported by LEAP's Analysis View. These expressions include functions for interpolation, step functions, smooth curves and linear, exponential and logistic projections.

Print Expressions is used to print out expressions for the current scenario. It will print expressions for either the current variable or for all variables.

4.1.3 Growth Dialog

This dialog is used to quickly build an expression reflecting an exponential growth rate from the base year value of a variable. Enter a percentage value, and when you click OK, LEAP will build an expression of the form Growth(x%). This dialog is not available when editing Current Accounts, nor when editing variables measured in percentage units.

Tip: *Do not enter a % character in the value you enter.*

4.1.4 End Year Dialog

This dialog is used to quickly build an expression reflecting an interpolation function from the base year value of a variable to a value in the end-year of the analysis. Enter a value and when you click OK, LEAP will build an **Interp** expression of the form Interp(Year, X). Tip: for more elaborate interpolation functions, use the Time-Series Wizard.

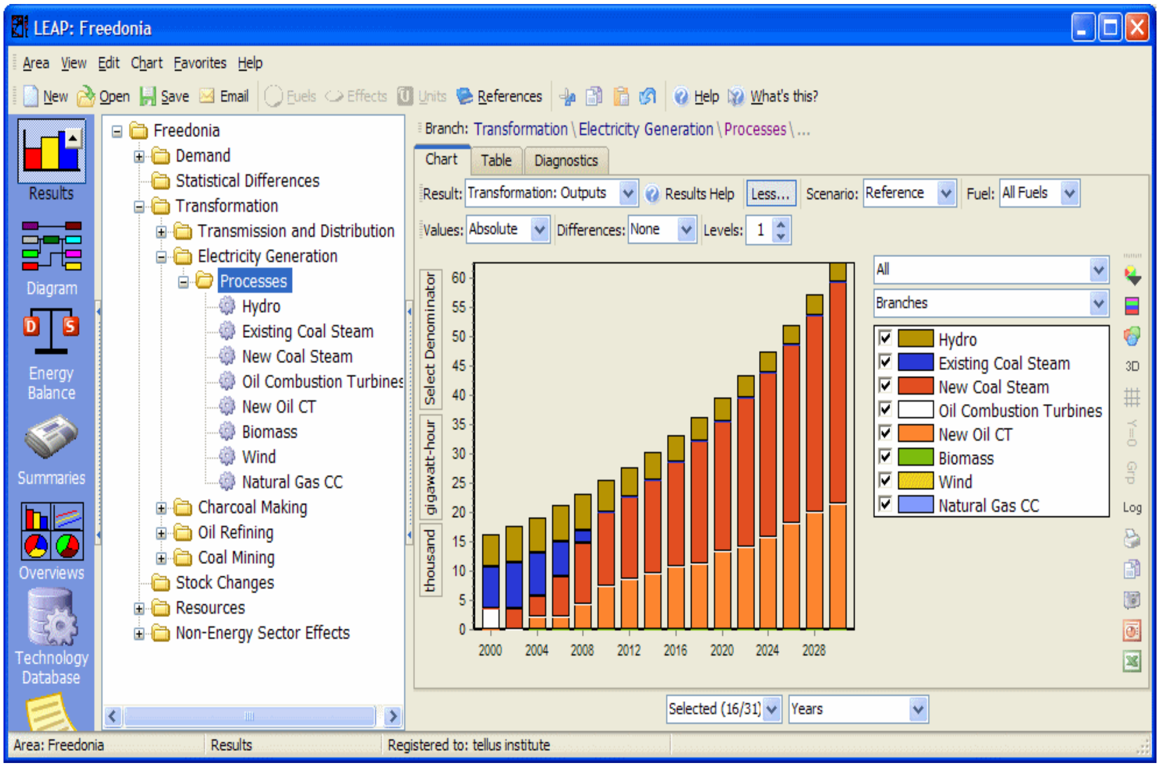
4.1.5 Printing

Most parts of the LEAP user interface can be printed including charts, tables, the RES diagram and the LEAP and TED trees. When you select Print ( ), a print preview appears. Using this dialog you can set most printing options, such as the printer name, the margins, and which pages you wish to print. When you are ready to print, click on the Print ( ) button appearing in the dialog toolbar.

The print preview option's menu contains various options for configuring your printouts:

- From the **File Menu**, you can design the look of your printout, set-up the printer page, and print the report.
- From the **View Menu** you configure the appearance of the preview screen.
- From the **Format Menu,** you can set options for page numbering and date/time stamps on the report.
- From the **Go Menu** you can navigate through the pages of the report.

4.2 Results View



The Results View is used for reviewing the results of your scenario calculations in either chart or table form. In addition to its role as LEAP's main reporting tool, the Results View is also important as the main place where you debug your intermediate results to ensure that your data, assumptions and models are valid and consistent.

Two tabs at the top of the view let you switch between **Charts** and **Tables**: both formats contain the same basic information. In addition, a third tab, labeled **Diagnostics**, sometimes appears showing warnings and informational messages concerning your results. This tab only appears if diagnostic messages were generated during calculations. For more information, see Diagnostics.

To view a given chart or table, it is generally easiest to work first with the chart format. Once you have established the information you require you can then switch to the table report. Use the on-screen selection boxes to create a chart. You can change any of the selection boxes at any time, but typically you will follow the following basic steps to create a new chart:

1. Use the selection box at the top of the screen to first pick the category of results you are interested in. For example, you might pick a result category such as net final energy demand, or costs.

2. Using the **tree**, you can pick the branches for which you wish to see results. For example, you might choose to see demands in the household sector, or costs for the whole area.

3. Use the **selection boxes** attached to the chart's **X axis** and **legend** to pick the data dimensions you want to see on each axis of the chart. Different categories of results will have different data dimensions. For example, energy demand data has the dimensions: years, branches, fuels, and scenarios. You can create a chart showing any two of these dimensions on the X-axis and legend of the chart. Examples of demand charts you can create include: fuel by year (for a given branch and scenario), branch by year, for one or all fuels and a given scenario, scenarios by year (for a given branch and one or all fuels), etc. Some restrictions apply. For example, the years dimension cannot be plotted on the legend axis. Those dimensions not placed on the X axis or legend are listed in the Results View toolbar shown at the top of the screen, allowing you to pick one item (or where appropriate the total of all items) in that dimension. So for example, if you chose to view a scenario x year chart for energy demands, you will also use the toolbar to choose whether you wish to display results for one fuel, or the total for all fuels or selected fuels. When picking a dimension for the X axis or legend you will also be able to specify whether you want to show all items in the dimension or only selected items. If you choose "selected" you will be shown a dialog box in which you can check of the items to be displayed.

4. Use the various additional on-screen controls to further customize your chart.

    - The **Scale** and **Units** buttons shown on the chart or table axis are used to pick the scaling factor and unit for the chart. The class of the unit (energy, power, mass, volume, etc.) is determined by the category of result you are examining. LEAP automatically chooses a scaling factor (thousands, millions, billions, etc.), but you can subsequently override this by clicking the scaling button. For most reports, you can also choose a denominator variable. For example, you may wish to view energy demand per unit of GDP, or carbon emissions per person. Click on the denominator button to set or remove the denominator variable.

    - When displaying energy demand results, you can display results in either **final** or **primary** energy equivalent units. Primary units are provided for those who prefer to display electricity and heat consumption in terms of the equivalent amount of primary energy required to produce it. When displaying reports in this fashion, LEAP makes use of the **conversion efficiencies** specified as the last column in the Fuels database. By default, all values are set to 100%, except for electricity, which is set to 33%. Currently, this value does NOT automatically reflect actual generation, transmission and distribution efficiencies of your LEAP scenarios, so you may want to edit the default values to reflect the average efficiency in your Area.

5. To reduce the complexity of the screen and to save space, the more advanced reporting options are hidden by default. To display the following options, click on the **More** button:

   - Use the **Values** selection box, to display absolute, percentage, cumulative or indexed values or to show year on year growth rates for each year of the study.

   - Use the **Differences From** selection box if you wish to see the differences between scenarios or Current Account values, or if you wish to see differences versus previous year values. If you want the absolute results for scenarios, select "None". Note: you can combine the scenario differences and Values selections to show for example cumulative differences from one scenario to another.

   - When viewing cost results, an additional **Costs** selection box appears, letting you choose either real (i.e. constant value) costs or discounted costs.

   - **Cross-Tabulated Reports:** When viewing results across different branches of the tree (e.g. when viewing energy demands over time), an additional **Levels** control is shown letting you pick the number of levels of depth to be reported. This lets you examine how a total value at a given branch is made of the various branches underneath. When the level is set to one (the default), you will be shown results for the branches immediately below the one you clicked on in the tree (e.g. the various demand sectors). When set to two you will see two levels of branches (e.g. the various subsectors under each demand sector). The maximum number of levels supported is three. When displaying multiple levels, you can click on the **Match Names** checkbox to group branches of the same name. This option can be useful, for example, if you want to see total cooking or lighting energy consumption in multiple regions or across urban and rural households.

6. Use the Chart and Table toolbars on the right of the screen (or right-click on a chart) to customize the appearance of the chart or the table, to copy results to the Windows clipboard ( ), and to print ( ) or export results to Microsoft Excel ( ) and PowerPoint ( ). Options on the toolbar let you select the type of chart ( ), type of stacking ( ), and formatting options such as 3D effects, log scales, grid lines, and the number of decimal places reported in numeric values.

4.2.1.1 Saving Favorite Charts

You can save your favorite charts including all settings for the axes, type of chart, and formatting, using the Favorites menu. This feature is similar to the bookmark/favorites features found on popular Internet browsing software. Later, in the Overviews View, you can group together favorite charts to create overviews of different results. Use the **Save Chart as Favorite** option to bookmark the current highlighted chart. You will be asked to give the favorite a name. Use the **Delete Favorite** option to delete the saved favorite. To switch to a favorite chart, select its name from the favorites menu.

4.2.2 Diagnostics

During its calculations, LEAP performs a number of different checks on your data set. The outcome of these checks are reported as diagnostics messages, which are displayed on the Diagnostics tab of the Detailed Results View. The Diagnostics messages are displayed in table form showing the branch, scenario and year for which the message was generated. When no diagnostic messages are generated, the Diagnostics tab is not visible.

Two different types of checks are conducted:

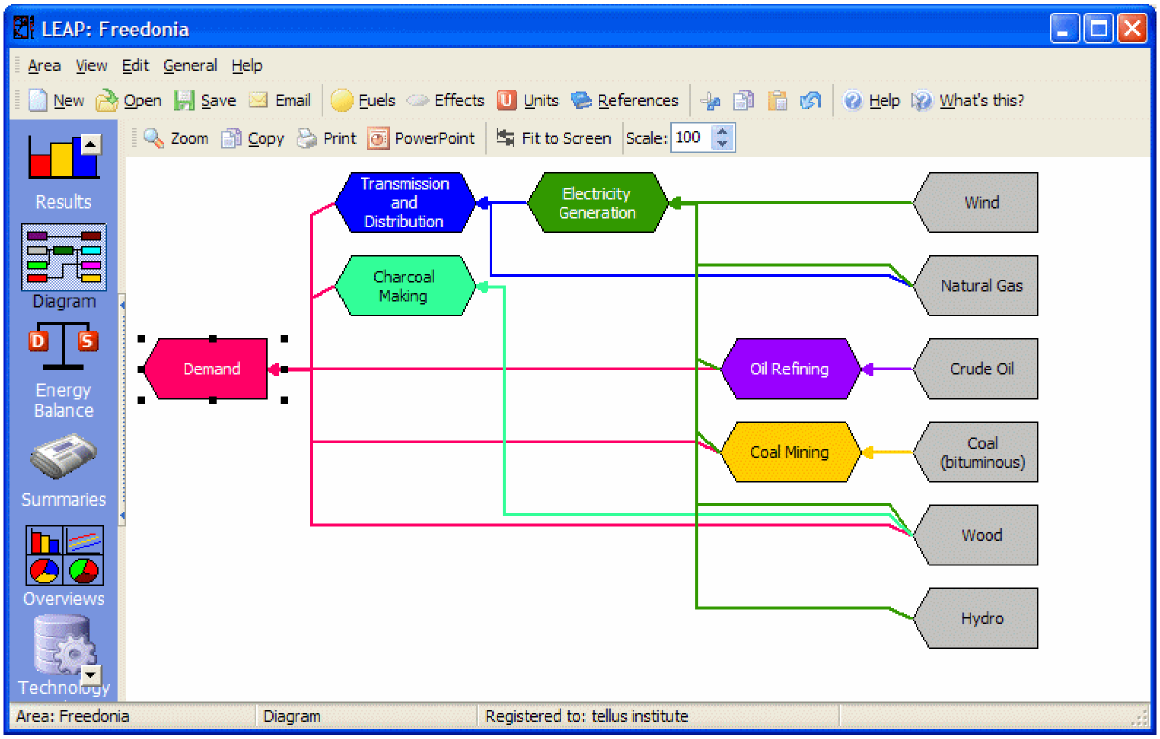
1. **Consistency Checks:** LEAP looks for common errors such as (a) whether all of the fuels specified in your demand analysis are produced in your Transformation analysis; (b) whether your Transformation analysis is producing fuels for which there are no requirements, (c) whether Transformation modules are incorrectly ordered (for example if Transmission and Distribution is placed below Electric Generation), and (d) whether Demand branches are not fully defined.

2. **Checksum Validation:** If you enter checksums for the level of final demand or primary requirements for fuels on the Calculation Checksums screen, LEAP will validate that its calculated demand and primary requirements match those checksums. Deviations from those checksums will be reported in the Diagnostics screen.

Note that some diagnostics measures will appear as warnings (⚠), since they clearly represent a problem, while others will be shown only as informational messages (❗).

Use the Diagnostics messages to interactively debug your analysis. Double-click on a message to directly switch-back to the Analysis View with the cursor placed on the relevant tree branch.

4.3 Diagram View



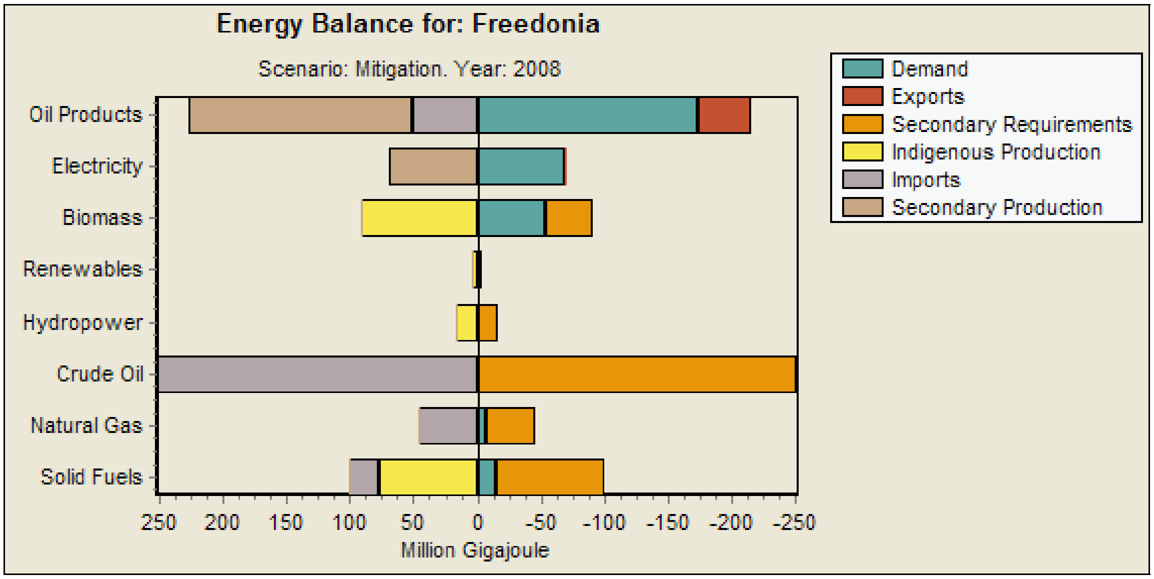
The Diagram view displays a Reference Energy System (RES) diagram showing the main energy flows in your Area from resource extraction, through the conversion and transport of fuels, through to final energy demand. As you edit Transformation data structures either in the Analysis View or in the Diagram View (e.g., adding or deleting modules, processes and fuels), the Diagram View is automatically updated.

The gray labeled nodes on the right of the RES diagram show the indigenously produced primary resources in your area (the diagram does not currently display imports or exports). The colored nodes in the center of the diagram show the **modules** in your **Transformation** system on far left of the diagram is a node representing final demands. The colored lines on the RES show the individual primary input fuels (feedstocks) to each module. They also show how secondary energy produced by each module is consumed either in another module or by final demand. Note that to prevent the diagram becoming too complex, secondary fuels produced in the system are not displayed individually, but are aggregated into a single colored line. Lines on the diagram are color coded to show the modules to which they are connected.

From the top level RES diagram, you can double-click on a node to zoom-in and examine the processes within each Transformation module including their input and output fuels. Alternatively click on the zoom button (). When examining a module diagram, double-clicking on a particular process will open that process in the Analysis View.

By default, the diagram is scaled to fit the window. If you resize the window, click on the **Fit to Screen** button to resize the screen. Use the **Scaling** control on the toolbar to resize the diagram to other sizes. Click **Copy** ( ) to copy the diagram image to the Windows clipboard, and **Print** ( ) to print/preview the diagram. Click the **PowerPoint** button ( ) to add the diagram as a slide to a Microsoft PowerPoint presentation.

4.4 Energy Balance View



The energy balance view displays a summary of energy consumption, conversion and production for any calculated scenario and any year in the Area you are studying.

The energy balance view provides a number of tools for configuring the tables, charts and diagrams. Options include the ability to select the scenario, year and region to be displayed, to change the energy units in which results are reported, to change the colors of the chart and diagram ( ), and to increase ( ) and decrease ( ) the number of decimal places in which values are shown. The toolbars contain the controls for setting these options. Using the appropriate toolbar buttons, you can print ( ), export the table to Microsoft Excel ( ) or add the chart or energy flow diagram to a Microsoft PowerPoint presentation ( ). When displaying results by fuel, fuel grouping, or region a slider control is shown at the foot of the energy balance. Use this to quickly select among different years.

Energy balances can be displayed as a standard format **Energy Balance Table**, a **chart**, or an **energy flow diagram**. These are further described below:

1. The Energy Balance Table

In table form, the energy balance is divided into 3 main vertical sections as shown in the adjoining diagram.

Indigenous Production (+)	A
Imports (+)	B
Exports (-)	C
Resources	D=A+B+C
Transformation (outputs - inputs)	E
Demand	F=D+E

1. **Resources:** The first section shows primary resource requirements and contains three rows: indigenous production, imports and exports (shown as negative values by convention).

2. **Transformation:** The second section shows the energy consumed and produced during the conversion of primary resources into secondary fuels, as well as the energy lost during the transportation and distribution of fuels. Each row corresponds to a Transformation module (listed in reverse of the order shown in the Analysis View). Energy inputs to a module are shown as negative values, outputs are shown as positive values, and the net losses from each module are thus shown in the "total" column on the far right of the balance.

3. **Demand:** The third section shows final demands in the Area. Each row of the balance shows the sum of final demand in one of the top level branches of the demand tree (i.e. a sector).

Two additional rows labeled **Stock Changes** and **Statistical Differences** are visible for Current Accounts only if you place a checkmark next to the option "Base Year Statistical Differences and Stock Changes", on the Default tab of the Basic Parameters screen, and subsequently enter the corresponding data.

By default, the columns of the energy balance table are the aggregate fuel groupings defined in the Fuel Categories screen. The rows in the energy balance can be reordered using the reorder buttons on the Fuel Categories screen (**General: Fuel Categories**). You can also display detailed fuels, years or even regions as the columns of the energy balance table. When showing years or regions, the energy balance shows the total energy flows summed across all fuels.

2. The Chart

The chart form of the energy balance shows a more aggregate representation of the data shown in the energy balance table. It consists of two side-by-side horizontal bar charts. The chart on the left shows final and secondary energy consumption broken down into final demand, export and secondary consumption components. The chart on the right shows energy supplies broken down into indigenous production, import and secondary production components. By default, each bar in the chart corresponds to a fuel grouping, although as with the table form of the balance, you can also display years or fuels as the bars in the chart.

3. The Energy Flow Diagram

Somewhat similar to a standard energy balance table, the energy flow diagram (shown below) displays the flows of energy through an area from primary resources (indigenous production and imports), through each Transformation module, to final demand and exports. Typically, energy flows are displayed for each fuel or fuel grouping. Each fuel is displayed as a column, while major resource, Transformation and final demand categories are displayed as rows. You can also use the flow diagram to display total energy flows for each region or year (summed across all fuels).

Energy flows are displayed as colored boxes, with the width of the box proportional to the annual flow of energy. Empty boxes are drawn in 4 situations:

1. Where losses occur in a Transformation module (e.g. losses during electric generation or transmission and distribution), or
2. a fuel is consumed as a feedstock or auxiliary fuel in a Transformation module (e.g. crude oil is consumed in an oil refining module), or
3. a fuel is exported from the system, or
4. a demand remains fully or partially unmet.

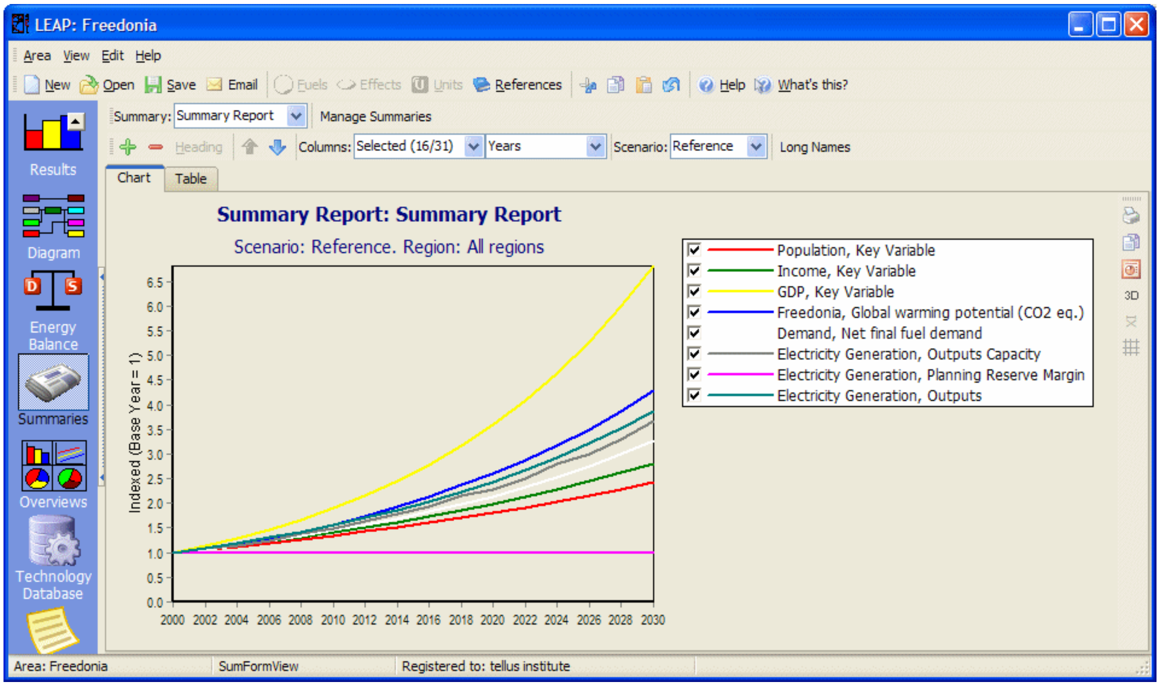
The boxes decrease in size from one module to the next (reading down) where one of the above situations occur, but increase in size in the following situations:

1. Where a new fuel is produced as a result of a module operating (e.g. electricity is produced in an electric generation module).
2. Fuel is indigenously produced or imported into the system.

The energy flow diagram is very similar to the Reference Energy System shown in the Diagram View. However, unlike the diagram view it shows flows of energy for any given scenario or year, making it a much more useful view of results.

Note also that, unlike a standard energy balance table, in the energy flow diagram exports are shown as a class of final demand, rather than as a class of primary production.

4.5 Summaries View



The summaries view is a general purpose tool with which you can create your own customized tabular and graphical reports. Reports can include any data or results values as well as your own commented headings. Reports consist of rows, each of which displays either a heading or one variable for a given branch in the tree and columns which can be configured to display either years or scenarios. Each report can be viewed as either a table or chart, by clicking Chart and Table tabs at the top of the screen.

The summaries view is also used to access the special cost-benefit summary report, which summarizes the costs and benefits of scenarios compared to a chosen baseline scenario. This special report cannot be deleted, and you cannot alter its rows.

Click on the Manage Summaries option to create any number of named summary reports. Then use the Summary selection box to select among the various summary reports.

Use the following options to work with individual reports:

Add: Click to add a new branch/variable combination as a row of the report at the cursor position. A three-step wizard will be displayed from which you pick a branch, a variable and a unit.

Delete: Click to delete the currently highlighted row of the report. Note that you will not be deleting any data, you will only be removing the row from the report.

Blank Row: Click to insert either a blank (spacer) row in the report, or to insert a labeled subheading. You will be prompted to enter text for the heading. Leave this blank to enter a blank row.

Up: Click to move the current row up.

Down: Click to move the current row down.

Long Names: Click to toggle long or short branch names in the summary report. Short names contain just the label associated with a particular branch, while long names include the full path of the branch (i.e. including the names of higher level branches in the tree).

Columns: Use the two Columns selection boxes to select all or selected **years** or **scenarios** as the rows of the report. Notice that only scenarios marked for calculation in the Manage Scenarios screen are available. When displaying years as columns, a further selection box will be displayed in which you select a scenario to be displayed in the report. Similarly, when scenarios are the columns, a further selection box will be displayed in which you select a year to be displayed in the report.

In addition to these options, you can use the toolbars on the right of table and chart to increase ( ) or decrease ( ) the number of decimals displayed in a table, to change the table font ( ), to export tables to Excel ( ), to print and preview tables and charts ( ), to copy charts and tables to the Windows clipboard ( ), and to export charts to PowerPoint ( ).

4.5.1 Cost-Benefit Summary Report

The cost-benefit summary report is a specially designed summary report, available from the Summaries View screen. As such it cannot be deleted, and you cannot alter its rows.

The cost-benefit summary report view displays a comparative overview of the costs and benefits of each calculated scenario in your analysis, compared to a chosen baseline scenario. Typically you will choose a scenario representing a "business as usual" set of policies to act as the baseline (counter factual) scenario.

The summary displays a tabular report showing the incremental total cumulative costs of each calculated scenario summed across all of the study years, with each cost discounted to the base year at the user-specified discount rate. You can change the default discount rate to see how this effects the cost-benefit calculations. You can also change the monetary unit in which the summary is reported. Use the Units menu option to create your own currency units.

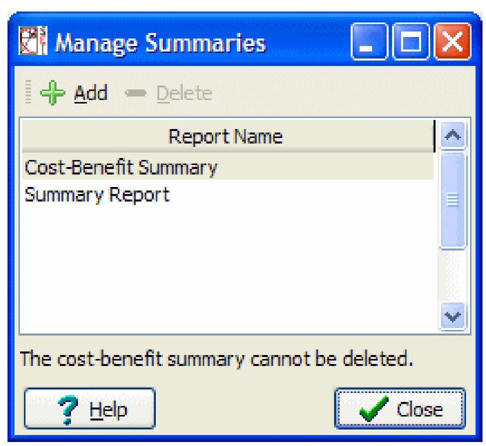
The cost summary shows costs and benefits for each Demand sector, and each Transformation module, as well as those derived from the indigenous production, import and export of fuels and resources in the Area. It also shows total costs for the system as a whole and the overall benefit/cost ratio of each scenario. The cost summary will also optionally compare the environmental externality costs of each scenario. If you want to include these costs, make sure that you check off "Include Externality Costs" on the costing tab of the Basic Parameters screen, accessed from the main menu. To edit the externality values assumed for each pollutant, go to the Effects screen.

Costs relative to the baseline scenario are shown as positive values, while benefits are shown as negative values. It is important to remember that costs are only incurred when there are physical differences between scenarios AND when unit costs for those differences have been entered. Thus, it is possible for scenarios to differ physically but not in terms of costs, if you forget to specify (for example) the unit cost of resources or the unit cost of generating capacity. Thus, be sure to enter all appropriate unit costs in the Demand, Transformation and, Resource data entry tables before using the cost summary.

At the bottom of screen, the cost summary displays the total cumulative emissions of all greenhouse gases avoided by each scenario (shown in terms of the global warming potential of those pollutants in tonnes of Carbon equivalent). By default, LEAP uses the 100 year integration global warming potential factors suggested by the IPCC. You can change these assumptions, on the Effects screen. The cost summary also displays the overall cost of saving carbon emissions in each scenario (with and without the co-benefits of avoided emissions of non-greenhouse gas pollutants). Note that this value reflects the discounting of both costs AND carbon emissions.

Note: the cost-benefit summary report can only be viewed when at least two scenarios have been created.

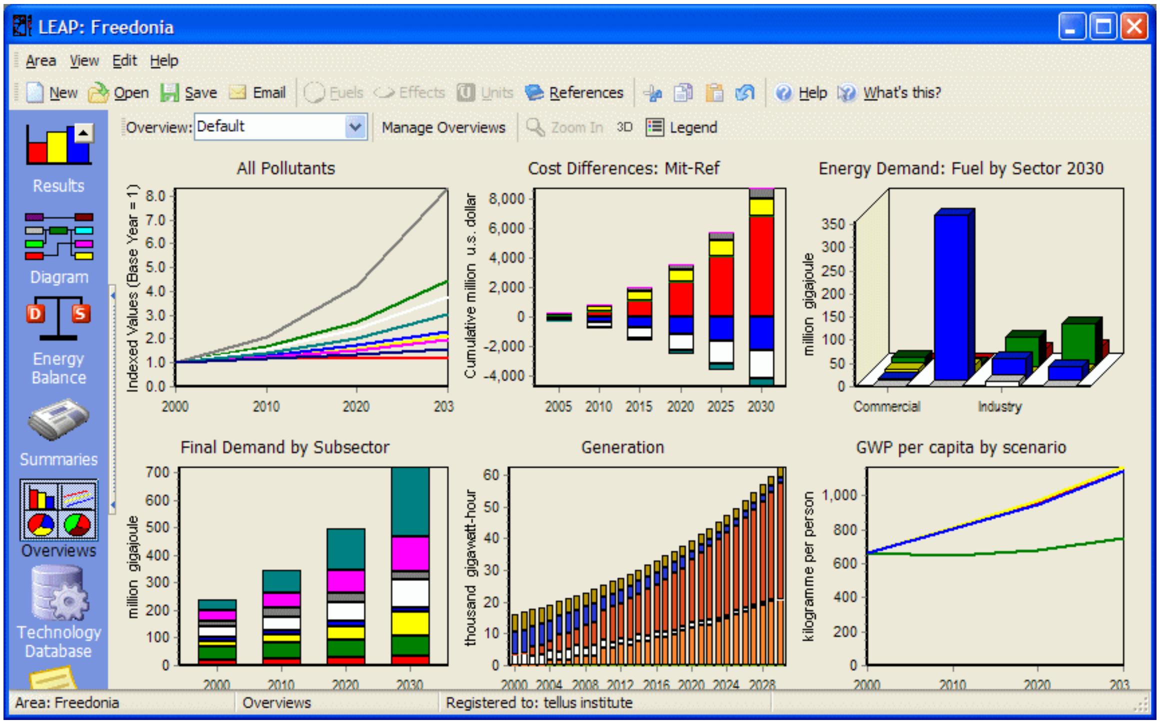
4.5.2 Manage Summaries



The Manage Summaries screen is used to add, delete and rename summary reports. Use the **Add** button () to add a new summary report (you will be prompted for a name). Use the Delete button () to delete a summary report. You can also rename reports by retyping their names in the table shown on screen.

Note: one report, the cost-benefit summary report is a specially designed summary report and cannot be deleted.

4.6 Overviews View



The Overviews View is used to group together multiple "Favorite" charts (created earlier in the Results View) on screen. With Overviews, you can simultaneously examine different important aspects of the energy system, such as costs, environmental impacts, and resource requirements. The Overviews view is only accessible once you have saved one or more favorite charts, and created one or more scenarios.

You can create multiple named Overviews, each of which can display up to 16 different charts. The first time you access the system, LEAP will display an overview containing all (up to a maximum of 16) of the favorite charts you have saved. At this point you can use the Overview Manager to select which favorite charts you want to include in your overview. You can also use the Overview manager to add a new overview and to rename and delete overviews.

Double-click a chart, or click the zoom button (🔍) to switch to the Results View and display the currently selected chart.

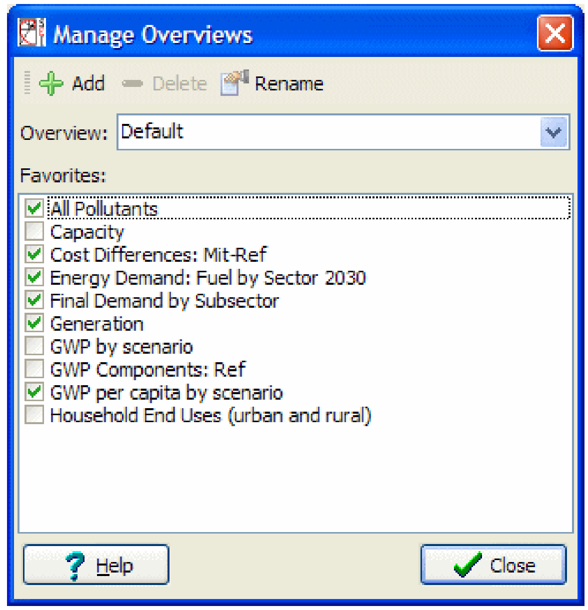
You can apply a number of formatting options across all charts shown in the Overview. Click on **3D** to set the 3D effect for all charts. Click on legend (☰) to show or hide all legends.

4.6.1 Overview Manager

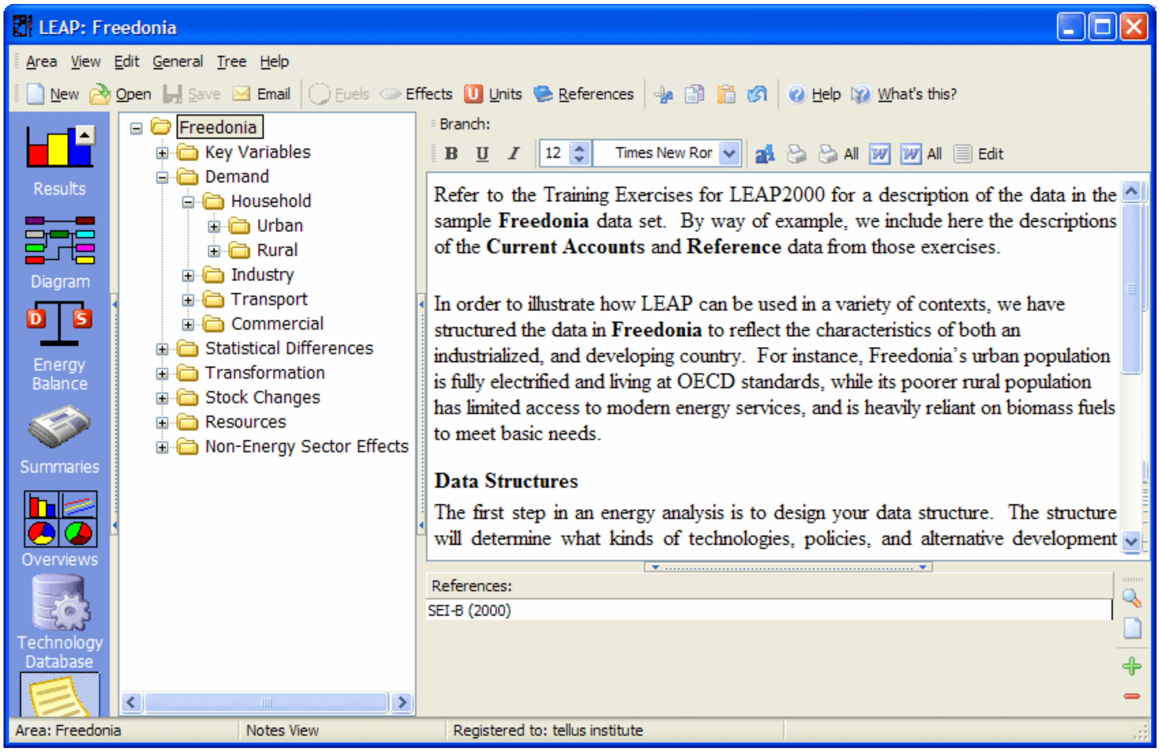
Use the Overview Manager (accessed from the Overviews Toolbar) to

- Add (), delete () and rename () overviews, and to
- quickly select which favorite charts are to be included in an overview.

Use the selection box to select which overview you wish to manage, and then click the check boxes next to the list of favorite charts to include or exclude charts. When you click the close button, the edited overviews will be displayed on screen.



4.7 Notes



The notes screen is a simple word processing tool with which you can enter documentation and references for each branch of the tree. To edit the notes, either type directly into the window, or right-click and select **Edit** to display a larger window with additional word-processing features.

Notes can include formatting (bold, underline, fonts, etc.) and can also include standard Windows "objects" such as spreadsheets. Use the Print and Print All buttons ( ) to print one or all of the notes or the **Word** buttons ( ) to export one or all of the notes to Microsoft Word. The notes view is linked to the References database, providing a centralized facility for referencing your data and assumptions. To edit the list of References, use the **New** ( ), **Add** ( ) and **Delete** ( ) buttons.

5 Main Menu

The main menu in LEAP provides access to the most important functions of the program. There are seven sub-menus:

5.1.1 Area Menu

The area menu is provides option for creating, opening, saving and managing areas, as well giving access to Area-wide operations such as setting print options and exiting LEAP. It also contains the Language option, used to switch the language in which LEAP is displayed.

5.1.2 View Menu

The View menu allows you to switch between the seven basic views in the LEAP system. It also lets you show or hide the View Bar, which by default is shown on the left of the screen. If the View Bar is hidden (to make more room on screen), use the View menu to switch views. See the View Bar help topic for a description of each view.

5.1.3 Analysis Menu

The Analysis menu gives access to the main tools used in editing your data in Analysis View including the Scenario Manager, the Time-Series Wizard, the Expression Builder, and the Import from Excel and Export to Excel options. It also gives access to the option to Print Expressions. To make data entry more responsive, it is now possible to switch-off the automatic updating of charts and tables in Analysis View. To do this, select menu option: **Automatic Calculation.** When automatic calculations are switched-off, you can press the **F9** key to manually update charts and tables, or select menu option **Analysis: Calculate Now**.

5.1.4 Edit Menu

The edit menu gives access to standard Windows editing operations: cut (Ctrl-X), copy (Ctrl-C), paste (Ctrl-V) , select all, and undo (Ctrl-Z). Note that the Undo feature is limited to a single undo operation and only within a given text editing box. LEAP does not currently support undoing of operations that effect data structures, nor does it support multi-level undo.

5.1.5 Chart Menu

The chart menu contains options for formatting charts in the Analysis and Results View. See also: Chart Toolbar.

5.1.6 General Menu

The general menu gives access to various screens used to edit settings and supporting data that does not otherwise appear in the main Analysis View. These include:

Basic Parameters: used to edit the basic settings of your analysis such as the base and end year, the default energy and monetary units and the cost-benefit analysis methodology to be used in the analysis.

Fuels used to view or edit the list of fuels used in your Area.

Fuel Groupings used to view or edit the list of fuel groupings used in your Area.

Regions: used to view and edit the list of regions in your Area.

Region Groupings: used to view and edit the list of region groupings

Effects used to view or edit the list of effects for your Area.

Units: used to view or edit the list of units used in your Area.

References used to view or edit the list of references for your Area.

Lifecycle Profiles: used to edit technological profiles and age distributions for stocks of devices across different yearly vintages.

Load Shapes: used to view and edit a library of different load shapes that can be used to specify how annual electric and other demands vary by season and time of day for different demand devices. This option is only enabled if you specified endogenous loads on the General: Basic Parameters screen.

Time Slices: used to edit the seasonal and time-of-day divisions into which annual electric and other loads can be divided. This option is only enabled if you specified endogenous loads on the General: Basic Parameters screen.

Constants: used to edit the names and values of constants that can be used in LEAP's expressions.

Σ Calculation Checksums: used to enter checksums for easier spotting and diagnosis of calculation errors.

User variables: used to create and edit additional user-defined variables,

5.1.7 Tree Menu

The tree menu is used to edit and navigate through the Tree, which appears in the Analysis and Results views. Options on this menu allow you to add and delete branches, and to modify their properties. See "Editing the Tree" for more information. Many of these functions are also available by right-clicking on the Tree. Note: a simplified version of this menu is displayed when editing TED data.

5.1.8 Favorites Menu

The Favorites menu, which is only displayed when in Results View, lets you save favorite charts including all settings for the axes, type of chart, and formatting. This feature is similar to the bookmark/favorites features found on popular Internet browsing software. Later, in the Overviews View, you can group together favorite charts to create overviews of different results. Use the "Save Chart as Favorite" option to bookmark the current highlighted chart. You will be asked to give the favorite a name. Use the "Delete Favorite" option to delete the saved favorite. To switch to a favorite chart, select its name from the favorites menu.

5.1.9 Help Menu

The Help menu gives access to the contents, index and search pages of LEAP's help system. You can also press the **F1** key at any time to access context-sensitive help appropriate to the screen you are working in. You can also get quick usage tips by selecting **Show Tip**.

The Help menu also gives access to the LEAP web sites (this requires an Internet connection) and lets you send an email to SEI-Boston requesting technical assistance. This feature requires that you have a MAPI compliant email system installed on your PC, such as Microsoft Outlook or Netscape Navigator. An "About" screen gives you contact information should you wish to contact SEI-Boston by mail, phone or fax. This screen also gives you system information which can be useful in identifying problems you may encounter while running LEAP. An option labeled "**Check on Internet for Updates**" automatically checks for newer versions of LEAP over the Internet, and installs them onto your PC. Note that this is the preferred method of updating the software as it requires a much smaller download compared to a full download and installation of the system.

NB: the versions of LEAP available on the Internet work by default in "evaluation" mode (i.e., with the "Save" feature disabled). For those using this version, the "Register LEAP" option can be used to enter a user name and registration code to fully unlock the software. User names and registration codes are distributed by SEI-Boston to licensed users of the system. Visit the LEAP web site for more information on licensing LEAP.

6 Interface

6.1 The Tree

The tree, which appears in the Analysis View, the Results View, and the Notes View is a hierarchical outline used to organize and edit the main data structures in a LEAP analysis. In the Analysis View you can edit the tree structure (for example, by right-clicking with the mouse on a tree branch, or by using the Tree menu options), and you also click on the tree to select the data you want to view and edit. In the Results View, you again use the tree, but this time as a means of accessing the various results calculated for different branches of the tree (for example energy demand in a particular sector or electricity production in different power plants).

Data in the tree are organized under four major categories, which normally appear as the top level of branches in the tree:

- **Key Variables:** under which you create and organize independent variables used to "drive" the calculations in your Demand, Transformation and Resource analyses. Key Variables are not directly calculated in LEAP, but they are useful as intermediate variables that can be referenced in your modeling calculations.

- **Demand:** under which you create the disaggregated structure of your energy demand analysis. For more information, see: Demand Analysis.

- **Transformation:** under which you create the structure of your Transformation analysis. Transformation analyses simulate the conversion and transportation of energy forms from the point of extraction of primary resources and imported fuels all the way to the point of final fuel consumption. As with your demand analyses, you can create alternative scenarios to represent different future Transformation configurations reflecting alternative assumptions about policies and technologies. Transformation data are defined at two main levels of detail. The ***module*** level represents energy industries or sectors such as electricity generation, refining, district heating, or charcoal production. Below each module, you describe the individual ***processes*** within a module such as particular electric power plants or oil refineries, and the **output fuels** produced by the module. At the module level, you define the basic parameters for simulating the operation of the energy industry, such as whether you wish to specify capacity restrictions, and how you want to simulate the dispatch of different processes. For each process, you define technology data such as the input fuels to each process, capacities, efficiencies, capacity factors, capital and operating and maintenance costs, and emission factors. For more information, see: Transformation Analysis.

- **Resources:** under which you create a data structure to reflect the production of indigenous resources and the import and export of secondary fuels. For more information, see Resource Analysis.

- **Non-Energy Sector Effects:** under which you can create scenarios for Non-energy related effects. Typically you will use these branches for inventories and scenarios of non-energy sector greenhouse gas (GHG) emissions, as a complement to the analysis of energy sector greenhouse gas emissions and mitigation measures conducted in the other parts of LEAP. For more information, see Non-Energy Sector Effects Analysis.

- **Stock Changes and Statistical Differences:** These two additional top level branch categories are visible only if you place a checkmark next to the option "Statistical Differences and Stock Changes", on the Default tab of the Basic Parameters screen.

When using the tree in the Results and Notes Views, an additional top level branch is displayed showing the name of the current Area. Clicking on this branch lets you review results summed across both Demand and Transformation branches (for example, total emissions for the area). This branch does not appear in the Analysis View. Note also that some branches for which no results are available are hidden in the Results View. These include the "Key Variables" branch, and all branches below it, as well as Transformation Outputs branches.

Trees in Multi-Region Areas

In areas with more than one region you can use the Tree: **Select Visible Branches** option to selectively show or hide branches in different regions. Hidden branches are not included in a region's calculations.

6.1.1 Tree Branches

Different types of branches in the tree are represented as different icons or pictures. The types of data entered at each branch (i.e. the tabs that appear in Analysis View), will depend on the type of branch, its position in the tree (for example whether it is a Demand or Transformation branch), and the **properties** you set for that branch. The meaning of each icon is explained below:

Category branches are the most common type of branch. They are used mainly for organizing the other branches into hierarchical data structures. For example, in your demand analysis, you can use category branches to create a set of sectors, subsectors and end-uses, into which you place the various energy-using devices you wish you model. In Demand branches these data structures are very flexible. You can create any number of levels of branches, and use different levels in different sectors. In your Transformation branches, categories are used to indicate the main energy conversion **modules** such as electric generation, charcoal making and oil refining and to organize the various **processes** and **output fuels** in each module. Note that in the Transformation tree, unlike the demand tree, you cannot have flexible levels of data disaggregation. In the Resource branches, categories are used to organize resource into primary resources and secondary fuels. Categories are also used in cases where you choose to disaggregate your primary resource accounting analysis.

Technology branches are represented by a small gray cog wheel icon. In the Demand tree they are used to represent final energy consuming devices, and hence are uniquely associated with a particular fuel. In the Transformation tree, these branches are used to indicate processes: the individual technologies or groups of technologies within a module that responsible for converting or transporting energy such as a particular electric power plant or oil refinery.

End-Use branches can only be created in the Demand tree. They are used to indicate a branch at which energy intensities are specified for an aggregate end-use, rather than being associated with a specific fuel or device. These branches are useful in 3 main cases: a) where you have energy intensity data for an end-use, and only have fuel share data (not intensity data) for the fuels and devices within the end-use; b) where you have devices that use more than one fuel; and c) where you wish to conduct a **useful energy analysis.** In this case you need to check the additional useful energy analysis checkbox on the branch properties screen. For more information on useful energy analysis, refer to the Demand Analysis help screen.

Key Variable branches only appear in the Key Variables tree, and are used to indicate independent time-series variables. (E.g. GDP, industrial output, population, consumption, investment, etc.). Key Variables are not directly calculated in LEAP, but they are useful as intermediate variables that can be referenced in your modeling calculations. Key Variables are defined globally and then used in the different analyses as a means of projecting results. For example, Key Variables can be used in the Demand program in conjunction with elasticities to project energy demands.

Fuel branches are represented by a small sun. In the Transformation tree they indicate the various **output fuels** produced by each Transformation module. In the Resource tree, they indicate the primary resources and secondary fuels produced, imported and exported in your area. In the Stock Change and Statistical Differences branches they represent fuels for which you can specify base year stock change and statistical differences.

Environmental Loading branches are represented by a gray cloud.

Some restrictions exist on where you can create different branches. For example, you cannot move branches between the four major categories (Key Variables, Demand, Transformation, and Resources) and in most cases you cannot mix branches with different icons at a single level. These restrictions affect the various Tree editing options that let you add, delete, copy, paste, and move branches.

6.1.2 Editing the Tree

The tree, which appears in the Analysis View, the Detailed Results View, and the Notes View is a hierarchical outline used to organize and edit the main data structures in a LEAP analysis. In most respects the tree works just like the ones in standard Windows tools such as the Windows Explorer. You can rename branches by clicking once on them and typing, and you can expand and collapse the outline by clicking on the +/- symbols to the left of each branch icon. Additional options to edit the tree can be accessed in a number of ways:

- By right-clicking on the tree and selecting an option from the pop-up menu that appears,
- by using Tree menu (which contains an expanded set of options),
- by clicking on the **Properties** ( ), **Add** ( ) and **Delete** ( ) buttons on the main toolbar, or
- by using short-cut keys for the most common option (e.g. **Alt-P** for Properties, **Ctrl-Ins** to add a branch, **Ctrl-Del** to delete a branch, etc.). Valid short-cut keys are displayed on the main menu.

A few of the most common options are worth explaining further:

Select Visible Branches: This option is available only in a multi-region area and is used to selectively show or hide branches in different regions.

Up and Down: These buttons are used to move relative to its immediate neighbors. Use these buttons to quickly reorder branches, or alternatively you can drag-and-drop branches as you would in Windows Explorer.

Properties (Ctrl-P) sets the properties of a tree branch. Different types of branches have different properties.

Add (Ctrl-Ins) adds a new branch to the tree. In general new branches are added below the currently highlighted branch. However, when a "leaf" branch such as a Demand device or Transformation process exists, another branch at the same level will be added. When adding a branch you will be asked to specify the name and properties of the new branch using dialog boxes listed above.

Delete (Ctrl-Del) is used to delete the current highlighted branch and all branches underneath it. You will be asked to confirm the operation before the branch is deleted, but bear in mind that a delete cannot be undone. Note however that you can exit LEAP without saving you data set to restore it to its status prior to the previous Save operation.

Cut Branches (Ctrl-X) is used to mark a branch and all branches below it to be cut. Later when you select **Paste Branches ( ),** the marked branches will be moved to the new position selected in the tree. Notice unlike a conventional cut operation in a standard Windows program, the cut operation does not actually delete the branches, nor does it copy the branches to the Windows clipboard.

Copy Branches (Ctrl-C) is similar to the Cut operation except that on the subsequent Paste command, branches are subsequently copied not moved. Note that restrictions exist on certain operations. For example, you cannot copy or move branches between the four major categories (Key Variables, Demand, Transformation, and Resources) and in most cases you cannot mix branches with different icons at a single level.

Insert Branches from Folder is used to insert a set of branches located in another LEAP area into the current data set at the currently highlighted branch.

Auto-Expand specifies whether the branches in the tree automatically expand and collapse as you click on them.

Expand All fully expands the tree.

Collapse All fully collapses the tree.

Outline Level expands or collapses the tree to show all branches up to the selected level of depth.

Print: previews and prints the tree. Only those branches that are expanded will be printed, so you may want to right-click on the tree and select Expand All before using the print option.

Find searches the tree for a named branch.

Find Again searches from the current branch for the next occurrence of the text entered in the Find dialog.

Find Fuels searches the branches of the tree for all branches consuming or producing a selected fuel. The results are shown in a separate dialog box as a list of branch names, any one of which can be clicked to jump directly to that branch in the main tree display. This option is only available in the Analysis View.

Font is used to change the typeface and size of displayed tree.

Lock/Unlock is used to lock or unlock a branch and optionally any branches below it. Once locked, a branch cannot be edited.

6.1.2.1 Drag-and-Drop Editing of Branches

When editing Current Accounts data, you can move a branch (and all branches below it) by dragging and dropping it onto another branch. To copy rather than move a branch, hold down the **Ctrl** key and then click and drag the branches. This approach allows you to rapidly create data sets, especially those containing many similar groups of branches (for example a household sector with many similar regionally disaggregated subsectors). There are various restrictions on which branches can be dragged and where they can be dropped.

6.1.3 Insert Branches from Folder

This option is used to insert a group of branches located in another LEAP area into the current data set at the currently highlighted branch. This option can be useful for example if you wish to merge separate sectoral analyses into an overall integrated analyses. Note that you can only add branches to Demand and Key Variables branches.

This option has four basic steps:

1. **Pick the folder containing the branches to be inserted.** You will need to pick a file named "masterstructure.db". This is the file containing the data for the tree structure.

2. **Pick the branches to be inserted.** LEAP will insert the branch you pick and all branches below it. In order to preserve expressions, LEAP will also insert the associated "Key Variable" branches.

3. **Review the mapping of scenarios from the current area to those in the folder from which you are inserting branches.** Bear in mind that each data set may

have different named scenarios. To merge the data you will need to map them to a common list.

4. **Review the mapping of fuel from the current area to those in the folder from which you are inserting branches.** As with scenarios, each data set may also have different named fuels. To merge the data you will need to map them to a common list. In most cases the default mapping will suffice.

When you have completed these four steps, LEAP will then insert the branches.

Note: When using this option, you must ensure that both data sets have common data for units, and environmental effects.

6.1.4 Select Visible Branches in Regions

Click the button to select this screen. It is only available when your area has more than one region. Use it to show or hide tree branches in regions: effectively allowing you to have different tree structures in each region. Hidden branches are not included in a region's calculations. You can only show and hide Demand, Transformation and Key variable branches. In the demand tree you can show and hide category and technology branches. In the Transformation tree you can only show or hide complete Transformation modules.

Use the **All** button to make all branches visible in a region. Use the **None** button to hide all branches in the region. Use the **Expand All** and **Collapse All** buttons to set the tree outline level. When you click close and return to the Analysis view the tree will show only the selected visible branches in each region.

6.2 Main Toolbar

The main toolbar is used to access the most commonly used functions in LEAP. The options on the toolbar are as follows:

New Area (Ctrl-N) creates a new Area. You will be prompted for a name and asked whether you wish to create an area by copying from another, or by starting from a default (blank) set of data.

Save (Ctrl-S) saves the current Area, including any data edited in LEAP or TED. This button is only enabled when you have made a change to the data set.

Fuels (Alt-F) is used to view or edit the list of Fuels used in your Area.

Regions (Alt-R) is used to view and edit the list of regions in your Area. This button is only displayed if there is more than one region in the Area.

Effects (Alt-E) is used to view or edit the list of Effects for your Area.

Units (Alt-U) is used to view or edit the list of Units used in your Area.

References is used to view or edit the list of References for your Area.

Cut (Ctrl-X) copies any selected text to the Windows clipboard and then deletes it.

Copy (Ctrl-C) copies any selected text to the Windows clipboard.

Paste (Ctrl-V) pastes text from the Windows clipboard.

Help (Ctrl-F1): shows the "Getting Started" Page of the online help.

What's This Help (Shift-F1): click this button, then click on any other part of the main screen to get context-sensitive help.

6.3 Chart Toolbar

The chart toolbar is used to customize and print charts in LEAP. It consists of the following buttons:

Chart Type selects the type of chart (pie, bar, horizontal bar, area, line, and point). Various restrictions apply to the types of charts you can choose. For example, you can only pick pie charts when the there is a single set of summable values, and you can only pick area charts when values are summable.

Stack Type is used in area, bar and horizontal bar charts to pick how series are formatted. The options are: **stacked**, **not stacked**, **grouped**, **percent stacked**, and **not stacked - 3D**. This last option displays series behind one another in a 3D effect. Note that stacking of charts is only available when it makes to stack the variable or dimension. So for example, a variable such as efficiency cannot be stacked, and nor can different scenario values of any variable.

Color Palette is used to select among different chart color palettes. The palettes include one that is similar to the palette used in Microsoft Excel, and another that uses patterns that are suitable for printing in black and white.

3D toggles whether charts are shown with a 3 dimensional effect. Note that due to software limitations, any charts with negative values cannot currently be shown with 3D effects.

Log toggles the use of a logarithmic scale on the chart. Note that log scales do not work well if the chart contains negative values.

Grp toggles the grouping of items in charts and tables.

Legend toggles whether a legend is displayed on the chart. Legends are always displayed in the Detailed Results View.

Gridlines toggles the display of grid lines on a chart.

Copy copies the chart to the Windows clipboard in metafile format. Chart images can be pasted into any Windows program that supports image objects.

Print prints and previews the chart.

Select Background Image inserts a background image behind your chart. You will be prompted to select a JPG, GIF or BMP file, and given the chance to preview the image before selecting it. Note that the html directory and sub-directories under the LEAP2000 program directory contain a useful library of energy and environmental photographs that you might find useful as background images. Background image settings are saved along with your other settings when you save a "Favorite" chart, and can then be displayed when you use LEAP's Overview feature.

Clear Background Image removes the background image from the current chart.

PowerPoint adds a chart as a slide to a Microsoft PowerPoint presentation.

Excel exports the current table to Microsoft Excel.

6.4 Table Toolbar

The Table toolbar is used to customize and print tables in LEAP. It consists of the following buttons:

Increase Decimals increases the number of decimal places displayed in a table.

Decrease Decimals decreases the number of decimal places displayed in a table.

Copy copies the table to the Windows clipboard. Tables can then be pasted into any Window that supports text.

Print previews and prints the table.

Excel exports the current table to Microsoft Excel.

Font lets you change the style, typeface and size of the font used to display the table.

6.5 Analysis View Toolbar

The Analysis View toolbar provides tools for working with the data entry screens of the Analysis View:

The **Region Selection Box** lets you choose a region to edit. This selection box is only displayed if your area has more than one region.

The **Scenario Selection Box** lets you choose either the Current Accounts data or one of the scenarios you have created for editing.

Manage Scenarios is used to create, delete, organize and set the properties of the scenarios in an Area.

Create Scenario is used to quickly edit or create a new scenario by reviewing its Key Parameters. This button is only displayed if you have created a Scenario Template for the area, describing the list of key parameters in scenarios.

Expression Builder is a general purpose tool that helps you construct LEAP's expressions by dragging and dropping functions and LEAP and TED Branches/Variables into an editing box.

The Time-Series Wizard is a tool that helps you construct the various time-series expressions supported by LEAP's Analysis View. These expressions include functions for interpolation, step functions, smooth curves and linear, exponential and logistic projections.

Print Expressions is used to print out expressions for the current scenario. It will print expressions for either the current variable or for all variables.

7 Scenarios

At the heart of LEAP is the concept of **scenario analysis**. Scenarios are self-consistent story-lines of how a future energy system might evolve over time in a particular socio-economic setting and under a particular set of policy conditions. Using LEAP, scenarios can be built and then compared to assess their energy requirements, social costs and benefits and environmental impacts. All scenarios start from a common base year, for which you establish your **Current Accounts** data.

You can use scenarios to ask an unlimited number of "what if" questions, such as: what if more efficient appliances are introduced, what if different electric generation capacity expansion plans are pursued, what if indigenous reserves of oil and gas are discovered, what if renewable energy technologies are introduced, etc.

Scenarios in LEAP encompass any factor that can change over time, including those factors which may change because of particular policy interventions, and those that reflect different socio-economic assumptions. Variations, in these latter types of factors are normally referred to as a sensitivity. In LEAP, sensitivities are included in a scenario. Because of this, its is important in your cost-benefit analysis that you only compare scenarios with the same socio-economic assumptions.

7.1.1 Scenario Inheritance

An important concept in using scenarios is the idea of scenario inheritance. In LEAP's Analysis View, you create mathematical expressions that define the data values of each branch/variable combination your analysis. Scenario inheritance allows you to create hierarchies of scenarios that inherit default expressions from their parent scenario. Initially, you create expressions for the Current Accounts. These can either be constant expressions, or expressions that generate a time-series of values. Then, you can create additional scenarios, with expressions that either simply inherit the Current Accounts expressions, or override these for particular branches and variables. So, for example, you might create a scenario that examines a household lighting efficiency program that inherits most of its expression from a baseline "business as usual" scenario. Because the HLEP scenario inherits from the baseline scenario, when initially created it will contain exactly the same expressions as the baseline scenario, and hence if calculated will yield exactly the same results. To fully define the scenario you only need to type in expressions to reflect the branches and variables affected by the household lighting program. The inherited expressions for all other branches stay the same. You can define any number of levels of inheritance. So for example you could make a second household lighting scenario that inherits from HLEP, with slightly revised assumptions. This approach makes it very easy to edit and organize scenarios, since a) they can be created with a minimum of data entry and b) common assumptions in families of scenarios can be edited by just editing the parent scenario.

When editing scenario data in LEAP's Analysis View, the expression fields in data entry tables are color coded to show which expressions have been entered explicitly in the current scenario, and which are inherited either from a parent scenario or from the data specified for Current Accounts. Red text indicates a value entered explicitly in the current scenario, while black text indicates an inherited value (or data entered in Current accounts). You can also use the **Show Scenario Branches** option (Main Menu: Tree: Show Scenario Branches) to list and optionally jump to any of the branches entered explicitly in the current scenario.

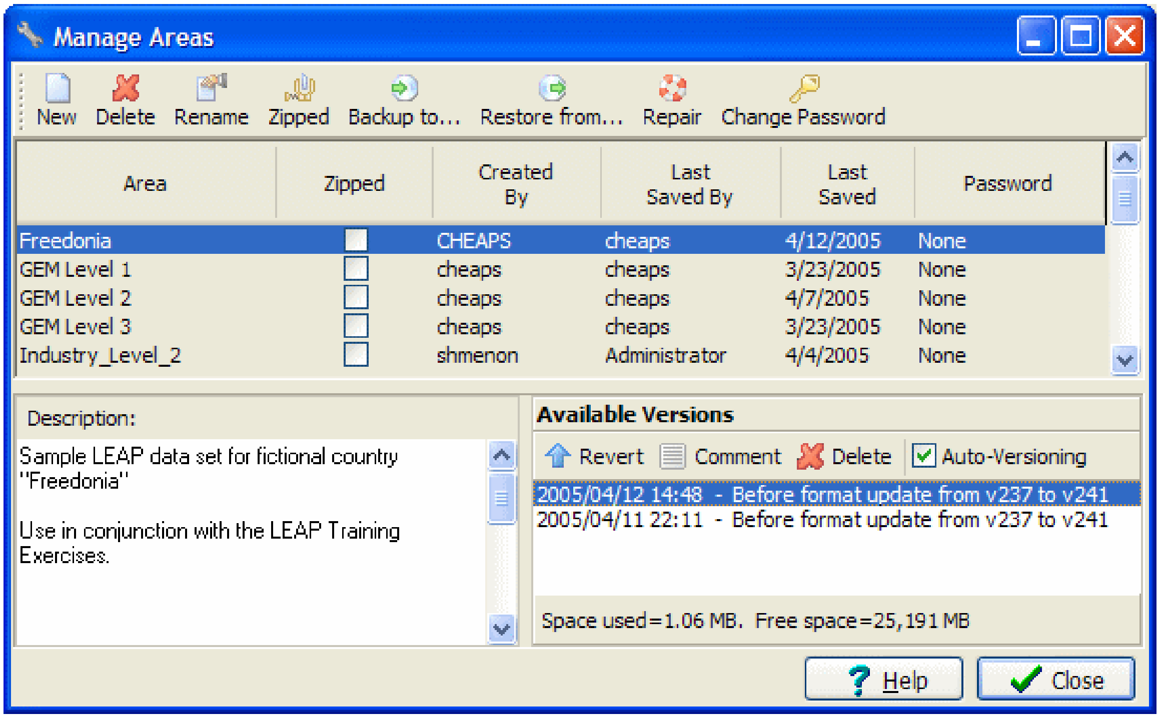
7.1.2 Multiple Scenario Inheritance

In addition to the direct scenario inheritance described above, you can also create scenarios that inherit expressions from more than parent scenario. This multiple inheritance approach is useful for examining a wide range of individual policy measures, which can then be combined in different ways to create different integrated scenarios.

For example, a series of individual measures could be developed in the Scenario Manager including a renewable portfolio standard (RPS), appliance efficiency standards (AES), and commercial cogeneration (COGEN), etc. These and other measures can be examined individually and then combined into overall scenarios that capture their interactions (for example, the benefits of appliance efficiency standards combined with a renewable portfolio standard will be less than the sum of the benefits of the two scenarios considered separately).

8 Major Supporting Screens

8.1 Manage Areas



Use the Manage Areas screen (Main Menu: Area: Manage Areas), to create, delete, and organize the data sets (Areas) on your computer. The Manage Areas screen is divided into three panes. The table in the top pane shows the areas installed on your computer. Below you can view and edit notes associated with each area, and manage the backup versions of areas (see below).

Top Panel

The top table contains the following columns:

- **Name:** the name of the area.
- **Zipped:** a checkmark indicating whether the area is currently zipped (i.e. compressed into a single "zip" file). You can double-click a checkmark to zip or unzip an area.
- **Created By:** the user who originally created the area (on older format data sets, this will be marked "unknown").
- **Last Saved By:** the user who last saved changes to the area.
- **Last Saved:** the date when changes were last saved.

- **Password:** the password-protection status of the area: none, required to edit, or required to open.

Toolbar

The Manage Areas toolbar gives access to a variety of options for managing areas:

New Area: Use this option to create a new Area data set. You can create one based only on the default data, or you can create it as a copy of an existing Area.

Delete: Use this option to delete an area. NB: deleted areas are permanently deleted from your hard-disk, and unless previously backed-up, cannot be restored.

Rename: Use this option to rename a folder.

Zipped: Use this option to compress an entire area's data files into a single "zip" file. Zip files are a standard format file used for archiving data. They can compress a LEAP area by 80% or more, helping to conserve disk space on your PC, and making it easy to send data sets via email. No additional software is required to use zip files with LEAP. However, zip files can also be opened by the latest versions of Windows as well as by third party tools such as WinZip (http://www.winzip.com).

Copy to... Use this option to make a back-up copy of an area. The area will first be archived into a single zip file. You can backup to any drive or folder on your PC or on a local area network connected to which you are connected.

Restore from... Use this option to restore a previously backed-up data set, or to mount an area sent to you by another person. You will be prompted to select the name of a zip file. LEAP will check the zip file to ensure that it is a valid LEAP Area data set.

Repair: Use this option to check an area data set for errors, including corrupted data files and orphaned data. Where possible, LEAP will attempt to fix these errors. If it cannot, it will report the problem to you. If errors cannot be fixed, contact the staff of SEI-Boston for assistance. This option will also "pack" the data files of your area, removing unused space and compacting the data files.

Change Password: Use this option to add, change or delete passwords for protecting access to an area. If an area already has a password, you will be prompted to enter the current password, before you can enter as new password. Note: for password-protected areas, the delete, repair and rename options require that you first enter a password.

Available Versions

LEAP saves multiple versions of areas, in case you decide you want to go back to a previous version of your data. Backup versions of Areas are automatically created when the area is saved. Previous versions are placed in the _backup folder and named with the area name and the backup date and time. For example, a version of FREEDONIA from 2.30 PM on March 2, 2005 would be named freedonia_2005_3_2_14_30.zip.

As versions accumulate, LEAP will selectively and automatically delete some of the previous versions saved, balancing the need to keep previous versions, with the need to preserve hard disk space. Several versions will be preserved from the previous 24 hours, then one per day for the last seven days, then one per week for the last month, then one per month for the last year, then one per year before that. Note: LEAP will never automatically delete a version for which you have given a comment. You may also manually create a version from the **Area: Make Version** menu option with an optional comment. Treat these versions as milestones. For example, once you have finished entering the Current Accounts for an area, you might create a version with the comment "Current Accounts complete." As another example, suppose you had just finished a study and written a paper, you might create a milestone version, with the comment "Data set corresponding to March 2005 paper."

The bottom-right part of the Manage Areas screen lists any available backup versions for the area selected in the top table and allows you to manage these backups. The panel has its own toolbar containing three options:

- **Revert:** This option lets you revert to a previously backed-up version of a data set. Use this option with great care as it will overwrite the current version of your data set.

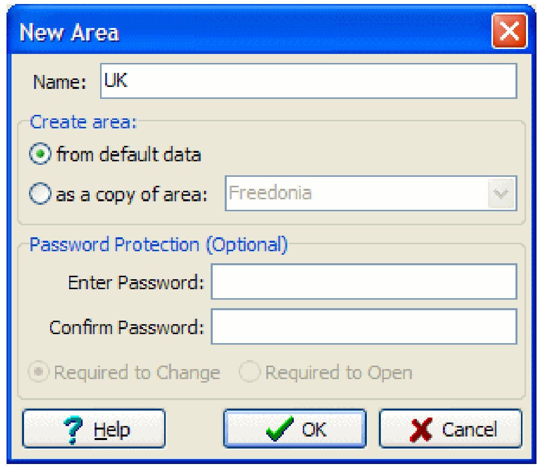
- **Comment:** allows you to add a comment to a backup. For example, you may wish to mark backups made after important events such as project milestones.

- **Delete:** deletes a backup.

- **Auto-Versioning:** Use this check box to globally enable or disable the automatic creation of versions. We strongly recommend leaving this option enabled.

8.2 New Area

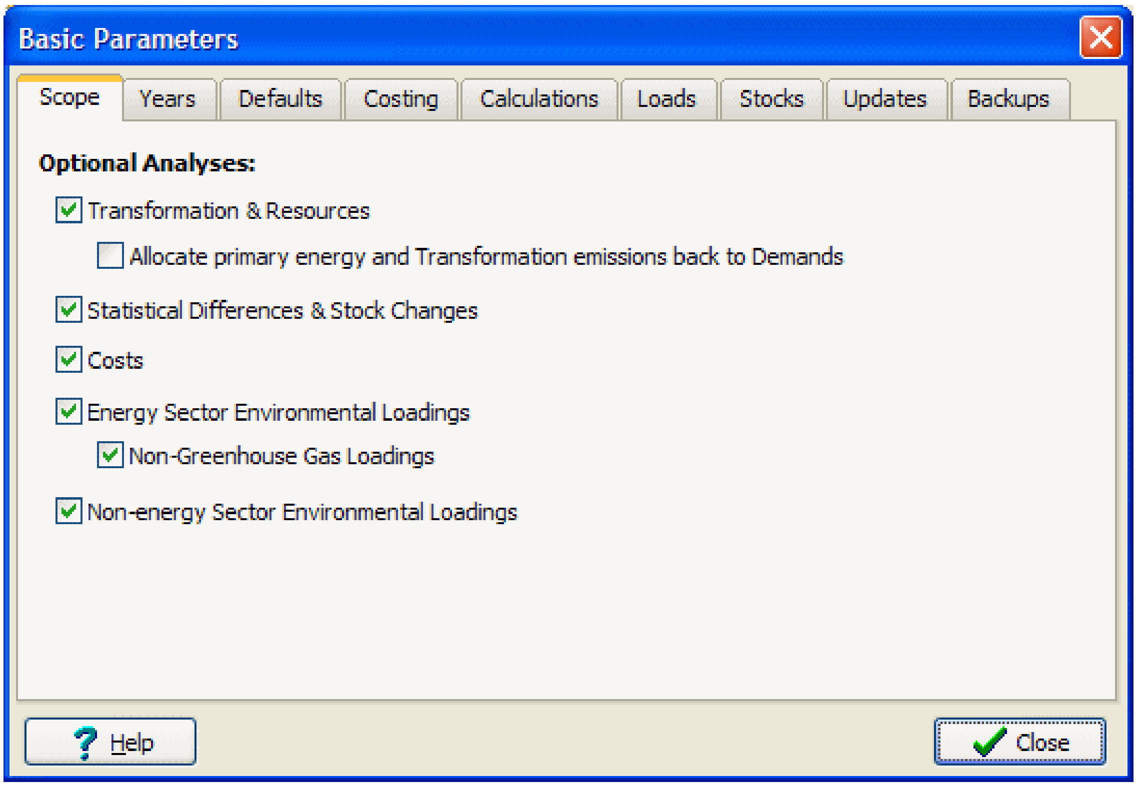
The New Area screen is the place where you create a new Area. You can create an area either from LEAP's default (blank) data set, or by copying from an existing data set.



You can also optionally specify a password to protect an area. When specifying a password, use the radio buttons to indicate whether the password is required to open the area, or whether it is required only to save changes to the area (i.e. to open the area as a read-only data set). When no password is specified, the area can be freely opened and changed.

After creating a new area you will be asked if you wish to review the Area's Basic Parameters.

8.3 Basic Parameters



The Basic Parameters screen is used to define the basic settings for your analysis. It is divided into six tabs: Scope, Years, Defaults, Costing, Calculations, Loads, Stocks, Updates and Backups.

8.3.1 Scope

Select which optional analyses to include in your analysis. At a minimum you must conduct energy demand analyses, but the following analyses are all optional: (1) Transformation and Resources, (2) base year statistical differences and stock changes, (3) costs and (4) energy sector environmental loadings, and (5) non-energy sector environmental loadings. Note that statistical differences and stock changes can only be included if you also include Transformation and Resource analyses.

Tip: you can temporarily disable parts of your analysis by unchecking one or more of these options in order to speed-up calculations. This will not delete any data, but will significantly speed-up LEAP's calculations. For example, you can disable

Transformation & Resources and Environment calculations while debugging a demand analysis.

8.3.2 Years

Use this tab to set the **Base Year and End Year** of your analysis. The **Base Year** corresponds to the *Current Accounts* data set. LEAP performs annual calculations for each year from the Base Year to the End Year. Results can be viewed for any or all of these years. You can also optionally enter up to 4 default time-series years. These years will be used by default in the Time-Series Wizard, when specifying Interpolation, Step function and other time-series expressions.

Tip: to speed-up your calculations when debugging your analyses, you can temporarily specify fewer years for your analysis by reducing the end year. This will not affect any data you have entered. See also: Tips on Speeding-Up Calculations

8.3.3 Defaults

Use this tab to set the default values for parameters such as the energy unit, real discount rate (%), monetary unit, transport unit and monetary unit base year. The monetary unit base year need not be the same as the study base year, however for simplicity, we recommend that the two be the same. When setting the default energy and monetary units in particular, note that they are defaults only. When entering data and viewing results you can easily make use of other units. Note also that you can add your own units using the Units screen.

8.3.4 Costing

Use this tab to specify the scope of the cost-benefit calculations in LEAP. NB: This tab is only visible if **Costs** are checked on the Scope tab.

Boundary for Cost-Benefit Calculations: LEAP allows you to specify a costing boundary: the Transformation module after which costs associated with energy conversion and extraction are no longer counted. Specifying a limited boundary that does not encompass all modules, can be very useful for modeling systems in which you only have data on the costs of fuels as they are consumed, and you do not have data on the costs of upstream technologies such as oil refining and coal mining. For example, you might specify the boundary as electricity production. This means: a) that LEAP will not consider capital and O&M costs for upstream activities (modules) such as oil refining or coal production; and b) that costs will be applied to the feedstock fuels delivered to electricity plants (e.g.,. diesel) rather than to the resources (e.g. crude oil) from which they are produced.

You have two basic options:

1. **Full system costing.** This approach draws the boundary around the entire Area and counts costs for all modules. Fuel costs will be counted in terms of (1) the cost of

indigenous resources extracted within the area, (2) the costs of imported fuels and (3) the revenues from exported fuels. All Demand and Transformation capital and operating and maintenance costs are considered. This approach does NOT include the costs of domestically produced secondary fuels (e.g. electricity produced in power stations or oil products produced in refineries), thus avoiding double counting any benefits that accrue from (for example), saving electricity.

A drawback of this approach is that it often difficult to effectively capture the costs of certain activities such as oil refining or coal mining. Capital and operating and maintenance costs of these activities are often difficult to obtain, and it is often difficult to determine the economic value of primary resources in the ground such as coal and natural gas. Moreover, market prices are commonly used reflect costs after resource processing and conversion, such as delivered coal or natural gas.

2. **Restricted costing boundary.** To address these issues, you can draw a more restricted benefit-cost boundary around your energy system by nominating a particular module where the costing boundary is drawn. LEAP then counts the costs of all fuels delivered to the system measured up to that point. The costs of fuels delivered to the module at the costing boundary will be used (delivered fuel costs), rather than the indigenous resource costs, In addition LEAP also counts the costs of any fuels imported into the system or any fuels exported from the system, so long as those imports or exports occur downstream of the costing boundary. Transformation capital and operating and maintenance costs are only counted for those modules within the boundary. All demand-side capital and operating and maintenance costs, and all environmental externality costs are included, just as in the complete system boundary method.

   With this method, you may find that the costs of imports and exports do not match up with the physical amounts of fuels imported and exported. For example, the reported total costs of importing a fuel may be less (e.g. $4000) than the product of the imported fuel cost (e.g. $50/ton) and overall import levels (e.g. 100 tons). This is because some imports (e.g. 20 tons) may occur outside the costing boundary.

Include Environmental Externality Costs: Check this box to select whether or not to include externality costs in your costing results. Externality costs for different pollutants are entered on the **Effects** screen.

8.3.5 Calculations

Use this tab to set various calculation settings. In most cases you will not need to change any settings on this tab.

- **Calculation Iterations:** Use these options to set the maximum number of iterations and the convergence criteria for Transformation calculations. Transformation calculations will iterate to allow for "feedback" energy flows. For more information refer to Calculation of Systems with Feedback Flows. After each iteration, residual requirements are left over (the requirements for fuels consumed in the lower modules but produced by the higher modules). To properly account for these requirements, these residual requirements are added to the original energy demands and the calculation is repeated. This repeats until the **change in all residuals** is less than the specified fraction of the **total residuals** for all fuels (by default 0.1%), or until the residuals are less than the specified absolute amount (by default 10 GJ), or until the **maximum number of iterations** is reached (in which case the calculation is deemed to have failed. Typically, setting larger convergence criteria will result in fewer calculation iterations but a less precise solution. Note that there is no guarantee that all energy systems will converge, particularly if the feedback flows are a large fraction of total energy flows.

- **Allow Lagged Results in Expressions:** You can optionally create expressions that reference lagged values created during LEAP's calculations. Any calculated results can be referenced lagged by one year. Enabling this option will cause slower calculations, so if you do not require lagged results leave this option unchecked for faster calculations.

8.3.6 Loads

Use this tab to specify whether electric (and other) load shapes are entered exogenously (at each electric sector Transformation module), or whether they are calculated endogenously by summing across the load shapes specified for individual demand device. If you want to model seasonal or time of day variations in electric power plant dispatch you will need to model load shapes endogenously. For more information, refer to the Time Slices topic.

8.3.7 Stocks

This tab is only relevant if you are conducting transport ( ) or stock turnover ( ) analyses. It contains two check boxes as follows:

- **Top-down Sales and Stock Data:** Stock and sales data can entered in one of two ways:
  - **Bottom-Up:** in which you enter data for each individual technology. With this approach, you will only be able to see total stocks and sales for higher level aggregation categories in the Results View.
  - **Top-Down:** in which you enter total sales and stocks at the top level branches and then enter shares of stocks and sales in lower level branches. This approach is generally preferable because it allows you to examine the trends in total sales separately from the trends in shares of different technologies. For example, you may have one set of assumptions for the

growth in total sales of vehicles, and have several alternate scenarios for the penetration of different types of vehicle technologies.

- **Save Vintage data:** check this box if you wish to see stock results disaggregated by the vintage of devices. For example, you may wish to know how the total stock of vehicles in some future year is divided among vehicles originally sold in earlier years. Checking this box provide extra information in the Results view, but will also slow down calculations and reporting.

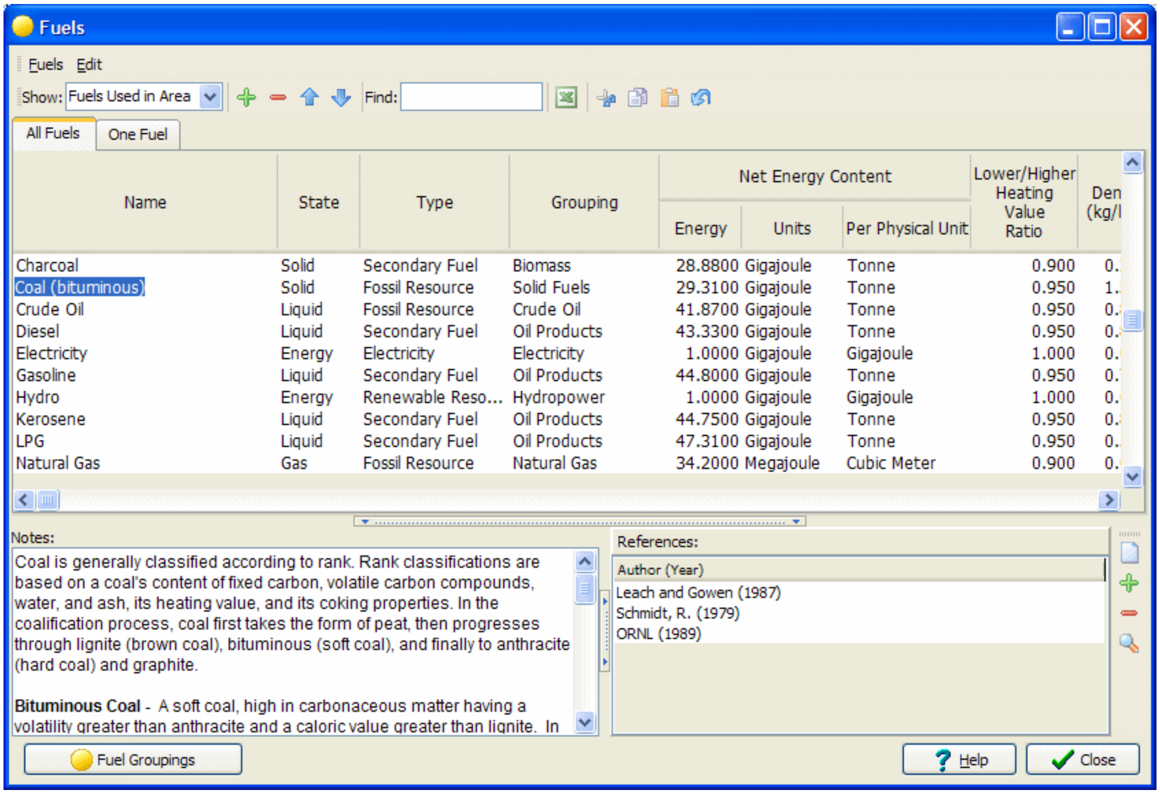
8.3.8 Updates

Use this tab to configure your Internet connection settings. These settings are primarily used by LEAP when it attempts to check for and download updates over the Internet (the Help: Check on Internet for Updates option). There are two main options:

- **Passive FTP:** You can use either passive or standard FTP. In most cases the default setting (passive FTP) is recommended.

- **Proxy Settings:** All other settings are used to set-up a connection to a proxy server. By default this is disabled. Typically, this is only needed by users who access the Internet via a local area network (e.g. in a university or some other large organization). Contact your network administrator to obtain the settings for your network. NB: this feature is experimental. Please contact SEI-Boston if you have problems with it.

8.4 Fuels



The fuels screen is the place where you can view or edit the list of fuels used in your LEAP analysis. The screen displays a wide range of data about the energy content, density, carbon content, and chemical composition of each fuel and also includes detailed definitional notes and references for the included data (in the bottom two panes of the screen).

The default data provided with LEAP includes a standard fuels database based on IEA, UN and other standard international sources of data. This data should suffice for most LEAP analyses. However, you may wish to edit the data, for example to change the energy contents of certain fuels (especially coal and wood) to reflect the conditions in the Area you are studying. You may also wish to change the names of fuels to reflect the language in which your analysis will be conducted.

Some of the data fields in the fuels screen are worth describing in more detail:

- **State:** the chemical state of the fuel (solid, liquid, gas or energy). This field can only be edited when adding a new fuel.

- **Fuel Type:** Each fuel is classified into one of five types: fossil resource, renewable resource, biomass resource, secondary fuel, and electricity (a special type of secondary fuel). LEAP uses these classifications to determine how each fuel should be handled in your analysis.

- **Fuel Category:** When producing energy balances and other reports, it is sometimes useful to be able to show results aggregated across certain types of fuels (for example, showing all oil products rather than each individual product). To allow for this, LEAP allows you to assign a **fuel category** to each fuel. You can change the chosen category by editing the data in the Fuels screen. To change the list of Fuel Categories, go to the Fuel Categories screen (Main Menu: General: Fuel Categories)

- **Net Energy Content:** Energy contents are always net (lower heating values) in LEAP. The default energy contents are typical values and conform to official IEA figures wherever possible. Energy content values are entered in a chosen energy unit per physical unit of the fuel. Pure energy forms (electricity and heat) should always have an energy content of 1 GJ/GJ by definition. When entering energy contents for coal (which varies widely from country to country), refer to the notes for each fuel for guidance on average values for selected countries.

- **Chemical Composition Columns (Density, %Carbon, %Sulfur, %Nitrogen, etc.):** Environmental emissions associated with energy production and consumption often depend on the physical and chemical composition of the fuel involved. In TED, you can optionally choose to enter emissions coefficients dependent on fuel compositions. This can be useful, for example, when you are entering data describing CO_2 emissions from coal fired electricity generating plants. For this type of data the actual emissions will not simply depend on the quantity of coal consumed by the plant, but will also depend on the carbon content of the coal. By editing the fuel compositions shown here to more accurately reflect the compositions of the fuels used in the area you are studying, you can more accurately calculate the total emissions loadings of your scenarios, often without the need to create new entries in TED).

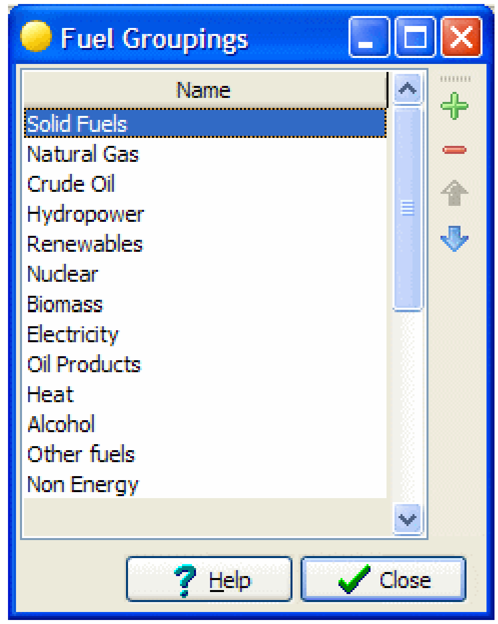
- **Carbon Stored When Fuel Consumed for Non Energy Purposes (%):** Indicates the fraction of the carbon in the fuel (by weight) that remains permanently stored when the fuel is used for non-energy purposes. This variable is used in conjunction with the non-energy fraction variable in an energy demand analysis.

By default, the fuels screen is filtered to display only those fuels currently being used in your area. To see the full list of fuels, choose **Show: All Fuels.** Use the **Find** box to quickly locate a fuel by name. You can also sort the display of fuels by name, state, type and category by clicking on the appropriate column title.

Use the Add (+) button to add a new fuel and the Delete button (−) to delete a fuel. Note however, that you cannot delete any fuels already in use in your analysis or in use in the TED database. It is recommended that you do not delete fuels in the Fuels database. Click the button to export the fuels database to Microsoft Excel.

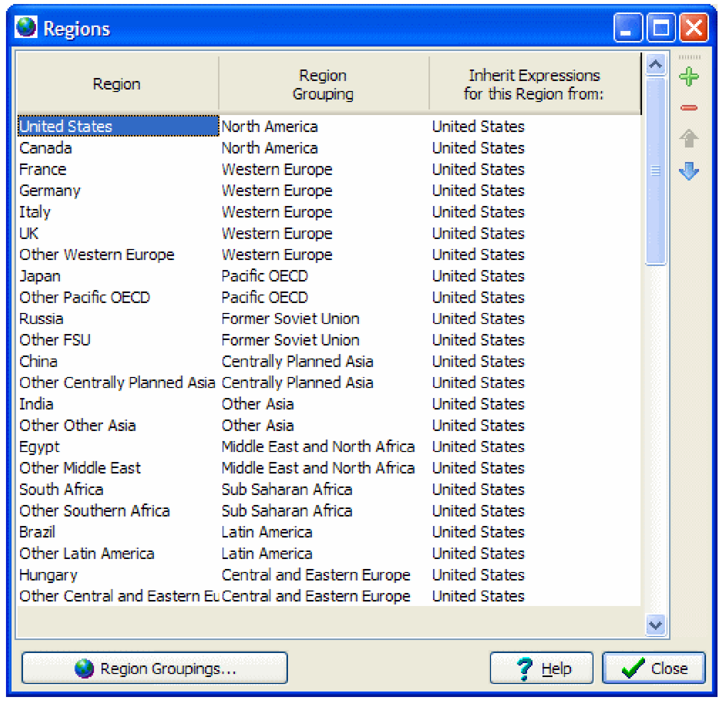
8.5 Fuel Groupings

When producing energy balances and other reports, it is sometimes useful to be able to show results aggregated across certain types of fuels (for example, showing all oil products rather than each individual product). To allow for this, LEAP allows you to assign a grouping to each fuel.



Use the **Add** () button to add a new grouping and the **Delete** button () to delete a grouping. Note that you will not be allowed to delete any groupings currently assigned to a fuel in your area. You may also wish to reorder the list using the **Up** () and Down () buttons, in order to reflect the order that these groups appear in your country's energy balance.

8.6 Regions



LEAP allows you to specify multiple regions within an area. So for example, if you are doing a regional analysis then each region might be one country, or if you are doing a country-level analysis then each region might be a different state or province.

Each region is a separate data dimension, so you can specify different data for each region and view results either for one region or summed across regions. The Region Groupings screen lets you specify groups of regions for reporting purposes. So for example, if you create a global analysis, you could specify each region as a country and then specify regional groupings for Europe, North America, Africa, Latin America, Asia, etc.

In addition to allowing you to enter different data for each region, the regions feature also allows regions to inherit expressions from one region to another for a given branch/variable/scenario expression. So for example, you might specify that region "South" inherits expressions from region "North". In this case you only need to enter data for region South where it differs from region North. This can greatly simplify data entry and model management.

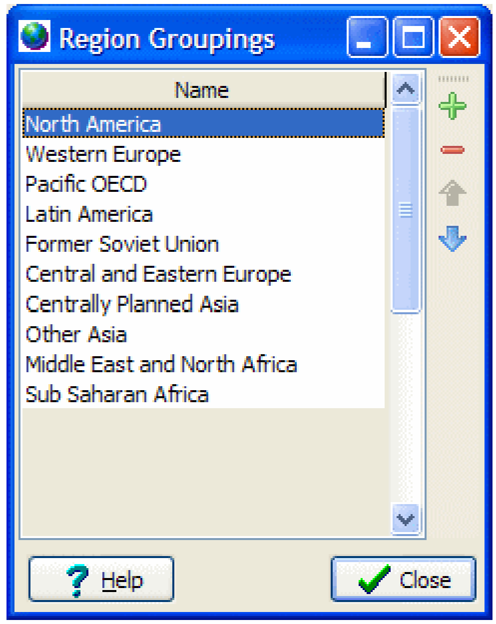
Both the region and region grouping features are optional. If your data set contains only one region (which is true of any data set created in older versions of LEAP), then regional dimensions will not appear in the results or energy balance reporting views.

Use the regions screen to view and edit the list of regions in your area, to specify how expressions in one region are inherited by the same branch/variable/scenario combination in another region, and to specify the regional groupings associated with each region.

Click the button to add a new region. Click the button to delete a region. Bear in mind that this will erase all of the data associated with a region. Click the and buttons to change the display ordering of regions. To rename a region, simply edit its name.

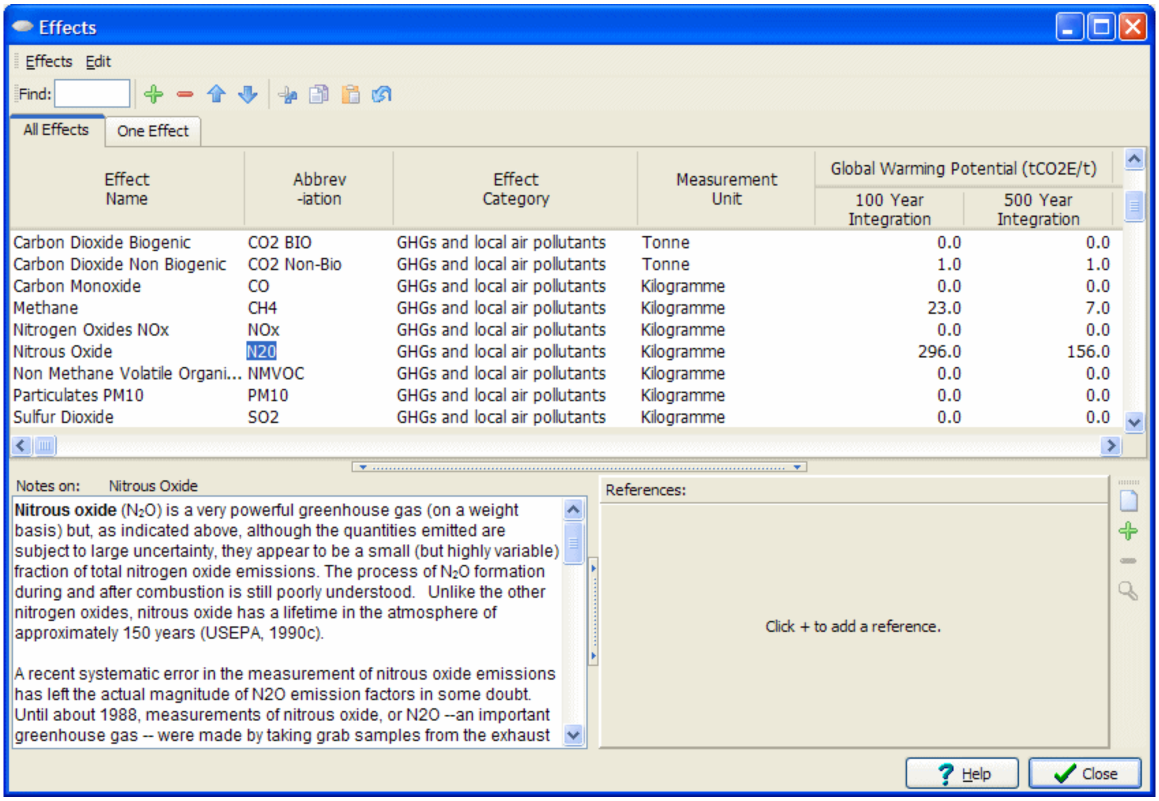
8.7 Region Groupings

The Region Groupings screen lets you specify groups of regions for reporting purposes. So for example, if you create a global analysis, you could specify each region as a country and then specify regional groupings for Europe, North America, Africa, Latin America, Asia, etc.



Results can be displayed grouped by region or by region grouping.

8.8 Effects



The effects screen is the place where you view or edit data on different environmental effects (i.e. pollutants and other direct environmental impacts). LEAP includes a default set of data on over 40 different effects, including documentation on the nature of each effect, information based on *A Guide to Environmental Analysis for Energy Planners* (Lazarus et. al., 1997).

While the effects database will suffice for most analytical requirements, you may wish to edit it to add your own pollutants, to change the name of existing pollutants, to edit the factors used for the global warming potential of greenhouse gas pollutants, or to specify externality costs for certain pollutants (for inclusion in your cost-benefit calculations).

Use the Add ( ) button to add a new effect and the Delete button ( ) to delete an effect. Note that, when adding an effect you will be shown a view with one effect at a time rather than the default view showing all effects on a single table. You can also switch between these two views by clicking on the one effect/all effects tabs at the top of the Effects screen.

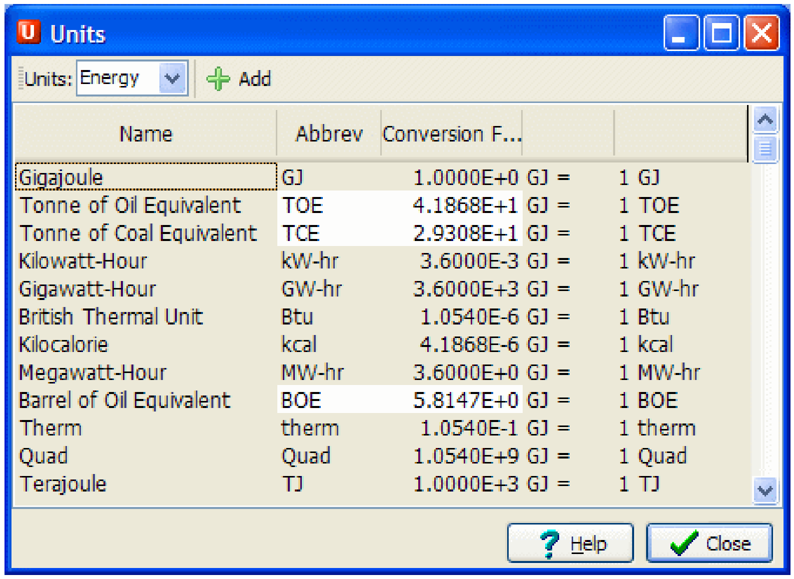
- **Global Warming Potential:** By default, LEAP uses the most up-to-date global warming potential (GWP) factors recommended by the IPCC (Intergovernmental Panel on Climate Change, 2001). GWP factors are specified for both a 100 year and a 500 year time horizon, and you can switch between these two sets of GWPs in the Results view. Based on the time horizon you select, LEAP uses different sets of global warming potentials for the non-CO2 gases that reflect the relative potential of the gas over each period. For example, methane has a 100 year GWP of 23, but a 500 year GWP of only 7. Since GWPs are always expressed relative to carbon dioxide, the GWP of Carbon Dioxide is set to 1.0 for both the 100 year and 500 year time horizons. LEAP contains data on the GWPs for carbon dioxide, methane, nitrous oxide and the most common non-energy sector gases with high GWPs (SF6, CFCs, HCFCs and HFCs).

- **Externality Costs:** You can enter externality costs for each effect representing abatement, damage, or other cost estimation methods. These costs can then be included in LEAP's cost-benefit calculations. To include these costs in your cost-benefit calculations make sure you enter a checkmark on the "**Include Environmental Externality Costs"** question, on the Costing tab of the Basic Parameters screen (Main Menu: General: Basic Parameters).

  It is important to recognize that there is no single correct effect externality costs. Not only will the cost be site specific (i.e. the same level of pollutants will have different impact costs depending on where they are released), but also any cost will be dependent on how it is defined (e.g. as an abatement or damage cost). It is important to recognize that any values are subjective (e.g. the costs placed on an injury). Nevertheless, this feature allows you to see the impacts on conventional benefit-cost analysis of judgments, which often are left implicit in energy planning exercises.

NB: In LEAP, you cannot examine indirect impacts from pollution emissions since LEAP does not include tools for analyzing issues such as pollution transport, exposure and dose/response effects, you can only examine emissions and other direct impacts. If you want to examine these types of issues additional tools will be required.

8.9 Units



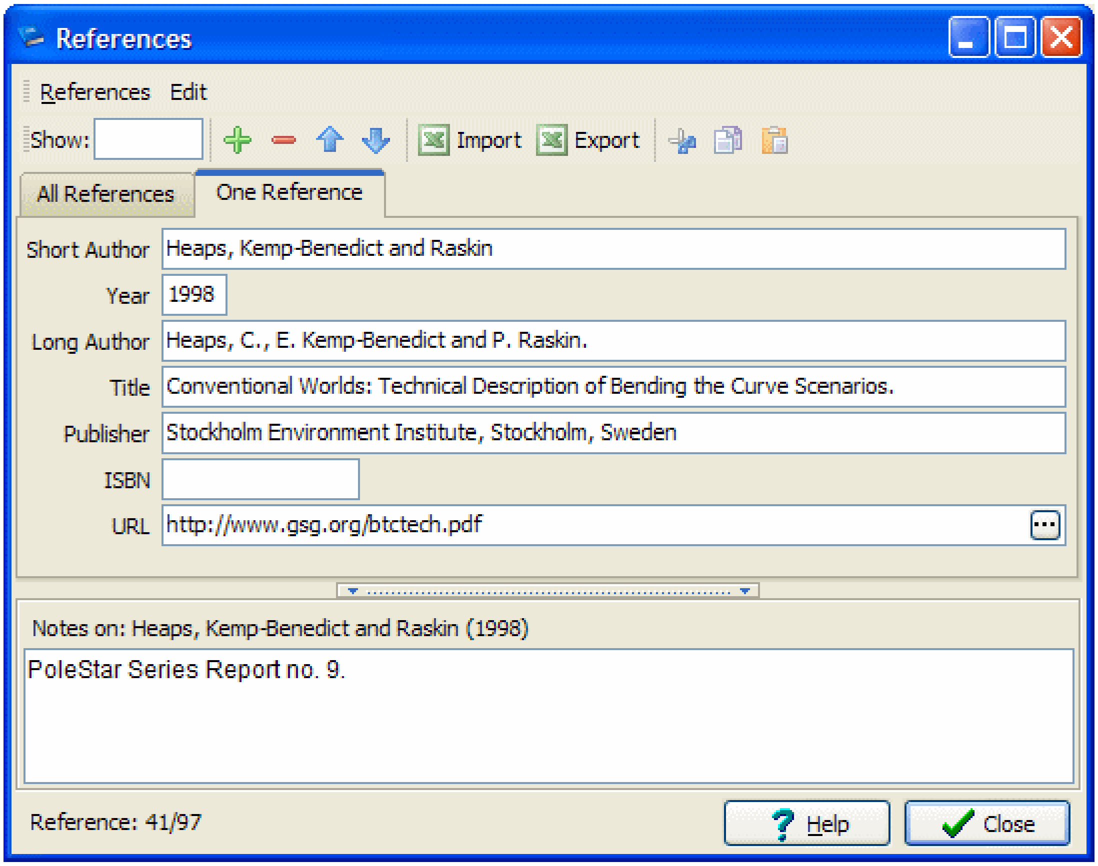
This option provides access to the Units database. LEAP includes a wide range of units for most classes of data, including data denominated by energy, power, mass, volume, length and currency units. The default units database provided with LEAP should suffice for most analyses.

In rare circumstances you may wish to edit some of the unit conversion definitions in LEAP, or add your own units. Most commonly you may wish to add to or update the currency units stored in LEAP, or add additional units to the "Other Units" list for use with the Activity Levels in your Demand analysis.

Click on the **Units Class** selection box to display different classes of units (mass, volume, energy, power, area, length, currency, and "other"). Use the **Add** (➕) button to add a new unit and the **Delete** button (➖) to delete a unit. To avoid errors, the most common units cannot be changed.

Note that the last class of units called "Other Units" do not have conversion factors associated with them, since they are never converted to other units of a similar class. These units are only used in Demand Activity Level screens.

8.10 References

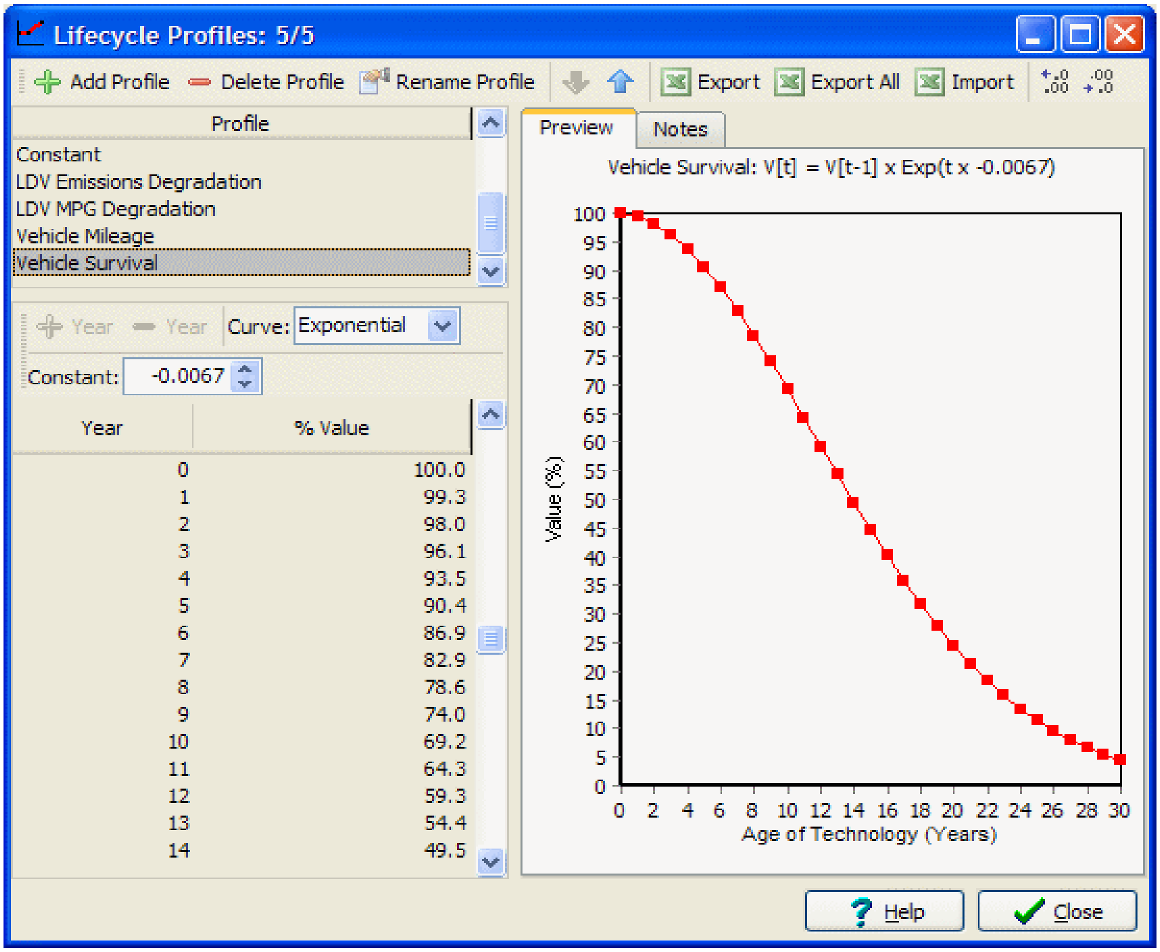


The references screen is a bibliographic reference database for storing your references. It can be linked to the notes you create in the Analysis View, to the Technology data you create in TED as well as to the list of Fuels, and Effects.

The References database includes all of the normal fields of a standard bibliographic database (Author, Title, Date, ISBN, Publisher) as well as a URL for locating the actual report on the Internet (if appropriate). When viewing URLs, click the "**...**" button to automatically open your Internet browser and view the relevant web site. The notes field can be used to describe additional information about the reference.

Use the Add () button to add a new Reference and the Delete button () to delete a Reference. Note that, when adding a Reference you will be shown a view with one Reference shown at a time rather than the default view showing all References on a single table. You can also switch between these two views by clicking on the one/all tabs at the top of the screen. Click the buttons to import or export the References database to and from Microsoft Excel.

8.11 Lifecycle Profiles



Lifecycle Profiles are used as a centralized way of describing technological behavior profiles and age distributions for stocks of devices across different yearly vintages. For example, one lifecycle profile might be used to describe how the fuel economy of a given type of vehicle worsens as the vehicle ages, another might be used to describe how the emissions of pollutants per unit of energy consumed or per unit of distance traveled increase as vehicles age.

Lifecycle profiles fall into two categories:

- **Aging Profiles** describe how a variable changes over time as devices age. These profiles are used in conjunction with a LEAP expression that describes how the characteristics for a new device (fuel economy, emission factors, vehicle mileage, etc.) change over time in any given scenario. The profile is used to describe how a characteristic behaves as a given vintage of devices age. These types of profiles are defined as a percentage value relative to the value of the variable for a brand new device. Thus, the first year value for this type of profile is always 100%.

- **Distribution Profiles** describe the distribution of vintages within a given overall stock of devices. They are only used when specifying stocks of devices in Current Accounts.

Use the **General: Lifecycle Profiles** menu option to view and edit a library of different lifecycle profiles for your Area. The screen is structured as two panes. On the left you see a list of profile names and the annual values associated with one selected profile. On the right you see a screen which previews those values. The right-hand-side of the screen can also be used to enter notes documenting the data and assumptions used to create the profile. Click on the Notes tab to enter or view notes for the profile

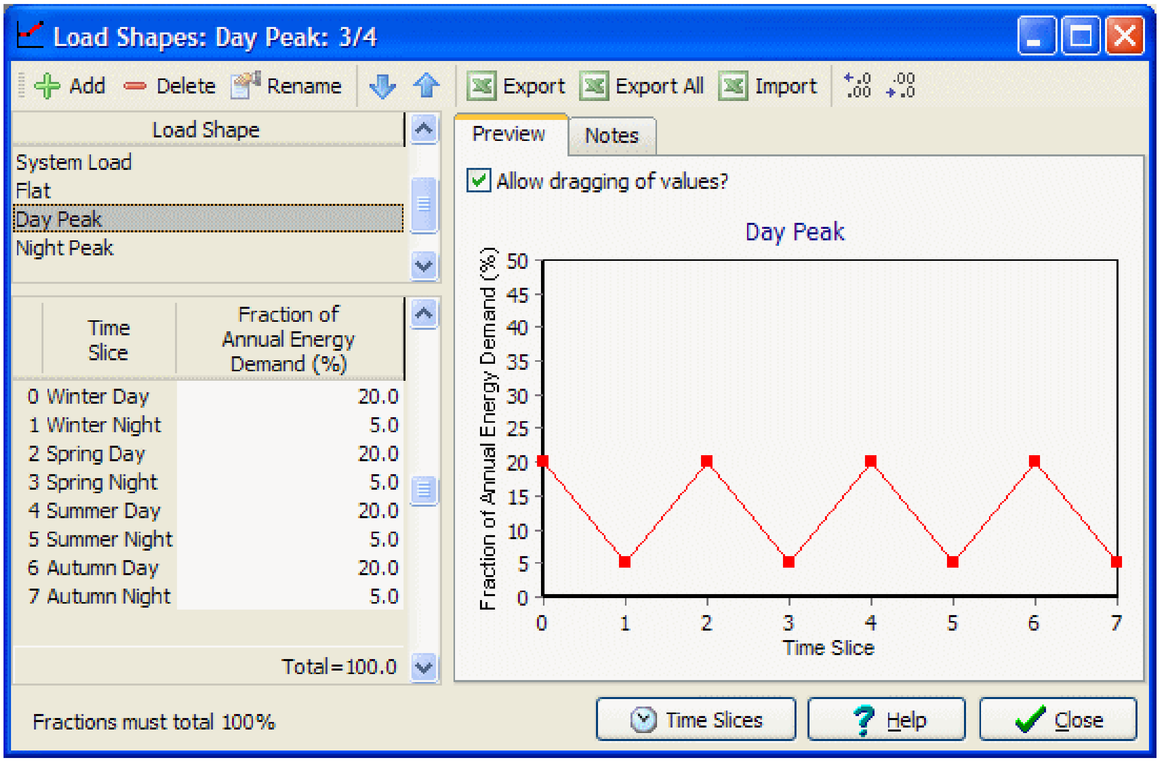
You can create any number of profiles. Click the and buttons to add or deleted profiles, and the button to rename a profile. Click the Excel buttons () to buttons to export one or all profiles or import a profile from an Excel spreadsheet. When importing a profile from Excel first mark and name a range of cells in Excel. The range must be either a single column or a single row or cells. LEAP assumes the range represents a contiguous set of values from year zero onwards.

The values for any given profile can be edited in one of two ways. Click on the **Curve** selection box, then choose whether you wish to enter **Data Points** via the keyboard, or specify an **Exponential** curve. In the former case you will be able to enter data in the table on the left of the screen, while in the latter case you will be able to specify the value of the **Constant** exponent of the curve. The curve itself will then be calculated according to the formula:

*V[t] = V[t-1] x Exp(t * Constant)*

Use the and buttons to change the number of decimal places displayed in the table, and when specifying data points you can use the and buttons to add or delete values.

8.12 Load Shapes

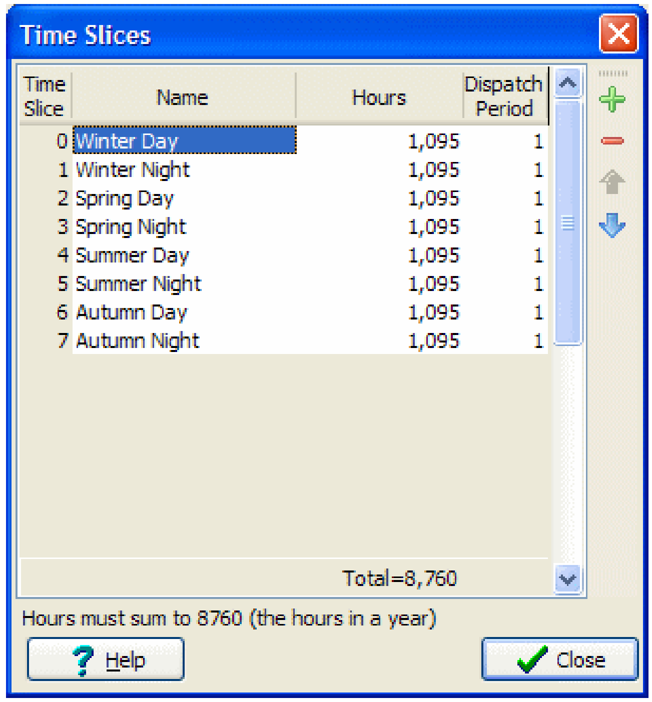


The load shapes screen is used to view and edit a library of different load shapes that can be used to specify how annual electric and other demands vary by season and time of day for different demand devices. You can create any number of load shapes. The load shapes screen is only enabled if you have set your area to use endogenous load shapes. This is done on the loads tab of the General: Basic Parameters screen. For more information on setting-up an area to use endogenous load shapes, please see the Time Slices help topic.

Each load shape is specified by entering the percentage fraction of annual energy demand that occurs in each slice of the year. Use the General: Time Slices screen to specify how a year is subdivided into different time slices. These fractions must sum to 100% for each load shape. You can specify any number of different load shapes. Later you will assign these to different demand devices from the Final energy intensity tab, shown for Demand branches in the Analysis View.

Click the add button ( ) to add a new load shape. Click the delete button ( ) to delete a load shape. Click the rename button ( ) to delete a load shape. Click on the up ( ) and down ( ) buttons to reorder load shapes. Click on the Excel buttons ( ) to export one or all load shapes to an Excel worksheet. Click the and buttons to increase or decrease the number of decimal places shown in the data entry table.. Click the Time slices button ( ) to view or edit the Time Slices data.

8.13 Time Slices



Time slices are the seasonal and time of day divisions into which annual electric and other loads can be divided. For example, electric device loads might be divided both by season (summer, winter, spring and autumn) and by time of day (week day, week night weekend day, weekend night). LEAP only makes use of these time slices if you choose to model load shapes endogenously.

By default, load shapes are specified exogenously for the overall system load curve as a sorted load curve from zero to 8760 hours (the number of hours in a year). This approach does not allow for explicit modeling of seasonal or time of day variation in the load or in how electric power plants are dispatched. If you want to model seasonal or time of day variations in electric power plant dispatch you will need to model the load shape endogenously by specifying the load profile for each electric sector device.

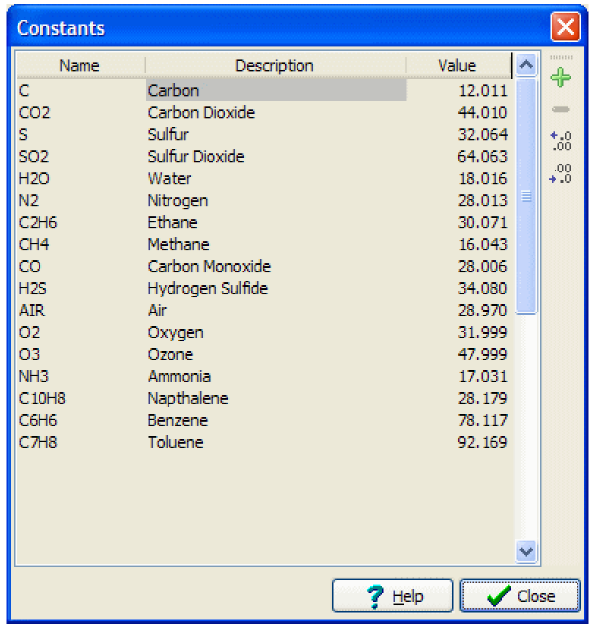
To set up endogenous modelling of electric sector load shapes you need to do the following:

1. On the **General: Basic Parameters** screen (), click the "loads" tab and select the **Endogenous** radio button. *NB: the time slices screen is only enabled if Endogenous loads are selected.*
2. On the **General: Time slices** screen (), review the list of time slices for your area. By default the time slices reflect both a seasonal and time of day division of the hours in a year. You can edit these time slices to better reflect the conditions in your area of study. For each time slice you must specify the number of hours it takes per year. The sum of hours across all time slices must equal 8760: the number of hours in a year. If you believe that your electric power plants have different availability factors or are dispatched differently in different seasons of the year then you will also need to assign different **dispatch periods** to each time slice. By default, LEAP uses a single dispatch period, but you can specify up to four. Later, in the Transformation modules where you simulate electric sector power plant dispatch, you will be asked to specify merit orders and maximum capacity factors (availability) for your processes for each dispatch period.

3. On the **General: Load Shapes** screen (📈) you can enter or edit different load shape profiles that reflect the shape of different types of loads in your system. For example, some devices may operate primarily in the summer (e.g. air conditioning) while others operate predominantly in the winter. You can specify load shapes for individual devices or enter average shapes that apply across a whole sector: bear in mind though that these average load shapes are likely to change in the future depending on how a sector evolves.
4. In the technology branches of the demand tree (⚙) select a load shape for each demand device. This must be specified on the **Final Energy Intensity** tab and can only be set when editing Current Accounts. Note that demand devices must have the same load shape in all scenarios.
5. Later, in the Transformation modules where electric sector power plants are specified, you will be asked to specify rules for the dispatch of the listed power plants.

Click on the up (⬆) and down (⬇) buttons to reorder time slices. Click on the add button (➕) to add a new time slice. Click on the delete button (➖) to delete the time slice. There is no particular limit to the number of time slices you can specify.

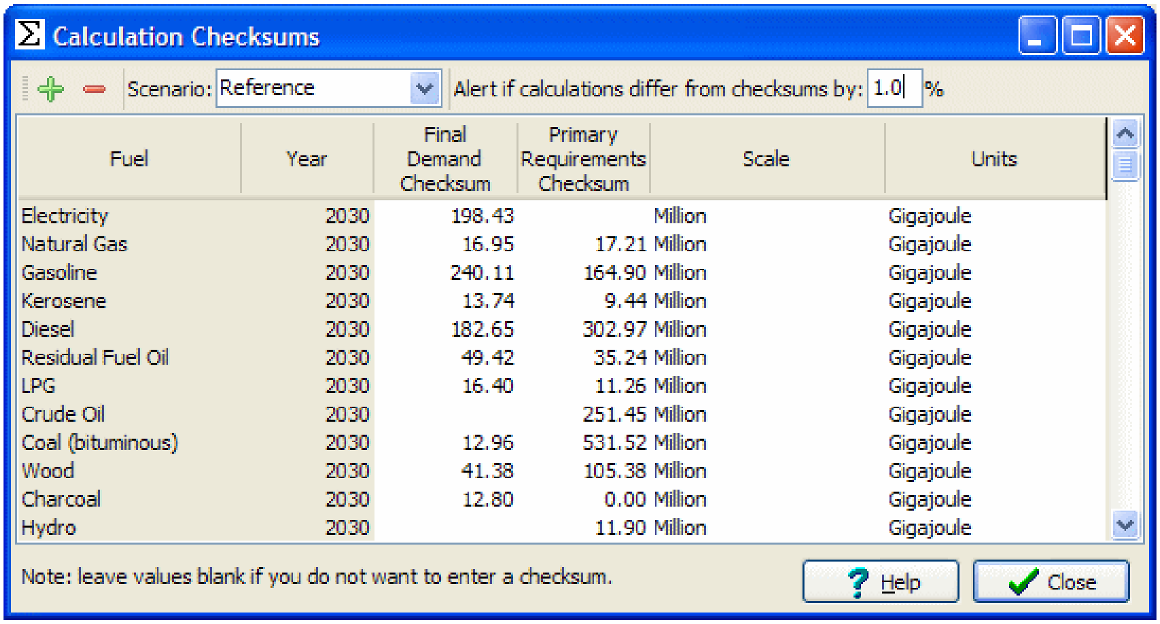
8.14 Constants



In addition to referencing variables (values that can change over time and between scenarios), your expressions can also reference the values of *constants* (including your own user-defined constants). A default set of constants are included that define various molecular weight constants. These are particularly useful in defining emission factors.

Use the Constants screen to view and edit the names and values of constants. Use the ✚ and ━ buttons to add and deleted constants, and use the ⁺.₀₀ and ⁺.₀ buttons to change the number of decimal places displayed on screen. Note that the basic molecular weight constants are locked and cannot be deleted.

8.15 Calculation Checksums

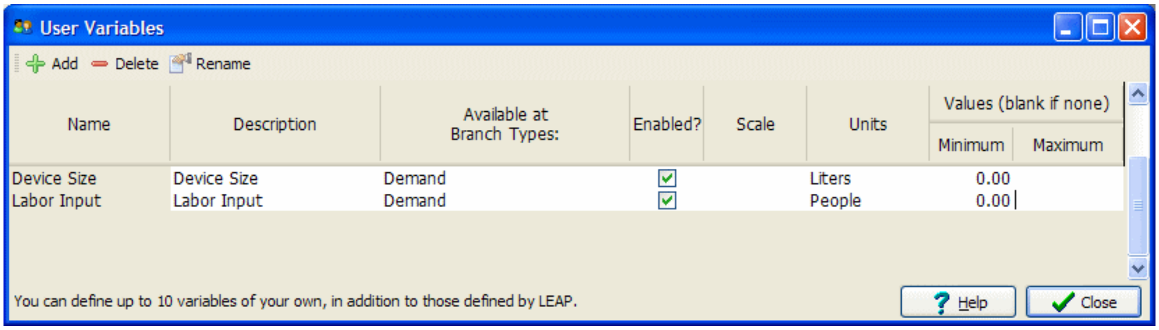


Checksums can be an important tool for debugging your analyses. You can optionally define checksums for two categories of results: the total final demand and/or the total primary requirements of fuels in a particular year and scenario. During LEAP calculations, these checksums will be compared to the calculated demand or primary requirements, and where the discrepancy is greater than the allowed percentage, a diagnostic message will be shown. Diagnostic messages are displayed as an additional tab on the Results View (alongside the Chart and Table tabs). When no diagnostic messages exist, the Diagnostics tab is not visible. For more information, see Diagnostics.

There are two basic methods for entering checksums. Either you can add them manually on this screen, or you automatically save a complete set of checksums from within the Results View (select menu option **Area: Create Checksums**). We suggest that once you have a fully completed scenario, you create a set of checksums for it using this option. In this way, any subsequent accidental changes to the scenario can be immediately identified, whenever results are recalculated.

When entering checksums manually, use the scenario selection box to first pick a scenario, then use the **Add** (+) button to add a new checksum the **Delete** button (−) to delete a checksum. When adding a checksum you will be asked to select the fuel and year for which you wish to enter the data. If you wish to specify the checksum for only one of the two categories, simply leave the other one blank.

8.16 User Variables



In addition to the many variables defined by LEAP, you can also create up to 10 of your own *User Variables*. Once defined on this screen the variable will be added as a tab in the data entry screens of the Analysis View. You can specify data for each variable in Current Accounts and any scenario. User Variables are currently only available for use in the intermediate calculations of the Analysis View. They cannot be reported in the Result Views, Energy Balance, Outlooks or Summary View. However, you may refer to these variables just as you would any other variables in the Analysis View, and the values of the variables can be specified using all of the same expressions available to other LEAP variables.

Each user-defined variable has the following information associated with it:

- **Name:** the label that appears on the Analysis View tab associated with the variable.

- **Description:** a longer description of the variable that will be displayed in a panel whenever the variable is being edited.

- **Available at Branch Types:** Set the types of tree branches at which each variable is available: Demand, Transformation, Environment, Resources, Statistical Differences, and Stock Changes. You can also select All Branches if you wish the variable to be available for all branches in the tree.

- **Enabled:** Use this checkbox to temporarily disable a variable. If disabled, the variable (tab) will not appear in the Analysis view.

- **Scale/Units:** The scaling factor and units in which the variable is measured. Note that these data are for information only. Expressions that relate the value of one variable to another do not make use of scaling factors, nor do they attempt to convert units.

- **Minimum/Maximum Values:** Use these columns to set minimum and maximum values for variables. When editing data, expressions will be tested to ensure they remain within any specified minimum and maximum constraints. Leave these fields blank if you do not want to specify minimum or maximum values for a variable.

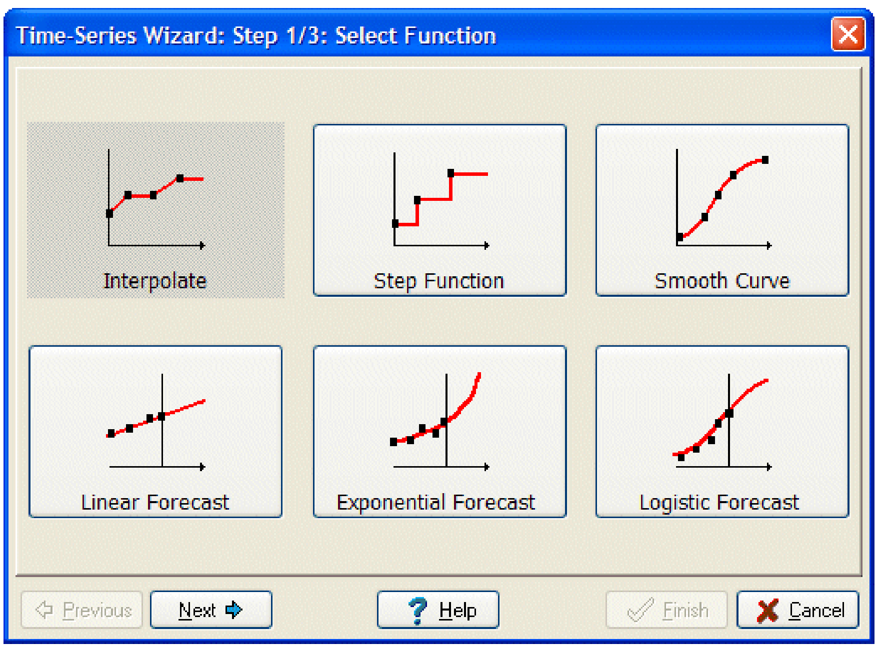
Note: in addition to defining your own *User Variables* you can also create variables under the Key Variables category on the tree.

8.17 Time-Series Wizard

The Time-Series Wizard is a tool that helps you construct the various time-series expressions supported by LEAP's Analysis View. These expressions include functions for interpolation, step functions, smooth curves and linear, exponential and logistic projections. The wizard is divided into three pages, which you step through using the **Next** () and **Previous** () buttons.

Page 1: Function

Use this page to select the type of function you want to create. The functions are summarized in graph form on screen as shown below, and are grouped into two main types.



The functions on the top row allow you to specify data points for various future years, and the function then calculates the values for intervening years:

- The **interpolation** function calculates values based on a linear (straight line) interpolation between the values you specify.
- The **step** function assumes that values change discretely at the specified data years. In other words, values stay constant after a specified data year, until the next specified data year.

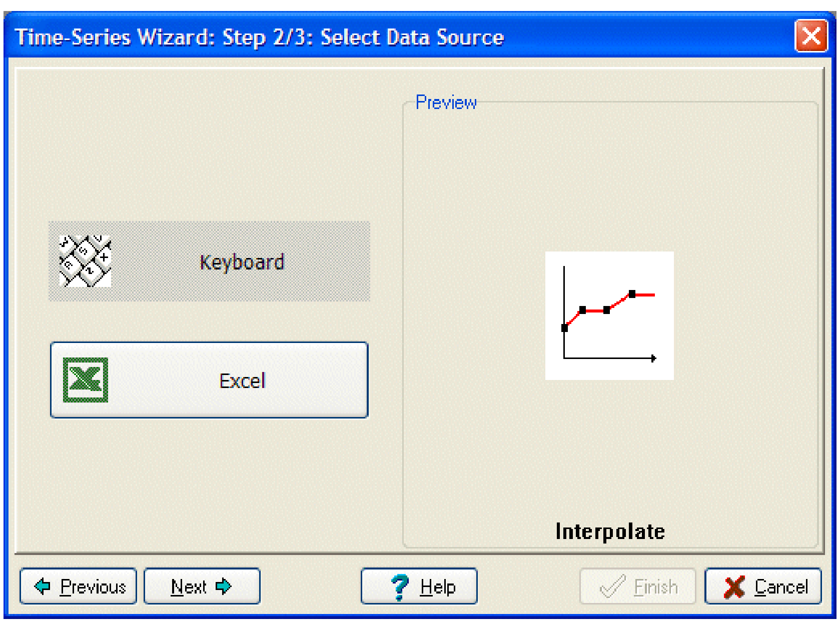
- The **smooth curve** function calculates a best-fit smooth curve based on a polynomial least-squares fit of the specified data points. To achieve a good fit, the smooth curve function requires at least 3 data points.

The interpolation and smooth curve functions are most useful when you expect data to change gradually (for example when modeling the gradual penetration of some common device such as refrigerators or vehicles). The step function is most useful for specifying "lumpy" changes to the energy system, such as the addition of specific power plants to an electric generation system.

The functions on the bottom row, allow you to specify historic data values (i.e. values before the base year). The different functions are then used to extrapolate data forward to calculate future values. Extrapolations are based on linear, exponential or logistic least-squares curve fits. Use these functions with care. The onus is on you to ensure that the projections are reasonable, both in terms of how a) well the estimated curve fits the historical data, and b) how policies and other structural factors may change in the future. In other words, be sure to consider how well you can identify past trends, but also if it is reasonable to expect these past trends to continue into the future. LEAP helps you with task a) by providing various statistics describing the curve-fit: the R^2 value, the standard error, and the number of observations. If you need to do a more detailed analysis, we suggest you use the data analysis features built-in to Microsoft Excel, and then link your results to your LEAP analysis (see below).

Page 2: Data Source

On page 2 shown below, you select the source of the data for the expression. Select whether you want to enter the data directly (i.e. type it in) or whether you want to link to the values in an external Excel spreadsheet.

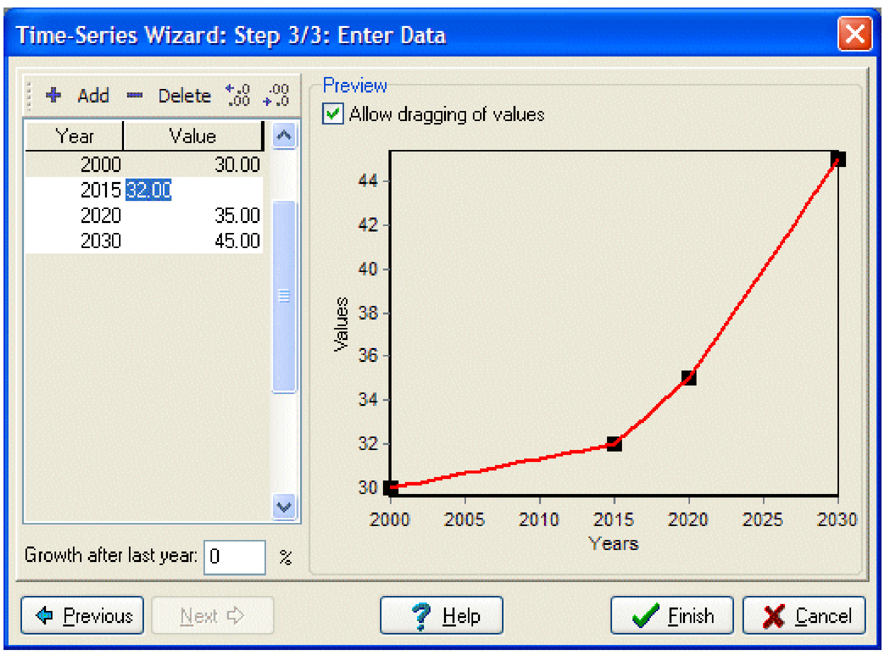


Page 3: Enter Data

Depending on you choice on page 2, in page 3 you either enter the data used by the function (as shown below) or select an Excel spreadsheet and range from which to extract the data for the selected time-series function.

- When entering data directly, use the **Add** ( ) and **Delete** ( ) buttons to add or delete new year/value pairs, or click and drag data points on the adjoining graph to edit values graphically. For the Interpolation function, an additional data field is shown allowing you to specify a percentage growth rate, which is applied after the last specified data year. By default this value is zero. In other words, by default values are not extrapolated past the last interpolation data year. The data you entered will be shown as the points on the adjoining chart, while the line drawn on the chart will reflect the projection method you chose on page one.

- In Current Accounts, when creating a linear or exponential regression, an additional check box will be displayed giving you the option of forcing the regression curve through the base year value.



When linking to a Microsoft Excel sheet, a slightly different screen will be displayed (shown below). On this screen, first enter the name of the worksheet file (.XLS) or use "**...**" button to browse your PC and local network for the file. Next enter the range name from which the data will be extracted, or click the button attached to the field to select from the named ranges in the worksheet. Ranges can be specified either as names, or as Excel range formulae (e.g. Sheet1!A1:B16).

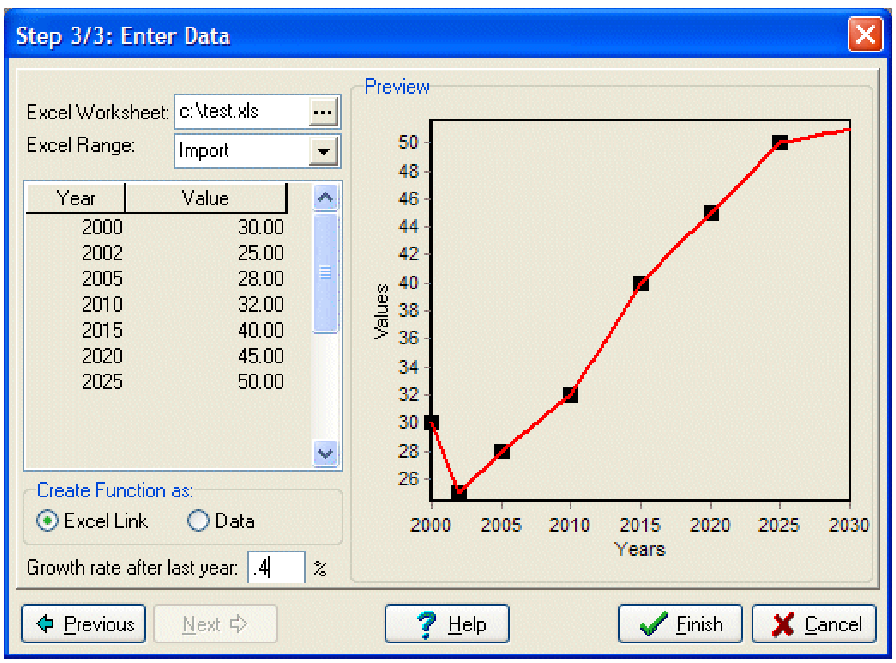
NB: Excel ranges must be structured in one of two ways:

- As 2 columns of data, in which the first column is years and the second is values, or as 2 rows of data in which the first row is years and the second is values.

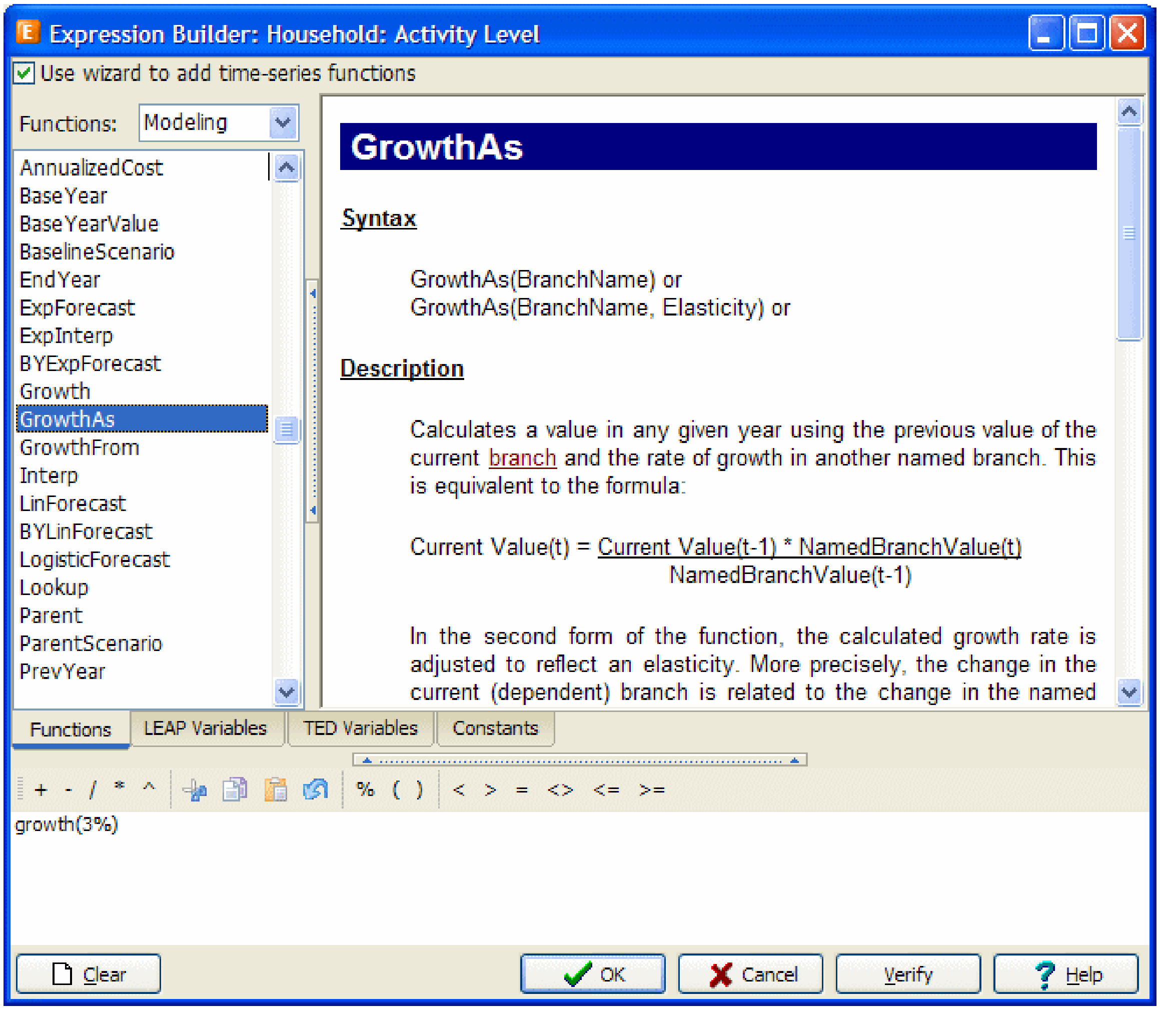
- In either case, the data must be organized in chronological order (from left to right or from top to bottom).

  Click on the **Get Excel Data** button to extract the data from Excel and preview the values in the adjoining graph. Notice that the points on the chart will be the values in the Excel spreadsheet, while the line drawn on the chart will reflect the projection method you chose on page one. We suggest that you store any subsidiary Excel worksheets in the same folder as your LEAP area data (i.e. a subfolder of the LEAP program folder). By using this approach, your Excel worksheets will be copied, backed-up and restored along with the other area data.

  Use the **Create Function As** radio buttons to choose how the data should be inserted into the expression you are editing: either as a live Excel **link**, which will be updated whenever the spreadsheet is edited and saved, or as **data**, which is initially copied from Excel, but will not subsequently be updated if the Excel spreadsheet is changed. Creating links to Excel spreadsheets is a good approach if you wish to do most of your editing work in Excel, or if you wish to conduct additional modeling outside of LEAP. However, it will also slow down LEAP calculations.



8.18 Expression Builder



The **Expression Builder** helps you construct expressions by dragging and dropping functions and LEAP and TED Branches/Variables into an editing box. You can access the Expression builder by clicking the button (E) attached to any expression in Analysis View, or by right-clicking on an expression and selecting Expression Builder.

The screen of the Expression Builder is divided into two resizable panes. At the top are a set of tabs that are used to access the names of the mathematical, logical and modeling functions built-in to LEAP, as well as to access the tree branches in both LEAP and TED. At the bottom of the screen is an editing box, into which you can directly type to edit an expression, or into which you can add an item from the top pane, either by dragging-and-dropping or by double-clicking on an item. At the right of the editing box are a set of buttons that give quick access to the most common mathematical operators (+, -, *, /, ^, etc.).

A toolbar at the top of the expression builder gives access to the most common editing options such as **Cut** (), **Copy** (), **Paste** (), etc. When constructing an expression, you can check whether the expression is valid by clicking on the **Verify** button. Finally, when you have finished with the expression, click on **OK** to put the expression back into the data entry table you came from, or click on **Cancel** to abandon the edit.

There are three tabbed pages at the top of the Expression Builder:

- **Functions** contain the list of functions built-in to LEAP. You can see a list of ALL functions or filter the list to show the modeling, mathematical and logical functions separately. On the right of the tab, each function is documented with notes describing syntax and usage, as well as examples of how it can be applied. The modeling functions are the main functions used for defining and calculating variables in LEAP. The mathematical functions are standard mathematical functions (log, exp, max, min, etc.). Wherever possible the names and syntax of these functions are the same as equivalent functions in Microsoft Excel. The logical functions are standard logical operators (IF, AND, NOT, OR, LessThan, etc.) used to construct conditional expressions that behave yield different results depending on the values of variables.

  Note: The expression builder will automatically show the help topic associated with the function highlighted in the edit box in the bottom part of the builder screen. As you click on a word in the edit box or move the edit cursor, the help topic displayed in the top half of the screen will automatically update.

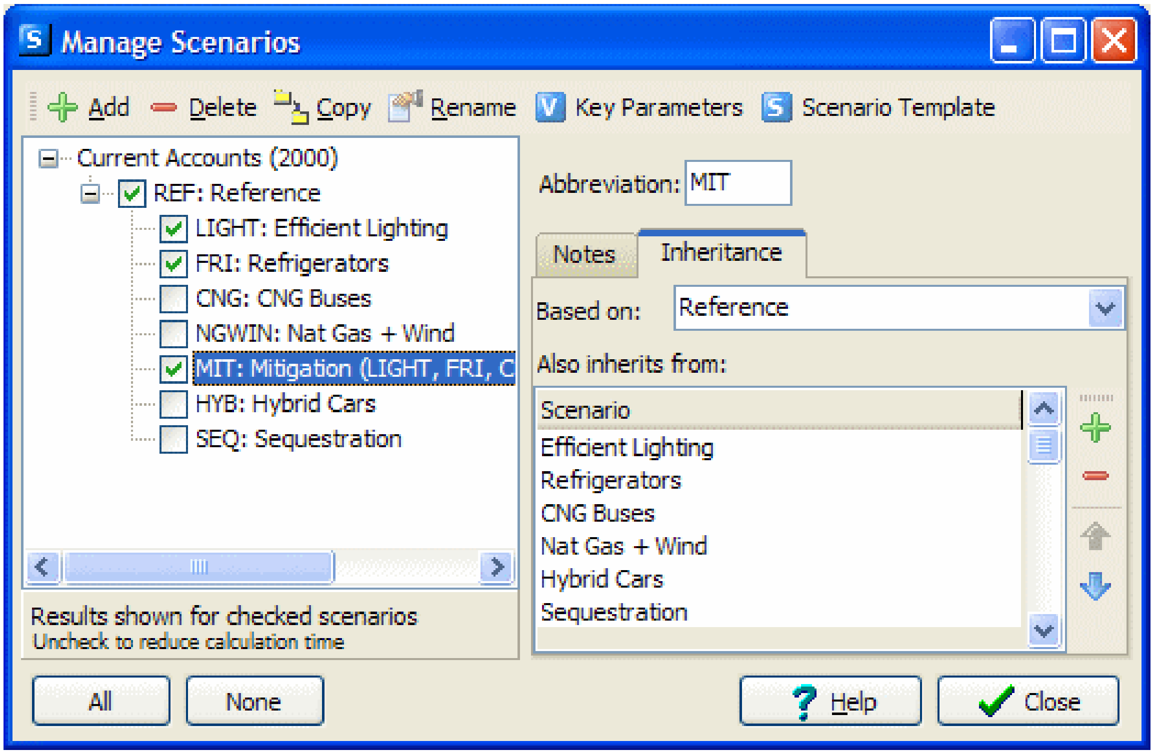
- **LEAP Variables** contains a tree outline listing all LEAP branches. When you drag and drop, or double-click on a branch to add it to the expression, a pop-up box will appear prompting you to pick a variable from the branch to which you wish to refer. When editing scenarios, you can also reference *lagged result variables*: these are the variables that are only evaluated during LEAP's calculation routines. When you reference them in Analysis View or in the Expression builder, LEAP will show the most recently calculated results for these variables. Note however, that following a full calculation the value may change. Referencing a result variable before it has been calculated will return a zero value. Note that result variables are always lagged (i.e. they return the value for the previous year). Hence, lagged result variables cannot be included in Current Accounts expressions. Note also that before you can reference result variables you need to enable the option **Allow Lagged Results in Expressions** on the Scope tab of the General: Basic Parameters screen. Enabling this option will cause slower calculations, so if you do not require lagged results leave this option unchecked for faster calculations.

- **Fuel Variables:** A further type of variable you can reference in expressions is fuel variables. These are the various chemical and physical characteristics of the fuel associated with a branch. Examples include the carbon, sulfur, and moisture content of the fuel, and its net heating value. Notice that only branches in which fuels are consumed or produced have valid fuel variables. These fuel variables reflect the data defined in the Fuels screen.

- **Constants:** Constants, including your own user-defined constants, can also be included in expressions. A default set of constants are included that define various molecular weight constants. These are primarily useful in defining emission factors. For example, a CO2 emission factor might be a function of the carbon content of the fuel, the fraction of the fuel oxidized, and the molecular weights of carbon and carbon dioxide. Thus, in units of kg CO2 per kg of fuel burnt, the emission factor would be written as follows:

CarbonContent * FractionOxidized * (CO2/C)

8.19 Manage Scenarios



Use the Manage Scenarios screen to create, delete, organize and set the properties of the scenarios in an Area. The Scenario Manager screen is divided into two panes. On the left, the Area's scenarios are listed in a hierarchical tree showing the main scenario inheritance structure. Scenario inheritance describes how each scenario inherits the expressions from the scenarios above it in the hierarchy. For more information, refer to Scenarios. Click on a scenario in the tree to edit it or to add a new scenario beneath it.

Also on the tree, for each scenario you can use the check boxes to set whether you want to results to be shown for each scenario (in the Results, energy balance, Overviews and Summaries views). Un-checking a scenario will speed-up calculations, but prevent you from seeing its results. Un-checking a scenario will NOT erase any data associated with the scenario. Use the **All** and **None** buttons at the foot of the screen to quickly check or un-check all scenarios.

On the right of the screen, you can edit the abbreviation for the currently highlighted scenario, edit the notes associated with each scenario, and edit the inheritance of each scenario. Use the **Based On** selection box to change the main parent of the scenario, and use the **Also Inherits From** box to edit the additional scenarios the scenario inherits from. For those branch/variable combinations in the scenario for which no expression has been explicitly defined, a default expression is inherited. The default expressions for a scenario are taken by first searching for expressions for a given branch and variable in the additional scenarios (i.e. those listed in the **Also Inherits From** box). The additional scenarios are searched in the order shown in the **Also Inherits From** box. You can change the order of inheritance for scenarios, using the **up** () and **down** () buttons next to the **Also Inherits From** box. If no expression is found in the additional scenarios, the expression is then inherited from the main parent scenario, followed by its immediate ancestors. Ultimately, all scenarios inherit from the expressions specified in Current Accounts. In multi-region areas, expressions may also be inherited from the default region.

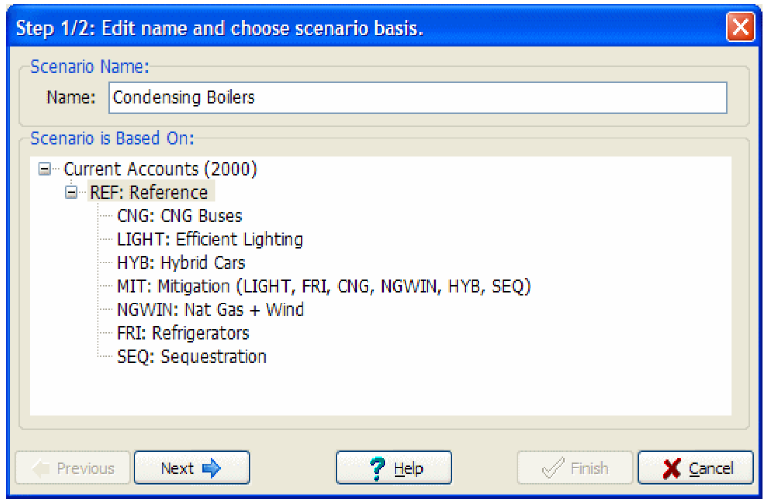
In the example shown above, a series of individual measures have been developed and then combined into an integrated scenario called Mitigation that captures their interactions.

The tool bar at the top of the Scenario Manager lets you add, delete and rename scenarios.

- Click **Add** () to add a new scenario, immediately under the current scenario.
- Click **Delete** () to delete a scenario. Bear in mind, that deleting a scenario, will also delete all data associated with that scenario.
- Click **Copy** () to make a copy of a scenario with a different name, and click on **Rename** to rename the scenario.
- Click **Scenario Template** () to edit or create a list of the key parameters used in your scenarios. Later you use this template to quickly create a new scenario, by editing the values for its key parameters.
- Click **Key Parameters** () to view or edit the key parameters associated with the current highlighted scenario.

8.20 Create Scenario/Scenario Key Parameters

Use this wizard to quickly edit or create a new scenario by reviewing its key parameters.



When creating a new scenario the wizard has two steps:

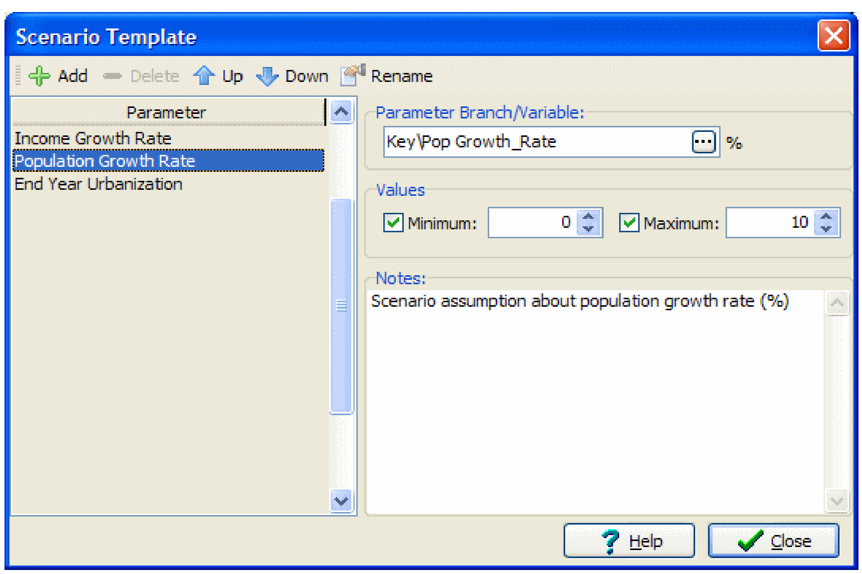
1. On the first screen, you enter a name for the new scenario and select the "parent" scenario, on which the expressions for the new scenario will be based.

2. On the second screen, you edit the values for the key parameters of the new scenario. The list of key parameters are set through the Scenario Template screen. The names of the parameters are listed on the left of the screen, while on the right of the screen you use either a "spinner" control or a "slider" control to input values for each parameter.

When editing the key parameters for an existing scenario, only the second page of the wizard is used.

8.21 Scenario Template

Use the scenario template option to create a list of the key parameters used in your scenarios. Each parameter is associated with one branch and variable in your LEAP analysis. We suggest that you use LEAP's Driver Variables for the key parameters in your scenarios. For each parameter you



can enter a short description of the parameter and set a maximum and minimum value.

Once you have created a scenario template, you can use the Create Scenario button ( ) in LEAP's analysis view to quickly create a new scenario, by editing the values for its key parameters.

The scenario template screen has a number of options for editing the template. Click on the add button ( ) to add a new parameter. You will be prompted for a name for the parameter and asked to select the branch and variable in your analysis to which the parameter is linked. Click on the delete button ( ) to delete the parameter. Note that this does not delete any data in your analysis, it simply removes the parameter from the template. Click on the up ( ) and down ( ) buttons to reorder the parameters in the template. Click on the rename button ( ) to rename a parameter.

9 Key Variables

In the Analysis View, the first major category on the tree is labeled **Key Variables.** Under this category you can create any number of macroeconomic, demographic and other time-series variables. Use **Key Variables** as a place to put data not treated elsewhere in LEAP's Demand, Transformation and Resource analyses. For example you may want to construct simple macroeconomic or demographic models under these branches, making use of LEAP's expression-based modeling capabilities, or you may simple want to use the area as a place to store the key assumptions of your scenario analyses.

Use the Key Variables Properties screen ( ) to create and then edit the name and units of each **Key Variable**. Key Variable branches can be of two types:

> **Category Branches**, which are used for organizing key variables into a hierarchical data structures. These branches do not contain data.
>
> **Key Variable Branches**, which are used to indicate variables and data (e.g. GDP, industrial output, population, consumption, investment etc). These variables are not output as results from LEAP, but are used instead as intermediate variables that can be referenced in your Demand, Transformation and Resource models. When adding key variables, enter the unit of the variable as text.

Note: in addition to defining variables under the **Key Variables** category, you can also add your own User Variables within your Demand, Transformation and Resource analyses. Use the General: User Variables screen to define your own User Variables.

10 Demand

10.1 Demand Analysis

Demand analysis is a disaggregated, end-use based approach for modeling the requirements for final energy consumption in an Area. You can apply economic, demographic and energy-use information to construct alternative scenarios that examine how total and disaggregated consumption of final fuels evolve over time in all sectors of the economy. You can also examine the costs and environmental implications of each scenario. Energy demand analysis is also the starting point for conducting integrated energy analysis, since all Transformation and Resource calculations are driven by the levels of final demand calculated in your demand analysis.

LEAP provides a lot of flexibility in how you structure your demand data. These can range from highly disaggregated end-use oriented structures to highly aggregate analyses. Typically a structure would consist of sectors including households, industry, transport, commerce and agriculture, each of which might be broken down into different subsectors, end-uses and fuel -using devices. You can adapt the structure of the data to your purposes, based on the availability of data, the types of analyses you want to conduct, and your unit preferences. Note also that you can create different levels of disaggregation in each sector.

Similarly, you also have choices in the methodologies you can apply for energy demand analysis. The following methodologies are available

- **Activity Level Analysis**, which itself consists of either Final Energy Demand Analysis, or Useful Energy Demand Analysis in which energy consumption is calculated as the product of an activity level and an annual energy intensity (energy use per unit of activity).

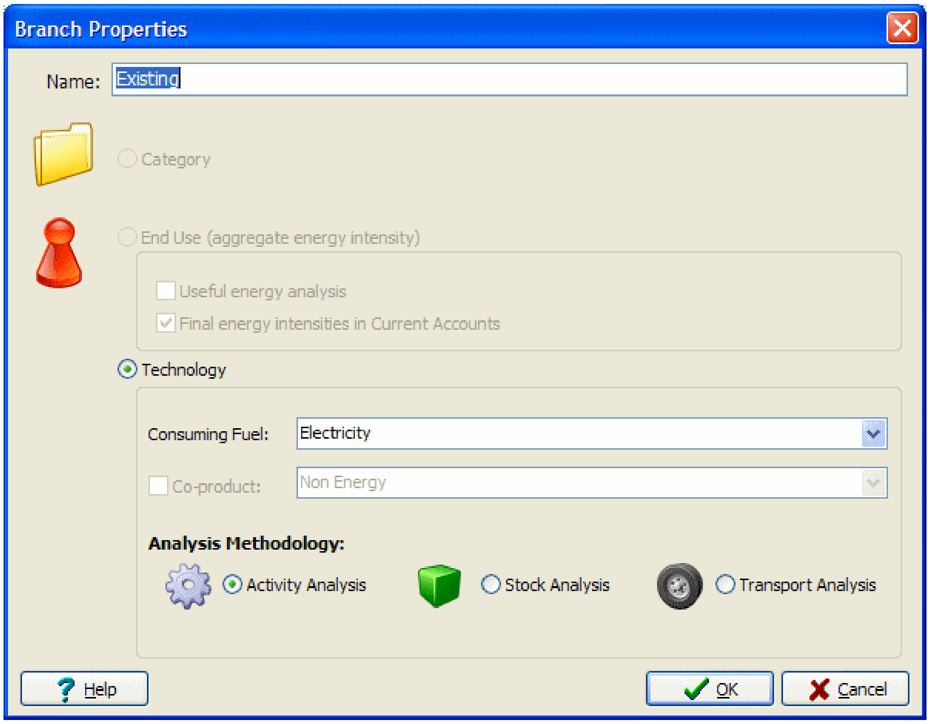
- **Stock Analysis,** in which energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device (defined as energy per device).

- **Transport Analysis**, in which energy consumption is calculated as the product of the number of vehicles, the annual average mileage (i.e. distance traveled per vehicle) and the fuel economy of the vehicles (e.g. liters per km or 1/MPG).

You can mix and match these different methodologies within a single data set: for example applying useful energy analysis for the analysis of industrial and commercial heating and employing final energy analysis for all other sectors.

In each case, demand calculations are based on a disaggregated accounting for various measures of social and economic activity (number of households, vehicle-km of travel, tonnes of industrial production, commercial value added, etc.) These "**activity levels**" are multiplied by the **energy intensities** of each activity (energy per unit of activity). Each activity level and energy intensity can be individually projected into the future using a variety of techniques, ranging from applying simple exponential growth rates and interpolation functions, to using sophisticated modeling techniques that take advantage of LEAP's powerful built-in modeling capabilities.

10.2 Demand Branch Properties



Use this screen to edit the properties (name, type, etc.) of a demand branch. Demand branches can be one of three types:

- **Category** branches are used mainly for organizing the other branches into hierarchical data structures. These branches only contain data for Activity Levels, and Costs.

- **End Use** (**Aggregate Energy Intensity)** branches are used to indicate a branch at which energy intensities are specified for an aggregate end-use, rather than being associated with a specific fuel or device. These branches are useful in three main cases: a) where you have energy intensity data for an end-use, and only have fuel share data (not intensity data) for the fuels and devices within the end-use; b) where you have devices that use more than one fuel; and c) where you wish to conduct a Useful Energy Demand Analysis**.** In this latter case you need to check the additional **Useful Energy Analysis** checkbox on the branch properties screen. When conducting a useful energy analysis, you can choose to enter current accounts data for the end-use in two different ways. Check the **Final Energy Intensities in Current Accounts** checkbox to specify final energy intensities (i.e. the amount of fuel used) or leave the box unchecked to specify useful requirements (i.e. the service demand) in Current Accounts. In either case you will always enter the useful demand for the end-use in scenarios. NB: the options you choose here will affect which variables (tabs) are visible in the Analysis View for the selected branch.

- **Technology** branches are used to represent final energy consuming devices, and hence when choosing this type of branch you will also need to select the fuel consumed. When conducting a useful energy demand analysis, technologies can optionally be set to produce a co-product. For example, a demand for heat in buildings could be met through a combination of conventional furnaces as well as combined heat and power (CHP) units that consume natural gas at one efficiency, while producing electricity at another efficiency. Use the branch properties screen to specify the co-product. Note that only technologies created under a useful aggregate energy branch can have co-products. If you specify a co-product, an additional variable (tab) will appear in the main data entry screen in which you can specify the co-product efficiency (i.e. the efficiency at which the fuel consumed is turned into the co-product). Note that the sum of the efficiency and co-product efficiency must be less than or equal to 100%.

When specifying Technology branches you will also need to specify the type of **methodology** you are going to use to analyze energy demands. Use this screen to select among the three basic Demand Analysis methodologies:

- **Activity Level Analysis**, which itself consists of either Final Energy Demand Analysis, or Useful Energy Demand Analysis, in which energy consumption is calculated as the product of an activity level and an annual energy intensity (energy use per unit of activity).

- **Stock Analysis,** in which energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device (defined as energy per device).

- **Transport Analysis**, in which energy consumption is calculated as the product of the number of vehicles, the annual average mileage (i.e. distance traveled per vehicle) and the fuel economy of the vehicles (e.g. liters per km or 1/MPG).

Tip: *when adding a new branch, if you want the branch name to be the same as the name of the fuel it uses, simply select the fuel first and LEAP will use the fuel name as the branch name.*

Note: in general you cannot mix branch types in immediately neighboring branches, so, for example, a category type and technology type cannot be placed next to one another. Because of this restriction, you sometimes may not be able to change the type of an existing branch if it already has neighboring branches. The exception to this rule is that category branches can be placed next to aggregate energy intensity branches.

10.3 Activity Analysis

In this, the default methodology, energy consumption is calculated as the product of an activity level and an annual energy intensity (energy use per unit of activity). Overall activities are defined as the products of the individual activities entered along a complete branch of the Demand tree. Typically, activities are specified as a single absolute value (e.g. number of households) multiplied by a series of shares or saturations/penetrations (e.g. the percent share of urban households, the penetration of an end-use such as air conditioning), and the penetration of each technology that meets the end-use.

Total energy consumption is thus calculated by the equation:

Energy consumption = activity level x energy intensity

There are two basic variations to this methodology: in a Final Energy Demand Analysis you specify energy intensities at the device level as the amount of fuel used per unit of activity; in a Useful Energy Demand Analysis you specify useful energy intensities at the next highest branch level (typically the end-use level), and then specify the efficiencies of each device.

Note: this method can also be used to project energy consumption directly (i.e. not per unit of activity). To do this, simply enter "No data" for the units in the Activity Level variable.

Tip: *use the methodology tab on the Demand Branch Properties screen to set-up an Activity Analysis for a demand device.*

10.3.1 Final Energy Demand Analysis

In conducting a final energy demand analysis, a typical approach is to disaggregate your demand data structure into four levels representing sectors, subsectors, end-uses and devices. An example of this approach showing the Activity Level table in the Analysis View is given below.

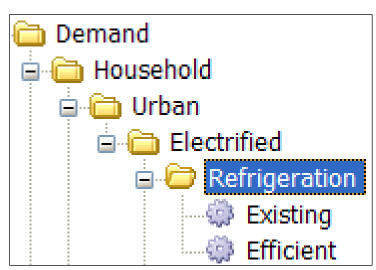
Activity Level

A measure of the social or economic activity for which energy is consumed.

Name	Current Accounts Expression	Scale	Units	Per
Household	8	Million	Household	
Urban	30	Percent	Share	of Households
Electrified	100	Percent	Saturation	of Households
Refrigeration	95	Percent	Saturation	of Households
Existing	Remainder(100)	Percent	Share	of Households
Efficient	0	Percent	Share	of Households

Activity levels for one of the four hierarchical levels are typically described in absolute terms (in this case the number of households is 8 million in the Current Accounts year), while the other three levels are described in proportionate (i.e. percentage share or percentage saturation) terms. In the example shown above, urban households are 30% of the total number of households in 2000, of these 95% have some type of refrigerator, and all refrigerators are existing (less efficient) models. None of the new, more efficient models have been introduced in the base year. Notice that at the top level, the user chose an absolute unit for the activity level (households). At lower levels, LEAP keeps track of the units, and hence knows that the percentage number entered at the second level is the share "of households". In general, LEAP lets you choose the numerator units for activity levels, whilst automatically displaying the denominator unit. When selecting an activity level unit, you can choose from any of the standard non-energy units. Use the Units screen (Main Menu: General Parameters: Units) if you need to add additional units.

The above data are shown for the Current Accounts year, but all values can be altered for future years in scenarios. This allows the planner to capture the combined effects of separate changes at many levels, such as, for example, the growth in the total number of households, the rate of urbanization, the penetration of refrigeration, and the market share of less efficient vs. more efficient refrigerator models. To project these data, you first use the Manage Scenarios option to create one or more scenarios. Then, in the Analysis View, you override the default (constant) expressions entered in Current Accounts for each branch, with new expressions that describe how each value changes over time.



The tree structure for this type of final energy analysis is shown on the right. Notice that all of the branches are created as category branches ( ) except for the bottom-most nodes, which are always created as technology branches ( ). For these bottom-level branches, you also define the annual energy intensities per unit of activity level (in this case per household) and specify the fuels used by the device (see below).

Final Energy Intensity

Annual final consumption of fuel per unit of activity level (for energy and non-energy pur

Name	Fuel Name	Current Accounts Expression	Scale	Units	Per
Existing	Electricity	500		Kilowatt-Hour	per Household
Efficient	Electricity	380		Kilowatt-Hour	per Household

When editing energy intensities, first select the fuel used by each device and then set the scale and units in which you want to enter the intensity. The scale and units columns can only be edited in Current Accounts. Changes to the energy intensity units' column subsequent to entering an intensity value will cause LEAP to offer to convert the value to the new units.

10.3.2 Useful Energy Demand Analysis

Tip: *use the Demand Branch Properties dialog to set-up a useful energy demand analysis.*

For cases in which you wish to explicitly consider demand-side efficiency improvements and fuel switching independently of the evolution of useful energy demands (e.g. the heat demand in a building), you may wish to use LEAP's useful energy analysis methodology instead of the default final energy analysis.

A useful energy analysis lets you independently consider three important trends: a) how the overall useful demand might change over time (for example as incomes rise and people consume more, or as building standards improve affecting heat demand per square meter), b) how the market penetration of different devices changes over time, and c) how the efficiencies of devices (i.e. final energy demand per unit of useful energy provided) is likely to evolve over time.

To configure a useful energy analysis, do the following:

1. Add an end use branch ( ) at the end-use level (e.g. heating, cooling, cooking).
2. On the Demand Branch Properties screen, check the box marked "**useful energy analysis**", and
3. Click **OK.**
4. Below this branch add additional technology branches ( ) to represent the various fuel-using devices that are available to meet the demands of the end-use.

Note that useful energy branches are always immediately above the technology branches in a demand tree. Only technology branches may be added below them. In the example shown on the right, three substitute fuels (fuel oil, electricity and natural gas) area used to provide commercial heating.

Current Accounts

When conducting a useful energy analysis, Current Accounts data can be specified in two different ways:

1. In the default method, you specify final energy intensities for the end-use, along with the fuel shares and efficiencies for each fuel or device level. Notice that device fuel shares are not the same thing as the activity shares entered in a final energy analysis. Fuel shares are the share of total final energy consumed by each device, while activity shares reflect the number of "activities" (e.g. the share of floor space heated by different boiler types). The percentage efficiencies you enter for each device are used to calculate the overall useful energy intensity for the end-use, and the activity shares for each device in the Current Accounts year. This first approach is most useful when you have Current Accounts data describing the total fuel consumed in the base year, and you wish LEAP to calculate the useful energy demand.

2. In the second method, you specify useful energy intensities directly in Current Accounts. This approach is useful in cases where you have data describing the useful demand for a branch (e.g. the heat demand in buildings).

Tip: *use the Demand Branch Properties dialog to select between these two alternatives. Notice that you can mix and match methods freely in different branches*

Scenarios

Irrespective of the method you choose for Current Accounts, in scenarios you project the useful energy demand, device efficiencies and activity shares into the future.

10.4 Activity Analysis Variables

10.4.1 Activity Level

Activity Levels are used in LEAP's Demand analysis as a measure of the social or economic activity for which energy is consumed.

In creating a demand analysis structure, you typically create a hierarchy of branches, in which activity levels are described in absolute terms (e.g., number of households) at one level of the hierarchy, and in proportionate terms (e.g. percentage share or percentage saturation) terms in the other levels of the hierarchy. The product of these terms yields the overall level of activity for a given device: one of the leaf branches in a Demand tree.

Energy consumption in the device is then calculated by multiplying the overall level of activity for the device by its energy intensity.

Notice that in some cases energy intensities can be defined at the end-use level, rather than the device level. Nevertheless, the general principle holds that LEAP calculates energy consumption as the product of activity levels and energy intensities.

10.4.2 Total Activity

Total Activity shows the result of multiplying down each of the Activity Level branch chains. A simple example is shown below.

Branch	**Activity Level**	**Total Activity**
Households	8 million	8 million households
Rural	50% share	4 million households
Refrigeration	20% saturation	800 thousand households

Note that this variable is calculated and cannot be edited by the user. However, its value can be referenced in expressions.

10.4.3 Final Energy Intensity

Final energy intensity is the annual average final energy consumption of a branch per unit of activity level. Final energy intensities are typically defined at the lowest level technology branches ( ), but can also be defined at the next level up, when specifying aggregate energy intensity branches ( ).

10.4.4 Non Energy Fraction

Use the non-energy fraction variable to specify the fraction of the fuel that is consumed for non-energy purposes. *NB: Non-energy consumption is calculated as a fraction of the product of the final energy intensity and activity level variables.* By default, the non-energy fraction is zero.

Fuels consumed for non-energy purposes are not subject to any of the emissions factors specified in the environmental loadings tab. That is they are assumed not to be burnt. However, CO2 emissions from fossil fuels consumed for non-energy purposes are calculated based on the fuel's **carbon content** and the fraction of the carbon that is **permanently stored when the fuel is used for non-energy purposes.** Both of these variables are specified on the fuels screen.

Thus the amount of CO2 emitted from fossil fuels used for non-energy purposes is calculated as follows:

CO2 = (Activity Level x Final Energy Intensity) x (Non Energy Fraction/100) x (Fuel Carbon Content/100) x (1-(Carbon Stored/100)) x (44/12)

(where the product of activity level and energy intensity are assumed to be specified in weight terms, and 44/12 is the factor that converts from Carbon to Carbon Dioxide terms.

This approach to CO2 accounting is most useful when you need to replicate the results of a detailed emissions inventory, which typically use the same accounting approach for non-energy fuel consumption.

The Non-Energy Fraction variable is always specified at a technology branch ( ), and is only available when using the standard final energy analysis method. It is not available when conducting useful energy analyses or transport analyses.

10.4.5 Useful Energy Intensity

The useful energy intensity screen only appears when conducting a useful energy analysis and is only defined at end-use branches ( ).

Unlike a final energy intensity, which specifies the amount of fuel used per unit of activity, a useful energy intensity is a measure of the energy service provided per unit of activity -- the "useful" energy. Examples include the heating load of a building (NOT the fuel used in its boilers) or the amount of heat in a cooking pot required to cook a meal (NOT the amount of wood burnt).

Useful energy intensities are calculated for Current Accounts based on the fuel shares and efficiencies of devices. This calculated value is displayed for you to project into the future when editing scenarios.

Refer to Useful Energy Demand Analysis for information on how to configure branches for entering useful energy intensities.

Note: Because they are not associated with a particular fuel, LEAP only lets you enter useful energy intensities in energy units.

10.4.6 Efficiency

Efficiency is the percentage annual average thermal efficiency of a demand device defined as 100 * *useful energy delivered* / *final energy consumed*. The final energy consumed is a fuel (which can also be electricity), while the useful energy delivered is typically heating or cooling. In order to be able to specify efficiencies, make sure your end-use branch is configured as an end-use branch ( ) and is set to conduct a useful energy demand analysis. Efficiencies can then be entered for any of the technology branches ( ), below this branch.

NB: Efficiency data are only visible for technology branches when conducting a Useful Energy Demand Analysis.

10.4.7 Fuel Share

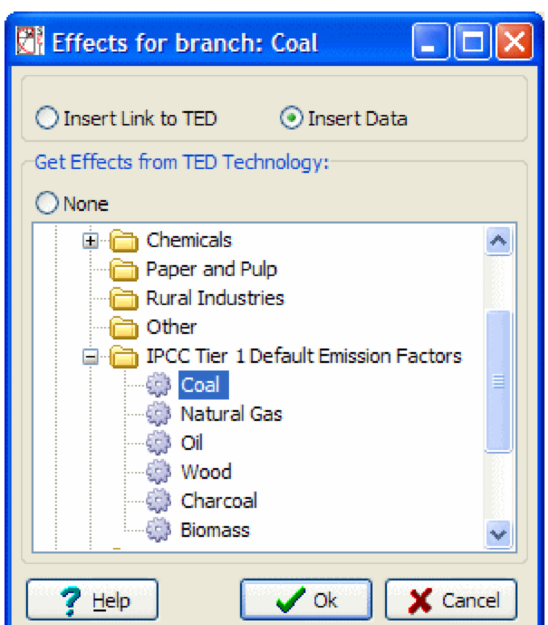
Fuel shares are the percentage share of final energy at an end-use ( ) consumed by one of the device branches below it. Notice that when the efficiencies of devices are not all 100%, then fuel share is not identical to activity level share. For example, consider an end-use such as heating that can be met by either natural gas boilers at 80% efficiency or electric boilers at 100% efficiency. If each boiler is sized deliver the same amount of heat, and each is installed in 50% of homes, then the activity levels shares of each will be 50%, but the fuel shares will be as follows: (Natural gas = 55.6%, electricity = 44.4%) To see why, look at the table below.

	Activity Share (A) (A)	Efficiency (B)	Fuel Required (A/B)	Fuel Share
Natural Gas	50%	80%	0.63	55.6%
Electricity	50%	100%	0.50	44.4%
Total	100%		1.13	100.0%

Fuel share data are only required for Current Accounts when conducting a useful energy demand analysis if you chose to specify final energy intensities in Current Accounts on the Demand branch properties screen. They are not required if you choose to specify useful energy intensities directly in Current Accounts. Fuel shares are always entered for the technology branches ( ).

10.4.8 Environmental Loadings

All devices in your Demand analysis, and all feedstock fuels, auxiliary fuels and output fuels in your Transformation analysis are potential sources of environmental loadings. Use the environmental loadings screen to associate environmental loadings with these branches. Each loading is specified as an effect (e.g. a pollutant emission) per unit of energy consumed or energy produced or per unit of vehicle distance (this latter approach is only available when conducting a Demand Transport Analysis). During its calculations, LEAP multiplies the loadings you specify on the Environmental loadings screens by the total amount of energy consumed in each year of each scenario. In the case of distance-based loadings, LEAP multiplies the loadings by the total mileage of all vehicles.



Linking to TED

The simplest way to specify environmental loadings for a given technology is to create a link to one of the library of technologies in the accompanying Technology and Environmental Database (TED). TED contains emission factors for hundreds of energy consuming and energy producing technologies, including the default emission factors suggested by the IPCC for use in climate change mitigation analyses. To create a link to TED, click on the TED button (TED) and use the subsequent dialog box (shown right) to select a technology from TED that closely matches the technology in your Area. Click on the button to go directly to TED and view the full information about the TED technology and its emission factors.

Notice that you are not required to specify loadings for all fuels, and in fact you will not normally wish to specify loadings for Demand devices consume heat or electricity since the emissions for those fuels occur upstream (e.g., during the generation of electricity) from the point of consumption and can be modeled in LEAP's Transformation calculations. However, you should note that the default emission factors in TED are all direct emission factors, not lifecycle emission factors. For example, the emission factors for a vehicle are the direct emissions from the vehicle: they do not include the *upstream* emissions from oil refining and oil extraction. You should also be aware that while TED is based on a literature review of recently published estimates of emission loadings; it does not currently contain a comprehensive picture of all effects from each of its source categories. For this reason, be sure to examine which effect categories are included for each TED technology.

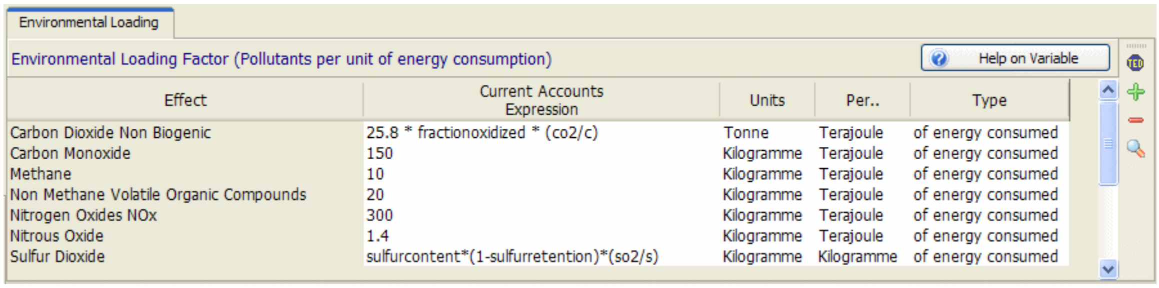
Entering Emission Factors Directly

The latest version of LEAP now allows you to manually enter your own emission factors, or override the default factors obtained by linking to TED. So for example, you might link to the IPCC factors for greenhouse gases, but then add your own country- or technology-specific factors for other air pollutants. As with other LEAP expressions, emissions factors can be specified as simple numbers or as mathematical formulae. In fact, many of the emission factors stored in TED are expressed as formulae in which the emission factor is itself a function of the chemical composition of the fuel being burnt. For example, SO_2 emission factors are generally a function of the sulfur content of the fuel, and CO_2 emission factors are often expressed as a function of the carbon content of the fuel. For more information on specifying environmental loadings, refer to information on the TED expressions.

To add an emission factor, click the button and select from the list of available effects. You can add additional effects on the Effects screen. Any environmental loadings created as links to TED are initially protected in Current Accounts and cannot be changed except by editing the data in TED itself. Click the button to delete an effect. Environmental loadings are also shown as branches on the tree in Analysis View marked with the cloud icon (), and can also be deleted directly be editing the tree. When editing scenarios, future values for environmental loadings can always be edited, even for those loadings linked to TED.

Units

For unlinked loading factors, you can edit the numerator and denominator units for each factor in Current Accounts. The choice of numerator units will depend on the effect being specified, while the choice of denominator units will depend on the state of the fuel being consumed or produced, and also on the type of loading factor. Most loading factors are specified per unit of energy consumed. However, you can also specify emissions per unit of energy produced for any output fuel. In addition, when conducting Demand Transport Analyses, you can also specify emission per unit of vehicle-distance traveled (e.g. grammes per vehicle-mile). This reflects how most pollutants are regulated for vehicles and thus how these factors are best modeled.


Environmental Loading

Environmental Loading Factor (Pollutants per unit of energy consumption)

Help on Variable

Effect	Current Accounts Expression	Units	Per..	Type
Carbon Dioxide Non Biogenic	25.8 * fractionoxidized * (co2/c)	Tonne	Terajoule	of energy consumed
Carbon Monoxide	150	Kilogramme	Terajoule	of energy consumed
Methane	10	Kilogramme	Terajoule	of energy consumed
Non Methane Volatile Organic Compounds	20	Kilogramme	Terajoule	of energy consumed
Nitrogen Oxides NOx	300	Kilogramme	Terajoule	of energy consumed
Nitrous Oxide	1.4	Kilogramme	Terajoule	of energy consumed
Sulfur Dioxide	sulfurcontent*(1-sulfurretention)*(so2/s)	Kilogramme	Kilogramme	of energy consumed

Dynamic Emission Factors

As with other variables, in scenarios you can specify how environmental loading factors are likely to change in the future. By default, the factors you specify in scenarios describe the average emission factors for the total stock of devices producing the loading. However, when conducting Stock Analyses and Transport Analyses in Demand the environmental loading factors will instead be interpreted as values for newly added technologies. In these cases, LEAP will internally calculate the stock-average environmental loading factors.

In addition, when conducting Stock Analyses and Transport Analyses in Demand, you can now specify an optional lifecycle profile that describes for each vintage, how emission factors degrade as technologies age.

10.4.9 Demand Costs

Use the **Demand Costs** data tab to specify the non-fuel costs of your demand scenarios (capital, O&M and administrative). These costs are used in LEAP's overall cost-benefit calculations to help evaluate your policies and measures. You can specify costs for any demand branch. Typically, you specify costs for each demand technology ( ), but you can also specify costs at higher levels of aggregation (for example the costs of sectoral demand side management programs). Bear in mind that for a comparative analysis of scenarios, you need only enter costs for branches where activities or energy intensities change compared to your baseline.

Note: Demand Costs are only available if the **Costs** checkbox is checked on the Scope tab of the Basic Parameters screen.

LEAP provides four different methods for specifying demand costs:

1. **Costs per Activity:** This is the default costing method. It allows you to specify non-fuel costs per unit of activity (e.g. costs per household for residential sector measures or costs per passenger-km in the transport sector). This method is simple to implement because it requires no additional data (other than a cost and an activity level). In cases where your activity level variable is not the same as the

physical number of devices affected the cost values you enter should be the annual cost per device multiplied the number of devices per activity (for example the number of light bulbs per household). Alternatively, you may wish to use the **Cost per Device** methodology described below.

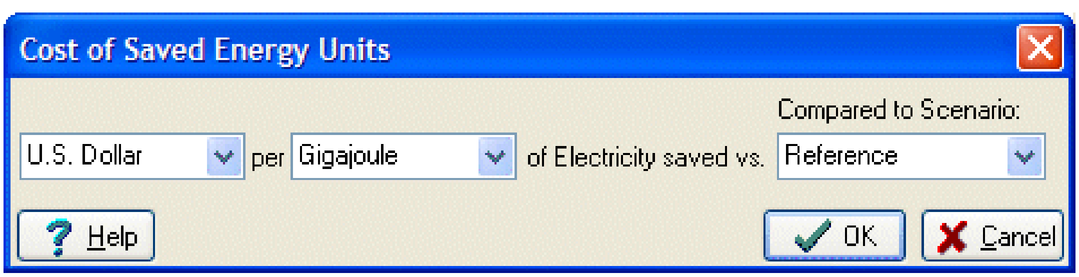
The value you enter is used in LEAP's calculations in the following way: $Cost_{s,t} = Cost\ per\ Activity_{s,t} \times Activity\ Level_{s,t}$

2. **Costs per Device Sold:** If you selected the Stock Analysis or Transport Analysis methods for a Technology (), then you will also be able to use this second costing method and enter costs per device sold. This method lets you track the costs of new and replacement devices, and for this reason tends to be a more accurate (although more data intensive) approach than the above method.

   The value you enter is used in LEAP's calculations in the following way: $Cost_{s,t} = Cost\ per\ Device\ Sold_{s,t} \times \text{Devices Sold}_{s,t}$

3. **Total Costs:** In some cases you simply want to specify a total annual cost at a demand branch (i.e. one that is not per activity level, per unit saved or per device sold). In these situations, choose the Total Cost method and enter the total annual costs in the expression. Use LEAP's AnnualizedCost function when you want to build-up this value by annualizing (levelizing) a capital cost. This cost method can be particularly useful when specifying overall program or administrative costs of programs at higher levels branches in your analysis.

4. **Cost of Saved Energy (CSE)** expresses the incremental cost of saving energy in a device relative to the energy used in some baseline scenario. The CSE method lets you directly compare the costs of demand side energy efficiency investments with those of conventional energy supply investments and is most appropriately used when you are changing the energy intensity of a particular device in a given scenario to reflect efficiency improvements, rather than switching from one branch to another.



When specifying a CSE you will need to enter the cost per unit energy saved relative to either Current Accounts or another scenario. Bear in mind that energy intensities may change over time even in a policy neutral scenario, so you should normally specify CSE costs relative to some *baseline* scenario. However, if you expect energy intensities to be constant over time then you can also specify CSE costs relative to Current Accounts intensities. When you pick the CSE method, a special screen will pop up (shown right) in which you can select the units (currency per unit of energy saved) and the scenario against which you will be specifying the costs.

The CSE value you enter should represent the annual average cost per unit of energy saved. Use LEAP's AnnualizedCost function when you want to build-up this value by annualizing (levelizing) a capital cost. You can also include operations & maintenance (O&M) and administrative costs in the CSE.

The CSE value you enter is used in LEAP's calculations in the following way:

- **When costs are specified relative to another scenario:**

  $$Cost_{s,t} = CSE_{s,t} * Activity\ Level_{s,t} * (Energy\ Intensity_{BL,t} - Energy\ Intensity_{s,t})$$

  Where s is the current scenario, BL is the *baseline* scenario, and t is the year.

- **When costs are specified relative to the Current Accounts intensity**

  $$Cost_{s,t} = CSE_{t} * Activity\ Level_{s,t} * (Energy\ Intensity_{0} - Energy\ Intensity_{s,t})$$

Note that CSE costs will be zero in the base year by definition since changes in energy intensity occur only in future scenario years.

10.5 Activity Analysis Calculations

For an activity analysis, calculations differ depending on whether you are conducting a final or useful energy demand analysis.

10.5.1.1 Final Energy Demand Analysis

In a final energy demand analysis, energy demand is calculated as the product of the total activity level and energy intensity at each given technology branch (). Energy demand is calculated for the Current Accounts year and for each future year in each scenario. In other words:

$$D_{b,s,t} = TA_{b,s,t} \text{ x } EI_{b,s,t}$$

Where D is energy demand, TA is total activity, EI is energy intensity, b is the branch, s is scenario and t is year (ranging from the base year [0] to the end year). Note that all scenarios evolve from the same Current Accounts data, so that when t=0, the above equation can be written as:

$$D_{b,0} = TA_{b,0} \text{ x } EI_{b,0}$$

The energy demand calculated for each technology branch is uniquely identified with a particular fuel. Thus, in calculating all technology branches, LEAP also calculates the total final energy demand from each fuel.

The total activity level for a technology is the product of the activity levels in all branches from the technology branch back up to the original Demand branch. In other words:

$$TA_{b,s,t} = A_{b',s,t} \text{ x } A_{b'',s,t} \text{ x } A_{b''',s,t} \text{ x } ...$$

Where A_b is the activity level in a particular branch b, b' is the parent of branch b, b" is the grandparent, etc. Note that those branches marked as having "No data" as well as the top level "Demand" branch are treated as having an activity level of 1. The activity level values of other branches with percentage units (e.g. percent shares or percent saturations) are always divided by 100 to yield a fractional value from zero to one in the calculations.

10.5.1.2 Useful Energy Demand Analysis

In a useful energy demand analysis, energy intensities are specified, not for a technology, but at one level up, for an aggregate energy intensity ( ).

- **In Current Accounts** you specify final energy intensities for the aggregate energy intensity branch ( ), and fuel shares and efficiencies for each technology branch ( ). These data are used calculate the overall useful energy intensity for the aggregate energy intensity branch and the activity shares for each technology as follows:

  For each technology branch:

  $$UE_{b,0} = EI_{AG,0} \text{ x } FS_{b,0} \text{ x } EFF_{b,0}$$

  Where b = 1..B

  Where $EI_{AG,0}$ is the final energy intensity in aggregate energy intensity branch, UE is the useful energy intensity in a technology branch b, FS is its fuel share, EFF is its efficiency, and b is one of B technology branches.

  The useful intensity of the aggregate energy intensity branch is the sum of the useful intensities for each technology branch:

  $$UE_{AGG,0} = Sum_{b = 1..B}(UE_{b,0})$$

  The activity share (i.e. the share of the number of technologies, rather than the fuel share) is the product of the fuel share and efficiency of each technology b:

  $$AS_{b,0} = UE_{b,0} / UE_{AGG,0}$$

Where AS is activity share.

The following example illustrates this calculation. Consider an aggregate energy branch with a final intensity of 100 GJ per activity (i.e. 100 GJ of fuel), and 2 technologies each of which has a 50% fuel share. The electricity technology has an efficiency of 100% and the natural gas technology has an efficiency of 70%. Thus, the useful energy intensities of the technologies are 100 * 50% *100% = 50 GJ/activity and 100 * 50% * 70% = 35 GJ/activity respectively, and the activity shares are 50/85 = 59% and 35/85 = 41% respectively.

	Final Intensity		Useful Intensity	
Heat	100		85	
	Fuel Share	**Efficiency**	**Useful Energy**	**Activity Share**
Electricity	50	100%	50	59%
Gas	50	70%	35	41%

- **In scenarios,** you enter expressions to independently project the Current Accounts values calculated above for the useful energy intensity of the aggregate energy intensity branch, the technology activity shares and their efficiencies. The final energy intensity for each technology is given by:

$$EI_{b,s,t} = UI_{AGG,s,t} \text{ x } AS_{b,s,t} / EFF_{b,s,t}$$

Overall energy demand for each technology is calculated in the same way as for a final energy demand. In other words:

$$D_{b,s,t} = TA_{b,s,t} \text{ x } EI_{b,s,t}$$

Note: when specifying aggregate energy intensities, but not conducting useful energy analysis, the above equations still hold and all efficiencies are set equal to 100%.

10.6 Stock Analysis

Use the Demand Branch Properties screen to set-up a Stock Analysis for a demand technology. Technology branches at which stock analyses are being conducted are shown in the tree marked with the stock icon ().

In this method, energy consumption is calculated by analyzing the current and projected future stocks of energy-using devices, and the annual energy intensity of each device. In Current Accounts, you specify the current stock of devices and the current stock-average energy intensity and environmental loadings. In scenarios, you project future additions (sales) of devices and the energy intensity and environmental loadings associated with those newly added devices. LEAP then calculates the stock average energy intensity and environmental loadings across all vintages and hence, ultimately, the overall level of energy consumption and environmental loadings.

Total energy consumption is thus calculated by the equation:

Energy consumption = stock of devices x energy intensity per device

For more information, please refer to Stock Analysis Calculations

10.7 Stock Analysis Variables

10.7.1 Sales

When conducting a Stock Analysis () you will need to specify information about the stocks and sales of devices or vehicles. This information is useful in situations where you want to more accurately model the costs of newly purchased devices or in situations where you want to model how a newly introduced energy efficiency, fuel economy or emission standard for sales of new technologies will translate into gradually improving overall average values across the total stock of devices (as new vehicles gradually replace older ones).

Start by entering the base year stock of devices and specify a lifecycle profile describing the age distribution of vehicles within that stock, together with the sales of devices in the base year. In scenarios you specify future sales of devices. Stocks of devices are calculated automatically based on the software's vintaging calculations.

Fleet Roll Over

When conducting a Transport Analysis, the Current Accounts Sales screen has two additional columns, which can optionally be used to specify information about how Government and business fleet vehicles are "rolled over" into private fleets after a number of years. The two additional columns are:

- **Roll over Branch:** For Government and business fleet vehicles, use this field to specify the branch into which rolled over stock will be placed. Typically, you will specify that all Government and business fleet vehicles are rolled over into a single branch (see example below). Note that roll over calculations are optional. If you do not wish to model rollover, leave all items in the **Roll over Branch** column set to **<None>**.

- **Roll over Profile:** Use this column to specify a lifecycle profile that specifies when each type of fleet vehicle is to be rolled over to the private stock of vehicles. This profile needs to be a time series, starting at 100% for new vehicles (i.e. no roll overs) and descending over time as any surviving vehicles get rolled over into the private vehicle stock.

Note that in any given year, the number of vehicles rolled over for a given vintage will be the product of the number of surviving vehicles of that vintage and the (100% - the roll over profile value).

Annual Sales or Additions

Branch Name	2000 Expression	Scale	Units	Survival Profile	Fleets Rolled Over to Branch:	Roll Over Profile
Private	4.3	Million	Vehicle	Private Car ...	<None>	Constant
Business Fleet	2.1	Million	Vehicle	Business C...	Private	Business Car Rollover
Utility Fleet	2.5	Million	Vehicle	Governmen...	Private	Business Car Rollover
Government Fleet	1.8	Million	Vehicle	Governmen...	Private	Government Car Rollov

10.7.2 Stocks

When conducting a Stock Analysis you will need to specify information about the stocks and sales of devices or vehicles. This information is useful in situations where you want to more accurately model the costs of newly purchased devices or in situations where you want to model how a newly introduced energy efficiency, fuel economy or emission standard for sales of new technologies will translate into gradually improving overall average values across the total stock of devices (as new vehicles gradually replace older ones).

10.7.3 Final Energy Intensity

Final energy intensity is the annual average final energy consumption of a branch per unit of activity level. Final energy intensities are typically defined at the lowest level technology branches ( ), but can also be defined at the next level up, when specifying aggregate energy intensity branches ( ).

10.7.3.1 Units

LEAP lets you enter energy intensities for technologies in energy, mass or volume units. It will also automatically convert your data from one unit to another. Note that when the fuel is a pure energy form such as electricity, the units must be an energy unit. When specifying energy intensities for an aggregate energy intensity branch, you can only enter the intensity in energy units.

10.8 Stock Analysis Calculations

For a given technology branch ( ), the following equations describe the calculations for the stock analysis methodology:

Stock Turnover

$$Stock_{t,y,v} = Sales_{t,v} \cdot Survival_{t,y-v}$$

$$Stock_{t,y} = \sum_{v=0..V} Stock_{y,v,t}$$

Where:

> *t* is the type of technology (i.e. the technology branch)
>
> *v* is the vintage (i.e. the year when the technology was added)
>
> *y* is the calendar year
>
> *Sales:* is the number of vehicles added in a particular year: entered as an expression.
> *Stock* is the number of devices existing in a particular year: either entered as an expression for Current Accounts or calculated internally based on historical sales.
>
> *Survival* is the fraction of devices surviving after a number of years: entered as a lifecycle profile.
>
> *V* is the maximum number of vintage years: determined automatically from the survival lifecycle profile, with a maximum of 30 years.

Energy Intensity

$$EnergyIntensity_{t,y,v} = EnergyIntensity_{t,v} \cdot Degradation_{t,y-v}$$

Where:

> *EnergyIntensity* is energy use per device for new devices purchased in year y. Entered as an expression.
>
> *Degradation* is a factor representing the change in energy intensity as a technology ages. It equals 1 when y=v. Entered as a lifecycle profile.

Energy Consumption

$$EnergyConsumption_{t,y,v} = Stock_{t,y,v} \cdot EnergyIntensity_{t,y,v}$$

Energy-Based Emissions (e.g. CO_2 and other Greenhouse Gases)

$$Emission_{t,y,v,p} = EnergyConsumption_{t,y,v} \cdot EmissionFactor_{t,v,p} \cdot EmDegradation_{t,y-v,p}$$

Emission results are calculated and then displayed in the Results View.

10.9 Transport Analysis

Energy consumption = stock of vehicles x annual vehicle mileage x fuel economy

Use the Demand Branch Properties screen to set-up a Transport Analysis ().

With this Demand Analysis methodology, energy consumption is calculated as the product of the number of vehicles, the annual average mileage (i.e. distance traveled) and fuel economy (e.g. liters per km or 1/MPG). The base year stock of vehicles is either entered directly or calculated from historical vehicle sales data and a lifecycle profile describing survival rates as vehicles age. In scenarios, you can enter projections for future sales of vehicles, and for future levels of fuel economy, vehicle mileage and environmental loadings of newly added vehicles. Other lifecycle profiles are used to describe how mileage, fuel economy and environmental loadings change as vehicles age. LEAP then calculates the stock average values for fuel economy, mileage and environmental loadings across all vintages and hence, ultimately, the overall level of energy consumption and environmental loadings.

Note: Unlike the other two demand analysis methods, which only allow emission factors to be specified per unit of energy consumed (e.g., kg/TJ), the Transport Analysis method also allows you to specify emission factors per unit of distance traveled by a vehicle (e.g. grammes/veh-mile), which is often more appropriate for regulated transport sector pollutant emissions.

10.10 Transport Analysis Variables

10.10.1 Stocks

When conducting a Transport Analysis you will need to specify information about the stocks and sales of devices or vehicles. This information is useful in situations where you want to more accurately model the costs of newly purchased devices or in situations where you want to model how a newly introduced energy efficiency, fuel economy or emission standard for sales of new technologies will translate into gradually improving overall average values across the total stock of devices (as new vehicles gradually replace older ones).

You must specify a lifecycle profile describing the age distribution of vehicles within that stock, together with the sales of devices in the base year. Future stocks of devices are calculated internally based on the software's vintaging calculations.

10.10.2 Sales

When conducting a Transport Analysis you will need to specify information about the stocks and sales of devices or vehicles. This information is useful in situations where you want to more accurately model the costs of newly purchased devices or in situations where you want to model how a newly introduced energy efficiency, fuel economy or emission standard for sales of new technologies will translate into gradually improving overall average values across the total stock of devices (as new vehicles gradually replace older ones).

Start by entering the base year stock of devices and specify a lifecycle profile describing the age distribution of vehicles within that stock, together with the sales of vehicles in the base year. In scenarios you specify future sales of vehicles. Stocks of vehicles are calculated automatically based on the software's vintaging calculations.

Fleet Roll Over

When conducting a Transport Analysis, the Current Accounts Sales screen has two additional columns, which can optionally be used to specify information about how Government and business fleet vehicles are "rolled over" into private fleets after a number of years. The two additional columns are:

- **Roll over Branch:** For Government and business fleet vehicles, use this field to specify the branch into which rolled over stock will be placed. Typically, you will specify that all Government and business fleet vehicles are rolled over into a single branch (see example below). Note that roll over calculations are optional. If you do not wish to model rollover, leave all items in the **Roll over Branch** column set to **<None>**.

- **Roll over Profile:** Use this column to specify a lifecycle profile that specifies when each type of fleet vehicle is to be rolled over to the private stock of vehicles. This profile needs to be a time series, starting at 100% for new vehicles (i.e. no roll overs) and descending over time as any surviving vehicles get rolled over into the private vehicle stock.

Note that in any given year, the number of vehicles rolled over for a given vintage will be the product of the number of surviving vehicles of that vintage and the (100% - the roll over profile value).

Annual Sales or Additions

Branch Name	2000 Expression	Scale	Units	Survival Profile	Fleets Rolled Over to Branch:	Roll Over Profile
Private	4.3	Million	Vehicle	Private Car ...	<None>	Constant
Business Fleet	2.1	Million	Vehicle	Business C...	Private	Business Car Rollover
Utility Fleet	2.5	Million	Vehicle	Governmen...	Private	Business Car Rollover
Government Fleet	1.8	Million	Vehicle	Governmen...	Private	Government Car Rollov

10.10.3 Mileage

Use this screen to specify the mileage of newly purchased vehicles of a given vehicle type. Mileage is defined as annual distance traveled per vehicle.

In Current accounts, you can select among various standard distance units (or you can even add your own on the Units screen). You can also optionally specify a lifecycle profile describing how mileage changes as vehicles age. If you do not have information on how mileage changes as vehicles age, simply leave the profile set to its default value of **Constant**.

Based on the mileage data you specify for newly purchased vehicles and the data you specified concerning vehicle stocks, sales and survival, the software will automatically calculate the stock average mileage. In the lower half of the screen you can use a toolbar to display either **New Vehicle Mileage** or **Stock Average Mileage** values as a chart or table.

When specifying Current Accounts mileage data, it can be important to specify historical values so that the software can accurately calculate the correct base year stock average value. If you simply specify a single value for the mileage of vehicles sold in the base year, then the software will assume that same value also applies to all vehicles sold in previous years. You can use Time-Series wizard to create an Interp function that specifies historical data for mileage.

10.10.4 Mileage Correction Factor

Overall vehicle mileage is calculated based on the data you specify for the **mileage of new vehicles** and the **mileage degradation profile** that describes how annual miles driven decreases as vehicles get older. These values are processed in LEAP's stock turnover calculations to yield the annual average mileage driven across the whole vehicle stock existing in each year.

You can specify a **mileage correction factor** to adjust the mileage value calculated for the total vehicle stock. This correction factor can be useful if you wish to create a model that examines driving rebound effects in which the miles driven in ALL vehicles (not just new vehicle) are responsive to certain policy variables such as the cost of gasoline.

10.10.5 Fuel Economy

Use this screen to specify the fuel economy of newly purchased vehicles of a given vehicle type ( ). Fuel economy is defined as energy consumption per unit of vehicle-distance traveled (or its inverse in the case of MPG).

In Current accounts, you can select among various standard units for specifying fuel economy data including miles per gallon (US and UK versions) and Liters per KM. You will also need to select the fuel used by the vehicle. You can also optionally specify a lifecycle profile describing how fuel economy worsens as vehicles age. Take special care with this profile. In the case of MPG fuel economy data this should be a constant or decreasing profile, while in the case of data specified in Liters per KM, the profile should be constant or increasing. If you do not have information on how fuel economy changes as vehicles age, simply leave the profile set to its default value of **Constant**.

When entering fuel economy data, the software can also help you convert values from one unit to another. Simply enter the value in one unit (e.g. MPG) and then select another unit (e.g. Liters/100 KM). LEAP will ask you if you wish to convert the value you entered. Notice also that you can enter data in any unit, and even mix units within an analysis. The software will automatically convert units to a common base unit during calculations, at which point you will also be able to review results in a wide range of different units.

The fuel economy data you enter, should represent the *on-road fuel economy of newly purchased vehicles*. Based on this data and the data you specified concerning vehicle stocks, sales and survival, LEAP will automatically calculate the stock average fuel economy. In the lower half of the screen you can use the toolbar shown below to display either **New Vehicle Fuel Economy** or **Stock Average Fuel Economy** values as a chart or table. You can also use the toolbar, to view the data in different units including MPG (US and UK), Liters per 100 KM or KW-hr per 100 KM (useful for electric and hydrogen/fuel cell vehicles).

When specifying Current Accounts fuel economy data, it can be important to specify historical values so that the software can accurately calculate the correct base year stock average value. If you simply specify a single value for the fuel economy of vehicles sold in the base year, then the software will assume that same value also applies to all vehicles sold in previous years. You can use Time-Series wizard to create an Interp function that specifies historical data for fuel economy.

10.10.6 Fuel Economy Correction Factor

Use the Demand Branch Properties screen to set-up a Transport Analysis for a demand technology. Technology branches at which transport analyses are being conducted are shown in the tree marked with the transport icon ( ).

The Fuel Economy Correction Factor variable is primarily useful when modeling U.S. vehicles in which the data on fuel economy provided by the Federal Government reflects a level of fuel economy that can be achieved in laboratory tests. Typically this value is higher than real-world levels of fuel economy that can be achieved on the road. A correction factor of about 0.8 is generally used to convert from "rated" to "on-road" fuel economies. Keep the default correction factor of 1.0 if your original fuel economy data reflects on-road conditions.

In LEAP's calculations, the Fuel Economy variable is combined with the fuel economy degradation profile data and processed in LEAP's stock turnover calculations to yield the stock average rated fuel economy. This value is then multiplied by the fuel economy correction factor to yield the stock average on-road fuel economy result.

10.11 Transport Analysis Calculations

Use the Demand Branch Properties screen to set-up a Transport Analysis for a demand technology. Technology branches at which transport analyses are being conducted are shown in the tree marked with the transport icon ( ).

For a given branch, the following equations describe the transportation calculations:

Stock Turnover and Stock Rollover

$$Stock_{t,y,v} = \left(Sales_{t,v} \cdot Survival_{t,y-v}\right) - RollOver_{t,y} + \sum_{\substack{f=1..T \\ f<>t}} RollOver_{f,y}$$

$$RollOver_{t,y} = Sales_{t,y} \cdot Survival_{t,y-v} \cdot \left(1 - RollSurvival_{t,y-v}\right)$$

$$Stock_{t,y} = \sum_{v=0..V} Stock_{y,v,t}$$

Where:

t is the type of vehicle (i.e. the technology branch)

v is the vintage (i.e. the model year)

y is the calendar year

T is the number of types of vehicles

Sales: is the number of vehicles added in a particular year: entered as an expression.

Stock is the number of vehicles existing in a particular year: either entered as an expression for Current Accounts or calculated internally based on historical sales.

Survival is the fraction of vehicles surviving after a number of years: entered as a lifecycle profile.

V is the maximum number of vintage years: determined automatically from the survival lifecycle profile, with a maximum of 30 years.

Rollover is the number of vehicles that get "rolled over" (i.e. sold) from government or business fleets into the private vehicle stock.

RollSurvival is the fraction of surviving vehicles that remain in the government or business fleet: entered as a lifecycle profile.

For example, the remaining stock of government cars built in 1990 in the calendar year 2000 will be the sales of those cars in 1990 times the fraction that survive 10 years (2000-1990) minus the number roll over into the private stock. NB: for any given type of vehicle (private, government, business, etc.) rollover can only occur in one direction. That is, cars cannot be both rolled-into and rolled-out of the stock.

Fuel Economy

$$FuelEconomy_{t,y,v} = FuelEconomy_{t,v} \cdot FeDegradation_{t,y-v}$$

Where:

FuelEconomy is fuel use per unit of vehicle distance traveled (i.e. 1/MPG). Entered as an expression.

FeDegradation is a factor representing the decline in fuel economy as a vehicle ages. It equals 1 when y=v. Entered as a lifecycle profile.

Mileage

$$Mileage_{t,y,v} = Mileage_{t,v} \cdot MlDegradation_{t,y-v}$$

Where:

Mileage is annual distance traveled per vehicle. Entered as an expression. *MlDegradation* is a factor representing the change in mileage as a vehicle ages. It equals 1 when y=v. Entered as a lifecycle profile.

Energy Consumption

$$EnergyConsumption_{t,y,v} = Stock_{t,y,v} \cdot Mileage_{t,y,v} \cdot FuelEconomy_{t,y,v}$$

10.11.1.1. Distance-Based Pollution Emissions (e.g. Criteria Air Pollutants)

$$Emission_{t,y,v,p} = Stock_{t,y,v} \cdot Mileage_{t,y,v} \cdot EmissionFactor_{t,v,p} \cdot EmDegradation_{t,y-v,p}$$

Where:

P is any criteria air pollutant.

EmissionFactor is the emissions rate for pollutant p (e.g. grammes/veh-mile) from new vehicles of vintage v. Entered as an expression.

EmDegradation is a factor representing the change in the emission factor for pollutant p as a vehicle ages. It equals 1 when y=v. Entered as a lifecycle profile.

Energy-Based Emissions (e.g. CO_2 and other Greenhouse Gases)

$$Emission_{t,y,v,p} = EnergyConsumption_{t,y,v} \cdot EmissionFactor_{t,v,p} \cdot EmDegradation_{t,y-v,p}$$

Emission results are calculated and then displayed in the Results View.

11 Transformation

In a Transformation analysis, you simulate the conversion and transportation of energy forms from the point of extraction of primary resources and imported fuels all the way to the point of final fuel consumption. As with your demand analyses, alternative scenarios can be used represent different future Transformation configurations reflecting alternative assumptions about policies and technologies.

The general data structure of a Transformation analysis is shown on the right.

> **Modules:** Under the top Transformation branch you can add any number of modules. A module is a branch representing an energy conversion sector such as electricity generation, oil refining, district heating, charcoal making, transmission and distribution, etc. Note that the ordering of modules will affect your calculated results. Energy flows from the primary resources listed at the bottom of the screen up through each of the Transformation modules, until it is eventually consumed in the Demand devices listed in your Demand analysis. At the module level, you also define the basic parameters for simulating the operation of the energy industry, such as whether you wish to specify capacity restrictions, and how you want to simulate the dispatch of different processes.
>
> **Processes:** Below each module, you can create any number of processes. Processes represent the individual technologies that convert energy from one form to another or transmit or distribute energy, such as individual power plants or groups of power plants. Processes are grouped under a single category branch labeled "Processes". For each process, you define technology data such as capacities, efficiencies, capacity factors, capital and operating and maintenance costs.
>
> > **Feedstock Fuels:** Each process has one or more feedstock fuels. Feedstocks are the fuels converted within the process itself, such that the efficiency of a process is defined as the ratio of the total energy content of all output fuels produced by the process divided by the total energy content of all feedstock fuels consumed.
> >
> > **Auxiliary Fuels:** Each process can optionally have one or more auxiliary fuels. Auxiliary fuels are used to represent subsidiary or own-use energy consumption in a Transformation process, such as electricity used in an oil refinery or the own-use of electricity in a power plant.
>
> **Output Fuels:** Each module has one or more output fuels. The module's processes are dispatched to try and meet any requirements for its output fuels. You can choose either to specify each fuel's share of the total energy output from a module, or to have LEAP calculate output shares on the assumption that they are proportional to the requirements on the module. NB: note that output fuels are specified for the module as a whole. In general, you can specify separate outputs for each process. However you can optionally specify a single co-product fuel (e.g.,

heat), which is only produced by some processes. Go to the module properties screen to specify a co-product fuel.

Transformation calculations are driven by the results of the your Demand analysis. Succeeding modules satisfy one set of fuel requirements but create another set of input requirements. (For example, an electricity generation module meets requirements for electricity but creates additional requirements for its own feedstocks. The final outcome of calculating all modules is a set of requirements for primary resources (fossil-fuel or renewable) and for imports of fuels into the Area.

11.1.1 Set Up

There are four basic steps involved in setting up a Transformation model:

1. **Identify Modules to Include**: A module represents an energy industry or sector such as electricity generation, oil refining, district heating, charcoal production, or electricity transmission and distribution. You will want to include all current modules, and, depending on the time-scale of your analysis any planned or potential future modules, even those that may not yet be significant, such as cogeneration, biofuel production, and perhaps even hydrogen production. One starting point would be to examine the rows in the conversion section of an energy balance to identify the modules for the area you are studying. Alternatively, you can work from the module structure which exists in LEAP's default data set. By editing the tree in your LEAP area, you can change the default module structure. Modules can be added, deleted or changed to fit your study's requirements.

2. **Sequence Modules:** Make sure you arrange modules on the tree into a correctly ordered list. The ordering of the modules reflects their position in the sequence of energy flows through an area. Thus, transmission and distribution modules are normally placed near the top (close to Demand), conversion modules such as electricity generation are placed in the middle, and primary resource extraction modules are placed at the bottom of the list.

3. **Set Module Properties:** In setting-up each module, it is important to consider how each module is to be represented. For example, whether you wish to model capacity constraints, or whether you want to assume that a module can always meet its requirements. Modules without capacity restrictions require less data and are generally easier to set-up and debug, but may not accurately reflect real-world situations.

4. **Determine Level of Detail and Enter Data**: Another important consideration is the level of detail to include in each module. Each module is divided into one or more processes. A process describes an individual technology or a group of technologies. You need to decide whether you wish to include each individual technology (e.g. each power plant) or whether you want to model groups of similar technologies as a single process (e.g. all diesel peaking plants). While

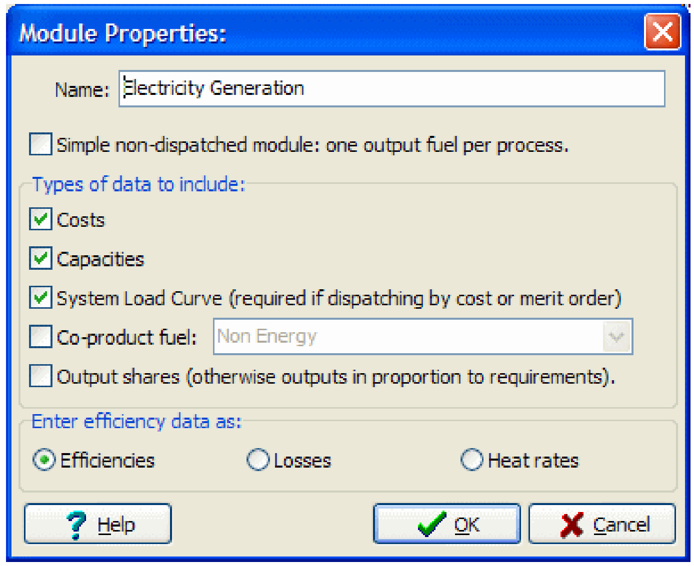
there are no particular limits on the number of processes you can include in each module, bear in mind that the more processes you include, the more complex your model will be to set-up, interpret and debug and the slower your calculations will be. For each process, you enter technical data such as capacities, efficiencies, and output fuels. You can also enter cost data, and describe the environmental loadings of feedstocks and auxiliary fuels through links to TED.

11.1.2 Transformation Data

The data you need to enter for a Transformation module, depend on the properties you set for each module, and in particular whether or not you choose to enter capacities and costs, and which dispatch rule you specify. Use the Module Properties screen to set these options.

11.2 Module Data

11.2.1 Module Properties



Use the Module Properties screen to edit the name and set the properties of each Transformation module. These settings will determine which data are shown in the Analysis View, and how the module will be treated during LEAP's calculations. Notice that some settings will only be visible when other settings have been chosen. In particular, when you choose **Simple Non-Dispatched Module**, most settings will be hidden.

There are two types of modules:

- **Simple, Non-Dispatched Modules:** Check the box if you wish to create a Simple Non-Dispatched Module. These are used in cases where you have one or more independently dispatched processes, each of which has its own output fuel. This type of module is particularly useful when you want to represent transport losses in a number of different fuels. For this type of module, the separate output fuels branch category is not used. Instead, you pick the output fuel for each process on the efficiency or loss tab. See the schematic diagrams below of simple modules and standard modules.

- **Standard Modules:** in which multiple processes are dispatched to try and meet the requirements for one or more output fuels. If you wish to examine capacity constraints or specify a load curve for power then you must use a standard module.

Types of Data to Include

Use these settings specify which types of data are to be entered for the module.

- **Costs:** If you do not intend to include cost data, then un-checking this setting will reduce the number of data tabs shown on the process data entry screens.

- **Capacities:** Processes without capacity data operate without capacity restrictions. These processes require less data and are generally easier to set-up and debug, but may not fully reflect real-world situations. Note also, that if you leave this setting unchecked then other options such as simulating system loads and dispatching processes by merit order will be unavailable.

- **System Load Curve:** Check this option if you wish to examine how a module's processes are dispatched to meet both the annual energy and instantaneous power requirements on a module. This option is required if you wish to dispatch processes by merit order or running cost. This option generally is relevant only when modeling electricity generation systems in which it is important to simulate both the annual demand for energy as well as how plants are dispatched to meet the instantaneous demand for power. This option is available only if "Capacities" is also checked.

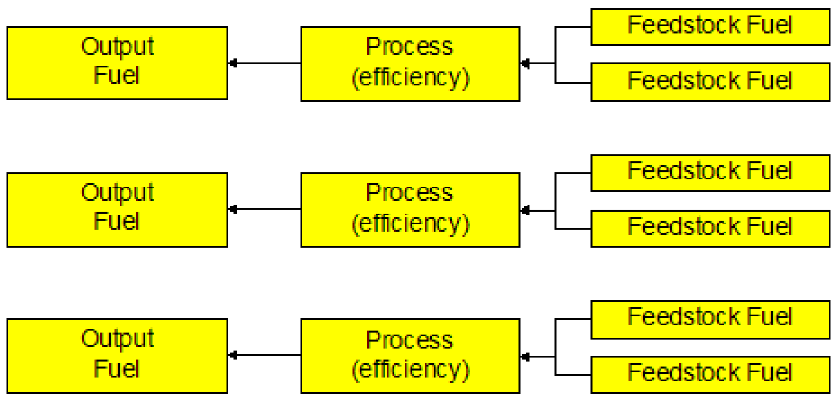
- **Co-product Fuel:** If you wish to simulate one or more processes that co-generate heat and electricity, then check this setting and select the co-generated fuel. Typically, you will specify electricity as your main Output fuel, and heat as the co-product fuel or vice-versa. This approach is generally recommended instead of specifying two separate output fuels, since it allows each process to produce different fractions of heat and electricity (by specifying separate efficiencies for the main output fuel(s) and the co-generated fuel). Note also, that it is possible to specify that only a subset of processes produce a co-product. For example, some thermal plants may produce heat, while hydro and wind plants will not. This is done by entering different values for the co-product share for different processes.

- **Output Shares:** Use this box to specify whether you want to explicitly enter data on Output Shares (the share of total energy output from provided by each fuel). If this setting is not checked, then output shares will be calculated in proportion to the requirements on the module. This option has no effect if a module has only one output fuel.

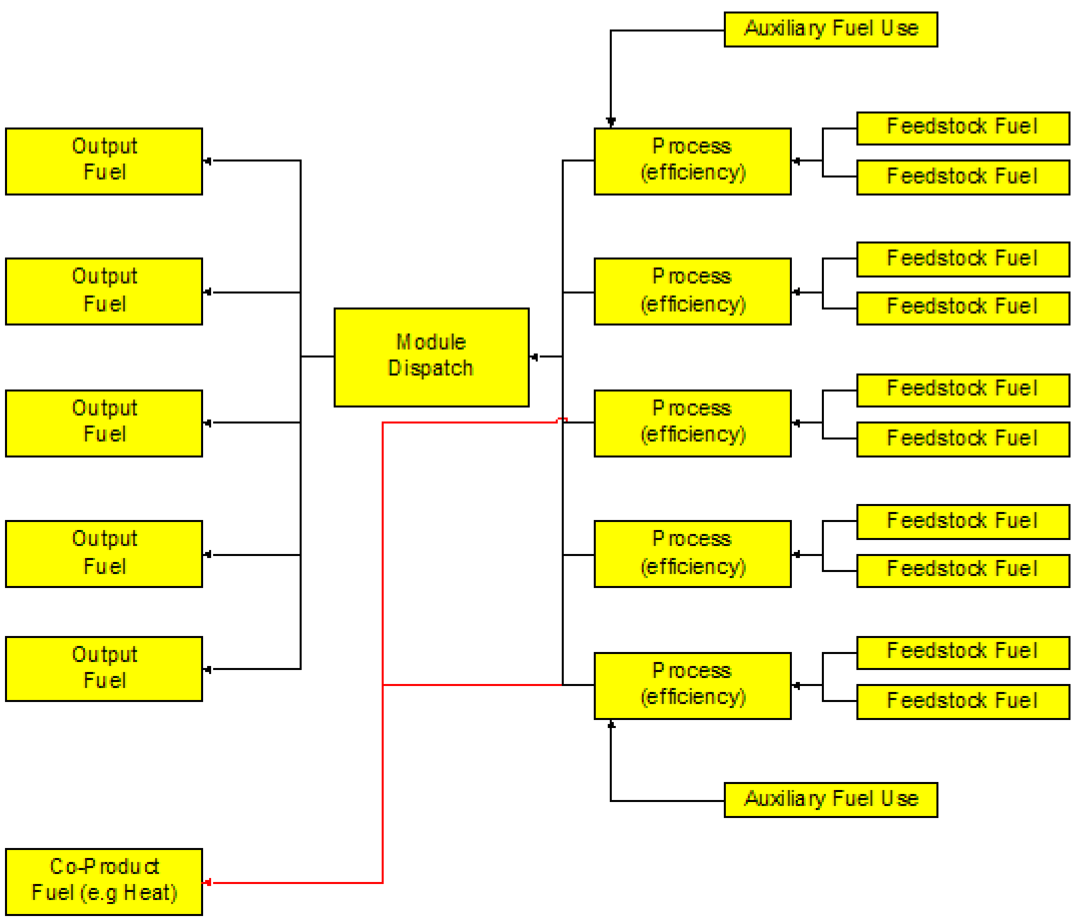
Enter Efficiency Data As

Use this box to specify how efficiency data is to be entered: as a percentage thermal efficiency (i.e. energy output per unit of energy input), as a heat rate (i.e. energy input per unit of energy output), or as a percentage loss. Note that when using heat rates, all processes must be specified with the same units (e.g. TOE/MWhr).

11.2.2 Simple Module Schematic



11.2.3 Standard Module Schematic



11.2.4 Module Costs

NB: Cost data is shown only if the **Cost Data** checkbox has been checked in the Module Properties screen.

Use the Module costs variable to specify costs for a whole module that do not vary per unit of capacity or energy consumed, as do the capital and operating & maintenance costs specified for each process.

Module costs can be useful for specifying one-time expenses such as a program to reduce to reduce the system load factor, or to reduce transmission and distribution losses.

11.2.5 Planning Reserve Margin

The planning reserve margin is used by LEAP to decide when to automatically add additional endogenous capacity. LEAP will add enough additional capacity to maintain the planning reserve margin on or above the value you have set.

Planning reserve margin is defined as follows:

*Planning Reserve Margin (%)= 100 * (Module Capacity - Peak) / Peak*

*Module Capacity = Sum(Capacity * Capacity Value)*
for all processes in the module.

Peak load is calculated based on the requirements for electricity and the module load factor (which may itself be based on the shape of a module load curve). Electricity requirements are calculated based on your energy demand analysis and any upstream electricity losses (for example in a Transmission and Distribution module).

11.3 Process Data

11.3.1 Process Dispatch Rule

The **Process Dispatch Rule** sets how a process is dispatched on and after the First Simulation Year. When dispatching processes to try and meet the energy and power requirements for each module, LEAP can operate in two different modes as follows:

- **Historical Dispatch** is used in each year before the first simulation year. In these years, LEAP runs each process up to the amount specified in the Historical Production variable.
- **Simulation:** From the first simulation year onwards, LEAP simulates dispatch using the **Process Dispatch Rule** specified for each process.

Process Dispatch Rules are set in Current Accounts for each process and cannot be varied across scenarios (although you can set different rules for each region). There are 5 different rules to choose from, but bear in mind that only some of these rules may be available depending on the data you choose to specify for the module. Use the Module Properties screen to indicate the types of data defined at each module.

Dispatch Rules

- **By Process Share:** This is the simplest rule in which you simply specify that a process will run to meet a certain percentage fraction of the requirements on the module (so long as their is sufficient available capacity). For example, you may wish to specify that an electricity module produces 50% of its electricity from coal, 20% from hydro and 30% from natural gas. These shares can change over time. This rule is useful if you have results taken from the calculations of another model that you wish to include in LEAP. For example: if you have separate electric sector projections of plant operation, you could enter those results in LEAP to check the validity of sectoral plans against the integrated planning viewpoint in LEAP.

The following are available only if capacity data are also specified:

- **In Proportion to Available Capacity:** With this rule, processes are dispatched to try and meet the requirements on a module. If the available capacity exceeds the amount needed to meet requirements then each process will be dispatched in proportion to its available capacity (Capacity * MCF). For example, if two plants are defined and one is rated at twice the available capacity of the other then they will run to produce outputs in a ratio of 2:1.
- **Run to Full Available Capacity:** With this rule, processes are run to produce their full available capacity regardless of the requirements on the module. You can use this option to simulate export-driven energy industries for which the level of domestic requirements are unimportant (e.g., an export driven refinery).

The following are available only if capacity and system load curve data are both specified:

- **In Ascending Merit Order:** Use this option to simulate the dispatch of electric generation power plants to meet both the annual demand for electricity as well as the instantaneous demand for power in different periods of the year. Plants will be dispatched according to their specified merit orders as defined in the Merit Order variables. Each plant will be run (if necessary) up to the limit of its maximum capacity factor in each dispatch period.

The following is available only if capacity, system load curve and costs data are all specified:

- **In Ascending Order of Running Cost**: This option is similar to the "merit order" option except that processes will be dispatched in ascending order of their overall running costs (defined as variable cost + fuel cost).

11.3.2 First Simulation Year

In earlier versions of LEAP you could only set historical production for the base year (in a variable called **Base Year Output** that has now been removed). In the latest versions of LEAP you can specify historical production for any years before the first simulation year. Moreover, this year can vary between processes.

Tips:

1. If you want dispatch to be simulated in ALL years (i.e. you want LEAP to never use Historical Production values) then set the First Simulation Year to a year before the base year.
2. Conversely, if you want LEAP to always use historical production values set the First Simulation Year to a year after the study end year.

11.3.3 Process Shares

If you have chosen to dispatch processes by entering process shares on the Process Dispatch Rules screen you will use this screen to enter the percentage share of energy requirements met by each process.

Because you can mix and match different dispatch rules it is possible to dispatch some processes by share and others by merit order. For example, you may wish to model a renewable portfolio standard that requires that (say) 15% of electric generation comes from wind and other renewable sources. These can be modeled using a percentage share dispatch, while other conventional power plants can be dispatched by merit order. For this reason, process shares do not need to sum to 100%, although they should sum to less than or equal to 100%.

11.3.4 Merit Order

The Merit Order of a process indicates the order in which it will be dispatched. The merit order variable is only shown when you have specified that a Transformation module's properties include capacity data and system load curve data, and is only used in a dispatch simulation if the Process Dispatch Rule is set to dispatch "in ascending merit order".

Processes with the lowest value merit order are dispatched first (base load) and those with the highest merit order are dispatched last (peak load). Processes with equal merit order are dispatched together in proportion to their available capacity (Capacity * Maximum Capacity Factor). Merit order values can be input as simple numbers or as expressions, just like other LEAP variables. Also just like other LEAP variables they can vary by scenario and over time (from year to year).

Merit order is defined for each *dispatch period* in a year. If the system load shape is defined exogenously (as a load curve entered at the module level) then only one dispatch period will be defined. However, if your system load shape is calculated endogenously then there may be up to four different dispatch periods and a merit order will have to be defined for each dispatch period. This allows processes to be dispatched differently in different seasons of a year. For example, a hydro plant may be dispatched as base load (merit order = 1) in a wet season and as peak load in a dry season. The General: Time Slices screen is used to view and edit how a year is divided into different dispatch periods. Use the **Load** tab on the General Basic Parameters screen to set whether the system load shape is defined exogenously or calculated endogenously.

11.3.5 Interest Rate

The real interest rate in percentage points used to annualize Transformation Capital costs, using the standard mortgage formula.

11.3.6 Lifetime

The life (in years) of a process. This variable is used to calculate when processes added under the endogenous capacity tab will be retired and replaced, thus incurring additional capital costs. Capacity specified on the exogenous capacity tab is NOT automatically retired. The lifetime variable is also the period used when amortizing Transformation capital costs.

11.3.7 Efficiency

Process efficiency data can be specified in three different ways: as a percentage efficiency, as a heat rate or as the percentage energy losses. You can set which method you want to use, by editing the module properties.

- **Efficiency:** The default method is to specify the percentage ratio of energy outputs (not including any co-product energy recovered) to feedstock energy inputs in each process. All efficiencies must be greater than zero. When entering efficiencies for processes, around 33% is typical for base-load steam generation. This also may be used as a nominal value for hydro-electric stations so that primary resource requirements for fossil fuels and hydro can be easily compared. Another common approach is to use a 100% efficiency for hydropower and renewable electricity generation systems. If you specifically enter imports as one of the process types, enter 100% for their efficiencies.

- **Heat Rate:** Efficiency data can also be specified as a heat rate (the rate of feedstock fuel required per unit of energy produced - efficiency data is often expressed in this form for electricity plants).

- **Losses:** Efficiency can also be specified as the percentage of energy lost in a process. This approach can be useful for specifying transmission and distribution systems.

11.3.8 Maximum Capacity Factor

The Maximum Capacity Factor (MCF) of a process is the ratio of the maximum energy produced to what would have been produced if the process ran at full capacity for a given period (expressed as a percentage). MCF is normally specified as the maximum average technical capacity factor defined by planned and forced outages. MCF data is entered along with capacity data, and the product of the two is the maximum available capacity in any given period.

The MCF variable is only shown when you have specified that a Transformation module's properties include capacity data.

The MCF variable is defined for each dispatch period in a year. If the system load shape is defined exogenously (as a load curve entered at the module level) then only one dispatch period will be defined. However, if your system load shape is calculated endogenously, then there may be up four different dispatch periods and MCF data will have to be defined for each dispatch period. The General: Time Slices screen is used to view and edit the how a year is divided into different dispatch periods.

Use the **Load** tab on the General Basic Parameters screen to set whether the system load shape is defined exogenously or endogenously.

11.3.9 Exogenous Capacity

Capacity data can be specified in two different ways in a Transformation analysis:

- **Exogenous Capacity** values are explicitly entered by the user, and are normally used to reflect existing capacity as well as planned/committed capacity additions and retirements. Notice that in all years you need to specify total capacity, NOT additions and retirements.

- **Endogenous Capacity** values are those capacity values calculated internally by LEAP in order to maintain a minimum planning reserve margin. Endogenous capacity additions occur in addition to the exogenous level of capacity specified on the **Exogenous Capacity** data table**.**

- In either case, bear in mind that the capacity variable is only available if you specify on the Module Properties screen to that capacity data is to be entered for a module.

Tip: For exogenous capacity additions and retirements, you can use the Time Series Wizard to specify a Step function that lists the capacity values in any year when an addition or retirement takes place

11.3.10 Endogenous Capacity

Capacity data can be specified in two different ways in a Transformation analysis:

- **Exogenous Capacity** values are explicitly entered by the user, and are normally used to reflect existing capacity as well as planned/committed capacity additions and retirements.

- **Endogenous Capacity** values are those capacity values calculated internally by LEAP in order to maintain a minimum planning reserve margin. Endogenous capacity additions occur in addition to the exogenous level of capacity specified on the **Exogenous Capacity** data table**.**

- In either case, bear in mind that the capacity variable is only available if you specify on the Module Properties screen to that capacity data is to be entered for a module.

Because endogenous capacity additions can only occur in future scenario years, the Endogenous capacity tab is only available when editing scenarios. It is not visible for Current Accounts.

For endogenously added capacity, instead of specifying the total capacity additions and retirements, you create a list of the processes that are available to be added, and specify the addition size and order of addition for each process. For example, if the type of power plants that are expected to be added to an electric system consist of 500 MW coal steam power plants, balanced by 300 MW oil combustion turbines, then you would enter the following information:

Endogenous Capacity Additions (Megawatt)

Processes added to maintain planning reserve margin defined for module (35% in 2000)

Addition Order	Build Order	Process	Addition Size 2001-2030 Expression
1	0	New Coal Steam	500
2	0	New Oil CT	300

Notice that the onus is on you to make sure that the plants specified will maintain a good balance between base load and peak load plants. In the screen shown above, 500 MW of coal steam plant will be added first (i.e. the process with addition order = 1), followed by 300 MW of oil combustion turbine plants (addition order = 2). Should further additions be required in any given year to maintain the reserve margin above the value specified on the Planning Reserve Margin screen, then a further 500 MW of coal will be built, followed by a further 300 ME of oil and so on. Click the **Add** button ( ) to add a process to the list. You can select any process already defined within the module. Click the **Delete** button ( ) to remove the process from the list. Notice that deleting the process here does not delete it from the tree. Use the Up ( ) and Down ( ) buttons to change the order of the processes in the list (i.e. the order in which LEAP cycles through the processes during the endogenous expansion calculation). When each endogenously added process reaches its specified lifetime, it will be automatically retired (and additional processes added if necessary). When specifying, the addition size, you can use

LEAP's built in expressions to specify different addition sizes as a function of years using a conditional function of the following type:

If(Greaterthan(Year, X), AdditionSizeFirstPeriod, AdditionSizeSecondPeriod)

Where X is any year, *AdditionSizeFirstPeriod* is the addition size on or before year X and *AdditionSizeSecondPeriodand* is the addition size after year X.

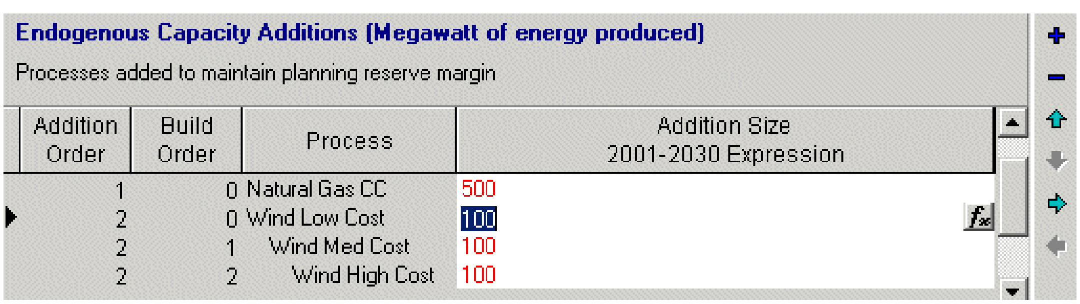
Note that the year in which LEAP starts adding endogenous capacity will depend upon such factors as:

- How quickly electricity requirements increase.
- The initial reserve margin (if it is much higher than the planning reserve margin then LEAP may not add extra capacity for many years), if its starting value is less than the planning reserve margin, LEAP will start adding capacity in the year after the base year.
- Whether any capacity is added exogenously.

11.3.10.1 Specifying a Supply Curve

You can also use this screen in conjunction with the "Maximum Built Capacity" variable to specify a supply curve for any given addition order in which one process is built first (up to its maximum built capacity) and thereafter another process is added. Typically, currently available and/or cheaper technologies will be built first. Use the button to mark a process as a next generation technology with a later "build order". This process will be shown on screen indented compared to the process above it, and during calculations will only be added once the "maximum built capacity" of the earlier generation process has been reached. Use the button to reverse this.

In the example shown below, 3 different classes of wind resources each with different and ascending costs, and each with different amounts of the resource available are specified as separate processes in LEAP, and then added the endogenous capacity screen as shown below with build orders. All three have the same addition order, but are arranged in ascending "build order" to reflect their increasing costs.



11.3.11 Maximum Built Capacity

Maximum Built Capacity specifies the maximum amount of capacity that can be built of a given process. Use it in conjunction with the Endogenous Capacity feature to construct supply curves in which one process is built first (up to its maximum built capacity) and thereafter one or more processes of another type are added. Typically, currently available and/or cheaper technologies will be built first.

For more information, refer to help on Endogenous Capacity.

11.3.12 Capacity Value

Capacity values are only used when calculating endogenous capacity additions. The capacity value is defined as the fraction of the rated capacity considered firm for the purposes of calculating the module reserve margin. For thermal power plants the value is normally 100%. Lower values can be used for intermittent and hydro renewable power plants reflecting their lower average availability. Some plants assumed to have no firm capacity can even have zero values (for example imported electricity may sometimes have no firm capacity).

Note: when specifying endogenous capacity, make sure that at least some of the plants listed on that screen have a reserve margin greater than zero. Endogenous capacity is added to maintain the specified planning reserve margin, so any plants with zero capacity value will not contribute at all to increased reserve margin.

Tip: To a first order of approximation, the capacity value of a renewable plant can be assumed to be equal to the ratio of the maximum capacity factor of the plant and the capacity factor of a standard thermal plant.

11.3.13 Historical Production

This variable specifies annual energy production (output) for a process. You can set the scale and units used to measure the variable in each module.

When dispatching processes to try and meet the energy and power requirements for each module, LEAP can operate in two different modes as follows:

- **Historical** dispatch is used in each year before the first simulation year. In these years, LEAP simply runs each process up the amount specified in the Historical Production tab. If the amount specified in the Historical Production tab would cause the process to exceed its maximum available capacity, LEAP will display a diagnostic error message.

- **Simulation:** From the first simulation year onwards, LEAP simulates dispatch using the Process Dispatch Rule specified for each process.

In earlier versions of LEAP you could only set historical production for the base year (in a variable called Base Year Output that has now been removed. In the latest versions of

LEAP you can specify historical production for any years before the first simulation year. Moreover, this year can vary between processes.

Tips:

1. If you want dispatch to be simulated in ALL years (i.e. you want LEAP to never use Historical Production values) then set the First Simulation Year to a year before the base year.

2. Conversely, if you want LEAP to always use historical production values set the First Simulation Year to a year after the study end year.

11.3.14 Transformation Capital and O&M Costs

NB: Cost data is shown only if the **Cost Data** checkbox has been checked in the Module Properties screen.

You may enter cost data for any process. However, for a comparative analysis of scenarios, you need only enter costs for processes which differ (in terms of energy consumption or production) from your baseline scenario. Three different types of costs can be specified in a Transformation analysis:

- **Capital Costs:** Use this tab to enter the total (i.e., non-annualized) capital costs per unit of capacity of each process. Capital costs should reflect all direct construction costs and any capitalized finance costs. Use the selection boxes at the top of the screen to select a scale and unit for the costs entered data. Capital costs are annualized in LEAP's cost-benefit calculations, based on the lifetime of each process, and the interest rate charged on the capital cost. The total capital cost is annualized into a stream of equal annual payments, starting in the year when any new capacity (either exogenously specified or endogenously specified) comes on line and lasting for the lifetime you enter

- **Operating and Maintenance Costs:** You can enter both fixed and variable operating and maintenance (O&M) costs. Fixed O&M costs are incurred regardless of the energy produced by a process, and are entered per unit of capacity. Variable O&M costs are entered per unit of energy produced. Note that if a module does contain capacity data, you may only enter variable O&M costs to represent the combined annualized capital and operating and maintenance (O&M) cost of each process.

  For capital costs only, you should enter a recovery period and the project interest rate. These parameters are used to annualize the total capital cost into a stream of equal annual payments, starting in the year when any new capacity comes on line and lasting for the recovery period you enter. Ensure that the financial recovery period you enter is consistent with the lifetime of the processes being constructed. LEAP does not simulate construction or any other financial costs incurred before a plant comes on-line.

- **Fuel Costs:** Fuel costs are used only if you choose to dispatch processes by running cost on the Module Properties screen. In this case, processes will be dispatched in ascending order of their overall running costs (defined as variable cost + fuel cost). To avoid double counting of fuel costs and benefits, module fuel costs do NOT form part of LEAP's overall cost-benefit calculations. See LEAP's costing methodology for more information.

11.3.15 Co-product

The production of a co-product from a module specified by entering the percentage fraction of the total energy input recovered from each process in a module. One co-product can be produced from each module and each process may produce different fractions. To use this feature, check the Co-product box on the Module Properties screen and select a fuel in the Co-product field. The co-product fuel must not be listed as an output fuel so it cannot be used to meet export targets, nor can additional "gap-filling" imports be specified to make up any shortfalls. Surpluses of co-product fuels are assumed to be wasted.

When a co-product fuel is defined, an additional data entry table appears in which you can enter the percentage of the energy in the input fuel which can be recovered as the co-product. Different values can be entered for each process, but the values must be less than 100% minus the percentage energy efficiency of each process.

11.3.16 Feedstock Fuels

Processes can have any number of feedstock fuels. Feedstocks are the fuels converted within the process itself, such that the efficiency of a process is defined as the ratio of the total energy content of all output fuels produced by the process divided by the total energy content of all feedstock fuels consumed. For each feedstock fuel, its fuel share is the percentage share of energy input it provides to its parent process. Typically, most process will have only one feedstock fuel, and hence the fuel share should be set to 100% in Current Accounts. Note that feedstock fuels are distinct from auxiliary fuels. Feedstocks are the fuels converted within the process, while auxiliary fuels are specified as energy consumed per unit of energy consumed or produced in a process. Auxiliary fuels reflect subsidiary fuel consumption in a process. They are NOT converted in a process, and hence their energy content is not included in how the overall energy efficiency of the process is calculated.

For each feedstock fuel you can also specify environmental effects, by creating a link on the Environment tab to a technology listed in the TED database.

11.3.17 Auxiliary Fuels

For each process you can specify one or more auxiliary fuels. Auxiliary fuels are specified as energy consumed per unit of energy consumed or produced in a process. Unlike feedstock fuels, auxiliary fuels are NOT converted in a process, and hence their energy content is not included in how the overall energy efficiency of the process is calculated. Auxiliary fuels are a useful of way of representing subsidiary or own-use energy consumption in a Transformation process, such as electricity used in an oil refinery or own-use of electricity in a power plant.

For each auxiliary fuel you can also specify environmental effects, by creating a link on the Environment tab to a technology listed in the TED database.

11.4 Outputs

Use the Output Fuels Properties screen to set the basic properties of each fuel produced by a module. There are no particular limits on the number of output fuels from each module. Notice though that all processes in a module produce the same set of output fuels, and each process produces those fuels in the same proportions.

11.4.1.1 Fuel

Select a fuel produced by the module from the fuels pull down menu. Fuels correspond to the ones listed in the Fuels Screen.

11.4.1.2 Production Priority

When a module has more than one output fuel, and if the module Dispatch Rule is not set to **Run to Full Capacity**, then one or more of the output fuels can be selected as a priority fuel. Processes will then be dispatched to meet the sum of domestic requirements + export targets - minimum imports for only the priority output fuels. Non-priority fuels are regarded as by-products of a module. That is, they are produced according to the Output Shares you enter, but processes are not dispatched specifically to meet their requirements.

If a module has only one output, or if the module dispatch rule is set to **Run to Full Capacity**, the Priority Fuel field will not be displayed. Also, if you set the Output Shares option to Proportional to Requirements (by leaving the box empty on the Optional Data Screen in the Module Properties Wizard), then priority fuels again need not be specified, since outputs will be produced in the same proportions as the module fuel requirements.

Consider the following example of a refinery producing 1200 units of three fuels: kerosene, gasoline and fuel oil, of which gasoline and kerosene are priority fuels, and fuel oil is a by-product. In the table shown below, note that the output mix from the refinery does not match the requirements for the fuels produced. The requirements for one of the priority fuels (gasoline) is met exactly, while a surplus of the other (kerosene) is produced. You can specify what happens to this surplus by setting the Surplus field to Export Surplus or Waste (see below). The requirements for fuel oil are not met.

Fuel	Production Required	Output Energy Share	Priority Fuel?	Energy Produced	Outcome
Kerosene	400	55%	Yes	660	Surplus
Gasoline	300	25%	Yes	300	Exact
Fuel Oil	300	20%	No	240	Shortfall
Total	**1000**	**100%**		**1200**	

11.4.1.3 Surplus Production

Surplus outputs can either be assigned to exports or can be left unused (wasted). You can use this feature to simulate cases such as the flaring of natural gas where useful energy is not fully utilized. Surpluses can arise either when a module is set to operate at full capacity (regardless of requirements) or when a module has two or more outputs that are priority fuels. In this latter case, a surplus occurs because the output mix from (say) a refinery is likely to be in different proportions than the requirements for the fuels produced. In such cases, the requirements for one of the fuels will be met exactly, and the rest will be met in surplus.

11.4.1.4 Shortfall in Production

Where shortfalls of outputs exist they can either be filled by additional "gap-filling" imports or some requirements will simply remain unmet in the module. The occurrence of shortfalls in a module does not necessarily indicate that overall supply does not meet demand. You may wish to simulate a system of modules in which two or more modules produce the same output fuel. For example, electricity generation may be simulated in both a central generating module and in an isolated or cogeneration module. In these cases, a shortfall in the first module may be filled by the output from the second module.

11.4.2 Output Shares

Output shares are the share of total energy output from a module provided by each output fuel. Output shares need only be entered when a module has more than one output fuel, and when you have chosen to enter output shares explicitly, by checking the **Output Shares** box on the Module Properties screen. If this box is not checked, all outputs will be assumed to be in proportion to the requirements on the module.

11.4.3 Imports

Imports can be specified explicitly, or they can be calculated endogenously as a "gap-filling" measure to make up for shortfalls of module outputs.

To simulate cases where importing energy is considered preferable to domestic production of a fuel, minimum import targets can be entered to (partially) meet domestic requirements before a module is operated. These imports are used to meet the domestic requirements and export targets of a module and so will reduce the operation of the module. Specify these types of imports on the **Import Target** Data Entry Table. Use the scale and units selection boxes at the top of the screen to select the units for the values you enter. Note that: calculated imports will not necessarily be as large as the minimum imports you enter. The actual level produced will be limited to no more than the sum of the domestic requirements plus the export target for the module.

You can also separately specify "**gap-filling**" imports that will make up for any shortfalls in output. To switch on these types of imports, make sure you select **Import fuel to meet shortfall** on the Output Fuel Properties screen. Otherwise, in the event of outputs being less than requirements, some requirements will remain unmet in the module, although subsequent downstream modules may be able to produce the fuel.

11.4.4 Exports

Fuel export targets are specified on a module by module basis in LEAP. Export targets are added to the domestic requirements which drive each module's operation. In addition, exports may occur as a result of a module producing fuels in surplus to the requirements. In these circumstances, if you want surplus fuels to be exported, make sure you select **Export Surplus** on the Output Fuel Properties screen. Otherwise, surplus outputs will simply be assumed to be wasted (lost).

11.5 Transformation Calculations

Transformation calculations are demand-driven. That is, each module is operated to meet the demands that arise from domestic requirements and export demands (net of any minimum specified level of imports). For the first calculated module (the one closest to demands), domestic requirements are set equal to final demands (see Demand Calculations). After each module is calculated, domestic requirements are decremented by the outputs produced from the module, but incremented by the input fuels required by the module. Ultimately the calculation yields the requirements for primary resources (fossil and renewable), which can be compared to the amounts specified in your Resource branches.

Note that the ordering of modules will affect calculation results. Before calculating make sure you modules are in the correct order in the tree. (e.g., an electric transmission & distribution module should lie above an electric generation module).

11.5.1 Endogenous Capacity Expansion Calculations

If you have specified a set of processes that will have their capacity added endogenously, LEAP calculates how much capacity is added as follows:

- Existing capacity before the addition of endogenously calculated additions is calculated as follows for each process in each year:

  *Capacity Before Additions = (Exogenous Capacity + Endogenous Capacity Added Previously) * Capacity Value*

Where *Endogenous Capacity Added Previously,* is summed over the previous *Lifetime* years, so as not to include endogenously added capacity that is now retired. Note that exogenously specified capacity is not automatically retired: any retirements of this type of capacity need to be entered explicitly as lower values. The *Capacity Value* term is used to adjust the actual capacity value of intermittent renewable energy processes, which are assumed to have less capacity value than thermal power plants. (Thermal power plants typically have a capacity value of 100%).

- Peak system power requirements on the module are calculated as a function of the total energy requirements and the system load factor:

  *Peak Requirement [MW] = Energy Requirement [MW-hr] / (Module Load Factor * 8760 [hrs/year])*

  Where the load factor is either entered as data, or calculated as the average height of a load curve.

- The reserve margin before the addition of endogenously calculated additions is calculated as follows:

  Reserve Margin Before Additions = (Capacity Before Additions - Peak Requirement) / Peak Requirement

- The amount of endogenous capacity additions required is calculated as follows:

  *Endogenous Capacity Additions Required = (Planning Reserve Margin - Reserve Margin Before Additions) * Peak Requirement*

- Finally, endogenous capacity additions are calculated for each process by cycling through the processes listed on the Endogenous Capacity screen in the order listed on the screen. In each year, capacity continues to be added in the amounts specified on the screen in the Addition Size column, until the amount added is greater than or equal to the *Endogenous Capacity Additions Required*.

11.5.2 Process Dispatch Calculations

During Transformation calculations, LEAP dispatches the processes in each module to try and meet the requirements for energy on the module. Depending on the dispatch rule you choose (specified on the Module Properties screen), different calculation algorithms area used to calculate how much of each process is dispatched (i.e. the energy outputs from each process).

Two specialized dispatch rules ("Dispatched by Merit Order" and "Dispatched by Running Cost") are available for simulating the dispatch of processes (typically electric power plants) in order to meet both the peak power requirements and the energy requirements on a module.

11.5.3 Dispatching Processes on a Load Curve

If the Module Dispatch Rule specified on the Module Properties screen is set to "Dispatched by Merit Order", or "Dispatched by Running Cost", then during Transformation calculations, LEAP will simulate how processes are dispatched to meet both the power requirements specified by a cumulative annual load curve and the overall annual energy requirements on a module. For more information on how load curves are specified in LEAP, see topic System Load Data

> **NB:** this simulation only occurs in future scenario years. In the Current Accounts year, process shares are calculated in proportion to the Base Year Outputs data specified by the user. For information on these calculations, see topic: Process Dispatch Calculations.

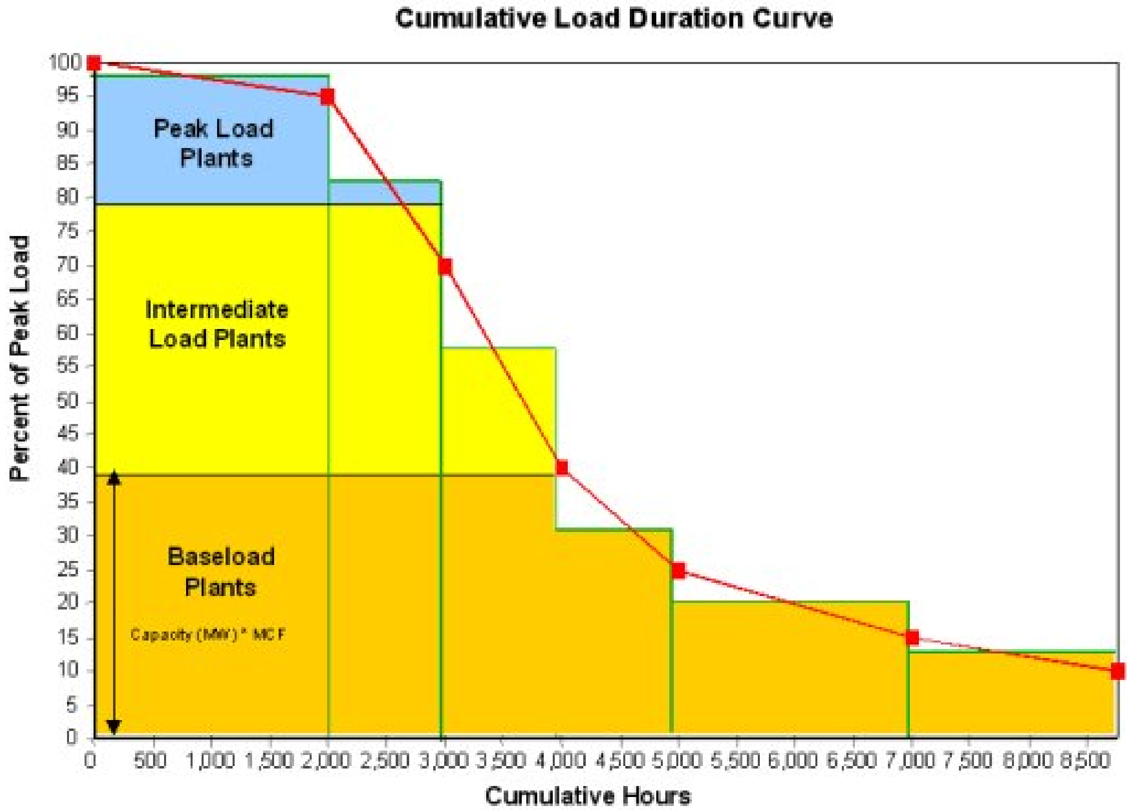
Merit orders are either specified explicitly on the Process Properties screen, or if the Dispatch Rule is set to "Dispatched by Running Cost", they are determined as follows:

$$RunningCost_i = VariableOMCost_i + FuelCost_i / Efficiency_i$$

To simulate the dispatch of processes, LEAP first makes a list of processes, sorted by their merit order. This information is used to calculate the available capacity of each group of processes with the same merit order, (i.e. those that are dispatched together).

Next, LEAP makes a discrete approximation of the load curve and divides it up into 6 vertical "strips" (see below), as defined by the 7 data points you specified in the Load Curve screen. The height of each strip is equal to the overall system peak load requirement multiplied by the average percentage of peak load of two adjacent points on the specified load curve. The width of the strip is the difference in hours of those same two adjacent data points. Overall peak system load requirement is calculated from the energy requirements on the module, and the module's load factor (the mean height of the load curve) as follows:

$$PeakSystemPower\,Requirement[MW] = \frac{Energy\,Requirement[MWhr]}{LoadFactor \times 8760}$$



***Tip:** for greater accuracy, specify more points where the load curve is steepest.*

Next, each group of processes is dispatched in vertical "strips" in order to try and fill the area under the load curve. Base load plants are dispatched first at the bottom, followed by intermediate and peak load plants. To properly represent the average technical availability of each plant (i.e., allowing for periods when plants are unavailable because of planned or unplanned outages), the maximum height of each strip is the available capacity for each group (i.e. the sum of Capacity x Maximum Capacity Factor) for all processes in the group. Each group is dispatched in turn until the load curve strip is filled. In cases where the available capacity of the group exceeds the amount required, the actual amount of each process dispatched is reduced, so that each process is dispatched in proportion to its available capacity.

11.5.4 Shortfall and Surplus Calculations

Once LEAP has calculated the outputs from each process in a module, it uses the settings you specify on the Output Fuel Properties screen to simulate how LEAP deals with situations of shortfalls and surpluses in the production of each output fuel.

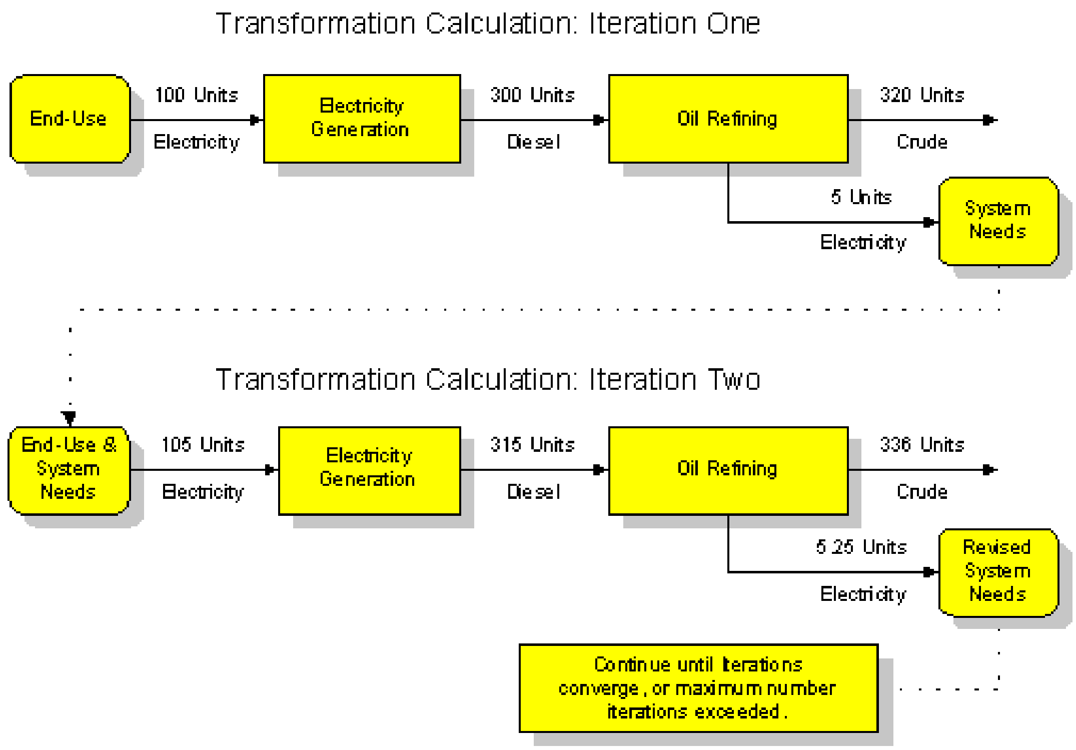
- **Under shortfall conditions** requirements unmet by production can either be met with additional "gap-filling" imports, or they can remain unmet. Notice that this latter case does not necessarily imply that a requirement is unmet in the system as a whole. An upstream module that is simulated later on may produce the same output fuel.

- **Under surplus conditions** additional production can either be exported or wasted

11.5.5 Calculation of Systems with Feedback Flows

To accommodate more complex energy supply systems, the Transformation calculations allow for energy systems with energy flow feedbacks. For example, in the diagram shown below, an oil refinery might produce diesel for use in power generation, while the oil refinery itself might consume some of the generated electricity.

These systems are solved by repeating (iterating) the basic Transformation calculation, but with adjustments made to total demands after each iteration to reflect any unmet requirements for upstream energy flows.



1. In the figure shown above, a final demand for 100 units of electricity is met by a power plant using diesel and operating at 33% efficiency. This, in turn, requires 300 units of diesel, which are produced by a simplified (one product) refinery operating at 94% efficiency. Thus, the overall demand for crude oil is 320 units. To produce the diesel, the oil refinery itself uses 5 units of electricity. In the first calculation iteration, these 5 units of electricity demand remain unmet by the system .

2. In the second iteration, the 5 units of unmet requirements are added to the final energy demand that drives the calculation. This causes the power plant to generate 105 units of electricity using 315 units of oil. This, in turn, requires that the refinery uses 320 units of crude and 5.25 units of electricity.

3. The third iteration begins with the generation of 105.25 units of electricity, and iterations continue until successive changes in the electricity requirements become small. At this point, the system has converged to a solution.

Important:

- LEAP will only iterate calculations for fuels listed as secondary fuels (including electricity), and which have also had their resource property set to disallow imports. To make this setting for a fuel go to the **Resources: Secondary Fuels** branch and set the properties for the fuel in question.

- Note that it is possible to create systems that will not converge. If convergence is not reach within 20 iterations, or if the calculations tend to diverge, then LEAP will report an error and halt the whole calculation.

12 Stock Changes and Statistical Differences

In the tree, two additional top level branch categories labeled **Stock Changes** and **Statistical Differences** are visible only if you place a checkmark next to the option Statistical Differences and Stock Changes", on the Default tab of the Basic Parameters screen.

- **Stock Changes**: under which you can specify supply of primary energy from stocks. Negative values indicate an increase in stocks. The values you specify will be added to the total primary supply of the fuel, and will appear as a separate row in the energy balance view between the Transformation and Resource sections.

- **Statistical Differences:** under which you can specify the differences between final consumption values and energy demand data. Typically, the data you enter in your Transformation analysis (e.g. imports and production of energy) will be derived from data provided by government or large energy producers (oil refineries, electricity companies, etc.), whereas your energy demand estimates may be based on end-use surveys. Often demand and supply data will be somewhat inconsistent. You can express the differences by entering data in the Statistical Differences tables. You can specify statistical differences for any fuel consumed in your area or any other secondary fuel produced. The values will be added to the final demand values calculated in your Demand analysis, and will appear as a row in the energy balance view between the Demand and Transformation sections. Enter a positive value to increase the energy demand or a negative value to decrease it.

13 Resource Analysis

The Resource Analysis screens in LEAP are used to enter data on the availability of primary resources, including both fossil renewable resources, as well as information on the costs of indigenous production, imports and exports of both primary resources and secondary fuels.

Depending on the costing boundary you choose for your cost-benefit analysis, you will either be asked to supply the "in the ground" costs of indigenous resources, or the delivered costs of fuels.

Resource tree branches are always subdivided into two categories: primary resources and secondary fuels, and the branches immediately below these two categories are automatically generated and updated by LEAP to reflect the individual fuels consumed and produced in your area. As you add or delete fuels from your Demand and Transformation analyses, the list of fuels is automatically updated.

The data you enter on indigenous resource availability depends on whether the resource is a fossil or renewable energy form. For fossil resources (including uranium) you enter the total available reserve of the resource, while for renewable energy forms you enter the annual energy available from the resource.

By default, the availability of each resource is specified far the area as a whole. Resource availability can also be built-up from a more disaggregated analysis, in which total availability is subdivided by region or some other type of classification. This approach can be particularly useful for keeping track of biomass resources. To conduct a disaggregated analysis, simply add additional branches and sub-branches below the resource you wish to disaggregate.

The following Resource data screens are used:

- **Base Year Reserves:** For fossil resources only, enter the reserves of the resource in the Base Year. Depending on your analysis, you may wish to define fossil reserves as the either proven or ultimately recoverable reserve. Notice that this data is not specified in future (scenario) years. Depending on the state of the resource, you can specify reserves in energy or physical units.

- **Yield:** For biomass resources and renewable energy forms, enter the annual availability of the resource. This can be specified either as a total annual value, or as an annual availability per unit of land area (click on Resource Properties to change this setting). When specifying yield per unit land area be sure to also enter data on land area (see below).

- **Land Area:** for renewable energy specified per unit of land area enter data on land area, use this screen to enter the area of land devoted to producing the resource.

- **Accessibility:** for biomass resources, in addition to specifying yield, you also need to specify what percentage of the yield is accessible. This can vary from 0% for totally inaccessible land to 100% for fully accessible resources. For more information, see woodfuel accessibility.

- **Indigenous , Import, Export and Delivered Costs:** In principle, economic theory suggests that shadow costs reflecting the full opportunity costs, not market costs, should be used in specifying resource costs. In practice, market prices are often used. In cases where the resource has no market price (e.g., traditional woodfuel collection) a proxy should be used such as the cost of substitute fuels or of sustainable forestry. Generally the costs of imports and exports are identified directly with market prices. For imports, the CIF (cost, insurance and freight) costs would apply, and for exports, the FOB (free on board) costs would apply. Costing indigenous resources is more subtle since the data you provide will depend on a) whether you have included mining and extraction industries as modules in your Transformation program, and b) the costing boundary used for your analysis. Assuming you have defined these modules and your cost boundary is drawn around the entire system, then you should enter capital and O&M costs for the extraction modules in your Transformation analysis, and use "resource depletion costs" for each indigenous resource. If you are using a more restricted costing boundary, then you will need to enter the delivered cost of the fuels produced by the extraction industries. In its cost-benefit calculations, LEAP will use these delivered costs and ignore the capital and O&M costs of the extraction modules.

14 Cost-Benefit Analysis

You can use LEAP to perform integrated social cost-benefit analysis on the scenarios you create. The Cost Summary View is the main tool for cost-benefit comparisons of scenarios.

LEAP's cost-benefit analysis calculates the costs of each part of the energy system: the capital and operating maintenance costs of purchasing and using the technologies in the Demand and Transformation systems; the costs of extracting primary resources and importing fuels and the benefits from exporting fuels. In addition you can also optionally broaden the scope of your cost-benefit calculations to examine environmental externalities, by assigning costs to the emission of pollutants and any other direct social and environmental impacts of the energy system.

When comparing scenarios, it is important that only those scenarios with similar economic assumptions be compared. For example, it would be inappropriate to compare two scenarios with different population or GNP growth rates, since those factors are not part of the energy policies being considered.

Cost-benefit analysis is based on the social costs of resources, not the final prices of energy to the consumer. Cost-benefit analysis centers on the costs (sometimes called the "opportunity costs") to society of a given set of actions. It does not take the perspective of a particular consumer or producer. Social costs and prices need not be the same. For example, electricity prices may differ from the costs of producing electricity, due to subsidies, transfer payments and market distortions.

Cost-benefit analysis in LEAP is not intended to provide an analysis of financial viability. Instead, it helps identify a range of socially-acceptable policy scenarios. Detailed financial analysis can then be carried out to identify which scenarios are also financially acceptable.

To provide flexibility in how a cost-benefit analysis is conducted, LEAP allows you to specify a costing boundary: the Transformation module after which costs associated with energy conversion and extraction are no longer counted. Specifying a limited boundary that does not encompass all modules, can be very useful for modeling systems in which you only have data on the costs of fuels as they are consumed, and you do not have data on the costs of upstream technologies such as oil refining and coal mining. For example, you might specify the boundary as electricity production. This means: a) that LEAP will not consider capital and O&M costs for upstream activities (modules) such as oil refining or coal production; and b) that costs will be applied to the feedstock fuels delivered to electricity plants (e.g.,. diesel) rather than to the resources (e.g. crude oil) from which they are produced. For more information on setting-up costing boundaries, see the Basic Parameters screen.

15 Non-Energy Sector Effects

While its focus is the energy sector, LEAP also optionally lets you create inventories and scenarios for Non-energy related effects. Typically you can use this feature for including inventories and scenarios of non-energy sector greenhouse gas (GHG) emissions, as a complement to the analysis of energy sector greenhouse gas emissions and mitigation measures conducted in the other parts of LEAP.

To set-up an analysis of non-energy sector effect, first select the Analysis View, then go to the Scope tab of the Basic Parameters screen and make sure the **Non-Energy Sector Environmental Loadings** box is checked. An additional top-level category branch ( ) will appear marked **Non-Energy Sector Effects**. Non-energy sector effects are analyzed by creating a hierarchical structure of effects under this top-level branch in much the same way that you create a hierarchical tree structure to analyze energy demands. The structure will consist of category branches ( ) used only for organizational purposes, and effect branches ( ) at which you specify annual total emissions loadings. Use the standard tree editing controls to manipulate the tree structure including: **Add** ( ), **Delete** ( ), and **Properties** ( ).

When you click, the **Add** or **Properties** buttons, you will be shown a small dialog box in which you specify the name and branch type. You can analyze any effect listed in the effects database. Effects are specified in the relevant units for each effect. Typically most effects are measured in mass units.

Unlike an energy demand analysis in which total effects are calculated as the product of energy consumption and an emission factor, in the non-energy sector you specify total annual effect loadings. Of course you can use LEAP's expressions to calculate the total as a function of one or more independent variables. As in your energy analysis, you can analyze any number of different emissions scenarios.

16 Results Categories

16.1 Demand

Energy Demand

This results category displays the energy demand in one or more demand branch. Results can be shown organized by branch, fuel, scenario, year and region (in multi-regional areas).

You can show either the **total** final demand for fuels including both energy and non-energy requirements or **energy only** requirements. Showing energy only requirements will cause LEAP to subtract the non-energy demand for fuels as specified in the variable "Non Energy Fraction". When this variable is zero, the (energy + non-energy) and (energy only) results will be the same.

Energy demand results can also be shown in either **final** or **primary** units. Primary units results are only available if you go to the General: Basic Parameters scope screen and check the box marked "allocate primary energy and Transformation emissions back to demands". When showing in primary units, LEAP shows the primary energy requirement implications of the levels of domestic consumption at one or more demand branch. So for example, if you click on a household/refrigeration branch you will see the primary energy required to make the electricity used in refrigerators (e.g. coal, hydro, etc. instead of electricity). In this calculation LEAP assumes that each final fuel gets a proportion of the average mix of supply side processes in each year. It does not distinguish between demand side technologies that operate at on- and off-peak, perhaps with a different mix of supply side technologies.

At its simplest (if you click on the top level demand branch) the results of this category should be similar to those shown for Resources: Primary Requirements category. However, the results may differ. In particular if you have systems with export requirements, then the two results will not be the same. This is because the requirements shown under the resources category accounts for all system requirements (including the fuels needed to meet export demands), while the requirements shown under the demand category shows only the primary energy required to meet domestic demands. Base year statistical differences and stock changes may also cause differences in the results.

When your data set includes analysis of co-production within the demand branches - for example when modeling combined heat and power (CHP) systems that consume a feedstock fuel such as natural gas while producing heat and electricity - you will also see another result category: **Demand Co-production:** which shows the production of the co-product (a negative demand).

Demand Co-production

This results category displays the amount of energy co-produced in one or more demand branches. Results can be shown organized by branch, fuel, scenario, year and region (in multi-regional areas).

This category is used to examine results in areas that have co-production of energy modeled within the demand branches - for example when modeling combined heat and power (CHP) systems that consume a feedstock fuel such as natural gas while producing heat and electricity. Note that only technology branches created as part of a useful energy analysis can have co-products.

Useful Energy Demand

This results category displays the useful demand for energy in one or more demand branches. Results can be shown organized by branch, fuel, scenario, year and region (in multi-regional areas).

Useful energy demand is only calculated in branches in which you have conducted a useful energy analysis. It is the amount of heat or useful energy service delivered, which normally less than the final energy content of the fuels being consumed due to losses in the final devices that use each fuel.

Load Shape

This results category complements the energy demand report (which shows annual energy demands) by showing the shape of the load (in power units) summed across different demand branches for the various Time Slices defined for your area. This report is only available if you have chosen to specify an endogenously calculated load shape. You can specify this on the Loads tab of the General: Basic Parameters screen. Load shapes can be viewed for detailed end-uses, or for more aggregate subsectors, sectors or for demand as a whole. Use the tree to view load shapes at different levels of aggregation.

Typically you will view this report by showing time slices on the X axis and branches on the legend of chart. You can also use the animation feature to see how the load shape evolves from one year to the next.

Stocks

This results category displays the number of devices or vehicles in one or more demand branches. Results can be shown organized by branch, scenario, year, vintage and region (in multi-regional areas). Stock is defined as the number of vehicles or devices existing in a given year. To be able to view stocks by vintage (i,e. categorized by the year in which the device was originally added) go to The General: Basic Parameters screen. and ensure that "Save Stock Vintages" is checked on the Stocks tab.

Stocks and Sales results are only available for those branches where you are conducting a stock analysis or a transport analysis. To set up a stock analysis or a transport analysis, go to the Methodology tab on the Properties screen for each applicable technology branch.

Sales

This results category displays the number of devices or vehicles sold (i.e. added to the stock) in one or more demand branches. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

Stocks and Sales results are only available for those branches where you are conducting a stock analysis or a transport analysis. To set up a stock analysis or a transport analysis, go to the Methodology tab on the Properties screen for each applicable technology branch.

16.2 Statistical Differences

In the tree, two additional top level branch categories labeled **Stock Changes** and **Statistical Differences** are visible only if you place a checkmark next to the option Statistical Differences and Stock Changes", on the Default tab of the General:Basic Parameters screen.

Statistical Differences reports the differences between final consumption values and energy demand data. The values will be added to the final demand values calculated in your Demand analysis, and will also appear as a row in the energy balance view between the Demand and Transformation sections. A positive value indicates an increase in energy demand and a negative value a decrease.

16.3 Transport

New Vehicle Rated Fuel Economy

This results category displays the rated fuel economy (in miles per gallon) for new vehicles added to the stock in each year. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

This category is only available for those branches where you are conducting a transport analysis. To set up a transport analysis, go to the Methodology tab on the Properties screen for each applicable technology branch.

The new vehicle rated fuel economy simply shows the data you specified in the Fuel Economy variable. This data is combined with the fuel economy degradation profile data and processed in LEAP's stock turnover calculations to yield the stock average rated fuel economy. Finally, this value is multiplied by the fuel economy correction factor to yield the stock average on-road fuel economy result.

The Fuel Economy Correction Factor variable is primarily useful when modeling U.S. vehicles in which the data on fuel economy provided by the Federal Government reflects a level of fuel economy that can be achieved in laboratory tests. Typically this value is higher than real-world levels of fuel economy that can be achieved on the road. A correction factor of about 0.8 is generally used to convert from "rated" to "on-road" fuel economies. Keep the default correction factor of 1.0 if your original fuel economy data reflects on-road conditions.

Stock Average On-Road Fuel Economy

This results category displays the stock average on-road fuel economy (in miles per gallon) for all vehicles that exist in each year. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

This category is only available for those branches where you are conducting a transport analysis. To set up a transport analysis, go to the Methodology tab on the Properties screen for each applicable technology branch.

The data you enter for new vehicle rated fuel economy is combined with the fuel economy degradation profile data and processed in LEAP's stock turnover calculations to yield the stock average rated fuel economy. Finally, this value is multiplied by the fuel economy correction factor to yield the stock average on-road fuel economy result.

Vehicle Mileage

This results category displays the annual distance travelled (in miles or kilometers) for the vehicles in one or more demand branches. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

Vehicle mileage results are only available for those branches where you are conducting a transport analysis. To set up a transport analysis, go to the Methodology tab on the Properties screen for each applicable technology branch.

Vehicle mileage is calculated based on the data you specify for the mileage of new vehicles and the mileage degradation profile you specify that describes how annual miles driven decreases as vehicles get older. These values are processed with LEAP's stock turnover calculations to yield the annual average mileage driven across the whole vehicle stock existing in each year. Finally, you can also specify a mileage correction factor which is used to adjust the mileage value calculated for the total vehicle stock. This correction factor can be useful if you wish to create a model that examines driving rebound effects in which the miles driven in ALL vehicles (not just new vehicle) are responsive to certain policy variables such as the cost of gasoline.

16.4 Transformation

Requirements

This results category displays the energy requirements on a given Transformation module. In other words the amount of energy the module "sees" or is asked to produce. Notice that the amount of energy actually produced by a Transformation module is shown in the Outputs report and may be more or less than the requirements depending on the capacity of the module and the process dispatch options you have chosen. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

Inputs

This results category displays the annual feedstock energy consumed by a given Transformation module. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

Outputs

This results category displays the annual energy produced by a given Transformation module. In the case of an electric generation module, this corresponds to the level of generation. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

Unmet Requirements

This results category displays the amount of unmet energy requirements (if any) for a given Transformation module.

Capacity

This results category shows the capacity of the processes in a given Transformation module. In electricity generation modules, capacity is shown in megawatts or similar units. This variable is only reported if you have specified capacity data for the module. Results can be shown organized by branch, scenario, year and region (in multi-regional areas). You can also separately view the capacity that resulted from the exogenous and endogenous methods of specifying capacity expansion in LEAP.

NB: Capacity results are always shown in terms of production capacity even if you chose to specify capacity data in terms of consumption in the analysis view.

Efficiency

This category shows the percentage ratio of energy outputs (not including any co-product energy recovered) to feedstock energy inputs in each process. All efficiencies must be greater than zero.

This result is a simple echo of the data entered in the efficiency variable.

Imports Into Module

This results category displays the amount of energy imported at a given Transformation module. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas). Imports can result from a number of different situations:

- You can specify an import target for the module. This is a target level of imports that will occur before any of the processes in the module are actually dispatched. Thus when specifying target imports, be aware that they may prevent the module from operating. Target imports can be a useful way of simulating how the demand in geographically remote areas are met. For example, a region of a country may be so remote that its requirements for oil products are always met via imports, regardless of how much spare capacity exists in a country's oil refineries.

- Imports may also be used to fill gaps in supply when the module is unable to meet all the requirements on it, perhaps due to capacity limitations. To enable "gap filling imports, go to the Output Properties screen and select "Import Fuel to Meet Shortfall" for the relevant output fuels of a module.

Exports from Module

This results category displays the amount of energy exported from a given Transformation module. Exports can result from a number of different situations: Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

- You can specify an export target for the module and the module will produce to meet this target along with any domestic requirements on the module.

- The module may produce surplus amounts of certain output fuels. On the Output Properties screen you can tell LEAP whether this surplus production is to be exported or wasted.

Reserve Margin (%)

This results category shows the amount of reserve margin in a given module. This variable is generally only relevant for electricity generation modules. This variable is only reported if you have specified capacity data for the module. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

Reserve margin is defined as follows:

> *Reserve Margin (%) = 100 * (Module Capacity - Peak Load) / Peak Load*
>
> Where:
>
> *Module Capacity = Sum(Capacity * Capacity Value) for all processes in the module.*

Peak load is calculated based on the requirements for electricity and the module load factor (which may itself be based on the shape of a module load curve). Electricity requirements are calculated based on your energy demand analysis and any upstream electricity losses (for example in a Transmission and Distribution module).
Reserve margin may not be the same as the data you entered for the *Planning Reserve Margin.* Assuming that you have specified certain processes that will be added automatically using the Endogenous Capacity screen, then the actual reserve margin reported here should be greater than or equal to the planning reserve margin. This is because LEAP automatically adds new plants as needed in order to keep your reserve margin on or above your planning reserve margin. On the other hand, if plants are not being added automatically and if you have not exogenously specified sufficient capacity expansion, then it is possible that the actual reserve margin may fall below the planning reserve margin.

Peak Power

This results category shows the peak power output for a given module. This variable is generally only relevant for electricity generation modules and is shown in megawatts or another power unit. This variable is only reported if you have specified capacity data for the module. Results can be shown organized by branch, scenario, year and region (in multi-regional areas).

Peak load is calculated based on the requirements for electricity and the module load factor (which itself is based on the shape of the load curve). Electricity requirements are calculated based on your energy demand analysis and any upstream electricity losses (for example in a Transmission and Distribution module).

Actual Capacity Factor (%)

This result shows the ratio for each process of the actual energy produced in one year to what the process would have produced if running at full capacity over the whole year (expressed as a percentage). This variable is only reported if you have specified capacity data for the module. Actual Capacity Factor (ACF) is constrained to be less than or equal to the data you specify for the Maximum Capacity Factor (MCF).

Maximum Capacity Factor (%)

This result is a simple echo of the data entered for the Maximum Capacity Factor variable. This variable is only reported if you have specified capacity data for the module.

Load Factor (%)

This results category shows information about the level of usage of a module's processes. Load factor is defined as follows:

$$\textit{Load Factor} = \frac{\textit{Total Output (MWh/yr.)}}{\textit{Maximum System Load (MW) x 8760}\ \text{(hr/year)}}$$

This results is generally only applicable for electricity generation modules. This variable is only reported if you have specified capacity data for the module.

Use the Module Properties screen to specify whether or not you want to enter system load information, and to specify whether you want to specify peak load information in the form of a detailed System Load Curve or directly as a load factor. It is strongly recommended that you fully specify a system load curve whenever possible.

Power Dispatched

This results category gives a detailed report of how processes (power plants) were dispatched to meet the power requirements on a module in the various Time Slices defined for your area. It is shown in megawatts or another power unit. Typically you will view this report by showing time slices on the X axis and branches on the legend of chart. You can also use the animation feature to see how the dispatch of processes evolves from one year to the next.

Assuming that most of your processes have their Process dispatch rule set to dispatch "In Ascending Merit Order" then the display will be easiest to read if you sort the process branches by merit order with the base load plants at the bottom and the peak load plants at the top. In this way you will be able to see the base load plants stacked at the bottom of the chart and the peak load plants (if they get dispatched) stacked above.

16.5 Resources

Primary Requirements

This results category shows the primary energy requirements in the area. Results can be shown organized by branch, fuel, scenario, year and region (in multi-regional areas).

Indigenous Production

This results category shows the amount of indigenous production of primary resources. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

Imports

This results category shows the amount of imports of primary resources and secondary fuels into each region. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas). In addition in multi-region areas you can see total imports into a region as well imports coming from beyond the area (i.e. not from the other regions included in the area)

Exports

This results category shows the amount of exports of primary resources and secondary fuels from each region of your analyzed area. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas). In addition in multi-region areas you can see total exports from each region as well exports being sent beyond the area (i.e. not to the other regions included in the area).

Self-Sufficiency (%)

This results category shows the percentage ratio of indigenous production to total resource requirements.

Reserves

This results category shows the remaining reserves of depletable fossil fuels. Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas). Results can be shown organized by branch, scenario, year, fuel and region (in multi-regional areas).

Stock Changes

In the tree, two additional top level branch categories labeled Stock Changes and Statistical Differences are visible only if you place a checkmark next to the option Statistical Differences and Stock Changes", on the Default tab of the General:Basic Parameters screen.

Stock Changes reports the supply of primary energy from stocks. Negative values indicate an increase in stocks. Values are added to the total primary supply of the fuel, and will also appear as a separate row in the energy balance view between the Transformation and Resource sections.

16.6 Costs

This results category shows costs of your scenarios. Cost results are only available if you have specified cost data and if you have switched on the costing analysis in the General: Basic Parameters: Scope screen. Results can be shown organized by branch, scenario, year and region (in multi-regional areas). You can also view cost results by each different type of cost element including:

- Demand costs (capital and operating and maintenance costs) including costs specified as costs of saved energy.
- Transformation capital, and fixed and variable operating and maintenance costs.
- Indigenous resource and import costs.
- Export benefits.(negative costs)
- Environmental externalities.

16.7 Environmental Results

You can display results for any of the effects for which you have specified environmental loadings. Results can be shown organized by branch, fuel, scenario, year and region (in multi-regional areas). Environmental effect results are only available if you have checked "Energy Sector Environmental Loadings" in the General: Basic Parameters: Scope screen.

In addition to specifying results for an individual effect, you can also show the combined global warming potential (GWP) of one or more greenhouse gases. In addition to selecting different measurement units, GWP results can be shown measured in two different ways: in terms of the equivalent amount of Carbon (C) or Carbon Dioxide (CO2). Reports measured in terms of CO2 are simply a factor of 44/12 larger than those measured in terms of Carbon. The global warming potentials of each pollutant can be edited on the Effects screen and default to the standard values recommenced for a 100 year integration by the IPCC. You can also display multiple effects in a single result report using an indexed format report.

When showing GWP reports you have two further choices:

- **GWP - Shown at Branches Where Emissions Occur:** shows the emissions arising from the combustion of fuels in the Demand and Transformation branches, along with emissions (or sinks) in the non-energy sector branches. In other words, emissions arising directly from the combustion of fuels in a demand branch are shown at the demand branch. Emissions arising from activities in Transformation modules are shown at those Transformation modules.
- **GWP - Energy Sector Emissions Allocated to Demand Branches:** allocates the emissions occurring in the various Transformation modules back to the various demand branches. In this type of report emissions from sectors that generate secondary fuels such as electricity are allocated back to the demand-side branches in which the electricity is finally consumed. Similarly, emissions from oil refining are allocated back to the demand-side branches where oil products are finally consumed. Transformation emissions are allocated to demands based on the fraction of the total final fuel consumption that occurs at each demand branch. GWP emissions that occur directly at demand branches are also included in this type of report. NB: This results category is, by definition, only available at demand branches.

  This latter type of report can be useful for seeing the full lifecycle emissions of various demand sectors. For example, the household sector may appear more important versus the transport sector in the second type of report since that sector involves a lot of electricity consumption, the emissions for which are calculated in the Transformation modules.

  NB: this second type of report is only available if you have checked **"Allocate primary energy and Transformation emissions back to demands**" in the General: Basic Parameters: Scope screen.

Finally, for GWP reports you can choose between a 100 year or a 500 year time horizon. Based on the time horizon you select, LEAP uses different sets of global warming potentials for the non-CO2 gases that reflect the relative potential of the gas over each period. For example, methane has a 100 year GWP of 23, but a 500 year GWP of only 7. Since GWPs are always expressed relative to carbon dioxide, the GWP of Carbon Dioxide is set to 1.0 for both the 100 year and 500 year time horizons. Note that GWP factors can be edited (for example if the IPCC decides to revise them in the future), by visiting the Effects screen.

17 TED: The Technology & Environmental Database

Analysts often need ready access to comprehensive and up-to-date data describing energy technologies. Such data are spread across a range of sources, which are not easily accessible, particularly to analysts in the developing countries. To address this problem, LEAP includes a Technology and Environmental Database (TED) that provides extensive information describing the technical characteristics, costs and environmental impacts of a wide range of energy technologies including existing technologies, current best practices and next generation devices.

TED's Data Pages include quantitative data on the technology characteristics, costs, and environmental impacts associated with energy technologies. In addition, Information Pages review the availability, appropriateness, cost-effectiveness and key environmental issues for a wide range of energy technologies.

The first version of TED includes data on approximately one thousand technologies, referencing reports by dozens of institutions including the Intergovernmental Panel on Climate Change, the U.S. Department of Energy, and the International Energy Agency, as well as by regional institutions that have developed data specific to energy technologies found in developing countries. TED can be used as a standalone tool or, as an integral part of LEAP, it can be used to calculate the environmental loadings of your energy scenarios. TED's own core database of emission factors can be edited or supplemented by a your own data. We hope that TED will be seen as an open, publicly accessible database, and we encourage you to contribute additional sources of data which you think would be of use to energy and environmental professionals in the developing countries.

17.1.1 Tree

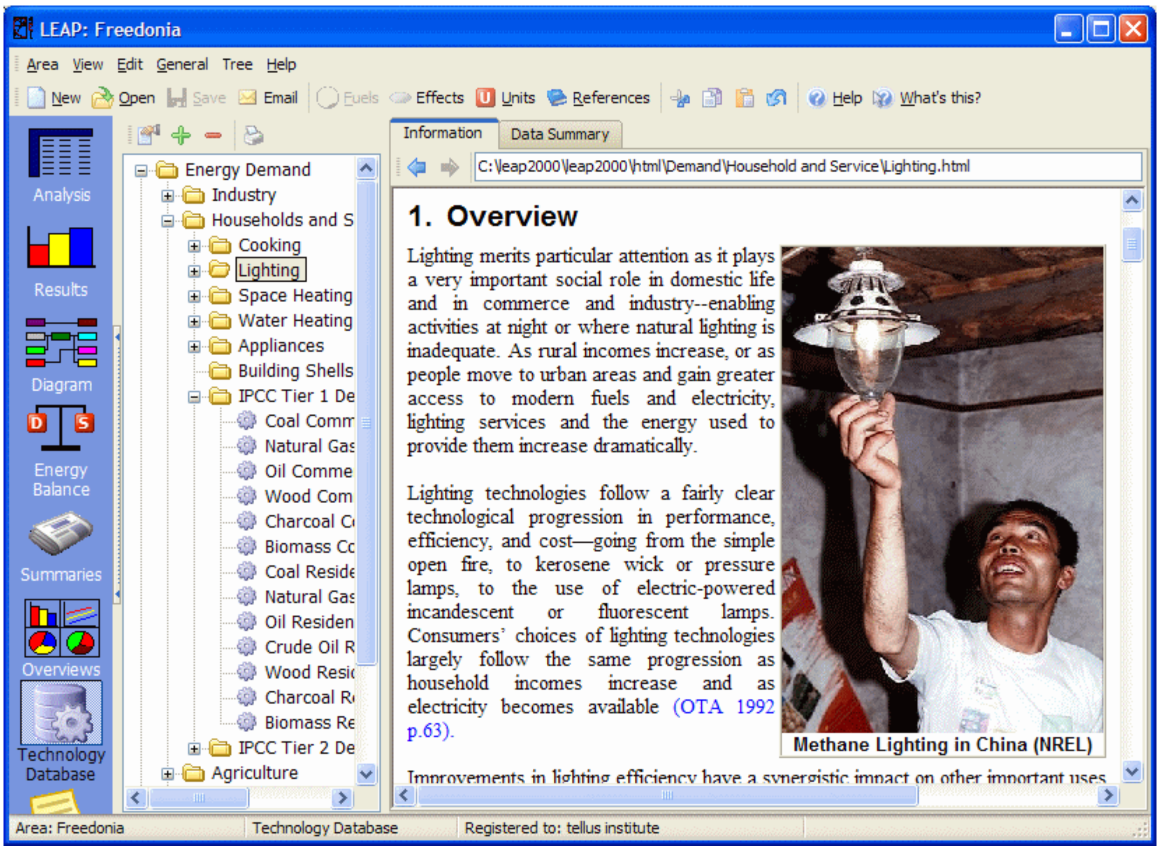
The tree, which always appears on the left of the TED screen is a hierarchical outline used to organize and edit your TED data. The tree contains two types of branches:

> **Category** branches are used mainly for organizing the other branches into hierarchical data structures. They contain no data, but can be associated with an information page. To do this, select the Branch Properties screen and type or browse for the file location (or URL) of the information page (an HTM or HTML file).
>
> **Technology** branches contain the data on a particular technology.

In most respects the TED tree works just like the ones in standard Windows tools such as the Windows Explorer. You can rename branches by clicking once on them and typing, and you can expand and collapse the outline by clicking on the +/- symbols to the left of each branch icon. Additional options to edit the tree can be accessed in a number of ways:

- By right-clicking on the tree and selecting an option from the pop-up menu that appears,
- by using Tree menu (which contains an expanded set of options),
- by clicking on the **Properties** ( ), **Add** ( ) and **Delete** ( ) buttons on the main toolbar, or
- by using short-cut keys for the most common option (e.g. **Alt-P** for Properties, **Ctrl-Ins** to add a branch, **Ctrl-Del** to delete a branch, etc.). Valid short-cut keys are displayed on the main menu.

17.2 Information Pages



In addition to its quantitative data, TED also includes information pages that review the availability, appropriateness, cost-effectiveness and key environmental issues for a wide range of energy technologies. TED Information pages are displayed on the right of the TED screen. Each TED branch can have one web page associated with it, and as you navigate through TED's branches on the left of the screen, different TED branches will be displayed on the right.

Information pages are actually web pages stored on your PC's hard drive, which are displayed using the Internet Explorer web browser (which is fully integrated into LEAP).

Thus, in addition to navigating the pages using TED's tree, you can also standard web browser techniques to navigate the information pages, including the **Back** (), **Forward** ().

Alternatively, you can use the links embedded in the text of the information pages. As you jump to other TED information pages, the cursor position in the TED tree will be updated to reflect the position in the tree of the new page. In some cases, these links will take you to pages on the Internet (i.e. pages that do not form part of the core TED information pages). You will require an Internet connection if you want to see these pages.

For more flexibility, you can directly type any URL (uniform resource locator) in to the address box to view any web page on the Internet (e.g. http://www.seib.org/leap), or you can right-click on a page and select **Browse Pages** () to open any web page (.htm or .html) on your PC or local area network.

Finally, since the information pages in TED contains only a few basic browser controls, you can also right-click a page and select **Open in Browser** to open the current page in your current default web browser.

17.3 Data Pages

TED data pages contain quantitative information about a technology. Data screens are divided into resizable panes. At the top you see a screen in which you can view and edit the data. At the bottom you see a pane which is further vertically split into two resizable panes. On the left is a box for viewing and editing a set notes associated with each technology. On the right is a screen for associating one or more bibliographic references with each technology. To edit the notes, right-click and select **Edit** to display the notes in a larger window, which includes a basic set of word processing controls. Notes can include formatting (bold, underline, fonts, etc.) and can also include standard Windows "objects" such as spreadsheets. To edit the list of References, use the **New** (), **Add** ()and **Delete** () buttons to link to the References database.

The top pane consists of up to five tabs:

- **General:** Use the General page to indicate what types of data are specified for each technology, and to specify basic information about the technology, such as its applicability (the country or region in which the technology is utilized), development status (current average best practice, prototype, next generation, etc.), lifetime and construction time. Depending on the what types of data are checked on the General page, some or all of the other data tabs will be displayed.

- **Energy Demand** lists the fuels consumed, and the annual energy intensity of the technology.

- **Energy Conversion:** (available only for energy conversion technologies) lists the fuels consumed and produced by the plant as well as the efficiency, and capacity of the plant.

- **Pollution Control Data** (available only for pollution control technologies). For technologies such as scrubbers or filters designed to reduce emissions from other technologies, specify the fuels consumed in the technologies to which the controls are attached, and the loss of energy efficiency in the energy technology caused by attached control. Finally, using the Add (+) and Delete (−) buttons, add one or more controlled effect to the pollutant reduction box, and specify how much of the uncontrolled emission is eliminated in percent.

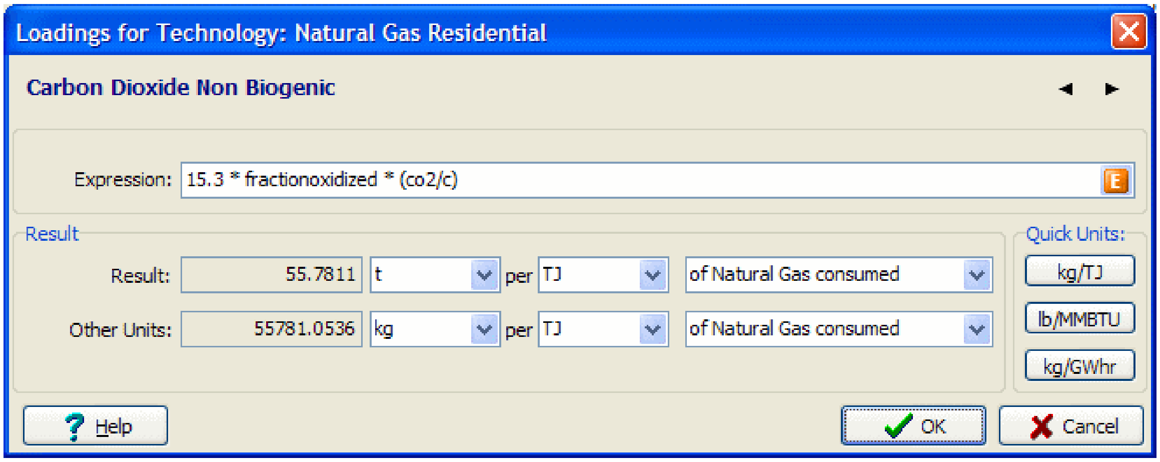
- **Costs** lists the capital and operating and maintenance costs of a technology. Capital costs can be specified as either base or total capital costs (the latter term includes interest charges).

- **Environment** lists the environmental loadings associated with a technology; for example how much CO_2 is emitted per unit of fuel consumed, produced or lost. You can change the standard units in which the data is reported by right-clicking on the effect and selecting denominator units. For energy conversion technologies, you can also select the basis for measuring the effect (i.e., whether it is specified per unit of energy consumed, produced or lost) by right-clicking and selecting "**Effects per Unit of...**" Double-click an effect to view or edit each loading in more detail on the environmental loadings screen. Notice that you can specify environmental loadings in different units, and TED will report them back in standardized units (e.g., kg/TJ). When specifying environmental data for energy technologies, you may link to up to three pollution control technologies using the control technologies screen.

17.4 TED Data Summary Page

In addition to viewing individual TED data pages, by navigating the branches of the TED tree, you can also use the Data Summary page to get an overview of all technologies within a particular category. To use this feature, click a category branch in TED and then click the Data Summary tab, TED will then search its database and display the names of matching technologies displayed in the rows of the summary, along with key information about the technologies, such as the type of data available (environmental, cost, etc.), the applicability (global, developing world, United States, etc.), and the reference for the source of data. The data summary list can be sorted by clicking on the title of a column, and you can quickly jump to a technology by double-clicking on a row

17.5 Environmental Loadings Factors Screen



The Environmental Loading Factors screen displays one effect at a time for a given technology. Use the **forward** and **back** buttons at the top of the screen to move through the list of all effects defined for the technology. To add or delete effects, you will need to exit the screen and use the **Add** ( ) and **Delete** ( ) buttons on the Environment tab of the TED data pages.

Environmental loading factors can be specified as numeric values, or they can be specified as expressions that depend on the chemical composition of the fuels being consumed or produced. Click on the **"..."** button to use the Expression Builder tool to create expression-based loading factors. Typically, a loading will be an emission factor (e.g. kg of pollutant per GJ of energy consumed), but loadings can also be specified any other unit of direct environmental impact.

Use the first row of selection boxes to choose the numerator units (e.g. pounds, kilograms or tonnes of pollutant) and denominator units (e.g. , BTUs, TJ, or TOE of energy consumed, produced or lost) in which the loading factor is to be entered. Loadings for energy supply technologies can be specified per unit of energy consumed, produced, or lost. Loadings for vehicles (for which an energy intensity per vehicle-km or per vehicle-mile are specified) can also be specified in those units.

Use the second row of selection boxes to convert the loading into some other set of units. For energy supply technologies, you can convert emission factors between loadings per unit of energy consumed (e.g. kg/GJ or kg/Tonne) and loadings per unit of energy produced (e.g. kg/GWhr of electricity). Note that this feature requires that you specify the efficiency of the supply technology. Use the **Quick Units** buttons on the right to quickly select standard units. For vehicles, if you have specified an energy intensity per vehicle-km or per vehicle-mile, then you can convert loading factors between loadings per unit of energy consumed and loadings per unit of transportation service.

When a technology is associated with one or more pollution controls (as specified on the Environment tab of the TED data pages), the Environmental Loading Factors screen will also display the level of emission abatement from the selected controls, and the final controlled loading factor.

17.6 TED Expressions

You can specify environmental loadings in TED as either constant numeric values (e.g. X kg/ TJ of coal combusted) or you can base them on the chemical composition of the fuels being consumed or produced. This can be useful, for example, when you are entering data describing CO2 emissions from coal fired electricity generating plants. For this type of data the actual emissions will not simply depend on the quantity of coal consumed by the plant, but will also depend on the carbon content of the coal. TED allows you to enter an emission factor that accounts for this effect. The actual calculated emission loading and the values calculated in your LEAP scenarios, should you choose to link LEAP to this TED technology, will then properly reflect the carbon content of the type of coal used in your local area. Fuel compositions are edited on the Fuels screen (Main Menu: General: Fuels)

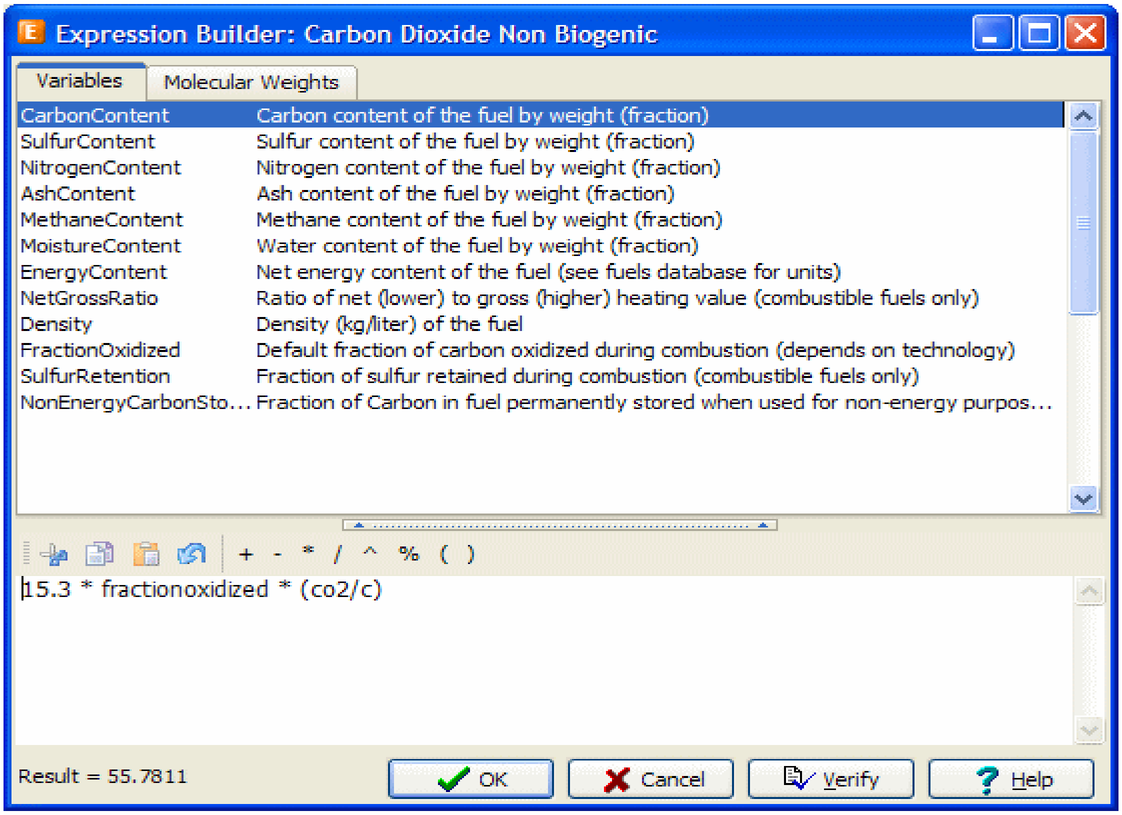
To enter this type of emission factor, you need to specify a loading using a mathematical expression that references the chemical composition of the fuel. In this case the expression would be:

Loading (kg CO_2 / kg of fuel consumed) = CarbonContent * FractionOxidized * (CO2/C)

The CarbonContent and FractionOxidized terms are values stored in the LEAP fuels database, while the CO2 and C terms are constants. The advantage of this approach is twofold. Firstly, environmental loadings specified in this manner are automatically updated whenever the LEAP fuels database is updated - without the need to edit the data in TED. Secondly, one default set of effects is more generally applicable, even in different regions in where fuel compositions are markedly different.

Use TED's Expression Builder screen to help specify these expressions.

17.7 TED Expression Builder



TED contains an Expression Builder tool (shown below) that helps you edit environmental loadings expressions in TED by dragging and dropping the potential variables and constants available in TED. You can access the Expression builder by clicking the "**...**" button attached to any TED expression.

The screen of the Expression Builder is divided into two resizable panes. At the top are two tabs. One contains the list of **Variables** that can be included in the expression (carbon content, sulfur content, energy content, ash content, etc.), while the other contains the list **Molecular Weight** constants that can be referenced. At the bottom of the screen is an editing box, into which you can directly type to edit an expression or into which you can add an item from the top pane either by dragging-and-dropping or by double-clicking on an item. At the right of the editing box are a set of buttons that give quick access to the most common mathematical operators (+, -, *, /, ^, etc.).

A toolbar at the top of the second pane gives quick access to the most common editing options such as **Cut** (), **Copy** (), **Paste** (), etc. When constructing an expression, you can check whether the expression is valid by clicking on the **Verify** button. Finally, when you have finished with the expression, click on **OK** to put the expression back into the environmental effect data screen you came from, or click on **Cancel** to abandon the edit.

18 Expressions

LEAP borrows an approach made popular in spreadsheets: the ability for users to enter data and construct models using mathematical expressions. Expressions are standard mathematical formulae used to specify the values of variables in LEAP's Analysis View. In Current Accounts an expression defines the base year value for a given variable at a branch, while in scenarios, the expression defines how that variable changes over time (from one year after the base year to the end of the study period). Expressions can range from simple numeric values to complex mathematical formulae. Each formula can optionally reference LEAP's many built-in functions, as well as referencing the values of other branches and variables entered elsewhere in the LEAP analysis. Expressions can even create dynamic links to the values stored in an external Microsoft Excel spreadsheet.

LEAP provides a number of ways of editing expressions. The most common are:

- Typing directly into the expression field in one of the data entry tables in LEAP's Analysis View.
- Selecting one of the commonly used functions: Interpolation (), Growth (), End-Year (), or Remainder using the pop-up selection box attached to each expression field.
- Using the Time-Series Wizard: a tool for easily entering time-series functions (Interpolation, Step, Smooth functions, and forecasting functions)
- Using the Expression Builder tool (): a general purpose tool for creating expressions by dragging-and-dropping functions and LEAP and TED data and result variables.

18.1.1 Color Coding of Scenario Expressions

When editing scenario data in LEAP's Analysis View, expressions are color coded to show which expressions have been entered explicitly in the current scenario, and which are inherited from a parent scenario (including from data specified for Current Accounts). Blue text indicates a value entered explicitly in the current scenario, while black text indicates an inherited value. In addition, when expressions are inherited between regions expressions are shown with purple text.

- Use the **Show Scenario Branches** option (Main Menu: Tree: Show Scenario Branches) to list and optionally jump to any of the branches entered explicitly in the current scenario (i.e. those colored blue).
- To reset an expression back to its inherited default, highlight the expression and press **Delete**, or right-click and select the **Reset to Inherited () option.**
- For more information on scenario expressions, refer to scenarios.

18.1.2 Referencing Variables and Constants in Expressions

- **Data Variables:** In an expression, the values of other branches/variables are referenced by typing the branch name followed by a colon followed by the variable name. For example, the value of the activity level variable in the Demand\Households branch would be referenced by typing "**Demand\Households:Activity Level**". Note: Expressions are not case-sensitive. You can enter variable and function names in any combination of upper and lower-case letters. When you have finished entering the formula, LEAP will put the names in a standard format: capitalizing the function names. When referencing branches that are immediate siblings or parents of the current branch, you need only specify the last part of the branch name (e.g. cooking). When referencing more distant branches, include the full path name (e.g. Demand\Households\Urban\Cooking). When referencing a different variable at the same branch, you need not enter a branch name. Similarly, when referencing the same variable at a different branch you need not enter the variable name. In fact, if you do enter this additional information, LEAP will strip-it-out when you submit the expression.

- **Fuel Variables:** A further type of variable you can reference in expressions is fuel variables. These are the various chemical and physical characteristics of the fuel associated with a branch. Examples include the carbon, sulfur, and moisture content of the fuel, and its net heating value. Notice that only branches in which fuels are consumed or produced have valid fuel variables. These fuel variables reflect the data defined in the Fuels screen.

- **Constants:** Constants, including your own user-defined constants, can also be included in expressions. A default set of constants are included that define various molecular weight constants. These are primarily useful in defining emission factors. For example, a CO2 emission factor might be a function of the carbon content of the fuel, the fraction of the fuel oxidized, and the molecular weights of carbon and carbon dioxide.

- **Lagged Result Variables:** When editing scenarios, you can also reference *lagged result variables*. These are the variables that are evaluated during LEAP's calculation routines (LEAP is calculated when you switch to one of the following views: Results, Energy Balance, Summaries, and Overviews). When you reference them in Analysis View or in the Expression builder, LEAP will show the most recently calculated results for these variables. Note however, that following a calculation the value may change (because of any edits you made in Analysis View). Referencing a result variable before it has been calculated will return a zero value when displayed in Analysis View, but the value will ultimately be resolved when LEAP is calculated. Result variables are always lagged (i.e. they return the value for the previous year). Hence, lagged result variables cannot be included in Current Accounts expressions. Note also that before you can reference result variables you need to enable the option **Allow Lagged Results in Expressions** on the Scope tab of the General: Basic Parameters screen. Enabling this option will slow calculations, so if you do not require lagged results we suggest you leave this option unchecked.

- **TED Variables:** TED Branches and variables can also be referenced in expressions. The syntax is similar to that used for referencing LEAP variables (i.e. branch: variable), expect that a special function TED() needs to be wrapped around the reference. Referencing TED data allows you to selectively use items of data stored in the TED database in your calculations.

  Tip: Using the Expression Builder tool is the easiest way to create expressions that references other branches and variables.

18.1.3 Expression Elaboration

Expression Elaboration is a small panel that automatically pops-up under the main data entry table in Analysis View to elaborate on the meaning of complex expressions: ones that refer to other branches and variables. *Expression Elaboration* is useful for helping you to understand and explain your analyses WITHOUT continually having to navigate from branch to branch in the tree.

18.2 Expression Operators

LEAP supports all of the standard mathematical and logical operators in expressions as follows:

Operator	Meaning
Arithmetical Operators	
+	**Plus:** adds the term on the left to the term on the right.
-	**Minus:** subtracts the term on the right from the term on the left.
*	**Times:** multiplies the term on the left by the term on the right.
/	**Divide:** Divides the term on the left by the term on the right. An error will occur if the term on the right is zero.
^	**Power:** raises the term on the left to the power of the term on the right
Logical Operators	
=	**Equal:** returns TRUE if the term on the left equals the term on the right: otherwise returns false.
<>	**Not Equal:** Equals: returns TRUE if the term on the left does not equal the term on the right: otherwise returns false.
<	**Less Than:** returns TRUE if the term on the left is less than the term on the right: otherwise returns false.
>	**Greater Than:** returns TRUE if the term on the left is greater than the term on the right: otherwise returns false.
<=	**Less Than or Equal:** returns TRUE if the term on the left is less than or equal to the term on the right: otherwise returns false.
>=	**Greater Than or Equal:** returns TRUE if the term on the left is greater than or equal to the term on the right: otherwise returns false.
AND	Returns true if both the left hand term and the right hand term are TRUE.
OR	Returns true if either the left hand term or the right hand term are TRUE.
NOT	Returns true if the left hand terms is true and right hand term is false, or if the right hand term is true and the left hand term is false.

Notes: In LEAP, the term TRUE has the value 1 and the term false has the value 0 (zero). Logical operators are typically used in conjunction with the If function, to yield two alternative results depending on whether the result is true or false. For example: IF(Variable1 < Variable2, ValueIfTrue, ValueIfFalse).

18.3 Reserved Words

The following words are reserved for use in LEAP's expressions and cannot be included as part of a LEAP branch name:

%
And
AnnualizedCost
BaseYear
BaselineScenario
BaseYearValue
Billion
BYLinForecast
BYExpForecast
Ceil
EndYear
Equal
Exp
ExpForecast
False
fnAND
fnOr
fnNOT
Floor
Frac
GreaterThan
GreaterThanOrEqual
Growth
GrowthAs
GrowthFrom
Hundred
If
Interp
LessThan
LessThanOrEqual
LinForecast
Ln
Log
LogisticForecast
Lookup
Max

Million
Min
Not
NotEqual
Or
Parent
PrevYear
PrevYearValue
Remainder
Share
Smooth
Sqr
Sqrt
Step
TED
Thousand
Total
TotalChildren
Trillion
True
Year

In addition, branch names are limited to no more than 50 characters, and no less than 2 characters, and may only contain alphabetic and numeric characters as well as the following additional characters: |, &, ~, ", _, ., $,# ,[,] ,{ ,} All branch names must begin with an alphabetic character.

Tip: *You cannot include the word "and" in a branch name. Use the "&" character instead.*

19 Expressions Reference

19.1 Modeling Functions

AnnualizedCost

Syntax

AnnualizedCost(CapitalCost, Lifetime, InterestRate, AnnualOMCost) or AnnualizedCost(CapitalCost, Lifetime) or

Description

Use this method if you want to calculate annualized (levelized) total capital costs. Annualized activity costs are calculated from the data you enter on total capital cost, the lifetime of the device, the interest rate charged for the loan on the capital cost, and the annual operating and maintenance cost. The levelized cost per activity is calculated by using a present value calculation to annualize the capital cost (using the lifetime and interest rate parameters) and then adding the annual operating and maintenance cost.

Parameters

- **CapitalCost:** the total (i.e. not annual) capital cost per activity unit. In cases where your demand data specifies the physical number of end-use devices enter the costs of each device. In other cases, where the activity unit is not a device (e.g. in households using multiple light bulbs) enter the capital cost per unit of activity. In other words multiply, the cost per device by the number of devices per activity (e.g. light bulbs per household).

- **Lifetime:** a whole number of years - the lifetime of the device or the period of loan on the capital cost as appropriate.

- **Interest Rate:** the rate charged on the loan for the capital cost (defaults to the study discount rate).

- **AnnualOMCost:** any annual recurring costs of the activity NOT INCLUDING fuel costs, such as operational, maintenance and administrative costs.

BaselineScenario

Syntax

BaseLineScenario or
BaseLineScenario(BranchName)

Description

Calculates the value of either the current branch or another branch in the baseline scenario. The baseline scenario is the scenario immediately inheriting from Current Accounts, and from which the current scenario is inherited. This function can be especially useful if you want to enter changes in values ("deltas") with respect to some baseline rather than having to enter absolute values.

Important: This function can only be used in non-baseline scenarios. It cannot be used in Current Accounts or any baseline scenarios immediately inheriting from Current Accounts. Note that an area may contain more than one baseline scenario, and that different policy scenarios may therefore have different baseline scenarios.

Examples

Typically you will use this function in conjunction with an Interp function to specify how one scenario differs from another,

BaselineScenario + Interp(BaseYear, 0, EndYear, 1)

In this example the scenario value starts out the same as the baseline scenario in the base year. By the end year, the scenario value is one greater than the baseline scenario value. The baseline scenario values may themselves increase or decrease.

BaselineScenario * Interp(BaseYear, 1, EndYear, 1.5)

In this example the scenario value starts out the same as the baseline scenario in the base year. By the end year, the scenario value is 50% greater than the baseline scenario value.

BaseYear

Syntax

BaseYear or BY

Description

The base year of the analysis as a numeric value.

Example

Year -BaseYear

Evaluated for a base year of 1995

2000 = 5.0
2020 = 25.0

BaseYearValue

Syntax

BaseYearValue or
BaseYearValue(BranchName)

Description

Calculates the base year value of either the current branch or another branch referred to as a parameter to the function.

BYExpForecast

Syntax

BYExpForecast(Year1, Value1, Year2, Value2,... YearN, ValueN) or
BYExpForecast(XLRange(Filename, Rangename))

Summary

Forecasts future values based on an exponential regression of historical data. Regression is forced through known base year value.

Description

Exponential forecasting is used to estimate future values based on a time series of historical data. The new values are predicted using linear regression to an exponential growth model (Y = m + X^c) where the Y terms corresponds to the variable to be forecast and the X term is years. Exponential forecasting is most useful in cases where certain values can be expected to grow at constant growth rates over the period in question (e.g. population levels).

Use this function with caution. You may need to first use a spreadsheet or some other package to test the statistical validity of the forecast (i.e. test how well the regression "fits" the historical data). Moreover, bear in mind that future values may be markedly different from historical ones, particular if structural or policy shifts in the economy such as changing energy policies are likely to have an impact on future trends.

Using the above two alternatives syntaxes the time-series data required by the function can either be entered explicitly in LEAP as year/value pairs or it can be specified as a range in an Excel spreadsheet. Use the time-series wizard to input these values or to link to the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200.

BYLinForecast

Syntax

BYLinForecast(Year1, Value1, Year2, Value2,... YearN, ValueN) or
BYLinForecast(XLRange(Filename, Rangename))

Summary

Forecasts future values based on a linear regression (y=mx+c) of historical data. Regression is forced through base year value.

Description

Linear forecasting is used to forecast future values based on a time-series of historical data. The new values are predicted using linear regression assuming a linear trend (y = mx +c) where the Y term corresponds to the variable to be forecast and the X term is years. Linear forecasting is most suitable in cases where exponential growth in values is not expected: for example when forecasting how market shares or technology penetration rates might change over time.

Use this function with caution. You may need to first use a spreadsheet or some other package to test the statistical validity of the forecast (i.e. test how well the regression "fits" the historical data). Moreover, bear in mind that future values may be markedly different from historical ones, particular if structural or policy shifts in the economy such as changing energy policies are likely to have an impact on future trends.

Using the above two alternatives syntaxes the time-series data required by the function can either be entered explicitly in LEAP as year/value pairs or it can be specified as a range in an Excel spreadsheet. Use the time-series wizard to input these values or to link to the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1900-2200.

EndYear

Syntax

EndYear

Description

The last year of the analysis as a numeric value (as specified in the Areas: General Parameters screen).

Example

EndYear-Year

Evaluated for an end year of 2020

2000 = 20.0
2018 = 2.0

ExpForecast

Syntax

ExpForecast(Year1, Value1, Year2, Value2,... YearN, ValueN) or
ExpForecast(XLRange(Filename, Rangename))

Summary

Forecasts future values based on an exponential regression of historical data. Regression is not forced through base year value.

Description

Exponential forecasting is used to estimate future values based on a time series of historical data. The new values are predicted using linear regression to an exponential growth model (Y = m + X^c) where the Y terms corresponds to the variable to be forecast and the X term is years. Exponential forecasting is most useful in cases where certain values can be expected to grow at constant growth rates over the period in question (e.g. population levels).

Use this function with caution. You may need to first use a spreadsheet or some other package to test the statistical validity of the forecast (i.e. test how well the regression "fits" the historical data). Moreover, bear in mind that future values may be markedly different from historical ones, particular if structural or policy shifts in the economy such as changing energy policies are likely to have an impact on future trends.

Using the above two alternatives syntaxes the time-series data required by the function can either be entered explicitly in LEAP as year/value pairs or it can be specified as a range in an Excel spreadsheet. Use the time-series wizard to input these values or to link to the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200.

ExpInterp

Syntax

ExpInterp(Year1, Value1, Year2, Value2,... YearN, ValueN, [Growthrate]) or ExpInterp(ExcelFilename, ExcelRangeName, [Growthrate])

Summary

Calculates a value in any given year by exponential interpolation between a time-series of year/value pairs. The interpolation assumes the interpolated values obey the following functional form:

$$Value = a + b \cdot Year^{\alpha}$$

Each intermediate year's value is calculated as follows:

$$Value_{iy} = Exp\left(k + \alpha \cdot \ln\left(Year_{iy}\right)\right)$$

Where:

$$\alpha = \ln\left[\frac{Value_{ey} - Value_{fy}}{Year_{ey} - Year_{fy}}\right] \quad k = \frac{\ln\left(Value_{ey}\right)}{\alpha \cdot \ln\left(Year_{ey}\right)}$$

iy = the intermediate period, the value of which is to be interpolated.
ey = the end period used as the basis for the interpolation.
fy = the first period used as the basis for the interpolation.

Description

Using the above two alternative syntax year/value pairs can either be entered explicitly or linked to a range in an Excel spreadsheet. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200. The final optional parameter to the function is a growth rate that is applied after the last specified year. If no growth rate is specified zero growth is assumed (i.e. values are not extrapolated).

Growth

Syntaxes

Growth(Expression) or
Growth(Expression1, Year2, Expression2) or
Growth(Expression1, Year2, Expression2, Year3, Expression3) or
Growth(Expression1, Year2, Expression2, Year3, Expression3, Year4, Expression4) or
Growth(Expression1, Year2, Expression2, Year3, Expression3, Year4, Expression4, Year5, Expression5)

Description

Calculates a value in any given year using a growth rate from the base year value. Because it references the base year value, this function is only available when editing scenarios. You can specify a single growth rate or using the alternative syntaxes, you can specify up to 5 periods with different growth rates. For example, in years after *Year2* the growth rate will be *Expression2*. In years after *Year3* the growth rate will be *Expression3*.

Example

Growth(0.05) or Growth(5%)

GrowthAs

Syntax

GrowthAs(BranchName) or
GrowthAs(BranchName, Elasticity) or

Description

Calculates a value in any given year using the previous value of the current branch and the rate of growth in another named branch. This is equivalent to the formula:

$$\text{Current Value}(t) = \frac{\text{Current Value}(t-1) * \text{NamedBranchValue}(t)}{\text{NamedBranchValue}(t-1)}$$

In the second form of the function, the calculated growth rate is adjusted to reflect an elasticity. More precisely, the change in the current (dependent) branch is related to the change in the named branch raised to the power of the elasticity. This is a common approach in energy modeling, in which the growth in one variable is estimated as a function of the growth in another (independent) variable.

Tip for users of LEAP for DOS: This second form is equivalent to the old "Drivers and Elasticities" method for projecting data.

Examples

GrowthAs(Household\Rural)

Growth(GDP, 1)

In this example (elasticity = 1), the current branch grows at the same rate as the named branch (GNP).

GrowthAs(GDP, 0.9)

In this example (elasticity = 0.9), the current branch grows more slowly than GNP.

GrowthAs(GDP, 1.2)

In this example (elasticity = 1.2), the current branch grows more rapidly than GNP.

GrowthAs(GDP, 0)

In this example (elasticity = 0), the current branch is constant (i.e. independent of GNP).

Interp

Syntax

Interp(Year1, Value1, Year2, Value2,... YearN, ValueN, [Growthrate]) or
Interp(ExcelFilename, ExcelRangeName, [Growthrate])

Summary

Calculates a value in any given year by linear interpolation of a time-series of year/value pairs. Each intermediate year's value is calculated as follows:

$$Value_{iy} = Value_{fy} + \left[Value_{ey} - Value_{fy}\right] \cdot \left[\frac{Year_{iy} - Year_{fy}}{Year_{ey} - Year_{fy}}\right]$$

Where:

iy = the intermediate period, the value of which is to be interpolated.
ey = the end period used as the basis for the interpolation.
fy = the first period used as the basis for the interpolation.

Description

Using the above two alternative syntax, year/value pairs can either be entered explicitly or linked to a range in an Excel spreadsheet. Use the LEAP Time-series Wizard to input these values or specify the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200. The final optional parameter to the function is a growth rate that is applied after the last specified year. If no growth rate is specified zero growth is assumed (i.e. values are not extrapolated).

Lookup

Syntax

Lookup(*ILV*, *IV1*, *DV1*, *IV2*, *DV2*)

Description

Looks up the value of an independent lookup variable (ILV), and returns a value for a corresponding dependent variable.

The lookup works as follows:

If *ILV* <= *IV1* then

$Result = DV_1$

If *ILV* >= *IV2* then

$Result = DV_2$

Otherwise (if *ILV* lies between *IV1* and *IV2*) then

$$Result = DV_1 + (DV_2 - DV_1) \times \frac{(ILV - IV_1)}{(IV_2 - IV_1)}$$

The lookup function can be useful in cases where you want a dependent variable to vary in direct proportion to another variable according to the straight line equation: y=mx+c.

Example

Imagine that the unit price of wind power will decrease from its current price of 10 $ to 8$ as a function of the installed capacity of the resource, but will go no lower than 8$ even if capacity increases above 400 MW. The current capacity is 50 MW. Hence for the price variable, you would enter an expression:

Lookup(Capacity, 50, 10, 400, 8)

When Capacity reaches 200 MW the price will be $9.1.

LinForecast

Syntax

LinForecast(Year1, Value1, Year2, Value2,... YearN, ValueN) or
LinForecast(XLRange(Filename, Rangename))

Summary

Forecasts future values based on a linear regression (y=mx+c) of historical data. Regression is not forced through base year value.

Description

Linear forecasting is used to forecast future values based on a time-series of historical data. The new values are predicted using linear regression assuming a linear trend (y = mx +c) where the Y term corresponds to the variable to be forecast and the X term is years. Linear forecasting is most suitable in cases where exponential growth in values is not expected: for example when forecasting how market shares or technology penetration rates might change over time.

Use this function with caution. You may need to first use a spreadsheet or some other package to test the statistical validity of the forecast (i.e. test how well the regression "fits" the historical data). Moreover, bear in mind that future values may be markedly different from historical ones, particular if structural or policy shifts in the economy such as changing energy policies are likely to have an impact on future trends.

Using the above two alternatives syntaxes the time-series data required by the function can either be entered explicitly in LEAP as year/value pairs or it can be specified as a range in an Excel spreadsheet. Use the time-series wizard to input these values or to link to the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1900-2200.

LogisticForecast

Syntax

LogisticForecast(Year1, Value1, Year2, Value2,... YearN, ValueN) or
LogisticForecast(XLRange(Filename, Rangename))

Description

Logistic forecasting is used to estimate future values based on a time series of historical data. The new values are predicted using an approximate fit of a logistic function by linear regression.

A logistic function takes the general form:

$$Y = A + \frac{B - A}{1 + e^{(-a.X + b)}}$$

where the Y terms corresponds to the variable to be forecast and the X term is years. A, B, a, b are constants and e is the base of the natural logarithm (2.718&ldots;). A logistic forecast is most appropriate when a variable is expected to show an "S "shaped curve over time. This makes it useful for forecasting shares, populations and other variables that are expected to grow slowly at first, then rapidly and finally more slowly, approaching some final value (the "B" term in the above equation).

Use this function with caution. You may need to first use some other package to test the statistical validity of the forecast (i.e. test how well the regression "fits" the historical data).

Using the above two alternatives syntaxes the time-series data required by the function can either be entered explicitly in LEAP as year/value pairs or they can be specified as a range in an Excel spreadsheet. Use the time-series wizard to input these values or to link to the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200.

Parent

Syntax

Parent
Parent(BranchName)
Parent(VariableName)
Parent(BranchName, VariableName)

Description

The current value of the specified variable in the parent branch of named branch. Both BranchName and VariableName are optional parameters so that, when used without any parameters, the function returns the value of the current variable in the parent branch of the current branch.

Tip

Because the simple form of this function points, not to a named branch, but to a relative branch address (the parent), it can be safely used in cases where you want to write a model for a particular set of subsectoral branches, and then copy branches for use elsewhere in the tree. See also: the "TotalChildren" function.

ParentScenario

Syntax

ParentScenario or
ParentScenario(BranchName)

Description

Calculates the value of either the current branch, or of another branch in the parent scenario: the scenario from which the current scenario immediately inherits. This function can be useful if you want to enter changes in values ("deltas") with respect to a parent scenario rather than having to enter absolute values. See also: BaselineScenario.

Important: This function cannot be used in Current Accounts.

Examples

Typically you will use this function in conjunction with an Interp function to specify how one scenario differs from another,

ParentScenario + Interp(BaseYear, 0, EndYear, 1)

In this example the scenario value starts out the same as the parent scenario in the base year. By the end year, the scenario value is one greater than the parent scenario value.

ParentScenario * Interp(BaseYear, 1, EndYear, 1.5)

In this example the scenario value starts out the same as the baseline scenario in the base year. By the end year, the scenario value is 50% greater than the parent scenario value.

PrevYear

Syntax

PrevYear

Description

The year previous to the one being evaluated as a numeric value. This function is not available when entering Current Accounts.

Examples

Evaluated in 2000 = 1999.0
Evaluated in 2020 = 2019.0

PrevYearValue

Syntax

PrevYearValue or
PrevYearValue(BranchName)

Description

Calculates the previous year's value of either the current branch or of another branch referred to as a parameter to the function. This function is not available when entering Current Accounts.

Remainder

Syntax

Remainder(Expression)

Description

Calculates the remainder between an Expression and the sum of the values of neighboring (sibling) branches. The parameter specifies the total to which all neighboring branches should sum. In other words, the function is calculated as

Tip:

Note that an error will occur if you attempt to use the remainder function in more than one neighboring branches.

Smooth

Syntax

Smooth (Year1, Value1, Year2, Value2,... YearN, ValueN) or
Smooth (ExcelFilename, ExcelRangeName)

Description

Estimates a value in any given intermediate year based on the year/value pairs specified in the function and a smooth curve polynomial function of the form

$$Y = a + b.X + c.\ X2 + d.\ X3 + e.X4 + \ldots;$$

When more points are available, a higher degree polynomial is used to give a more accurate fit. A minimum of 3 year/value pairs are required in order for the curve to be estimated.

Using the above two alternatives syntax, year/value pairs can either be entered explicitly or linked to a range in an Excel spreadsheet. Use the Time-series Wizard to input these values or to specify the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200.

Step

Syntax

Step(Year1, Value1, Year2, Value2,... YearN, ValueN) or
Step(ExcelFilename, ExcelRangeName)

Summary

Calculates a value in any given year using a step function between a time-series of year/value pairs.

Description

Using the above two alternatives syntaxes year/value pairs can either be entered explicitly or linked to a range in an Excel spreadsheet. Use the Time-series Wizard to input these values or to specify the Excel data. In either case, years do not need to be in any particular order, but duplicate years are not allowed, and must be in the range 1990-2200.

TotalChildren

Syntax

TotalChildren
TotalChildren(BranchName)
TotalChildren (VariableName)
TotalChildren (BranchName, VariableName)

Description

The sum of the specified variable across all children of the named branch. Both BranchName and VariableName are optional parameters so that, when used without any parameters, the function returns the sum of the current variable across the children of the current branch.

Tip

Because the simple form of this function points, not to a named branch, but to a relative branch address (all children), it can be safely used in cases where you want to write a model for a particular set of subsectoral branches, and then copy branches for use elsewhere in the tree.

Year

Syntax

Year or Y

Description

The year being evaluated as a numeric value.

19.2 Mathematical Functions

Ceil

Syntax

Ceil(Expression)

Description

The expression rounded up toward positive infinity. Use Ceil to obtain the lowest integer greater than or equal to X.

Exp

Syntax

Exp(Expression)

Description

The constant e raised to the power of Expression. The constant e equals 2.71828182845904, the base of the natural logarithm. EXP is the inverse of LN, the natural logarithm of number.

Floor

Syntax

Floor(Expression)

Description

The expression rounded toward negative infinity. Use Floor to obtain the highest integer less than or equal to X.

Frac

Syntax

Frac(Expression)

Description

The fractional part of Expression. Frac(Expression) = Expression - Int(Expression).

Int

Syntax

Int(Expression)

Description

The integer part of the expression (the expression rounded toward zero).

Ln

Syntax

Ln(Expression)

Description

The natural logarithm of the expression

Log

Syntax

Log(Expression)

Description

The base 10 logarithm of the expression

Max

Syntax

Max(Expression1, Expression2) or

Max(Expression1, Expression2, Expression3)

Description

Returns the maximum value of the list of parameters. Accepts up to 3 parameters.

Min

Syntax

Min(Expression1, Expression2) or

Min(Expression1, Expression2)

Description

Returns the minimum value of the list of parameters. Accepts up to 3 parameters.

Sqr

Syntax

Sqr(Expression)

Description

The square of the expression, equivalent to Expression * Expression or (expression ^2).

Sqrt

Syntax

Sqrt(Expression)

Description

The square root of the expression.

19.3 Logical Functions

If

Syntax

If(TestExpression, ResultIfTrue, ResultIfFalse)

Description

Use the If function to return one value if a condition is TRUE (<> 0) and another value if it is FALSE (=0)

TestExpression is any value or expression that can be evaluated to TRUE or FALSE. Test expressions are generally made up of two or more statements which are compared using LEAP's logical functions (and, or, lessthan, greaterthan, equal, etc.).

ResultIfTrue is an expression that is evaluated if TestExpression is TRUE.

ResultIfFalse is an expression that is evaluated if TestExpression is FALSE.

IF functions can be nested to construct more elaborate tests.

Examples

If(Income>1000, 10, 20)

If the branch named Income has a value greater than 1000 then the function evaluates to value 10, otherwise it evaluates to 20.

Equal

Syntax

Equal(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is equal to parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard equals operator "=" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

GreaterThan

Syntax

GreaterThan(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is greater than parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard greater than operator ">" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

GreaterThanOrEqual

Syntax

GreaterThanOrEqual(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is greater than or equal to parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard greater than or equals operator ">=" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

LessThan

Syntax

LessThan(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is less than parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard less than operator "<" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

LessThanOrEqual

Syntax

LessThanOrEqual(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is less than or equal to parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard less than or equals operator "<=" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

NotEqual

Syntax

NotEqual(Expression1, Expression2)

Description

Returns a value of 1 if parameter 1 is not equal to parameter 2. Otherwise returns a value of zero.

Note: This function is included for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the standard not equals operator "<>" directly in your expressions. This helps to simplify your expressions and make them easier to understand.

True

Syntax

True

Description

Used in logical tests. Has a value of one.

False

Syntax

False

Description

Used in logical tests. Has a value of zero.

fnAnd

Syntax

fnAnd(Expression1, Expression2) or
fnAnd(Expression1, Expression2, Expression3)

Description

Returns a value of true (1) if both parameter 1 and parameter 2 are true. Otherwise returns a value of false (0).

Note: This function is included mainly for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the word "AND" as a standard operator between two terms. This helps to simplify your expressions and make them easier to understand. Note also that because of the introduction of the new "And" operator, this function has been renamed from "And" to become "fnAnd". Any expressions in older data sets will automatically be renamed.

Example

fnAnd(1,0) = false
fnAnd(true, true) = true
fnAnd(false, false, false) = false

fnOr

Syntax

fnOr(Expression1, Expression2) or
fnOr(Expression1, Expression2, Expression3)

Description

Returns a value of true (1) if either parameter 1 or parameter 2 is true. Otherwise returns a value of false (0).

Note: This function is included mainly for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the word "OR" as a standard operator between two terms. This helps to simplify your expressions and make them easier to understand. Note also that because of the introduction of the new "OR" operator, this function has been renamed from "Or" to become "fnOr". Any expressions in older data sets will automatically be renamed.

Example

fnOr(1,0) = true
fnOr(True,True) = true
fnOr(false, false, false) = false

fnNot

Syntax

fnNot(Expression1, Expression2)

Description

Returns a value of true (1) if parameter 1 is true and parameter 2 is false, or if parameter 2 is true and parameter 1 is false. Otherwise returns a value of false (0).

Note: This function is included mainly for backwards compatibility with earlier versions of LEAP. In the latest versions of LEAP you can now use the word "NOT" as a standard operator between two terms. This helps to simplify your expressions and make them easier to understand. Note also that because of the introduction of the new "NOT" operator, this function has been renamed from "NOT" to become "fnNOT". Any expressions in older data sets will automatically be renamed.

Example

fnNOT(1,0) = true
fnNOT(true,true) = false
fnNOT(false,false) = false

20 Technical Support

Technical support is provided at no charge to licensed users of the system. Various options are available for obtaining support. We request that you first make use of the LEAP technical support forum. This site provides a moderated forum for users to request and receive technical support and to discuss LEAP-related issues with other users.

When requesting technical support by email, we strongly suggest that you send your data set as an attachment and include the system information from the Help: About LEAP screen.

Finally, before requesting help, be sure to check to see if a more recent version of the system is available. Use **Help: Check for Updates** to automatically check for a newer version over the Internet, and then install it onto your PC. Note that this is the preferred method of updating the software as it requires a much smaller download compared to a full download and installation of the system.

The full set of technical support options are as follows:

- **LEAP Web Site:** http://forums.seib.org/leap
- **Mail:** Stockholm Environment Institute-Boston, 11 Arlington Street, Boston, MA 02116, USA
- **Email:** leap@tellus.org
- **Phone:** (617) 266 5400
- **Fax:** (617) 266 8303

20.1 Hardware and Software Requirements

LEAP requires a 400 MHz or faster Pentium class PC with Microsoft Windows 98 or later (Windows NT/2000 or XP is recommended). A minimum of 64 MB of RAM and 50 MB of free hard disk space is also required. In addition, Microsoft Internet Explorer version 4.0 or later must be installed on your PC.

- An Internet connection is not required, but is useful for tasks such as emailing data sets, checking for updates to the software, and accessing additional data sets on the Internet.

- LEAP can communicate directly with Microsoft Excel, Microsoft Word, and Microsoft PowerPoint but these are not required.

- LEAP is designed as a single-user system. It is not intended as a multi-user system and we do not recommend running it from a shared network drive.

- LEAP is a 32-bit program. It will not work on earlier 16-bit versions of Windows. LEAP is not designed to be used on Apple, UNIX or Linux computers.

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