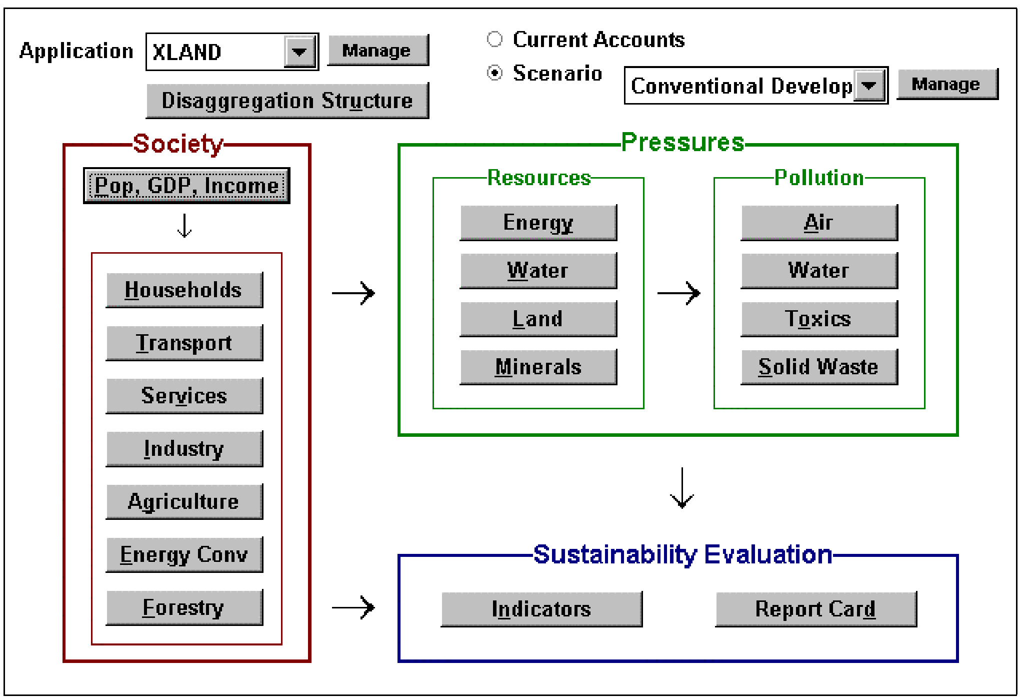
POLESTAR

System Manual for version 2000



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International Institute for Environmental Technology and Management

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September 1999

The POLESTAR Publication Series

The PoleStar publication series is produced by Stockholm Environment Institute's PoleStar Project. Named after the star that guided voyagers through uncharted waters, the PoleStar Project addresses critical aspects of the transition to sustainability. *Scenario analysis* illuminates long-range problems and possibilities at global, regional, national and local levels. *Capacity building* strengthens professional capabilities for a new era of development. *Policy studies* fashion strategies and actions. To aid these efforts, the project developed the PoleStar System, a comprehensive, flexible and user-friendly decision-support tool. The PoleStar System is now used internationally in diverse sustainability studies to organize pertinent data, formulate alternative development scenarios and evaluate strategies for sustainable development.

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PoleStar System Manual

Paul Raskin
Charles Heaps
Jack Sieber
Eric Kemp-Benedict

Stockholm Environment Institute—Boston
Tellus Institute
11 Arlington Street
Boston, MA 02116-3411
USA

Telephone: (617) 266-8090
Fax: (617) 266-8303
Email: polestar@tellus.org
http://www.seib.org/polestar

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TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 BACKGROUND 1
1.2 THE POLESTAR SYSTEM 1
1.3 THE POLESTAR USER INTERFACE 2

2 GETTING STARTED 5

2.1 SYSTEM REQUIREMENTS 5
2.2 INSTALLATION 5
2.3 REGISTERING POLESTAR 5

3 THE MAIN MENU 7

3.1 MANAGING APPLICATIONS 8
3.2 MANAGING SCENARIOS 10
3.3 DISAGGREGATION STRUCTURE 11

4 MODULES AND TABLES 16

4.1 BUTTONS 16
4.2 MENU OPTIONS 16
4.3 TABLES 19
4.4 GRAPHS 21

5 SUSTAINABILITY EVALUATION 24

5.1 REPORT CARD 24
5.2 INDICATORS 25
5.3 SUSTAINABILITY EVALUATION MENU OPTIONS 26

6 THE BASIC STRUCTURE 29

6.1 OVERVIEW 29
6.2 MODULE LINKAGES 29
6.3 POP, GDP, INCOME MODULE 30
6.4 HOUSEHOLDS MODULE 35
6.5 TRANSPORT MODULE 38
6.6 SERVICES MODULE 43
6.7 INDUSTRY MODULE 46
6.8 AGRICULTURE MODULE 49
6.9 ENERGY CONVERSION MODULE 56
6.10 ENERGY RESOURCES MODULE 65
6.11 WATER RESOURCES MODULE 69
6.12 LAND MODULE 71
6.13 MINERAL RESOURCES MODULE 77
6.14 AIR POLLUTION MODULE 79
6.15 WATER POLLUTION MODULE 80
6.16 TOXICS MODULE 81
6.17 SOLID WASTE MODULE 83

7 BUILDING CUSTOMIZED STRUCTURES 85

7.1 CUSTOMIZING TABLES 86
7.2 CREATING FORMULAS 90

ANNEX 1: SELECTED CONVERSION FACTORS 105

ANNEX 2: RULES FOR COMPUTING CELLS 107

1 INTRODUCTION

1.1 Background

Sustainable development seeks to reconcile environmental and socioeconomic objectives. The 1992 Earth Summit reached consensus that the sustainability paradigm should guide development policy at local, national, and global levels. Many nations, regions, and cities have begun to examine the implications of sustainability for policy and planning.

This examination leads to complex questions. How can current needs and aspirations be met while bequeathing satisfactory environmental and resource conditions to future generations? What technological, economic and behavioral adaptations are required? What are appropriate methods for conducting strategic assessments and developing sustainability action plans? What are useful measures or indicators of sustainability?

Fresh approaches are needed to address such questions. The transformation of the notion of sustainability from theory to a practical basis for action requires a process for strengthening analytical methods, institutional structures and human capacity for a new era of development.

1.2 The PoleStar System

The PoleStar System provides a flexible and user-friendly framework for building and assessing alternative development scenarios. PoleStar is an adaptable *accounting and model-building framework* designed to assist the analyst engaged in sustainability studies—not a rigid model reflecting one particular approach to environment and development interactions.

The PoleStar System is applicable at regional, national, and global scales. The analyst can customize data structures, time horizons, and spatial boundaries—all of which can be expanded or altered easily. The user can introduce new variables, indicators and relationships to match their needs. The system can synthesize information generated from formal models, from existing studies, or any other sources upon which the user wishes to draw.

To help you construct new applications, PoleStar comes with an initial framework, the **Basic Structure**. For many applications the Basic Structure will probably be sufficient to meet the needs of your study. In other cases, you may wish to construct your own structures. In these cases you can use the Basic Structure as the starting point for your analysis and make changes where required.

- **Current Accounts and Scenarios:** An application begins with the **Current Accounts**, a snapshot of the current state of affairs. Then, **Scenarios** are developed to explore alternative futures. A scenario is a set of future economic, resource and environmental accounts, based on assumptions and models developed by the user. Finally, environmental and resource *pressures* are computed and *evaluated* in comparison to user-defined sustainability criteria.

- **Modules:** Current Accounts and scenarios are developed through a series of **modules**. The Pop, GDP, Income module contains the variables that, in part, drive the scenario. In the Basic Structure the driving variables are GDP and population, but users may introduce their own high-level variables. More detailed data and scenario assumptions can be introduced in the other modules describing **Society** (Households, Transport, Services, Industry, Agriculture and Energy Conversion) to compute the pressures society's activities exert on the natural resources and the environment. Environmental **Pressures** are accounted for in the **Resources** modules (Energy Resources, Minerals, Land and Water Resources) and in the **Pollution** modules (Air, Water, Toxics and Solid Waste). The data in modules may be disaggregated by *region*, by *subsector* (*e.g.*, household type, industrial category, transportation mode, crop) and further by *process* (*e.g.*, household end-use devices, manufacturing process, vehicle type, farming practice). The number and types of regions, subsectors and processes are set by the user in order to match the aims of the analysis and data availability.

- **Evaluation:** The Evaluation modules provide a bird's-eye view of the environmental, resource and developmental performance of a scenario in relation to sustainability targets. The **Indicators** option allows the user to specify particular scenario variables as indicators, and compare trends in indicators in different regions or scenarios. The **Report Card** provides an overview of how user-selected indicators compare to user-defined targets.

The evaluation provides guidance for developing new scenarios, perhaps including alternative assumptions and policy targets affecting population patterns, lifestyle, technology, efficiency of raw material use, recycling levels and so on. By evaluating and modifying scenarios in an iterative manner, scenarios that meet long term goals may be distinguished from those that do not, providing guidance for the formulation of policies and actions for achieving a transition to a desirable, feasible, and sustainable future.

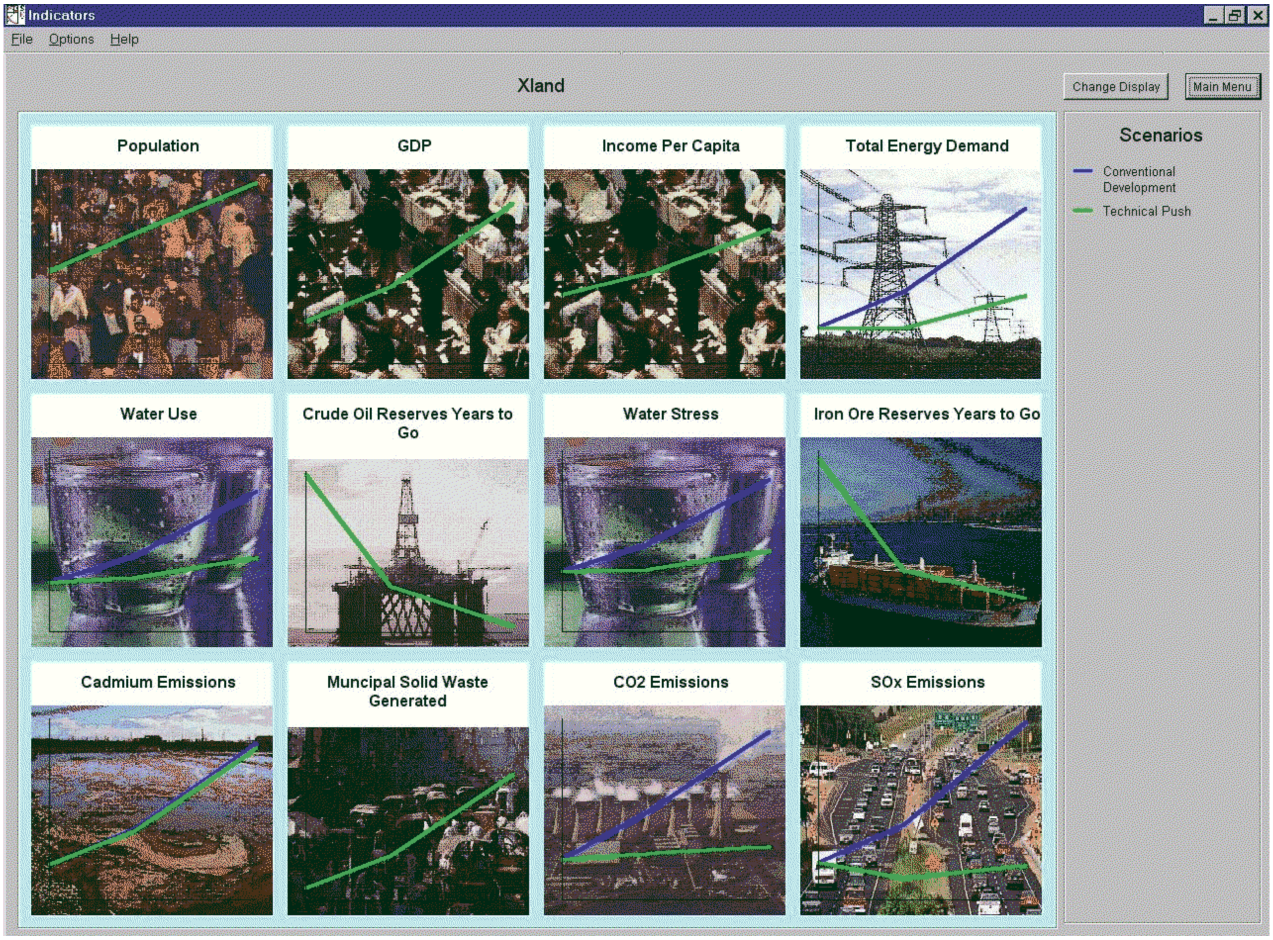
1.3 The PoleStar User Interface

The PoleStar user interface follows standard Windows 95 conventions. This manual assumes a basic working knowledge of the Windows operating environment. Refer to your Windows documentation for more information. While many PoleStar functions can be operated with the keyboard alone, a mouse or similar pointing device is required to access all PoleStar functions.

Graphical menu maps are the main tool for navigating through PoleStar. The PoleStar main menu (described in Chapter 3) is the main map of the PoleStar system. It is used to select and manage applications and their scenarios, and to access all of PoleStar's modules. The tables in each module are also presented as maps. Refer to the sections in Chapter 6 describing each module to see the corresponding table maps.

Tables are used in PoleStar's modules to enter quantitative data and to view outputs. They work much like standard spreadsheet worksheets, displayed on screen as tables of rows and columns. You can open and work on several tables at once. Refer to Chapter 4 for information on working with modules and their associated tables.

The **Sustainability Evaluation** box on the Main Menu contains the **Indicators**, and **Report Card** buttons. The Indicators option (sample below) is used to get a broad overview of your scenarios by examining charts showing the trends in important scenario indicator variables. You can flexibly choose which indicators to display and how they are presented. In the Report Card, scenarios are evaluated by comparing indicators to user-defined target values, which represent a pathway towards sustainable development. The Report Card includes a unique "birds-eye" view of scenarios presented as a series of red and green sustainability indicator lights. Refer to Chapter 5 for further information on the Sustainability Evaluation features in PoleStar.


Indicators
File
Options
Help
Xland
Change Display
Main Menu
Population
GDP
Income Per Capita
Total Energy Demand
Water Use
Crude Oil Reserves Years to Go
Water Stress
Iron Ore Reserves Years to Go
Cadmium Emissions
Muncipal Solid Waste Generated
CO2 Emissions
SOx Emissions
Scenarios
Conventional Development
Technical Push

2 GETTING STARTED

2.1 System Requirements

To run the PoleStar software you must have the following:

- A computer with an Intel 486 or better CPU (Pentium recommended)
- Microsoft Windows 95, 98 or NT (PoleStar will not run on Windows 3.1).
- 32 MB of RAM (64 MB recommended).
- At least 70 MB of free hard disk space for the initial installation.

You will also need room for your applications—typical applications take between 15 MB and 30 MB each.

2.2 Installation

Before installing PoleStar, close down any open applications in Windows. Then follow the instructions for the medium you are installing from. The PoleStar software is distributed in two different ways:

- **Installing from diskettes:** Insert the first installation diskette in the floppy drive on your computer. To start the installation program, click on the **Start** button on the Windows 95 task bar, and select **Run**. At the prompt type

  `a:setup.exe`

- **Installing from a copy downloaded from the Internet:** To start the installation program, click on the **Start** button on the Windows 95 task bar, and select **Run**. At the prompt type

  `c:\`*download directory*`\ps2000.exe`

  where "*download directory*" is the directory where you saved the file you downloaded from the Internet.

Once the installation program begins, follow the on-screen instructions to install PoleStar. By default, PoleStar will be installed in `C:\Program Files\Polestar`, but the installation program gives you the option to install in another directory. Messages will inform you of the progress of the installation process, and prompt you to insert other installation diskettes if they are needed. To run PoleStar after it is successfully installed, you must restart your computer. The installation program will offer to restart your computer for you.

The installation program creates a new folder called "PoleStar" under the Start Menu. To start the PoleStar program, click on the **Start** button on the Windows 95 task bar, go to **Programs**, then **PoleStar**, and select the PoleStar icon to start the program.

The first time PoleStar runs, it will install two sample applications, GLOBAL and XLAND. The GLOBAL application contains two scenarios for the world. The XLAND application is an example application developed for a fictional country, "Xland." It illustrates the features of PoleStar, and is used for examples in this manual. PoleStar also installs a default application structure called the Basic Structure. When you create a new application, this is the structure it is given.

2.3 Registering PoleStar

Evaluation copies of the PoleStar software are available for free download from the Internet at http://www.seib.org/polestar. The evaluation copies do not allow you to save data or modify the data structure. Otherwise, they are fully functional versions of the software. They allow you to view existing applications and evaluate the capabilities of the system, but cannot be used for analytical purposes.

If you wish to create new scenario applications, or alter and save changes to existing applications, you must register your copy of PoleStar. Licensed users of PoleStar can "unlock" evaluation copies of the software, and enable the saving of data. For information on licensing a full version of PoleStar, please contact SEI-B at the address shown below.

- **By mail:**

  Stockholm Environment Institute-Boston
  Tellus Institute
  11 Arlington Street
  Boston, MA 02116-3411
  USA

- **By telephone or fax:**

  Telephone: +1 (617) 266-8090
  Fax: +1 (617) 266-8303

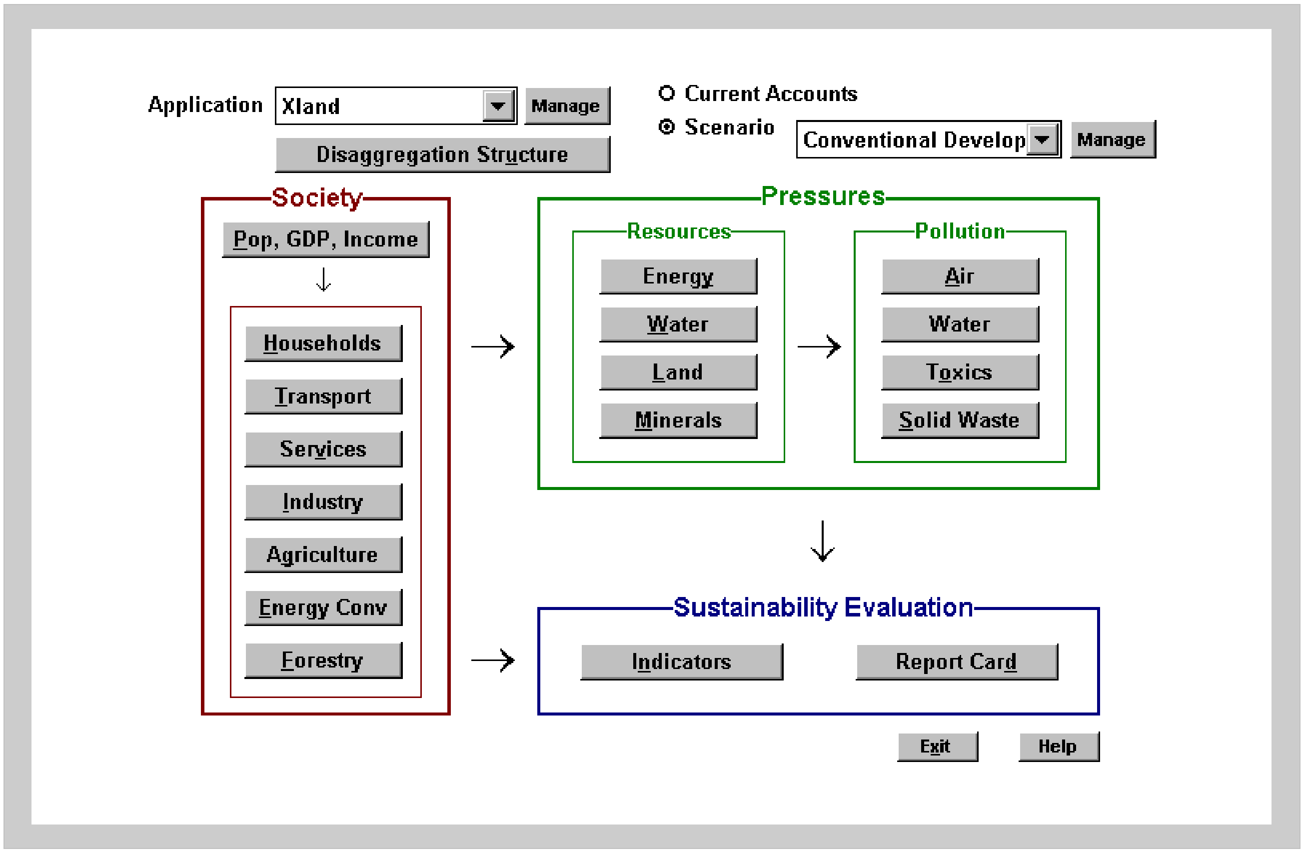
- **By e-mail:**

  polestar@tellus.org

- **On the web:**

  http://www.seib.org/polestar

3 THE MAIN MENU



The Main Menu is the departure point for all actions in PoleStar. Use it to select and manage applications and their scenarios, and to access PoleStar's modules.

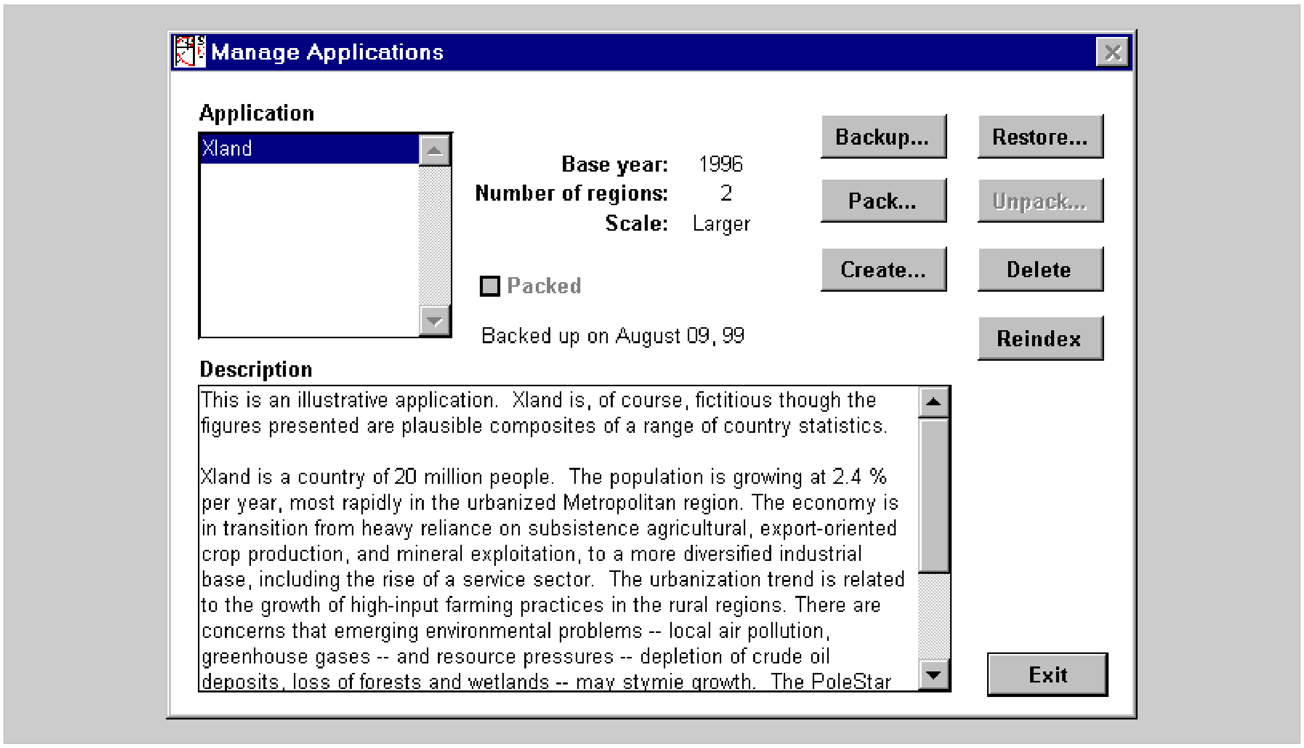
- **Application:** An **application** specifies the geographic area that is under consideration. An application can be for a country, locality, multi-country region, or the globe. PoleStar is supplied with sample applications illustrating both global and national analysis. Use the **Manage** option to create and organize your PoleStar applications. The number of applications you can create is limited only by available hard disk space.

- **Disaggregation Structure:** PoleStar emphasizes flexible data structures, and hence the data for each application has an adjustable disaggregation structure. Use the **Disaggregation Structure** window to create and edit data disaggregation structures, such as the regions in an application or the fuels you wish to include in your analysis. Consider beginning with a highly aggregate data structure, adding further disaggregation as your analysis progresses. Data structures can also be revised within the modules in which they appear. The **Disaggregation Structure** window is described in more detail in Section 3.3.

- **Current Accounts and Scenarios:** The analysis of each application is based on a set of Current Accounts data and one or more scenarios. Current Accounts are data that describe the Base Year socio-economic and environmental conditions in your application, while each scenario represents an alternative future path. Note that scenarios use the same data disaggregation structure as the Current Accounts. Use the radio button and pop-up menu on the Main Menu to select either the Current Accounts data or a scenario to work with. Use the **Manage** option to create and organize your scenarios.

- **Modules:** Current Accounts and Scenario data are grouped by topic into *modules*. PoleStar contains the following modules: Population, GDP and Income; Households; Transport; Services; Industry; Agriculture, Energy Conversion; Energy Resources; Water Resources; Land; Minerals; Air Pollution; Water Pollution; Toxics and Solid Waste. When you open a module by clicking it on the Main Menu, you will be presented with another diagram showing the tables that you can select for that module. Detailed descriptions of each module are provided in chapter 6.

3.1 Managing Applications



To create and then organize your PoleStar applications, use the Main Menu: Manage Applications option. To open the Manage Applications dialog, in the Main Menu click on the button labeled "Manage" that appears next to the application name. Several options are offered on a set of buttons in the dialog.

- **Create:** Click on the Create option to create a new application. Enter the application name, which can be any legal Windows95 filename, containing no more than twenty characters. Next select whether the application is **New** (containing default data structures such as lists of fuels, pollutants, land-use types, etc. and using the Basic Structure) or is **Based on** an existing application. For New applications, you will also need to indicate whether the application is small scale (less than 10 million population) or large scale (see **Scale** below). Select the "**Based on"** option when you want your application to begin with data copied from an existing application. Select the application on which the new application will be based. To help in choosing among different existing applications, descriptions are displayed as illustrated above.

  Base Year: The Base Year corresponds to the Current Accounts data (generally the most recent year for which data are available). If you are basing the new application on an existing application and change the Base Year, you should review any Current Accounts data copied to insure that they are consistent with the new Base Year.

  Scale: The scale of a PoleStar application affects the default units displayed in column titles. The scale can only be set when an application is created, so while you can change column titles and formulas later on, you should choose the scale with care at the start of your analysis, to avoid having to make extensive adjustments to your application later.

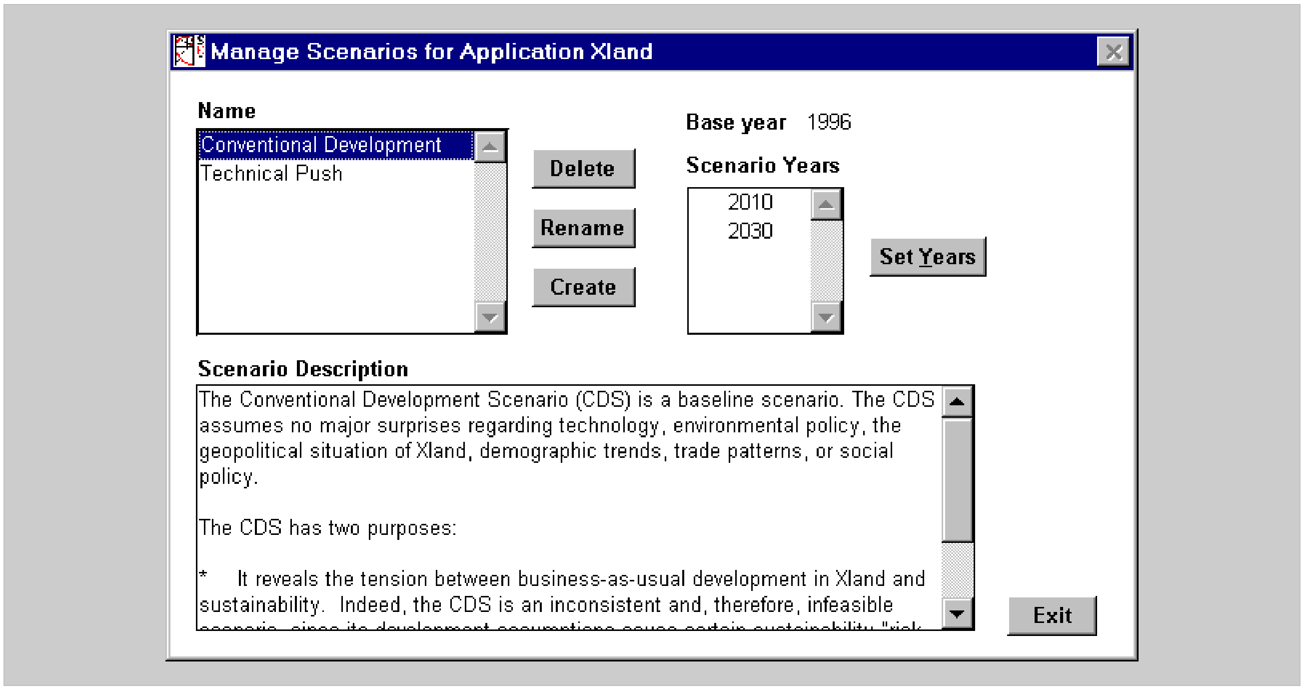
In general, you should select the smaller scale for applications dealing with cities, regions or countries with a population of less than 10 million in any of the projected time periods, or a GDP of less than 100 billion US$. Otherwise, for applications dealing with medium-to-large size countries or global analyses select the larger scale. For further guidance, the following table lists the ranges of values that are most convenient in the Smaller and Larger scales.

Activity	Smaller Scale	Larger Scale
Population	Less than 100 million	Greater than 100 thousand
GDP	Less than 1,000 billion US$	Greater than 100 million US$
Land Area	Less than 1,000 million ha	Greater than 1 million ha
Fuel Use	Less than 10,000 PJ	Greater than 1 PJ
Water Resources	Less than 1,000 billion m^3	Greater than 100 thousand m^3

Currency: Use this option to define the currency used in your PoleStar study. By default, PoleStar uses US$. If you wish, you may change the currency by entering a new currency unit abbreviation. Enter up to 4 characters for the abbreviation, and then (for scaling purposes) choose the amount in the local currency that is closest in value to 1 US$ (either 1 or 1000). Choose the currency setting with care, since it can only be set when an application is first created.

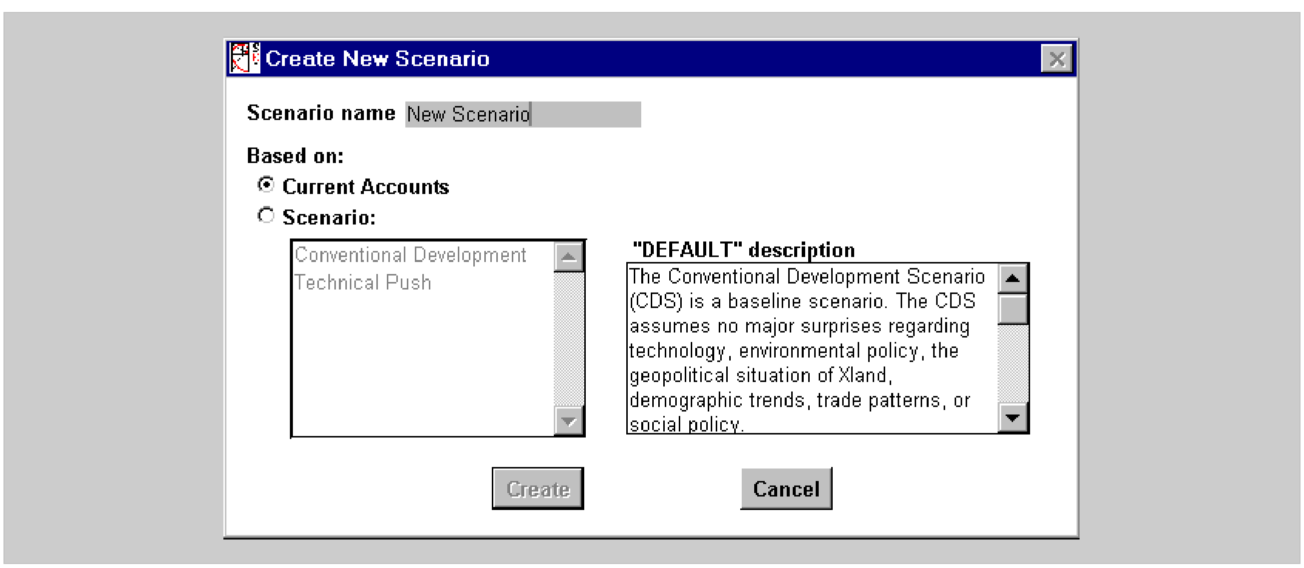
- **Backup/Restore:** The Backup option copies an application’s files to floppy disk. The files will be stored in packed format, as described below. Backup applications regularly to avoid loss of data. Use **Restore** to copy a backed-up application from floppy disk back to the hard disk.
- **Pack/Unpack:** Use Pack to archive a selected application’s files into a single compressed “ZIP” file to save space on your hard disk. Packed applications cannot be opened without first unpacking them. Typically, a packed application will take only 20% of the hard disk space used by an unpacked application. Use the **Unpack** option to reverse the Pack process.
- **Delete:** Use this option to delete an application. Deleted applications cannot be recovered (other than through **Backup/Restore**). You will be warned before an application is deleted. You should always back up applications to avoid loss of data due to accidental deletion.

3.2 Managing Scenarios



To create and then organize your PoleStar scenarios, use the Main Menu: Manage Scenarios option. To open the Manage Scenarios dialog, in the Main Menu click on the button labeled "Manage" that appears next to the scenario name. Options are offered on a set of buttons in the dialog.

- **Delete:** To delete a scenario, highlight one of the scenarios, then click the **Delete** button. A deleted scenario cannot be recovered. You will be asked to confirm the deletion before PoleStar proceeds to delete the scenario data.
- **Rename:** To rename a scenario, highlight one of the scenarios, then click the **Rename** button.
- **Create :** The **Create** button leads to an additional dialog box. First enter the **Scenario name**, then use the **Based on** radio button to select whether you wish to create the scenario from Current Accounts data only, or from an existing scenario. If the scenario is to be based on an existing scenario, then select that scenario from the list of available scenarios. Select **Create** to create the new scenario or **Cancel** to abandon the dialog box and return to the Select Scenario dialog box. Once you have created a new scenario, type in a description.



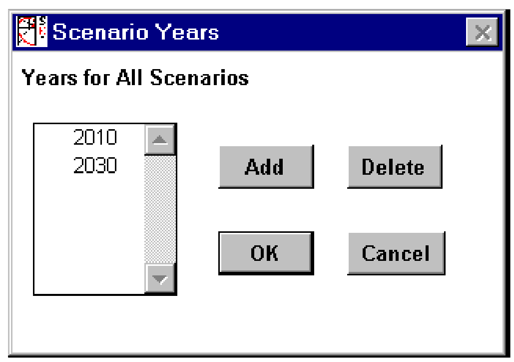
- **Set Years:** It is important to note that all scenarios share the same set of scenario years—the years for which you wish to enter scenario data and report results. Thus, when you create a new scenario, you will generally **not** change the scenario years. Clicking the **Set Years** button displays a dialog box listing the scenario years, with the option to **Add** and **Delete** years. You can create as many scenario years as you like, but be aware that each scenario year you add may require entering more data, depending on how the structure you are working with is defined (see chapter 7 on building customized structures in PoleStar). Also, the time PoleStar takes to recompute scenario results is proportional to the number of years. If you delete a year, be aware that you will lose all the data and formulas that have been previously entered for this year. By definition, scenario years must be after your application Current Accounts year. Select **OK** to confirm the changes to the list of years and return to the Select Scenario dialog box. This may take a few minutes as PoleStar updates your data. Select **Cancel** to abandon your edits and return.

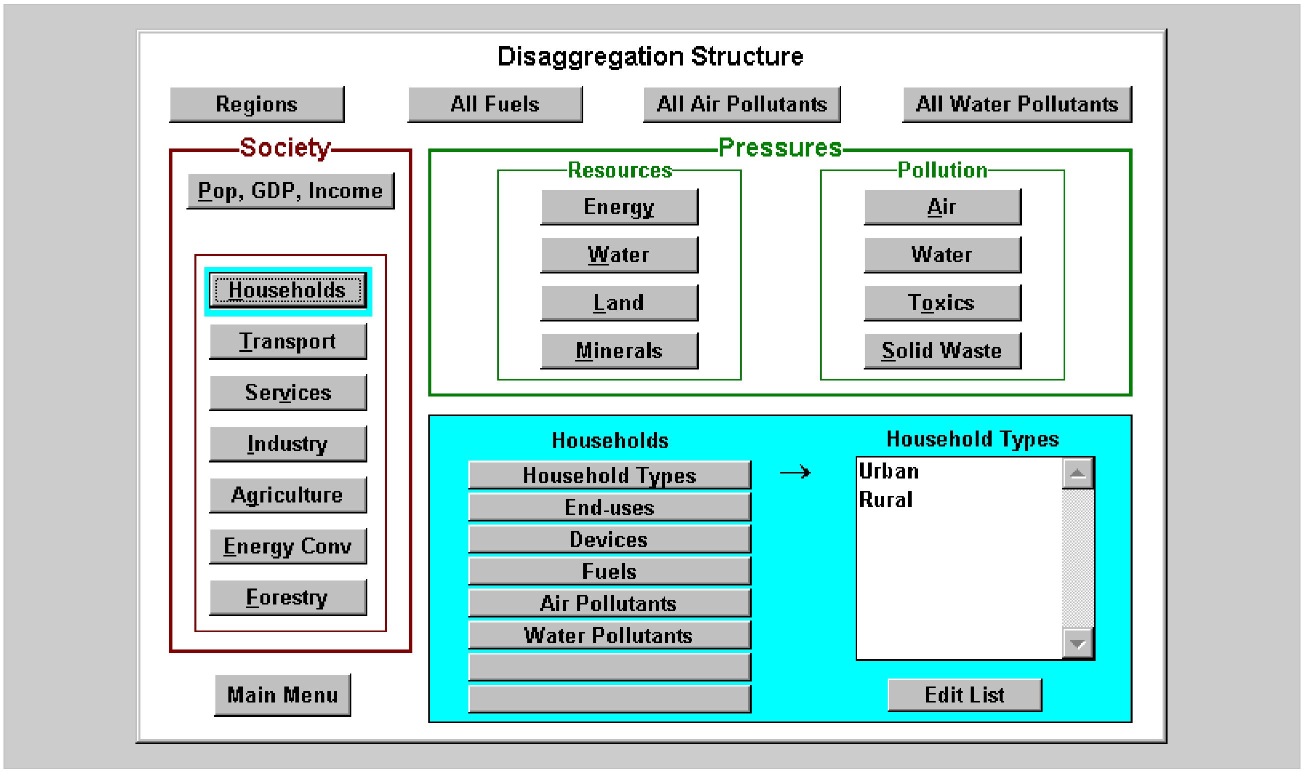
Tip: You can add or delete scenario years at any time. Start your analysis with a minimum number of years—an end year and perhaps one intermediate year. You can add other years later as the analysis requires. If you set more than one scenario year, PoleStar will fill in data for intermediate years.

3.3 Disaggregation Structure

The Disaggregation Structure window can be accessed either from the Main Menu or from within the Modules. (However, when it is accessed from within a module, only the structure relevant to that module can be edited.) The Disaggregation Structure window is used to create the structures that you will use for entering data in your application. Note that an application's disaggregation structure is shared between its Current Accounts data and scenarios. Although you should carefully design your disaggregation structure before starting to enter your data, it is worth noting that you can also return and re-edit the structure as your analysis proceeds.

The layout of the Disaggregation Structure window is very similar to that of the PoleStar Main Menu. To view the disaggregation structures belonging to a particular module (Pop, GDP, Income; Households; Transport; etc.), simply click on the appropriate module button. The corresponding list of disaggregation structures for that module will then be shown in the light blue box in the lower right-hand corner of the window. You can further view or edit any of these disaggregation structures by clicking the appropriate button and then clicking the **Edit List** button. When accessing Disaggregation Structures from within a module, you may only edit the disaggregation structures belonging to that module. Other disaggregation structures may be viewed but not edited. In these cases the **Edit List** button is labeled **View List.** Click on **Main Menu** to exit the Disaggregation Structure window and return to the PoleStar Main Menu.



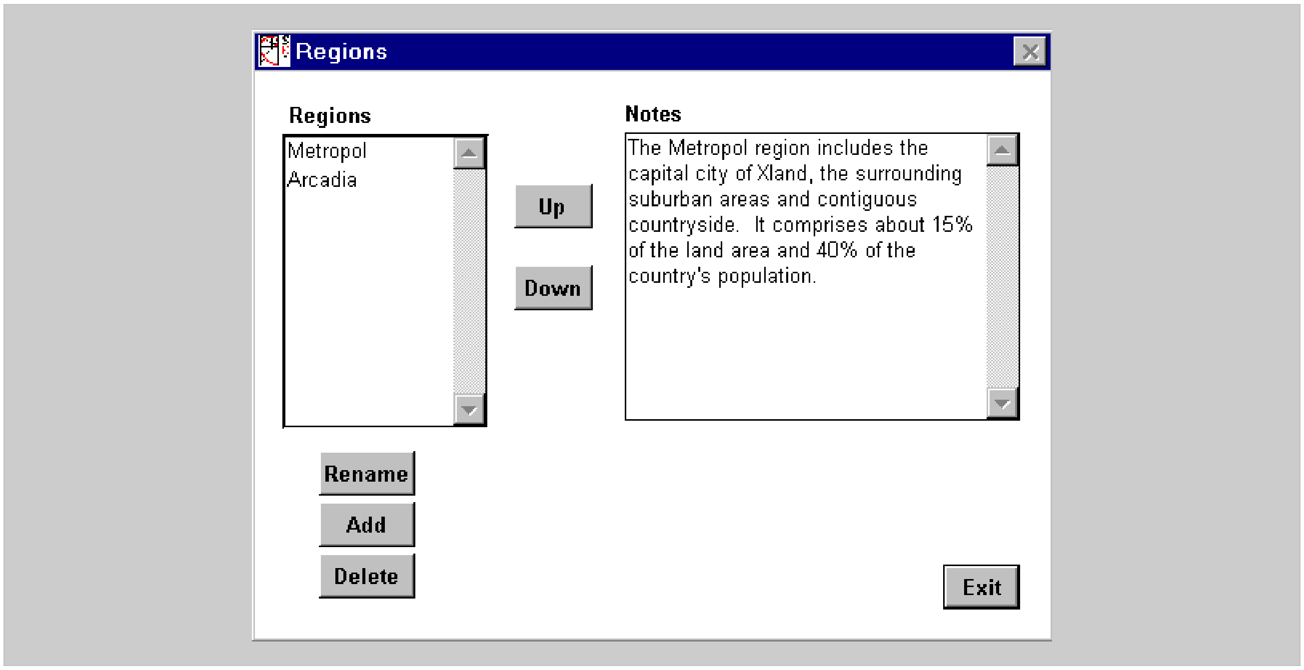


In this chapter we describe the *common data structures* that are used throughout PoleStar: **Regions**, **All Fuels, All Air Pollutants**, and **All Water Pollutants**. Module-specific disaggregation structures are described in the chapters corresponding to each module. Note that the term "All" is used to indicate that you are defining the superset of all regions, fuels and pollutants used in your Application. Later, you will select subsets of these lists for use in each module. For example, only certain fuels are used in the Households sector. This approach is designed to reduce data entry requirements in PoleStar.

3.3.1 Regions

Use the **Regions** button to enter the list of one or more *regions* into which your application is disaggregated. *Tip: for regions and other data structures, it is acceptable to define only 1 item. For example, you might have a single region called "All".*

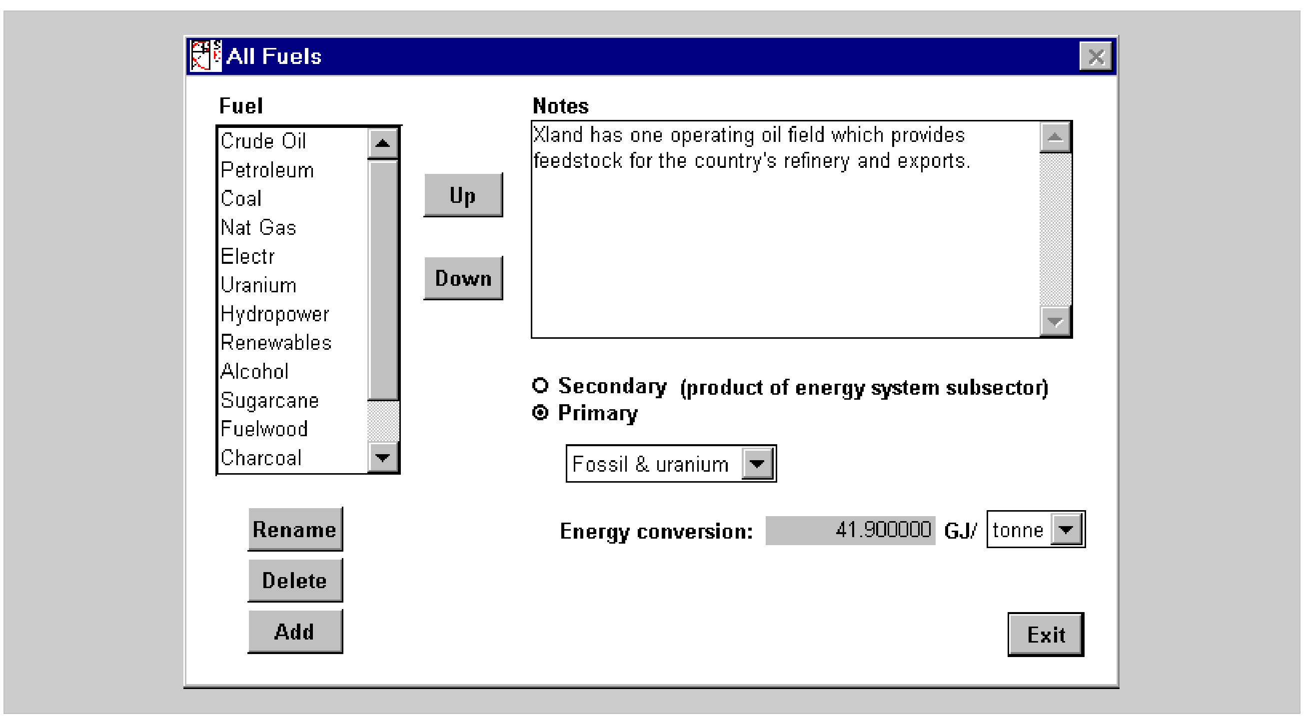
You can **Rename**, **Add,** and **Delete** regions by clicking on the dialog box buttons. Also, you can reorder the region list by using the **Up** and **Down** buttons. You can also enter text notes to document each region. Select **Exit** to leave the dialog box and return to the Disaggregation Structure window. The Save Data dialog box will prompt you to save any changes you have made.



3.3.2 All Fuels

Click on the **All Fuels** button to edit the master list of fuels used in your application. Within each module, you will then select a subset of fuels from this master list. The default data provided with PoleStar includes a standard list that should be a good start for most applications. You may wish to add more detail to the list (for example, by separating out gasoline, diesel, LPG, etc. from the default aggregate labeled "Petroleum"). However, try not to add more detail than is justified by the needs and data availability of your application.

You can **Rename**, **Add,** and **Delete** fuels using the dialog box buttons, and reorder the list using the **Up** and **Down** buttons. You may also enter text notes to document each fuel.



Each fuel on your list must be marked as either a *primary* fuel or a *secondary* fuel:

- **Primary Fuels:** Primary fuels are derived directly from natural sources (*e.g.*, crude oil, coal, natural gas, uranium, solar energy). For primary fuels, use the accompanying popup box to indicate the type of resource: fossil & uranium, hydro & geothermal, or other renewables.

  In order to compare primary fuels to their physical resource base, you will also need to enter their energy content (in Gigajoules) per unit of physical resources (*e.g.*, tonnes, cubic meters, etc.)[1]. The default energy contents are typical values and conform to official United Nations estimates wherever possible.

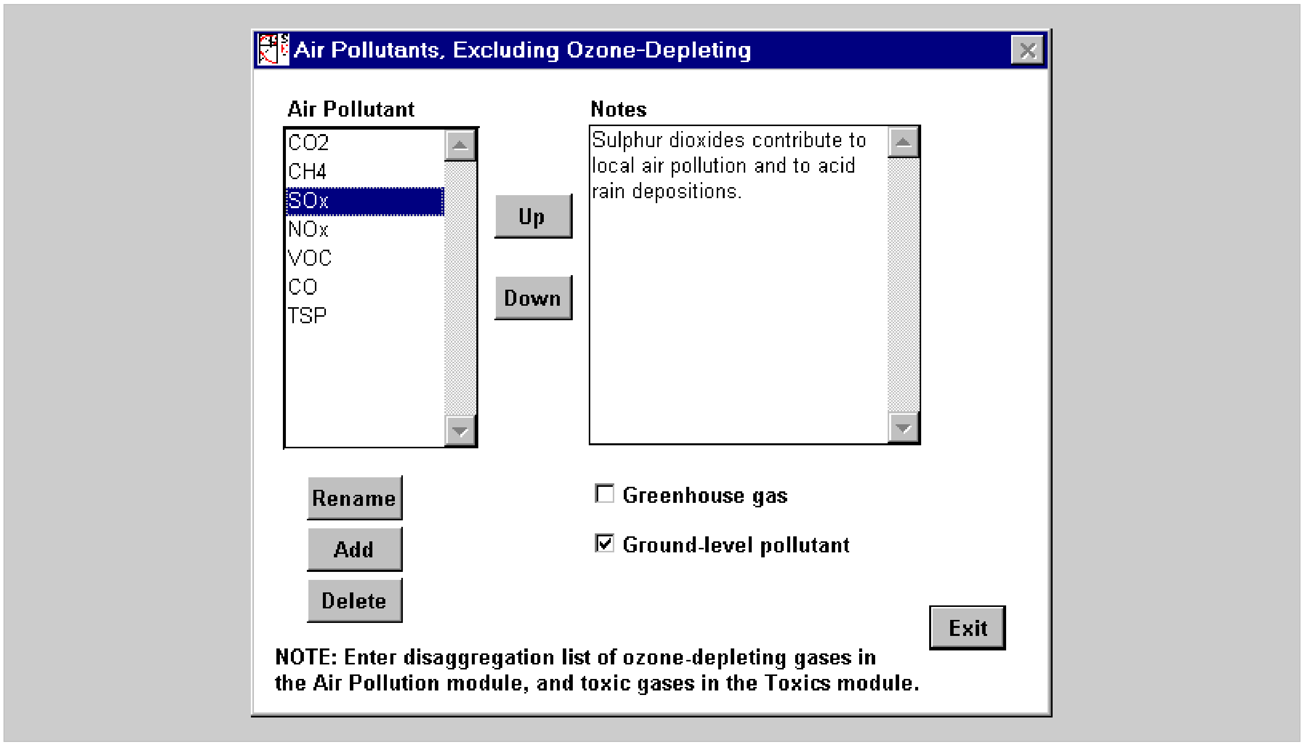
- **Secondary fuels:** Secondary fuels are those fuels that result from energy conversion processes such as electricity (from power plants), the various petroleum products (from refineries), charcoal (from kilns), ethanol/methanol (from refineries using organic matter as inputs), and so on. In the PoleStar Energy Conversion and Resources modules, all secondary fuels must either be produced as the product of an energy system subsector, or they must be imported. Notice that both primary (*e.g.*, coal, natural gas) and secondary fuels may be directly consumed by end-users.

Select **Exit** to return to the Main Menu. If you have made changes, the Save Data dialog box will prompt you to save any changes you have made.

3.3.3 All Air Pollutants

Click on the **All Air Pollutants** button to edit the master list of air pollutants for your application (greenhouse gases and ground-level pollutants). Note that ozone-depleting gases and toxic gases are listed separately in the Air Pollution and Toxics modules respectively. Within modules you can identify the subset of pollutants used in each module. The default data provided with PoleStar includes a standard list of pollutants that can be used as a starting list. You can **Add, Rename** and **Delete** pollutants using the dialog box buttons, and reorder the list using the **Up** and **Down** buttons. When adding a pollutant, use the check boxes to indicate whether the pollutant is a greenhouse gas and/or a ground level pollutant. You may also enter text notes to document each pollutant. Select **Exit** to return to the Main Menu. If you have made changes, the Save Data dialog box will prompt you to save any changes you have made.

[1] Units used in the Basic Structure and selected conversion factors are presented in Annex 1.



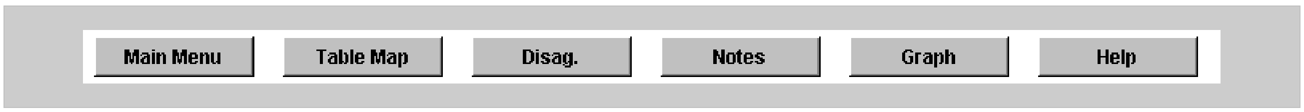
3.3.4 All Water Pollutants

Use the **All Water Pollutants** dialog box to enter a master list of water pollutants. Within modules you can identify the subset of pollutants used in each module. The default data provided with PoleStar includes a standard list of pollutants that can be used as a starting list. You can **Add, Rename** and **Delete** pollutants using the dialog box buttons, and reorder the list using the **Up** and **Down** buttons. You may also enter text notes to document each pollutant. Select **Exit** to leave the dialog box and return to the Main Menu. If you have made changes, the Save Data dialog box will prompt you to save those changes.

4 MODULES AND TABLES

Modules and their associated tables are used to enter quantitative data and to view outputs. All modules are accessed from the main menu. Clicking a module button causes PoleStar to display the corresponding **Table Map** for the module A Table Map displays buttons showing all of the tables available in the current module. Clicking one of these buttons causes PoleStar to open the module and display the table you selected. Each table works much like a standard spreadsheet worksheet, displayed on screen as a window with labeled rows and columns.

4.1 Buttons



Push buttons provide access to the most common tasks in a module:

- **Main Menu** (equivalent to the **Module: Exit to Main Menu** menu option): Click this button to quickly exit a module and return to the PoleStar Main Menu. When exiting, if you have made changes, you will be asked if you want to save your data.
- **Table Map:** displays the map of all tables available in the current module. Use the table map to open or switch to any table.
- **Disag.:** displays the Disaggregation Structure window for the current module. Use this button when you want to edit or view the data structures of the current module or view the data structures of other modules (not available in all modules).
- **Notes:** displays the documentation notes for the current module. Use this button to view or enter documentation on your analysis. Separate sets of notes can be created for Current Accounts and each scenario.
- **Graph:** displays a dialog box used to create graphs from the currently selected table (see section 4.4).
- **Help:** displays context-sensitive help on the current table.

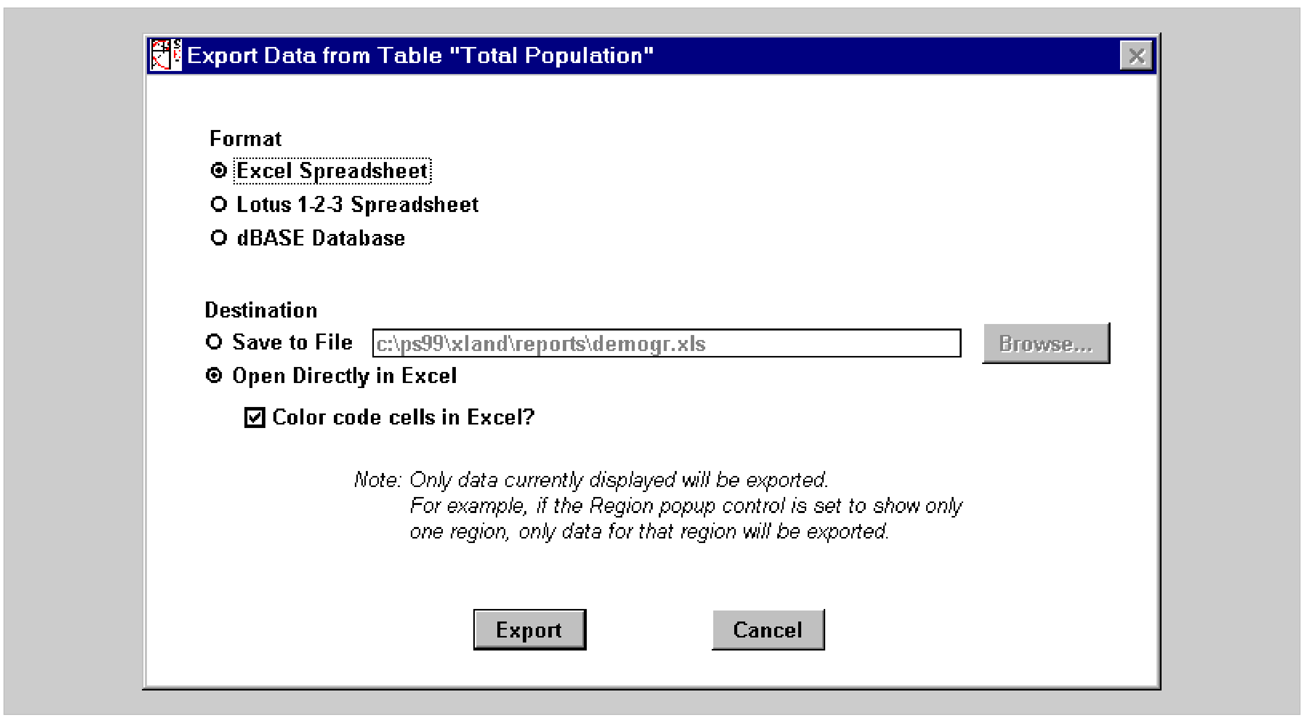
4.2 Menu Options

PoleStar modules use four groups of menu options: **Module**, **Edit**, **Window** and **Tools**:

- **Module:** The module menu contains two options: **Save** and **Exit to Main Menu**. The Save option is active only if you have made changes, and is useful when you are spending a long time editing a single table. Use it to save your data periodically to help avoid data loss from hardware or software crashes. When exiting, if you have made changes, you will be asked if you want to save your data.
- **Edit:** The Edit menu contains standard Windows editing functions (Undo, Redo, Cut, Copy, Paste, etc.). These options can also be accessed using the standard Windows shortcut keys (*e.g.*, Ctrl-C, Ctrl-V). Options are available only where appropriate.
- **Window:** The Window menu contains options for choosing which open table is active for data entry, changing the font used in tables, and closing the active table. Other functions for arranging windows are available by clicking on the upper left-hand icon on each Window's title bar.
- **Tools:** The tools menu contains options to print, save, import and export tables, set the table calculation mode, and access an on-screen calculator.

- **Print/Save:** displays a text version of the current table in a notepad-like window. You can then reformat this report (*e.g.*, by changing the size and typeface of the font) before printing, saving or copying the table to the clipboard.
- **Export:** exports the current table to a spreadsheet or database. When Export is selected, the form shown below appears. Specify the format to which you want to export (Excel, Lotus 1-2-3, or dBASE). Next you indicate the directory path and filename of the exported file. If exporting to Excel you may also choose to export the table directly to Excel. In this case, PoleStar will automatically open Excel (if it exists on your PC) and export the data into a new Excel worksheet. This option allows you to quickly export a table without needing to create an intermediate data file containing the table. When exporting directly to Excel, you may also choose to color code the Excel spreadsheet to show which cells are data (blue) and which are expressions (gray). The gray cells will be locked in Excel, as they cannot be imported (see below).

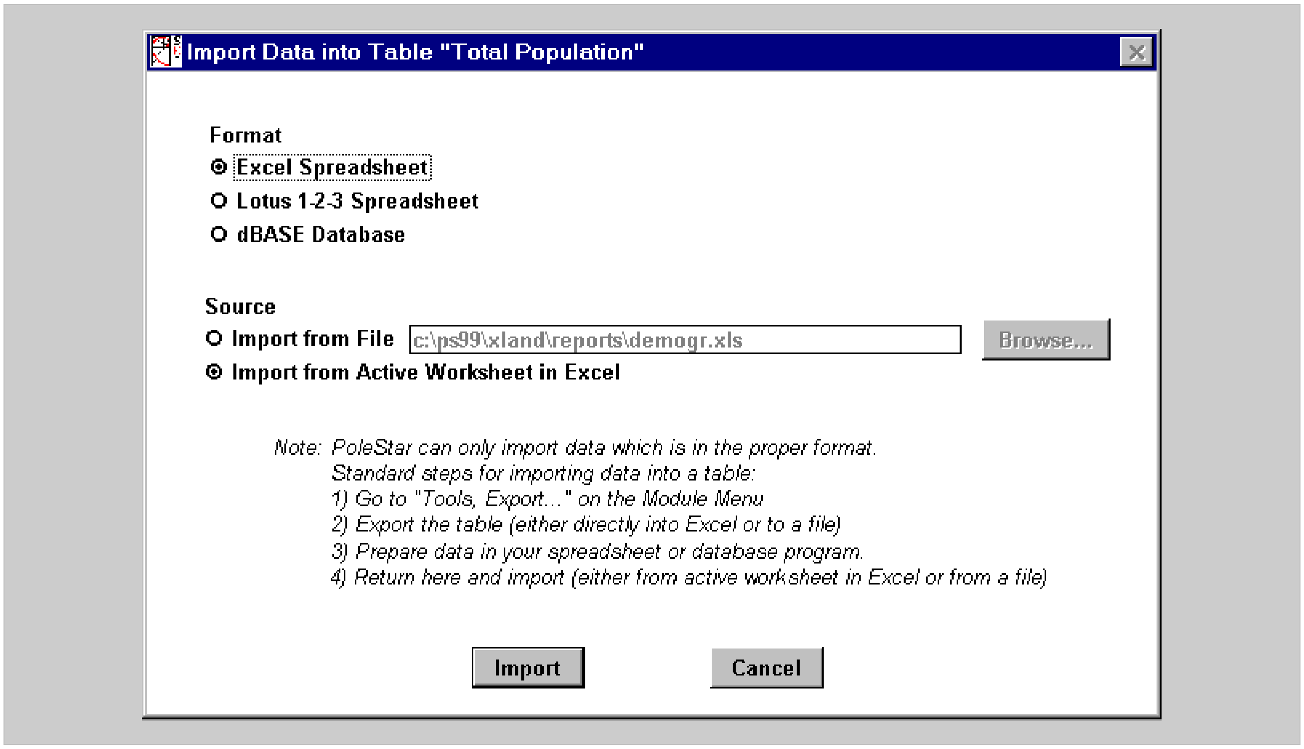
  Note that PoleStar only exports the table data currently selected in the module popups. So, for example, if you want to export a table for all regions, make sure you select "ALL" on the region popup.



Tip: We recommend that you only check the color code option when exporting to Excel versions 5 or higher. This feature is not reliable in Excel version 4 or earlier.

- **Import:** imports data from a spreadsheet or database into the current table. When Import is selected, the form shown below appears. Specify the format from which you want to import (Excel, Lotus 1-2-3, or dBASE). Next you indicate the directory path and filename of the import file. If importing from Excel you may choose to directly import from the active Excel worksheet. This requires that Excel is open with the relevant worksheet active.

  When importing, PoleStar looks for column headings that match the internal column titles of the active table. (The best way to create a spreadsheet or database with the correct column headings is to export a PoleStar table.) Only columns whose titles match will be imported—PoleStar will ignore any extraneous columns. In addition, PoleStar will not import locked (calculated) columns (colored gray)[2].



- **Automatic Calculation:** Just as with a spreadsheet program, PoleStar can automatically recalculate all open tables every time any data value changes, or wait and perform all pending calculations in a batch. The **Automatic Calculation** option toggles between these calculation modes (instantaneous and delayed). When automatic calculation is turned off, calculations will only be performed when you switch from one table to another or exit the module. This is useful for data entry, as you will not need to wait after each number entered for calculations to complete.
- **Calculate Now**: When automatic calculation is turned off, you may use the **Calculate Now** option to cause PoleStar to perform all pending calculations.

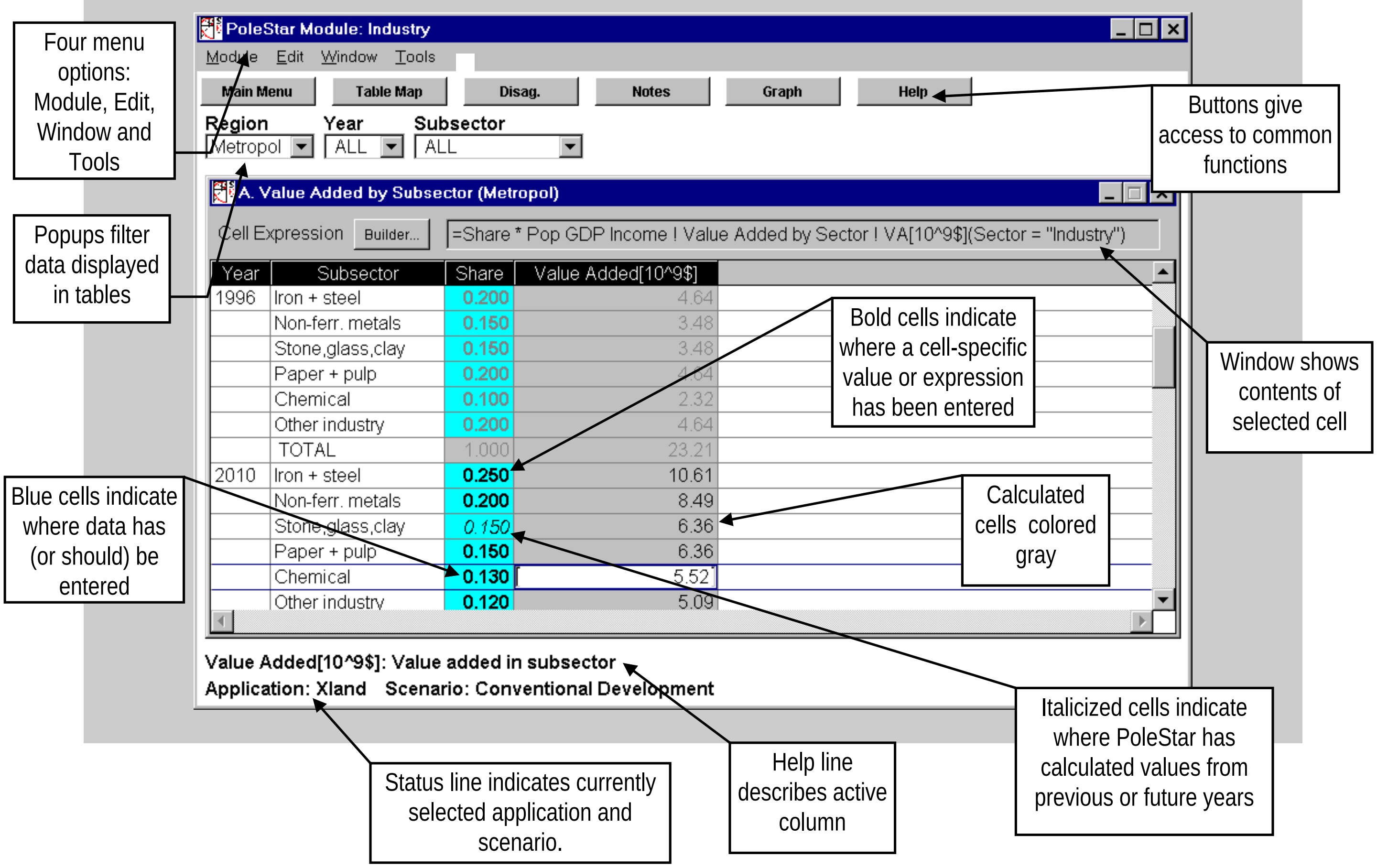
---

2 By default, PoleStar locks calculated cells in an exported spreadsheet. If you override this by unprotecting a sheet (using **Tools: Protection: Unprotect Sheet**) be aware that any edits to protected cells (shown in gray) will not be imported back into your PoleStar data.

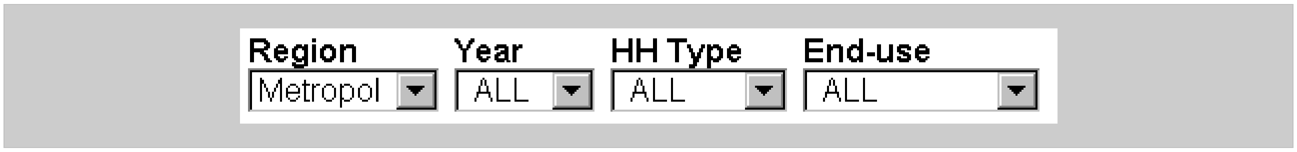
4.3 Tables

Each table works much like a standard spreadsheet worksheet, displayed on screen as a window with labeled rows and columns (see figure below). You can use the mouse to **re-size columns** in a table. To change a column's width, click and drag on the column separator line at the top of the column, between column headings. On the far left of each table is a special set of columns that gives the **dimensions** for the table. The cells in these columns have a white background. You cannot delete or change the titles of the dimension columns, but you can change the items that appear in the column cells by changing the disaggregation structure of your PoleStar application. You may temporarily change which dimensions are displayed by using the Table Popup Controls. The other columns in the table contain PoleStar **variables**. Aside from a few special columns in PoleStar that cannot be deleted, you may delete, add or move any of the columns in a table. For information on how to customize tables, see Chapter 7.

Working with PoleStar Tables



4.3.1 Table Popup Controls



Popup controls are used to select which table rows are displayed at any given time. With most data you can choose to display either one item (*e.g.*, a single region), ALL items or, where appropriate, the TOTAL across all items (*e.g.*, the totals across all regions). When ALL is selected, PoleStar displays a new column in the table listing the names of each item. In this way, you can control how much data is displayed on the table. This feature allows you to focus on a subset of data, or to scan across many alternative settings.

4.3.2 Entering Table Data

PoleStar color-codes tables to differentiate cells where data has or should be entered (colored blue) and cells that are calculated (colored gray).

Blue Cells - Data

Blue cells indicate where data are to be entered in a PoleStar application. To enter data, click on a cell and type a value at the highlighted cursor. Alternatively, you may edit the cell contents in the **Cell Expression** box at the top of the table. As you enter data, notice that calculated values that depend on your entry (including column totals) will be automatically recalculated and redisplayed, unless automatic calculation (on the Tools menu) is turned off.

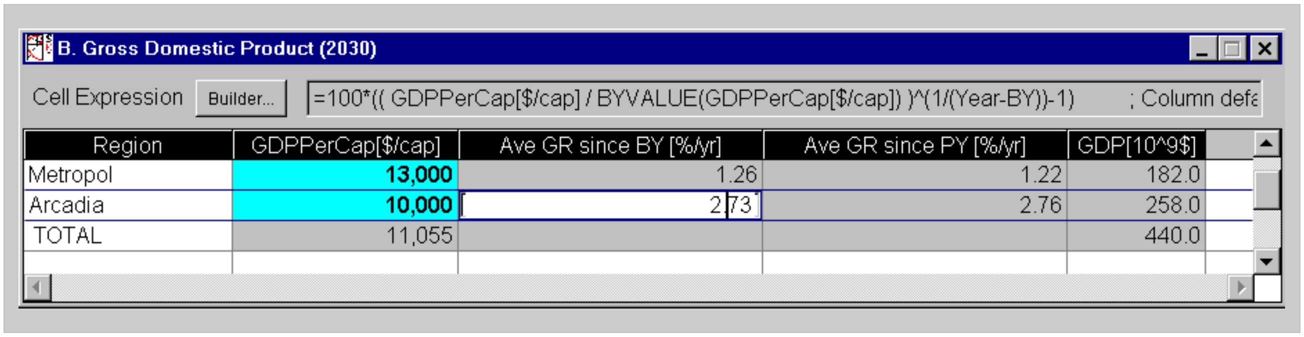
When adding additional years to a scenario, PoleStar will automatically fill in values for the new years by interpolating between values in earlier and later years. Years added after the last scenario year will be filled in with the value from that last year. Note that these new cells contain an interpolation formula, which updates the values in the cells should those in earlier or later years change. Even though these cells contain a formula they are colored blue to indicate that they reflect an assumption about these data values.

Gray Cells - Calculated

Gray cells are computed by their associated formula. Unless you wish to change the underlying calculations in your application, you will not normally need to edit gray cells.

*Tip: Bear in mind that the default contents of gray cells can be overwritten inadvertently. To force PoleStar to revert to the default expression for a cell, select the cell by clicking on it and press **Shift + Del**, or right-click on the cell and choose "**Remove this cell-specific value**".*

To view or edit the formula for a cell, click on the cell. The formula for the cell will appear in the **Cell Expression** box at the top of the table (as shown below). If you click on a blank cell, you will see "= N/A" in the Cell Expression box ("not applicable"), indicating that the cell does not hold a meaningful value, so that no data or formulas should be entered. For more information on how to create and edit formulas, refer to section 7.2.



Region	GDPPerCap[$/cap]	Ave GR since BY [%/yr]	Ave GR since PY [%/yr]	GDP[10^9$]
Metropol	**13,000**	1.26	1.22	182.0
Arcadia	**10,000**	2.73	2.76	258.0
TOTAL	11,055			440.0

Cell Fonts

In addition to color coding cells, PoleStar uses different fonts to indicate additional information about cells:

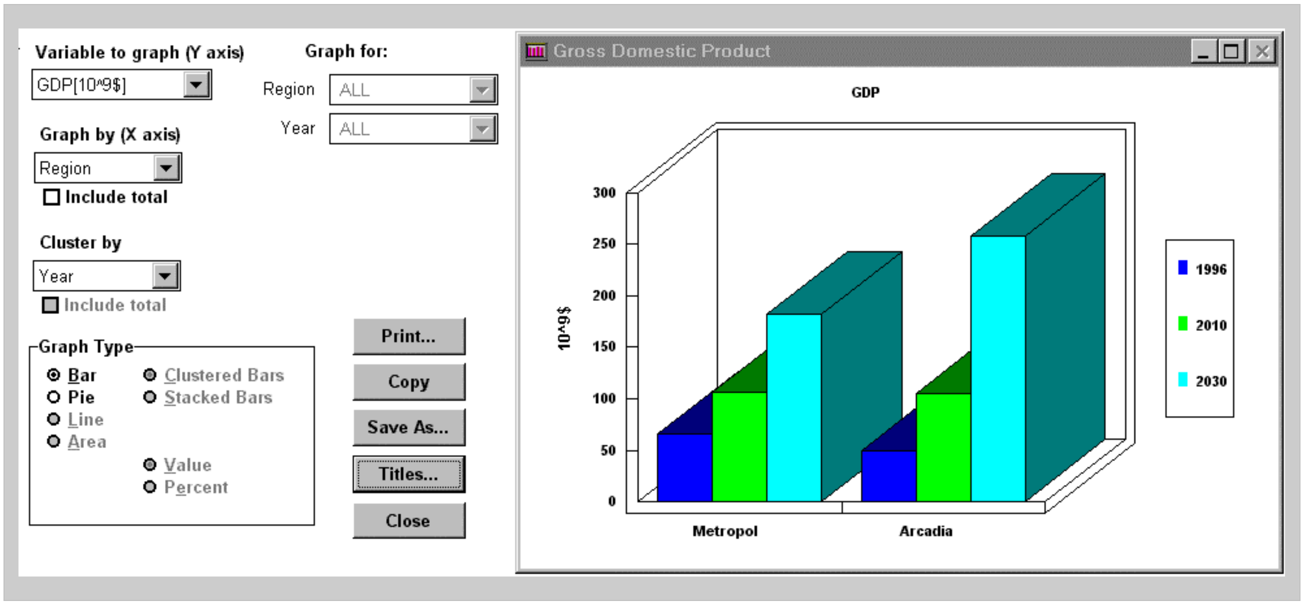
- A **bold** font indicates that a specific value or formula has been entered in the cell.
- A regular font indicates that the cell contains the column default expression. Two different column default expressions can be entered: one for Current Accounts and one for scenarios. To edit the column default expression, click with the right mouse button on the column title, and select **Edit This Column**. For more information on editing columns, see Chapter 7.
- An *italic* font indicates that PoleStar automatically created a default cell expression based on the contents of the cells in earlier and later years.

Refer to Annex 2: Rules for Computing Cells for more information on how PoleStar determines the value of a cell.

4.4 Graphs

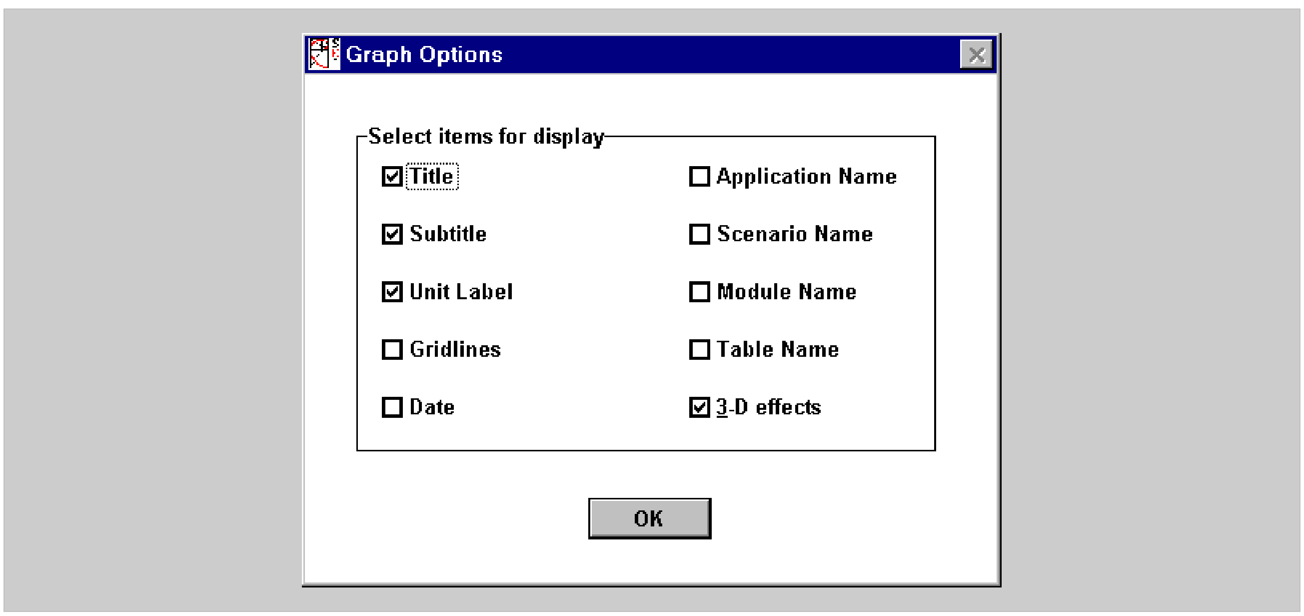
The graph button displays a dialog box used to create graphs from any table. First, use the **Variable to graph (Y axis)** popup to specify which variable (*i.e.*, table column) you want to graph (*e.g.*, GDP). Next, use the **Graph by (X axis)** popup to choose which dimension you want to graph on the x-axis (*e.g.*, years). You may select a second dimension for display, using the **Cluster by** popup (*e.g.*, regions). Next, specify the graph type: **bar**, (**clustered** or, where appropriate, **stacked**), **pie**, **line**, or **area**. Finally, use the popups on the right of the dialog to select the slice of data you want to graph. Some restrictions apply. For example, line and area graphs are available only when graphing by year. The graph is displayed on screen in an adjoining window and will be updated automatically each time you select a dialog box option. The graph window can be maximized to enlarge the graph. Displayed graphs can be copied and pasted as standard Windows pictures into many Windows applications such as Microsoft Word, Excel, Paintbrush or WordPerfect for Windows.

Note: PoleStar will allow most dimensions or quantities to be stacked, even though that may not be appropriate, because the values are not inherently additive. For example, intensities should not be stacked.



Use the on-screen buttons to **copy** a graph to the Windows clipboard or to **print** it. Graphs may also be **saved** to file in standard .PCX, .BMP or Windows Metafile (.WMF) formats.

You can further customize a graph by clicking on the **Titles** button and using the check boxes to indicate which items should be displayed on screen: title, subtitle, units, gridlines, date. application name, scenario name, module name, and table name. Use the **3D effects** check-box to toggle between two-and three-dimensional graph effects.



5 SUSTAINABILITY EVALUATION

The **Sustainability Evaluation** module allows you to review and evaluate major indicators that you select to highlight in your scenarios. It offers two tools: **Report Card** and **Indicators**.

5.1 Report Card

The Report Card module (shown below) is used to present and assess scenarios, by comparing selected indicators to user-defined "targets." Targets are trajectories that define a pathway from current conditions to a sustainable future. The Report Card presents a "birds-eye" view of scenarios as a series of red and green lights that indicate whether the indicator value in a scenario has met the sustainability target (green light), or not. Exploring scenarios in this manner can assist you in examining the compatibility of scenarios with sustainability objectives. The indicators included on the Report Card screen can be drawn from any of the variables included in your PoleStar analysis, and can be customized to fit the needs of different applications. These features make the Report card a powerful tool for presenting PoleStar scenarios to a non-technical audience (for example, during policy workshops or stakeholder meetings).

At the top of the Report Card screen is a pull-down menu for selecting which scenario you wish to evaluate.

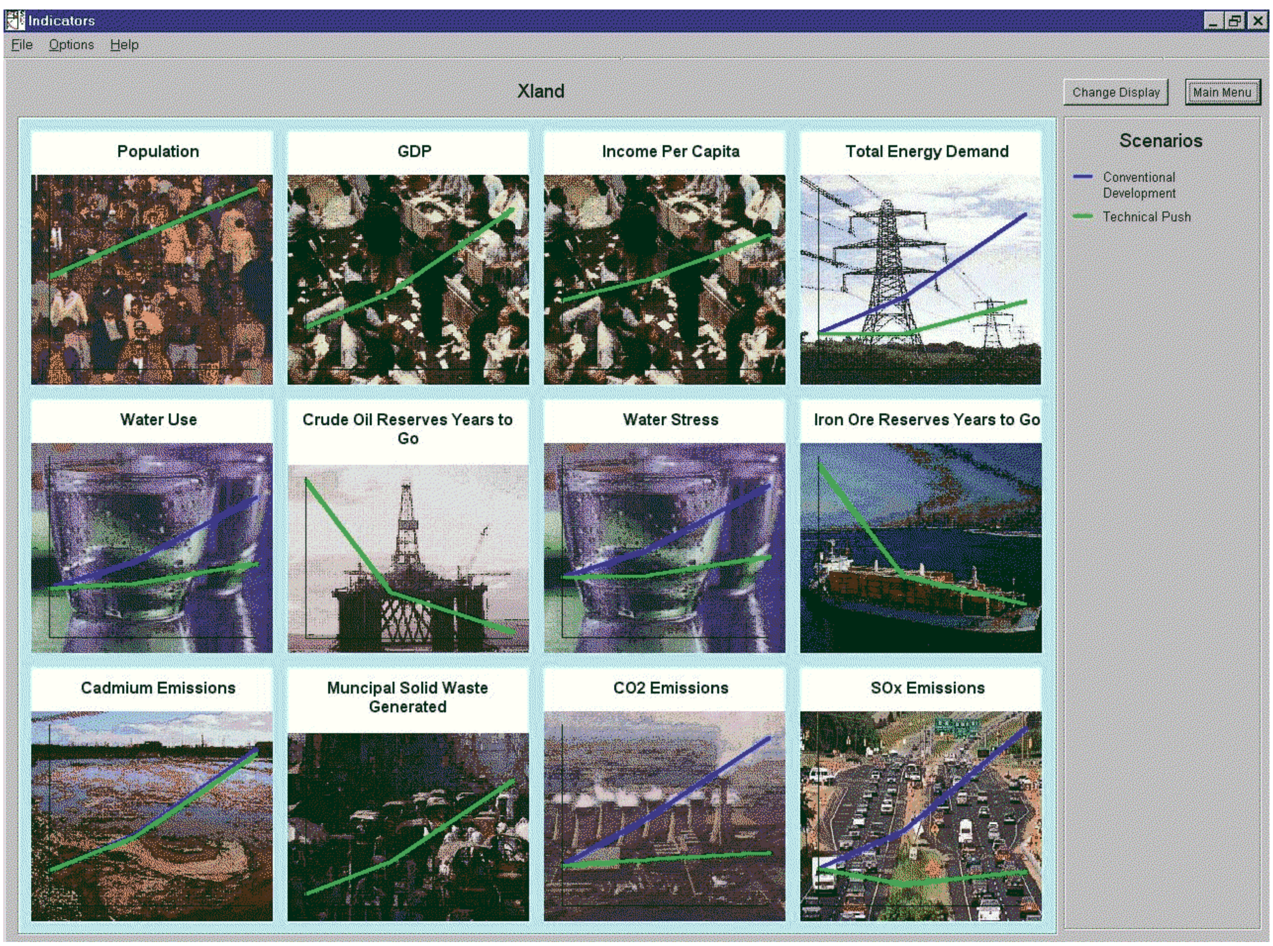
- **Indicator Lights:** On the left-hand side of the screen, a set of red and green "lights" is shown for each indicator. A green light indicates that the sustainability targets were met in all years and regions, while a red light indicates that in at least one year or region the sustainability targets were not met. A white light indicates that no targets were set for that particular indicator. The list of indicators included in the report card can be changed (see menu options below).

- **Indicator Charts:** On the right-hand side of the screen, a series of charts are plotted for the indicator highlighted on the left-hand side of the screen. Click an indicator on the left-hand side of the screen to see the charts for that indicator. The charts shown on the right-hand side of the screen compare the scenario values of the indicator to the sustainability target trajectory. Click on the **Regions** button to select which regions are charted. Double-click on a chart to enlarge it full screen. Using the Report Card charts, you can see whether the indicator is meeting, approaching or diverging away from a sustainable pathway. All charts are plotted in absolute terms in the units defined for the indicator, with "years" as the X axis of the charts.

- **Targets Values**: Use the **Options: Edit Target Values** menu option (or click on the **Target Values** button) to view or edit the target trajectories for your indicators. You will be taken to a standard PoleStar table where you can view or edit target trajectories for each Report Card indicator. You can filter the display of this table by region, year or indicator. When you have finished editing the targets, click on the **Report Card** button or select **Targets: Exit to Report card.** For convenience, you may also right-click on a chart and select "Edit Target Values" to go directly to the target trajectories for the selected indicator.

5.2 Indicators

Use the **Indicators** option to create overview graphs of the major indicators in your PoleStar scenarios. By default the Indicators screen displays one chart for each indicator for the application (as shown below).



By clicking on the **Change Display** button on the Indicators screen, you can change the **layout** of the screen, and appearance of the Indicator charts. Using the Options menu, you can also edit the list of indicators, change the width of the lines drawn on screen or switch the display of background images on and off. Refer to Section 5.3 below for information on how to edit the list of indicators.

To customize the Indicators screen display, click on the "change display" button. The Indicators screen title will change to a series of buttons and combo boxes as shown here:

Use the controls to change the layout of the screen display, assigning the three dimensions (indicators, regions and scenarios) between the individual charts, series and data dimensions plotted on the chart. Note though, that all charts are plotted over time (*i.e.*, with years on the X-axis). When selecting the items that appear on the charts or chart series, click the "…" buttons to select a subset of the complete list of indicators, regions or scenarios as appropriate. Charts across multiple regions or scenarios will have the same scale, to allow for easy comparison. In some cases, this can prevent smaller values from being visible, for example when plotting indicators for individual regions on the same screen as a chart that plots indicators for the application as a whole. In these cases, simply click the appropriate "…" button and temporarily deselect the display of application-wide indicators. Double-click on a chart to enlarge it full screen. When the Indicators screen contains charts in which multiple indicators (with different units) are plotted on a single chart, indicators are plotted relative to their Current Accounts values, not in absolute terms, so that all series start from the same value (1.0 in the Base Year). When you have finished customizing a chart, click the Title button to return to redisplay the Indicators Title.

5.3 Sustainability Evaluation Menu Options

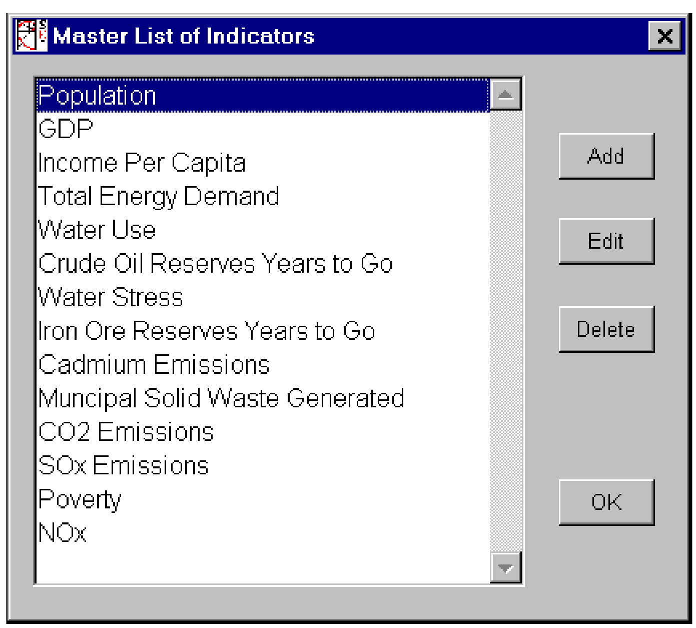
The Sustainability Evaluation module includes a number of menu options as follows:

File Menu

- **Return to Main Menu:** Select this option or click the Main Menu button to return to the PoleStar Main Menu

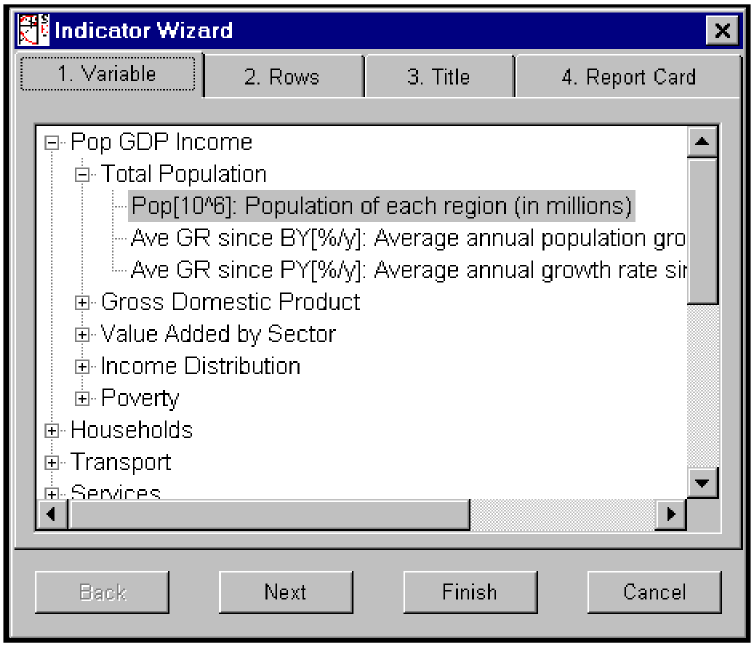
Options Menu

- **Edit Indicator List:** Select this option to edit the master list of indicators included in the Report card and Indicators screens. A dialog box (shown right) will be displayed showing the current list of indicators with three options: **Add**, **Edit** and **Delete.** Click on Add to add a new indicator. To change the properties of an existing indicator, select **Edit**. In either case, you will use the same four-step software "wizard" with which you can create or edit the properties of the indicator. Finally, you can click on **Delete** to remove an indicator. Bear in mind that this simply deletes the indicator from the Report Card and Indicator screens. It does not remove the variable from your



PoleStar analysis.

Using the 4 Step Indicator Wizard:



Click on the tabs at the top of the Indicator wizard or use the "Next", "Back" and "Finish" buttons to navigate through the wizard.

1. Variable: Choose the PoleStar variable (*i.e.*, table column) to be selected.

2. Rows: If appropriate, select the row of the table on which the variable appears that is to be associated with the indicator (*e.g.*, which fuel or which pollutant).

3. Title: Enter a name for the new indicator (by default the name is the based on the PoleStar variable), and optionally select a background image to be displayed on charts showing the indicator (see right).

*Note: The **Title** tab also shows the unit that will be used when the variable is graphed. The unit cannot be changed on this tab. To change the unit, go to the table that contains the variable, and edit its column properties. See Section 7.1 for information on how to edit columns.*

4. Report Card: if you want the indicator to be included in the Report Card, then check the "Show variable on Report Card" box and choose an appropriate Report Card category (social, resource pressure or environmental pressure). Finally, for each indicator indicate whether smaller or larger values are better. This information will be used in determining the red and green lights displayed on the Report Card.

- **Show Images:** Use this toggle (available only on the Indicators screen and only when charts are displayed for each selected indicator) to switch on and off the display of background images.

- **Set Line Width:** Use this option to change the width of lines graphed.

6 THE BASIC STRUCTURE

6.1 Overview

New PoleStar applications can be created in two ways. You can either create a completely new application or copy an existing application (see Section 3.1, "Managing Applications"). When you create a completely new application, it is given a data disaggregation structure and an initial set of formulas and data values as a starting point. This default application structure is called the **Basic Structure.**

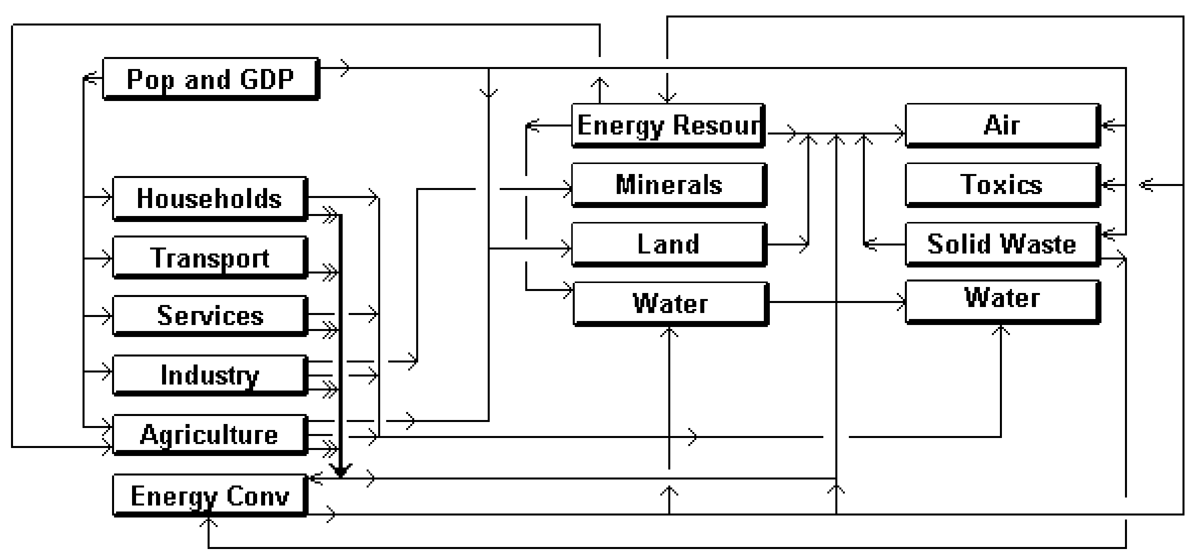
Note that the data disaggregation structure of the **Basic Structure** is quite detailed. For example, in the household module, the structure includes a detailed list of household types, end-uses and energy-using devices. Similarly, the industry module includes a detailed list of industrial subsectors. If this level of detail is more than you require for your application you can easily reduce it, by selecting the **Disaggregation Structure** option on the PoleStar main menu, and then deleting unwanted items. For example, in the households module you may want to use only one household type, one end-use, and one device per fuel for your energy analysis. See section 3.3 for more information. Changing the data disaggregation structure will not affect the underlying formulas defined in the Basic Structure.

You may find that the formulas entered in the Basic Structure meet the needs of your analysis. In this case, you can construct an application simply by changing the disaggregation structure and filling in data appropriate to your study. This approach to building applications is discussed in this chapter. If you find that the Basic Structure is not appropriate for your study, you can modify or extend it by building your own customized structures in PoleStar. For more information on building customized structures, see chapter 7.

*Tip: To see the formula used for any calculated cell (which appears gray), click on the cell—the formula will appear in the **Cell Expression** box at the top of the table the cell is in.*

6.2 Module Linkages

PoleStar Module Linkages in the Basic Structure



Many of the linkages between modules can be specified by the user. Some linkages are part of the fixed PoleStar structure. The major linkages in the Basic Structure are:

- **Pop, GDP, Income** (including information on value added by economic sector) drives the overall activity levels in other modules: Household, Transport, Services, Industry, and Agriculture. In addition, Population and GDP contributes directly to pressures in the Land, Toxics, and Solid Wastes modules. This module also allows data to be entered on income distribution and poverty levels.
- **Households, Transport, Services, Industry:** These modules use the information from the Population, GDP and Income module to derive energy conversion requirements, resource uses, and pollution emissions. That information is sent to the energy conversion module or the appropriate environmental pressures module.
- **Agriculture:** Agricultural requirements are based on population and diet assumptions. The Agriculture module sends estimates of energy conversion requirements and environmental pressures to the energy conversion, land, water resources, air and soils modules.
- **Energy Conversion:** Total final energy use in the Households, Services, Transport, Industry and Agriculture modules drives the Energy Conversion module. Energy generated in the Solid Waste module is also read into the Energy Conversion module. This module, in turn, estimates the water requirements, and air and water pollution associated with energy conversion, and sends that information to the appropriate environmental pressures module. The Energy Conversion module also calculates primary resource requirements, and sends that information to the Energy Resources module.
- **Resources:** The Energy Resources module reads information on primary fuel requirements from the Energy Conversion module, and generates information for the Water Resources and Air modules. The Minerals module is driven by input requirements to Industry. The Land module uses information from Population and Agriculture. Water Resources tabulates water requirements from the Households, Services, Industry, Agriculture, Energy Conversion, and Energy Resources modules.
- **Pollution:** The Air Pollution module tabulates the atmospheric emissions from many sources: Households, Services, Transport, Industry, Agriculture, Energy Conversion, Energy Resources, Land, and Solid Waste. Similarly the Water Pollution module tabulates water pollution loadings from each sector, and also allows the user to specify miscellaneous non-point sources of water pollution. Water pollution removal (treatment) fractions can also be specified, and these are used to calculate final water pollution loads. Toxics are driven by both Energy Conversion and the value added by economic sector. Solid Waste uses Population information.

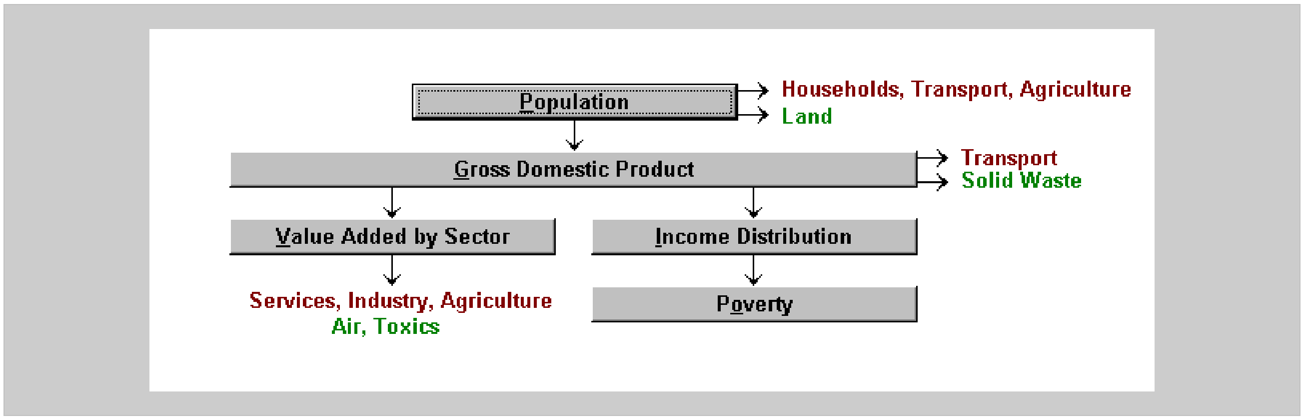
6.3 Pop, GDP, Income Module

The macroeconomic framework in PoleStar is defined by population, national income (GDP), and economic structure (GDP by Sector). These variables are set in the Pop, GDP, Income module and are used in the Basic Structure to set the overall scale and character of societal activity—driving many of the calculations in other parts of the Basic Module system. This module also deals with income distribution and poverty, allowing you to analyze issues related to equity in your scenario.

6.3.1 Disaggregation Structure

No data disaggregation structures need to be setup in this module. The Disaggregation Structure button is unavailable.

6.3.2 Tables



Total Population

For applications based on the Basic Structure, in the **Pop** column, enter total population by region in millions. (The Basic Structure uses the large scale—see section 3.1.) In scenarios, the average annual population growth rate is calculated and displayed in percent per year in columns **Ave GR since BY** and **Ave GR since PY**, the growth rate from the Base Year and from the previous year, respectively.

Gross Domestic Product

The GDP table is used to enter and compute information about total and per capita GDP levels. In the Basic Structure, these macroeconomic variables are used to drive many of the activities defined in other PoleStar sectors.

For applications based on the Basic Structure, in the **GDPPerCap[$/cap]** columns, enter per capita values for the annual Gross Domestic Product (GDP) by region (in dollars or in the currency you specified when creating the application). In scenarios, the average annual GDP per capita growth rate is calculated and displayed in percent per year in the columns **Ave GR since BY** and **Ave GR since PY**, the growth rate from the Base Year and from the previous year, respectively. Total GDP is calculated in the **GDP** column. As you enter data in the GDP per capita column, the other columns will be calculated using the regional population data (entered in the Total Population table) using the relationships of the Basic Structure as shown in the “cell expression” box.

Value Added by Sector

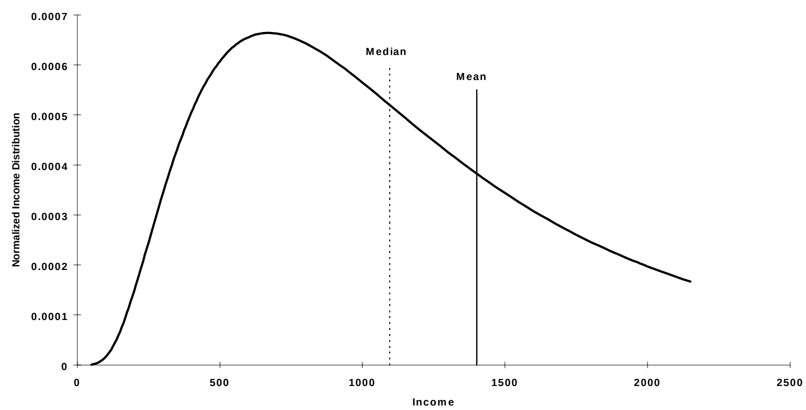
When building an application using the Basic Structure, in the **Share** column, enter the fraction of total GDP in each region that is derived from **industry**, **services, agriculture**, and **other**. NB: The GDP generated in each sector is referred to as the *Value Added* in that sector. Shares should sum to 1.0 for each region. Using the data you have entered, PoleStar will calculate the total value added derived from each sector in each region, and display it in the **VA** column, using the formula entered in the **VA** column.

Income Distribution

The Income Distribution table is used to examine changes in income distribution within each region of a PoleStar analysis. If you do not wish to include such an analysis, simply ignore this and the following table.

The distribution of income in a country or region is typically skewed, with most of the population concentrated at lower incomes. In the Basic Structure, regional income distributions are represented by lognormal curves (see box below). The lognormal distribution and related functions are described in Section 7.2.3.

Example Lognormal Income Distribution

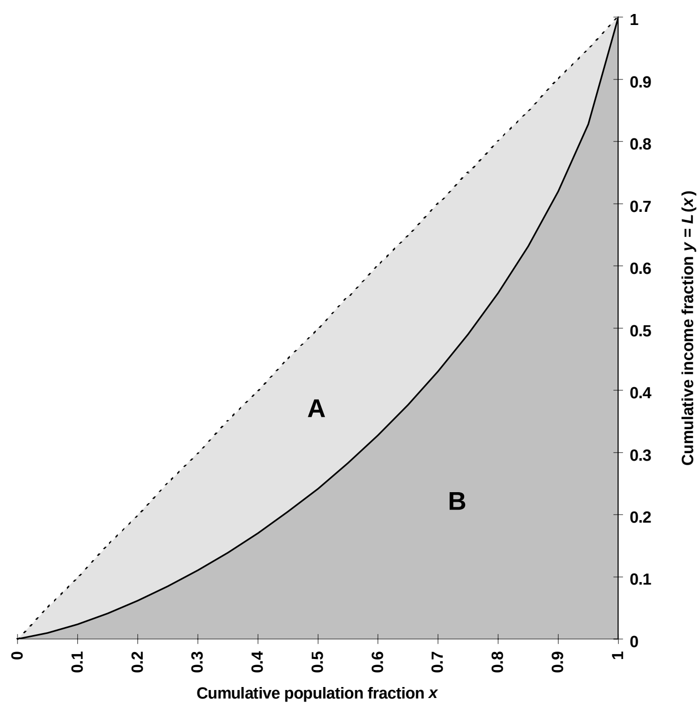


Aside from the population and mean income, the lognormal income distribution function is characterized by one other parameter, which represents the degree of income inequality within a region. For applications using the Basic Structure, enter Gini coefficients to specify income distribution (see box below). Other measures of income distribution on the table are calculated based on the Gini coefficient. The fraction of total income received by the lowest-earning 20% and highest-earning 20% of the population are called the low and high *quintiles*. These values are shown in the columns **Lowest Quintile** and **Highest Quintile**. The ratio of **Highest Quintile** to **Lowest Quintile**—the ratio of the income of the richest 20% to the poorest 20%—is shown in column **High to Low Ratio**. The median income is also shown. Because of the skewness of income distribution, the median income is less than the mean (or per capita) income, which is shown in the first column.

The Gini Coefficient

The Gini coefficient is a standard measure of income inequality related to the Lorenz curve. The Lorenz curve is a plot of the fraction of total income held by a given fraction of the population, with the lowest-income portion of the population counted first. A typical Lorenz curve is shown below. The Gini coefficient is given by the ratio of the areas A and (A+B) in the figure. The coefficient can take values from zero (perfect equality) to one (extreme inequality).

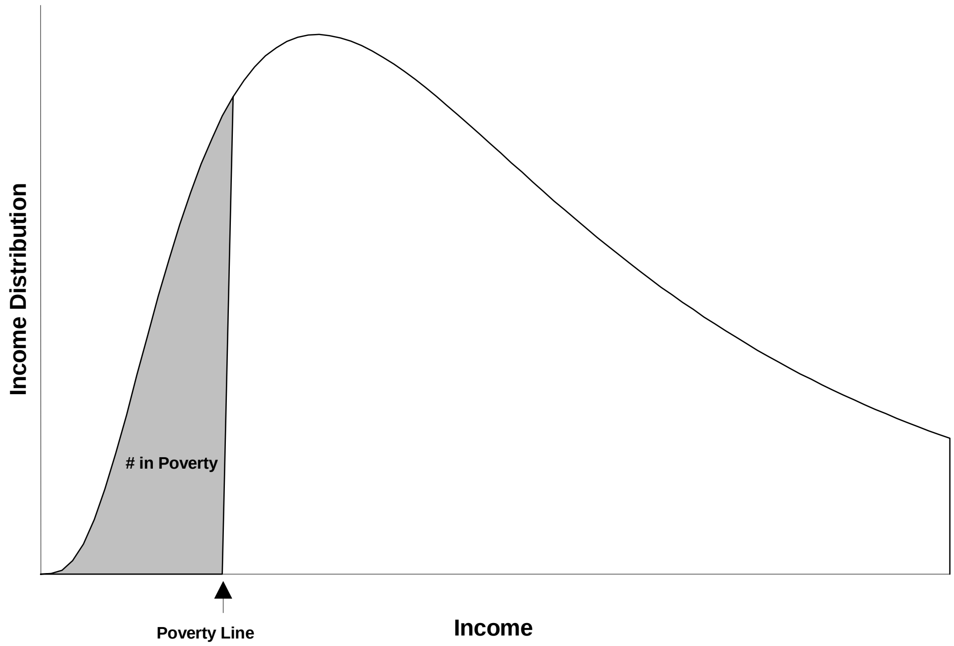
A Typical Lorenz Curve
(Dashed line corresponds to perfect equality.)



Poverty

The Poverty table is used to examine the number of people who fall below a user-specified “poverty line.” (The poverty line is a level of annual income below which people are living in poverty.) In the Basic Structure, in the Current Accounts, enter the percentage of the population living in poverty (**PovertyFrac**). Given the income distributions calculated in the previous tables, PoleStar uses the formula entered in the **Poverty Line** column (in $/capita) to calculate the base-year poverty line. This is done by calculating the area underneath the income distribution curve to the left of the poverty line (see box below). PoleStar also calculates the absolute number of people living in poverty (**Poverty**). For comparison, mean income (GDP per capita) is shown in the column **GDPPerCap**. For scenarios years, enter the future poverty lines as data and PoleStar will calculate the percentage of the population living in poverty.

The Relationship Between Income Distribution and the Poverty Line



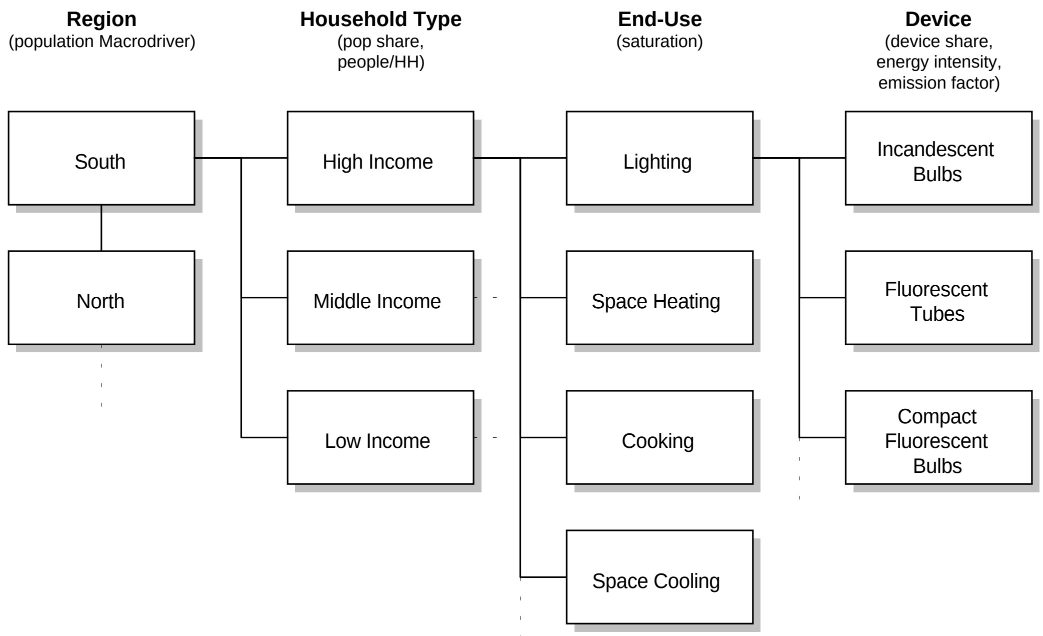
6.4 Households Module

The Households module allows you to create an end-use oriented picture of household resource use patterns (energy and water) and their related pollutant loadings. You can adapt the structure of the data and their relationships to your own purposes, based on the availability of data and the types of analyses you want to conduct. In the Basic Structure, the overall scale of activity is taken from the Population, GDP and Income module. The Basic Structure allows you to account explicitly for various demographic and economic patterns, end-use levels ("saturation"), device mixes, resource intensities and emission factors.

6.4.1 Disaggregation Structure

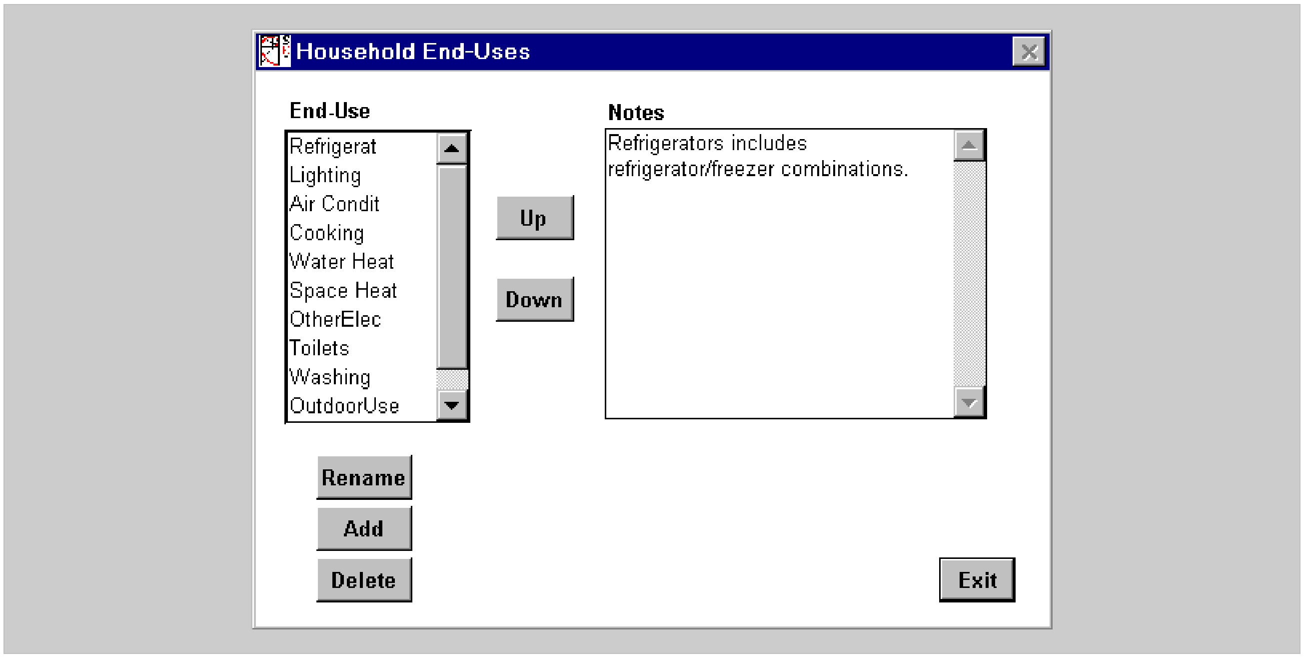
There are six buttons on the Disaggregation Structure window for Households. These are used to define the list of **Household types**, **End-uses** and **Devices** for your application, and to choose the list of **Fuels** and **Air** and **Water Pollutants** that apply to the households module. Using Disaggregation Structure dialog boxes, you use a 3-level hierarchy to enter household types (*e.g.*, urban, rural), end-uses (*e.g.*, cooking, heating, lighting, etc.) and devices (*e.g.*, coal stove, gas stove, electric stove, etc.). The data tables use this structure to define the device intensities and emission factors. For an aggregated structure, enter only one category (*e.g.*, "All") at any level.

Example of a Disaggregated Household Structure



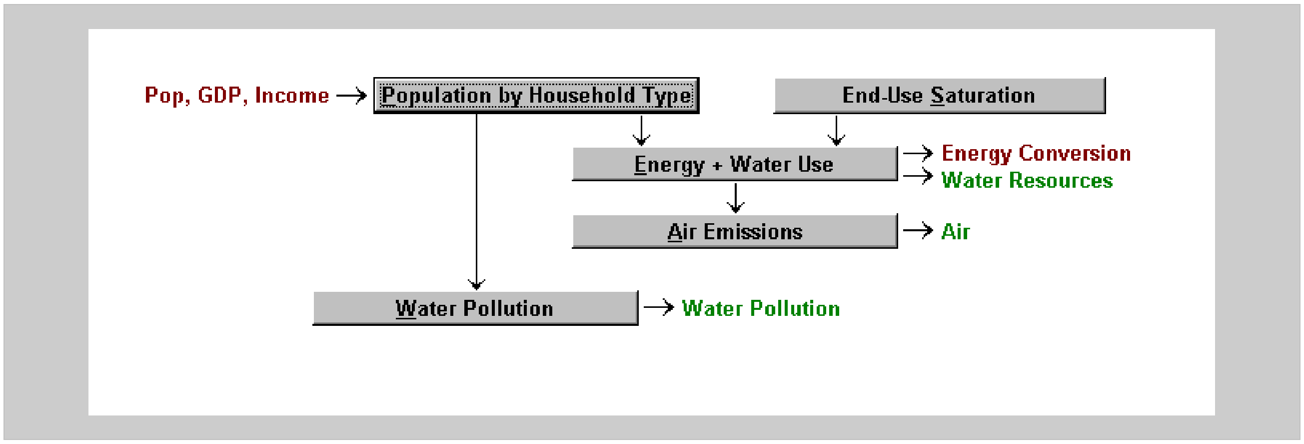
- **Household Types:** Use the **Edit List** option to enter any household types you may wish to use in your analysis (*e.g.*, urban/rural; low/medium/high income; single family/multiple family, etc.). The choice of categories will depend on data availability and the objectives of your study. You can Rename, Add, and Delete items using the dialog box buttons, and reorder the list using the Up and Down buttons. Similar options are available for all other Edit List dialog boxes.

- **End-Uses:** You may use the Edit List option to enter a list of household end-uses (*e.g.*, for energy—cooking, water and space heating, space cooling, refrigeration, etc., and for water—showers, baths, toilets, lawn sprinklers, etc.)



- **Devices:** You may further disaggregate end-uses into *devices*. Use the Edit List option to enter the list of energy and water using devices for each end-use of the Household module. Use the Household end-use popup to display the list of devices for each end-use. Remember to indicate the fuel used in each device. Choose N/A if the device uses water, but does not use any fuel.
- **Fuels:** Use the Edit List option to choose the group of fuels used in the Households and Services modules. This dialog box is shared between the Households and Services modules. Here, you select fuels from the master fuels list (which you may expand by going back to the Main Menu: Disaggregation Structure window).
- **Air and Water Pollutants:** Use the Edit List option to select the lists of air and water pollutants in the Households and Services modules. Here, you select pollutants from the master lists of air and water pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window). These dialog boxes are shared between the Households and Services modules.

6.4.2 Tables



Population by Household Type

This table is used to allocate regional population among different household types. If you are building an application based on the Basic Structure, enter the fraction of the total regional population in each household type in the **PopShare** column. Shares should sum to 1.0 over household types. The total population in each household type (in millions, for the large scale Basic Structure) will be displayed in the **Pop** column. In the Basic Structure the driver for household end-use activity levels is the number of people.

Tip: If you wish to use another driver (e.g., households), or enter any other data (e.g., on household size), you can modify the table structure and formulas, as described in Chapter 7.

End-Use Saturation

If you have elected to disaggregate by end-use, then in the Basic Structure this table is used to enter the end-use saturations for each end-use by region and end-use. If you did not disaggregate, a saturation of 1.0 is entered by default. In the **Saturation** column, enter the fraction of households using each end-use in each region by household type.

Energy & Water Use

Use this table to calculate energy and water use patterns. If you are building an application using the Basic Structure, in the **DevShare** column, enter the mix of devices meeting each end-use in each region and each household type. The number of people using each device is calculated and displayed in the **PopUsingDev** column.

The fuel used by the device is displayed in the **Fuel** column. In the Basic Structure energy units are expressed in Joules (J) (see Annex 1 for definitions of units). In the Current Accounts enter the total energy use in the **FuelUse** column. PoleStar will then compute the energy intensity for each device, and report the result in the **EI** column (in GJ per unit of activity). In scenarios, enter the energy intensity directly, and PoleStar will compute the total fuel used by each device, using the relationships built into the Basic Structure.

When using the Basic Structure, in the Current Accounts enter the total water use in the **WaterUse** column (in millions of m^3) for appropriate water-using devices. PoleStar will then compute the water intensity for each device, and report the result in the **WI** column (in m^3 per unit of the driver variable). In scenarios, enter the water intensity directly, and PoleStar will calculate water use and display the results in the **WaterUse** column, using the relationships built into the Basic Structure.

Air Emissions

Use this table to calculate the energy-related emissions from household devices. For applications built on the Basic Structure, in the **EF** column**,** enter emission factors (in kg/GJ) for each device and each pollutant. These data, together with the total fuel used by each device, calculated in the previous table, are used to calculate total emissions loadings, using the relationships built into the Basic Structure. The results are displayed in the **Emission** column (in tonnes of pollutants).

Water Pollution

Use this table to calculate water pollution levels from households. When building applications using the Basic Structure, in the **EF** column**,** enter emission factors (in kg/capita) for each water pollutant and each household type. These data, together with the total population for each household type, calculated in an earlier table, are used to calculate total water pollution loadings using the relationships built into the Basic Structure. The results are displayed in the **WaterPoll** column (in tonnes of pollutants).

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

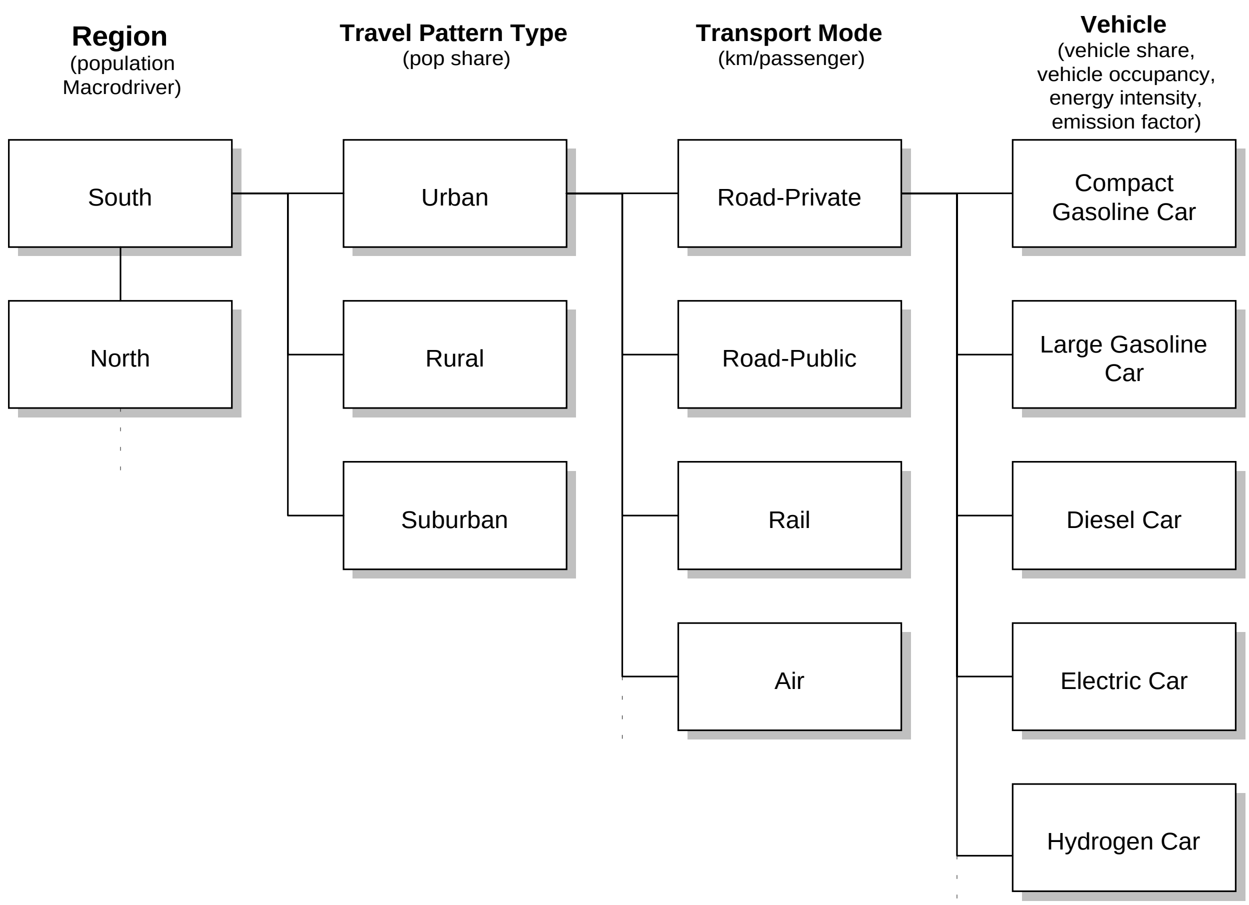
6.5 Transport Module

The table structure in the Transport module allows you to build up a picture of Transportation energy use patterns, and pollutant emissions. You can create either an aggregate or disaggregate analysis and adapt the structure of data and their relationships to your own purposes, based on the availability of data and the types of analyses you want to conduct. In the Basic Structure, the Transport module takes data from the Population, GDP and Income module and in turn generates information used in the energy conversion and air pollution modules.

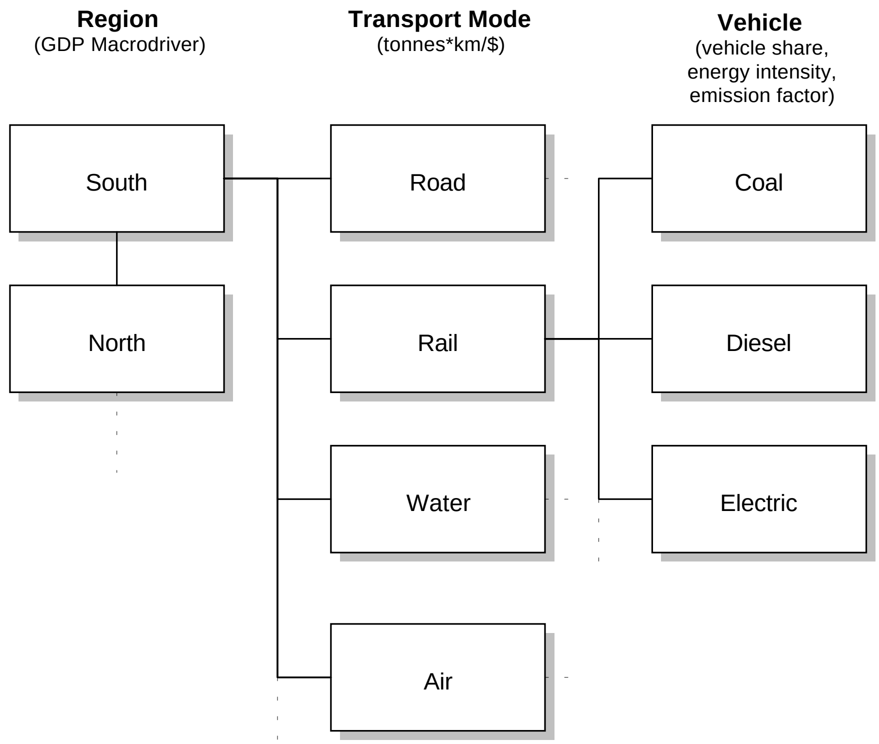
6.5.1 Disaggregation Structure

There are seven buttons on the Disaggregation Structure window for Transportation. The Disaggregation Structure is grouped into two data structures: one for passenger transport, and one for freight transport. For passenger transport, three buttons are used to build a three-level hierarchy of **Travel Pattern Types** (*e.g.*, urban/rural, or short/long distance), **Passenger Transport Modes** (road, rail, air, etc.), and **Passenger Vehicles** (*e.g.*, different types of automobiles). For freight transport, two buttons are used to define **Freight Modes** and **Vehicles**. Two additional buttons are used to choose the **Fuels** and **Pollutants** that apply to the module. You can adapt the disaggregation structure of data for your own purposes, based on the availability of data and the types of analyses you want to conduct.

Example of Passenger Transport Disaggregation Structure



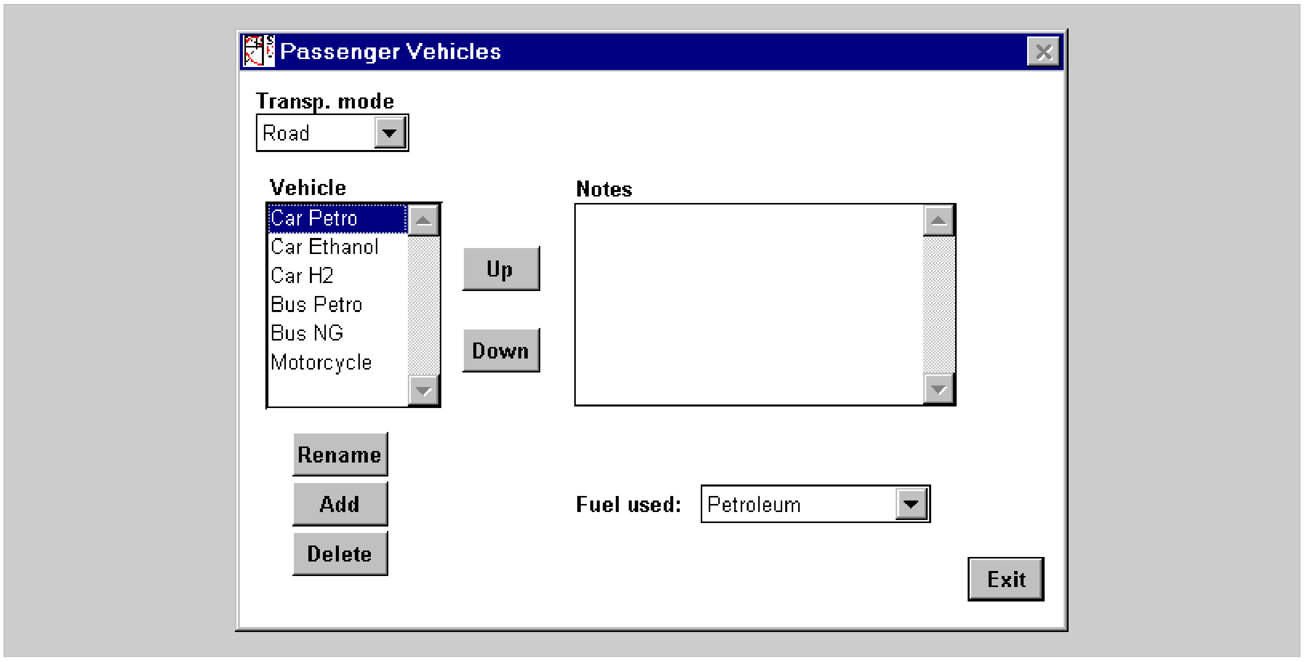
Example of Freight Transport Disaggregation Structure



- **Travel Pattern Types:** Use the Edit List option if you wish (and have data) to disaggregate the population into different groups representing alternative travel pattern types (*e.g.*, urban/rural, short/medium/long distance, etc.). You can Rename, Add, and Delete items using the dialog box buttons, and reorder the list using the Up and Down buttons. Similar options are available in the other Edit List dialog boxes.

- **Passenger Transportation Modes:** Use the Edit List option to enter the list of passenger transport modes (*e.g.*, road, rail, air, etc.).

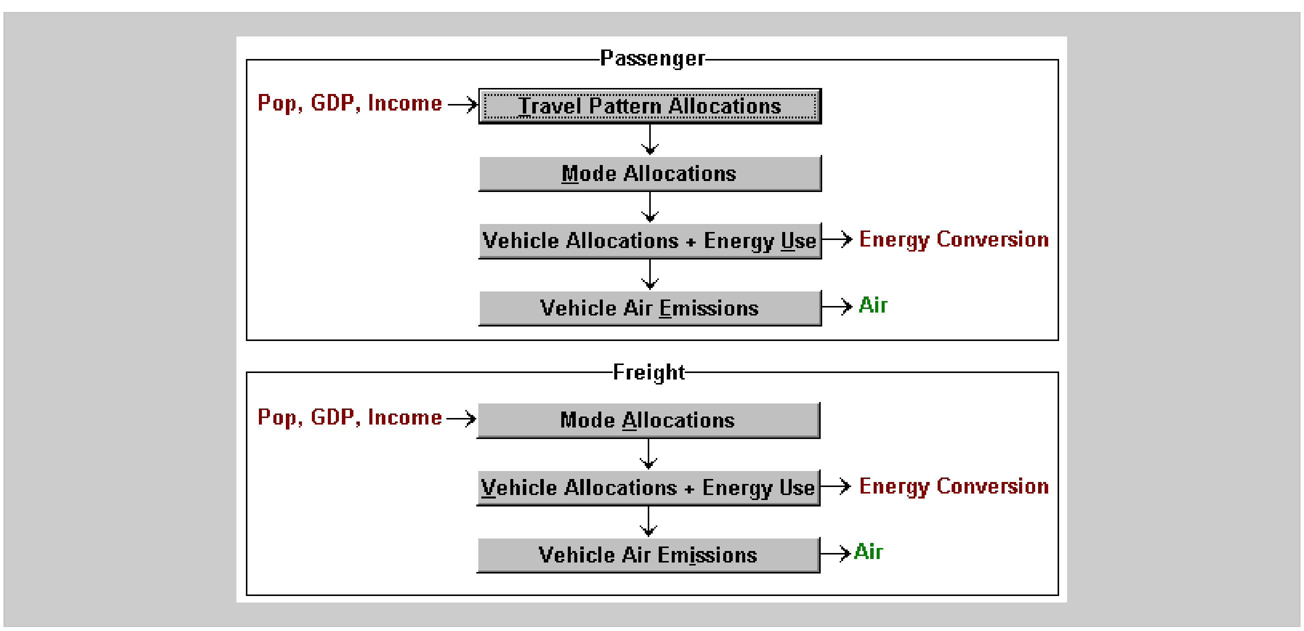
- **Passenger Vehicles:** Use the Edit List option to enter a list of vehicles for each passenger transportation mode. As you select different transport modes using the Transp. Mode popup, the list of vehicles for that transport mode will be displayed. For each vehicle indicate the Fuel Used in that vehicle.



- **Freight Modes:** Use the Edit List option to enter the list of freight transport modes (*e.g.*, road, rail, water, air, pipeline, etc.).
- **Freight Vehicles:** Use the Edit List option to enter a list of vehicles for each freight mode. As you select different transport modes using the **Transport Mode** popup, the list of vehicles for that transport mode will be displayed. For each vehicle, indicate the Fuel Used in that vehicle.
- **Fuels:** Use the Edit List option to choose the fuels used in the Transport module (both for passenger and freight transport) from the All Fuels master list.
- **Air Pollutants:** Use the Edit List option to choose the pollutants in the Transport module from the All Pollutants master list.

6.5.2 Tables

Seven tables, divided into two groups, are used to enter Transport module data: four for passenger transport, and three for freight transport.



Passenger Travel Pattern Allocations

When building applications using the Basic Structure, use this table to allocate each region's population (as defined in the Population, GDP and Income module) among the travel pattern types you have created in the Disaggregation Structure. Enter the fraction of the total regional population assigned to each travel pattern type in the **PopShare** column. Shares should sum to 1.0 over travel pattern types. The total population in each travel pattern type (in millions, when using the large scale Basic Structure) will be calculated and displayed in the **Pop** column. The definition of travel pattern types that you choose to use in the Transport module need not necessarily correspond to the population group definitions used elsewhere in PoleStar (for example, in the households module).

Passenger Mode Allocations

In the Basic Structure, in the **Trav** column, enter the annual average distance traveled per person in each travel mode (road, rail, air, etc.). Using the population data entered in the Passenger Travel Pattern Allocations table, PoleStar will calculate and display the total **passenger-km** values for each travel mode using the relationships built into the Basic Structure.

In the **Share** column, PoleStar will also calculate and display the modal share of total passenger-km values using formulas built into the Basic Structure. **Share** is the modal share of both total **passenger-km** and total **passenger-km/cap**.

Passenger Vehicle Allocations and Energy Use

Use this table to calculate the energy use of passenger transport vehicles for each region and mode. In the Basic Structure, vehicle energy use patterns are calculated by multiplying total travel by the vehicle energy intensity. In the large-scale Basic Structure, total travel is in millions of passenger-km and energy intensities are in Megajoules (1 MJ = 10^6 joules) per passenger-km.

In the Basic Structure, enter in the **Share** column the share of total passenger-km across all travel pattern types for each vehicle type. Shares should sum to 1.0 over vehicle types. PoleStar will calculate and display activity levels in the **TotTrav** column (in millions of passenger-km), using the relationships built into the Basic Structure. Then, in Current Accounts, enter the energy consumed by each vehicle in the **FuelUse** column, and PoleStar will then calculate and display the energy intensity in the **EI** column. In scenarios, enter the energy intensity directly, and PoleStar will calculate and display the total energy consumed by each vehicle using the formula entered in the **FuelUse** column.

Passenger Vehicle Air Emissions

In the Basic Structure, use this table to calculate the energy-related emissions from passenger transport vehicles. In the **EF** column**,** enter emission factors (in kg/GJ) for each vehicle and each pollutant. These data, together with the total fuel used by each vehicle, calculated in the previous table, are used in the Basic Structure to calculate total emissions loadings, which are displayed in the **AirEmis** column (in tonnes of pollutants).

Freight Mode Allocations

This table is used to represent freight activity—expressed as billion tonnes-km shipped (Gt-km)—by freight mode. In the Basic Structure, freight activity is expressed as the product of a freight intensity (t-km/$GDP) and GDP. In the Current Accounts for applications built on the Basic Structure, enter the freight transport activity for each mode, and PoleStar will calculate the freight intensity and shares using the relationships built into the Basic Structure. In scenarios, in the **FI** column, enter the total freight intensity for all transport modes combined (road, rail, air, etc.) for each region in tonnes-km per dollar of GDP. In the **Share** column, enter the share of freight transport by transport mode. PoleStar will use this share to calculate the freight activity by mode. Shares should sum to 1.0 over modes. PoleStar will calculate and display the total freight transport activity in the **Tot** column (in billions of tonnes-km) using the GDP values entered in the Population, GDP and Income module.

Freight Vehicle Allocations and Energy Use

Use this table to calculate the energy use of different freight transport vehicles for each region and transport mode. When building applications using the Basic Structure, in the **Share** column, enter the share of freight transport activity for each vehicle type within each mode. Shares should sum to 1.0 over types. In the **ActLevel** column, PoleStar will calculate and display the activity level (in the large-scale Basic Structure this will be in billions of tonnes-km). Then, in Current Accounts, enter the energy consumed by each vehicle in the **FuelUse** (fuel use) column, and PoleStar will then calculate and display the energy intensity in the **EI** column (in MJ per tonnes-km). In scenarios, enter the energy intensity directly. In the **FuelUse** column, PoleStar will calculate and display the total energy consumed by each vehicle using the relationships built into the Basic Structure.

Freight Air Emissions

Use this table to calculate the energy-related emissions from freight transport vehicles. For applications built using the Basic Structure, in the **EF** column**,** enter emission factors (in kg/GJ) for each vehicle and each pollutant. These data, together with the total fuel used by each vehicle, calculated in the Freight Vehicle Allocations table, are used to calculate total emissions loadings, which are displayed in the **Emission** column (in tonnes of pollutants). In the Basic Structure, in the Current Accounts, enter the total emissions loadings directly, and PoleStar will calculate the emissions factors. PoleStar calculates emissions for each vehicle using the relationships built into the Basic Structure.

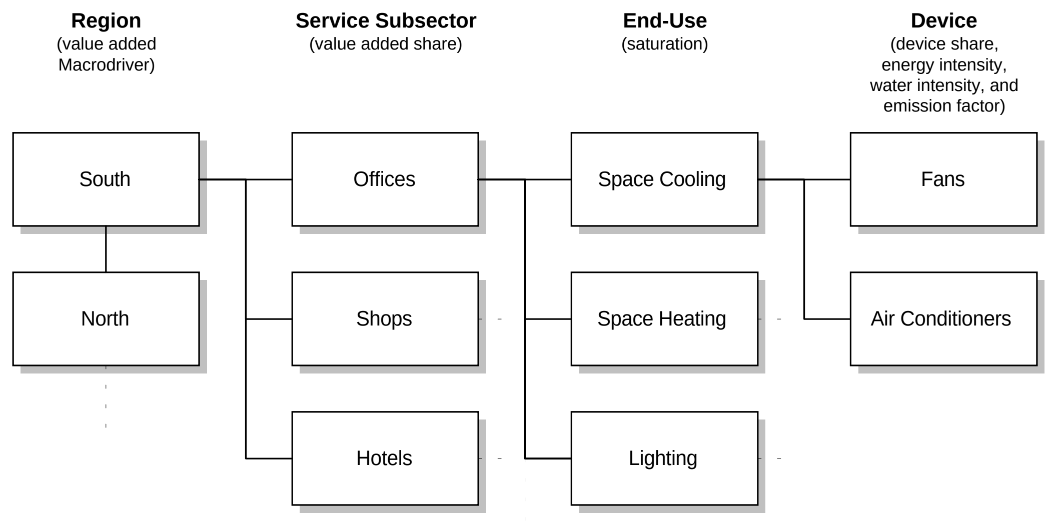
6.6 Services Module

The table structure in the Services module allows you to build up a picture of service sector energy and water use patterns and their related pollutant loadings. In the Basic Structure, the module takes information on Value Added by Sector from the Population, GDP and Income module, and in turn generates information used by the energy conversion, water resources, and air and water pollution modules. You can build either a simple aggregate analysis, or a detailed analysis of service sector energy and water use patterns and their related pollutant loadings.

6.6.1 Disaggregation Structure

There are five buttons on the Disaggregation Structure window for Services. Using the first three buttons, if you choose to do a disaggregated analysis you may enter a 3-level hierarchy of service **Subsectors** (*e.g.*, retail, education, health care, etc.), **End-uses** (space heating, lighting, appliances, etc.) and **Devices**. Two additional buttons are used to choose the **Fuels** and **Air Pollutants** that apply to the Services module. You can adapt the disaggregation structure of the data to your own purposes, based on the availability of data and the types of analyses you want to conduct. For an aggregated structure, enter only one category (*e.g.*, "All") at any level of disaggregation.

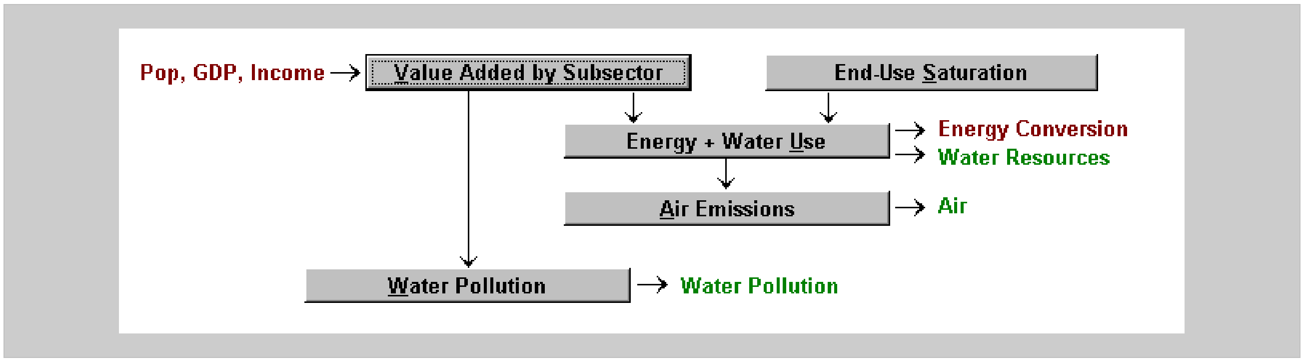
Example of a Services Module Disaggregation Structure



- **Subsectors:** Use the Edit List option to enter the list of service subsectors in your application (*e.g.*, retail, education, health care, government, hotels, etc.). You can Rename, Add, and Delete items using the dialog box buttons, and reorder the list using the Up and Down buttons. Similar options are available in the other Edit List dialog boxes.
- **End-Uses:** Use the Edit List option to enter the list of energy and water end-uses in the Services module (*e.g.*, space heating, space cooling, water heating, equipment, etc.).
- **Devices:** Use the Edit List option to enter the list of energy and water using devices for each end-use in the Services module. Use the **End-use** popup to display the list of devices for each end-use. Remember to indicate the **Fuel used** in each device (choose N/A if the device uses water, but does not use any fuel).
- **Fuels:** Use the Edit List option to select the list of fuels used in both the Households and Services modules, from the All Fuels master list (which you may expand by going back to the Main Menu: Disaggregation Structure window). This dialog box is shared with the Households Module.
- **Air and Water Pollutants:** Use the Edit List option to select the lists of air and water pollutants in the Households and Services modules. Here, you select pollutants from the master lists of air and water

pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window). These dialog boxes are shared between the Households and Services modules.

6.6.2 Tables



Value Added by Subsector

In the Basic Structure, this table is used to allocate the total service sector value added (defined in the Population, GDP and Income module) between the service subsectors. In the **Share** column, enter the fraction of the total regional service sector value added in each subsector. Shares should sum to 1.0 over subsectors. The total value added in each subsector will be displayed in the **Value Added** column (in billions of dollars or in terms of the currency you specified when creating the application).

End-Use Saturation

This table is used to enter the end-use saturations (the fraction of each subsector undertaking each end-use). When building an application using the Basic Structure, enter the fraction of the subsector within each end-use by region and subsector in the **Saturation** column. In the Basic Structure, saturations are set to 1.0 by default.

Energy & Water Use

Use this table to calculate energy and water use patterns. For applications based on the Basic Structure, in the **DevShare** column, enter the share of service end-use provided by each device. The total activity level is calculated and displayed in the **ActLevel** column using the relationships built into the Basic Structure.

When using the Basic Structure in Current Accounts, enter the total fuel used (in PJ) for the device directly, and PoleStar will calculate the energy intensities. In scenario years, enter **EI**, the energy intensity of energy-using devices (in MJ/$). The total amount of fuel used by each device is calculated and displayed in the **FuelUse** column (in PJ).

For applications based on the Basic Structure in Current Accounts, enter total water use directly, and PoleStar will calculate the water intensities. In scenario years, enter **WI**, the water intensity of water-using devices (in m^3/$1000). The total water used by each device is calculated and displayed in the **WaterUse** column in millions of cubic meters.

Air Emissions

You may use this table to calculate the energy-related emissions from service devices. For applications built using the Basic Structure, in the **EF** column**,** enter emission factors (in kg/GJ) for each device and each pollutant. These data, together with the total fuel used by each device, calculated in the Energy and Water Use table, are used to calculate total emissions loadings, which are displayed in the **AirEmis** column (in tonnes of pollutants), using the formula entered in the column.

Water Pollution

Use this table to calculate water pollution levels from the service sector. For applications built using the Basic Structure, in the **EF** column**,** enter emission factors in kg per $1000 value added in the service sector for each water pollutant and each subsector. These data are used to calculate total water pollution loadings, which are displayed in the **WaterPoll** column (in tonnes of pollutants), using the formula entered in the column.

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

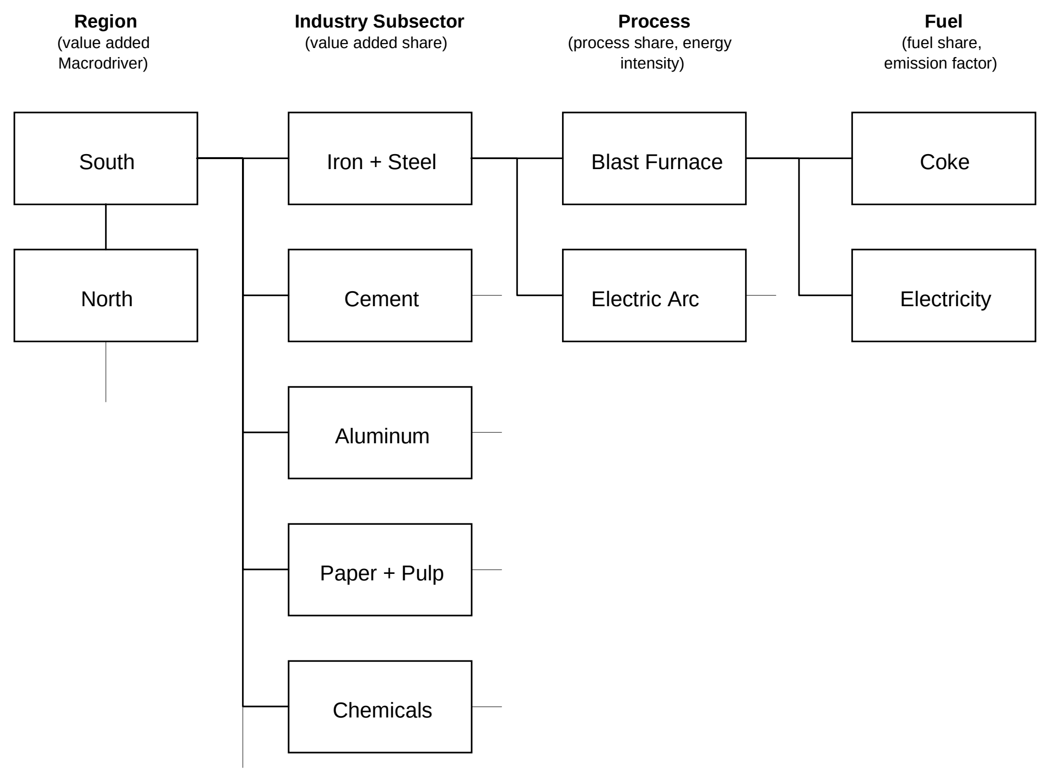
6.7 Industry Module

The table structure in the Industry module allows you to build up a picture of industrial energy, water and mineral consumption patterns and emissions (both from energy consumed in processes and from non-energy processes). You can adapt the structure of the data and their relationships to your own purposes, based on the availability of data and the analyses you want to conduct. In the Basic Structure, the overall scale of activities in the module is driven by Industrial Value Added data taken from the Population, GDP and Income module. The module generates information on energy, water and minerals consumption levels and their associated pollutant loadings which are then used in the energy conversion, minerals, water resources, and air and water pollution modules.

6.7.1 Disaggregation Structure

There are six buttons on the Disaggregation Structure window for Industry. These are used to define the Industrial **Subsectors**, Industrial **Processes,** non-fuel **Minerals**, and to choose the **Fuels** and Air and Water **Pollutants** that apply to the Industry module. Using the Disaggregation Structure dialog boxes, you can enter a 3-level hierarchy of **industrial subsectors** (*e.g.*, chemicals, iron + steel, cement, paper + pulp, etc.), **processes** (*e.g.*, blast furnaces, cement kilns, etc.) and **fuels**.

Example of Industry Module Disaggregation Structure

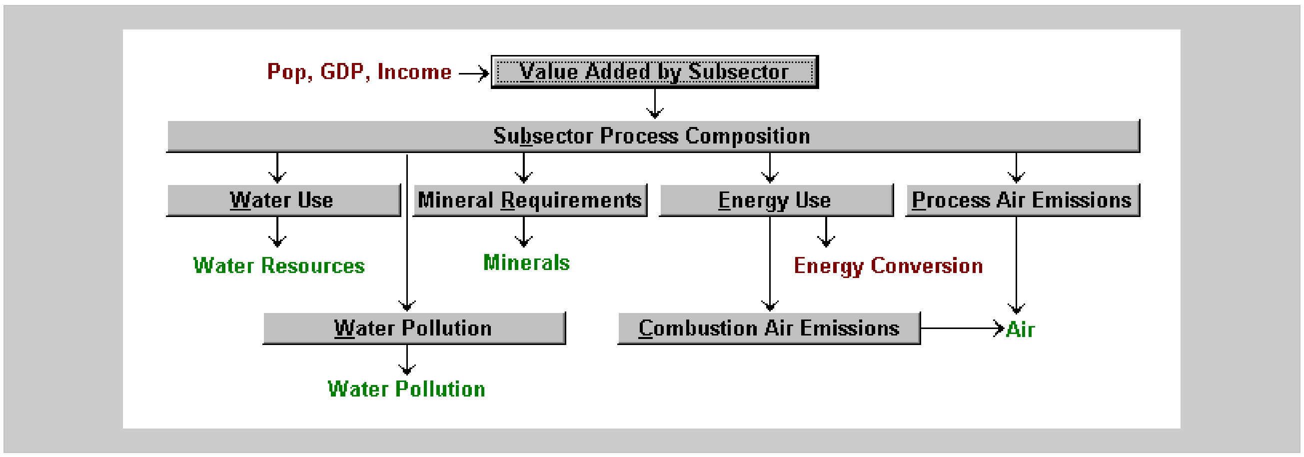


- **Subsectors:** Use the Edit List option to enter the list of industrial subsectors in your application (*e.g.*, iron + steel, chemicals, paper + pulp, aluminum, etc.). You can Rename, Add, and Delete items using the dialog box buttons, and reorder the list using the Up and Down buttons. Similar options are available in the other Edit List dialog boxes.

- **Processes:** Use the Edit List option to enter the list of energy or water using processes in each industrial subsector. For example, in the iron + steel subsector, processes might include: blast furnaces, electrical arc furnaces, open hearth furnaces, etc. Where no detailed data on processes are available, enter a single category, such as “All Proc.” Notice that industrial processes (unlike household devices) are not associated with a single fuel. You first define energy intensities (and calculate energy use) for each process, and then allocate the energy between each of the fuels defined for a process.

- **Fuels:** Use the Edit List option to choose the fuels used in the Industry module from the **All Fuels** master list (which you may expand by going back to the Main Menu: Disaggregation Structure window).
- **Minerals:** Use the Edit List option to enter the list of non-fuel mineral resources used in the Industry module. The list should include those unprocessed minerals that are important either because they are a scarce resource, or because their extraction and use causes significant environmental impacts. *Tip: If you do not wish to analyze minerals, simply leave mineral-related data blank on the data tables.*
- **Air and Water Pollutants:** Use the Edit List option to choose the air and water pollutants in the Industry module. Here, you select pollutants from the master lists of air and water pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window).

6.7.2 Tables



Value Added by Subsector

When building applications using the Basic Structure, in the **Share** column, enter the fraction of the regional industrial sector value added (defined in the Population, GDP and Income module) in each subsector. Shares should sum to 1.0 over subsectors. The total value added in each subsector will be displayed in the **Value Added** column (in billions of dollars), calculated using the formula entered in the column.

Subsector Process Composition

For applications based on the Basic Structure, in the **Share** column, enter the fraction of subsector value added allocated to each process. Shares should sum to 1.0 over processes. The total value added in each process will be calculated using the formula in the **ActLevel** column (in billions of dollars, when using the large scale Basic Structure).

Energy Use

When building applications using the Basic Structure, in Current Accounts enter the fuel use by fuel and PoleStar will calculate the fuel shares and the energy intensity, using relationships built into the Basic Structure. In scenarios, in the **EI** column (on the TOTAL Fuel line), enter the energy intensity of each process in each region and each subsector (in MJ/$). Next, in the **Share** column, enter the mix of fuels used in each process. Shares should sum to 1.0 over fuels. Using formulas entered in the Basic Structure, the total fuel used is then calculated and displayed in the **FuelUse** column. For the large scale Basic Structure, energy use is in Petajoules (1 PJ = 10^{15} Joules).

Water Use

When using the Basic Structure to build your application, in the **WI** column, enter the water intensity of each process in each region and each subsector (in m^3/$1000). The total water used is displayed in the **WaterUse** column (in millions of m^3, when using the large-scale Basic Structure). In the Current Accounts, enter total water use directly, and PoleStar will calculate and display the water intensity using the formula entered in the **WI** column.

Mineral Requirements

For applications based on the Basic Structure, in the **MI** column, enter the mineral intensity of each process in each region and subsector, for each mineral (in tonnes/$1000). The total minerals used are displayed in the **MineralUse** column (in tonnes, when using the large-scale Basic Structure).

Combustion Air Emissions

This table is used to compute energy-related emissions. When building applications based on the Basic Structure, in the **EF** column, enter emission factors (in kg/GJ) for each fuel and each pollutant per unit of fuel consumption. Total emissions loadings are then calculated and displayed in the **AirEmis** column (in tonnes of pollutants), using the formula entered in the column.

Process Air Emissions

This table is used to enter non-energy industrial emissions, such as CO_2 from cement production. If you do not choose to calculate toxic emissions for each industrial process, you will probably find it most convenient to compute process emissions of CFCs and other hazardous materials using the tables in the **Toxics** module. For applications based on the Basic Structure, in the **EF** column**,** enter emission factors (in kg/$) for each process and pollutant per dollar of economic activity. Total emissions loadings are then calculated and displayed in the **AirEmis** column (in tonnes of pollutants), using the formula entered in the column.

Water Pollution

Use this table to calculate water pollution levels from the industrial sector. For applications built using the Basic Structure, in the **EF** column**,** enter emission factors in kg per $1000 value added for each water pollutant, subsector and process. Using the formulas entered in the Basic Structure, these data are used to calculate total water pollution loadings, which are displayed in the **WaterPoll** column (in tonnes of pollutants).

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

6.8 Agriculture Module

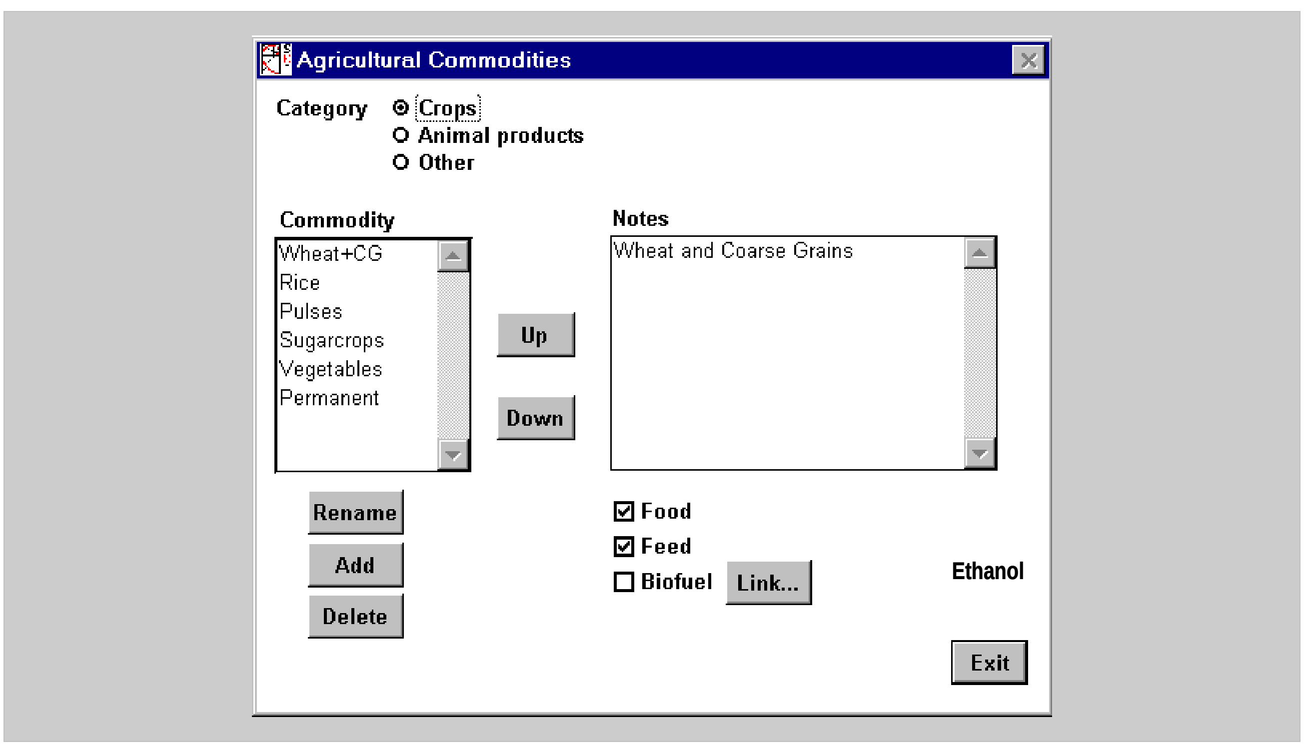
The table structure in the Agriculture module is designed to allow you to represent nutritional consumption and agricultural production based on assumptions on farming practices and trade. In the Basic Structure, land requirements for agricultural production are calculated and passed to the Land module, where they are combined with other types of land changes and pressures. Farming practices define resource requirements and environmental loads from agriculture, information which is passed in the Basic Structure to the Air, Water Resources, and Energy Conversion modules.

6.8.1 Disaggregation Structure

There are eight options on the Disaggregation Structure window for Agriculture. Here, you can define lists for **Population Groups**, **Commodities**, **Livestock Practices**, **Cropping Practices**, **Fuels**, **Other Inputs**, and **Air** and **Water Pollutants**.

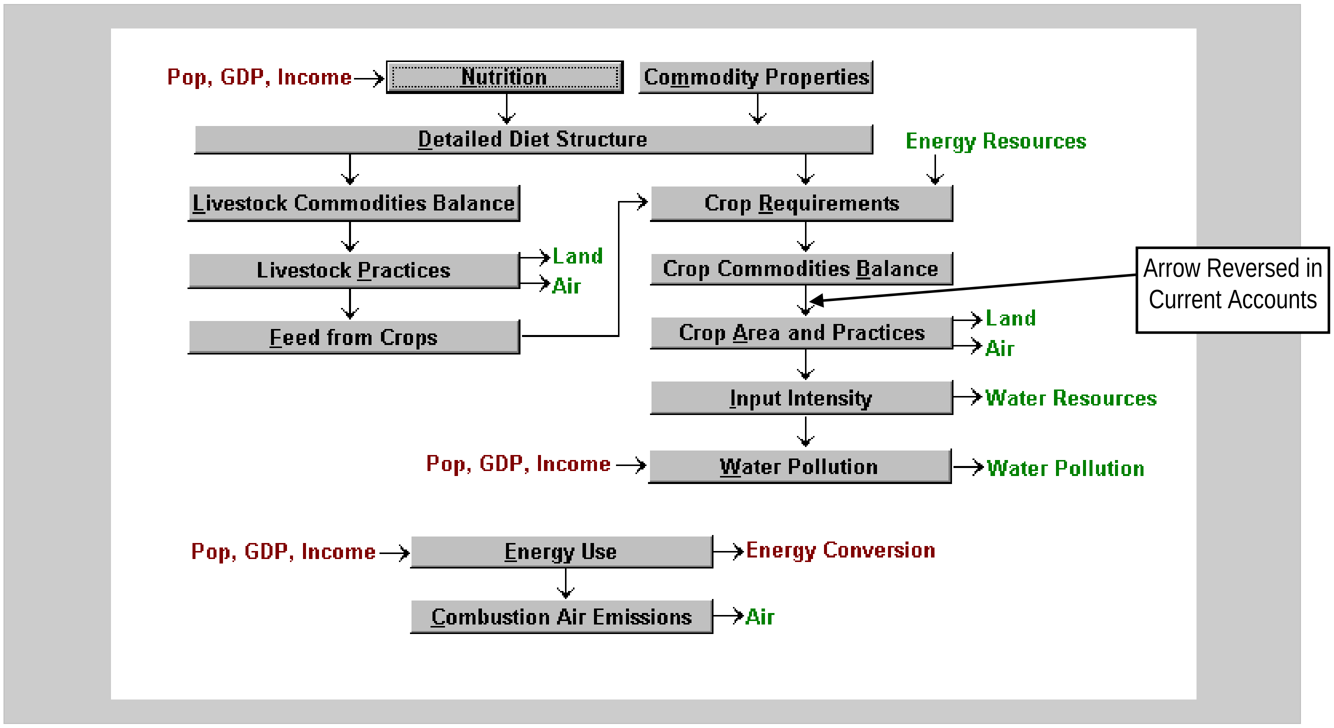
- **Population Groups:** Use the Edit List option to enter the list of population groups (for example, urban/rural; low/medium/high income, etc.) for the purposes of analyzing nutritional patterns. The choice of categories will depend on the chosen detail and objectives of your study and availability of data, and should reflect groups for which different diet patterns can be identified. You can Rename, Add, and Delete items using the dialog box buttons, and reorder the list using the Up and Down buttons. Similar options are available in the other Edit List dialog boxes.

- **Commodities:** Use the Edit List option to enter the structure of agricultural commodities. Commodities are grouped into three categories: **crops** (for example, rice, cereals, pulses, roots and tubers, etc.), **animal products** (for example, meat, milk, eggs, etc.), and **other** (for example, fish). Commodities of category **other** do not require data for production, trade or resource requirements. Select the **Category** radio button to display the list of commodities for each category. For each commodity, use the check boxes to indicate if the commodity is used as **food** for human intake or as **feed** for livestock. You can select more than one check box for each crop commodity. However, note that it is not possible to label an animal product as a feed. (Animal products may still be used as feeds, for example milk for calves. However, they appear as feeds in a different table from crops.) These check boxes will be used later by PoleStar to determine which commodities are displayed in the diet, crop and livestock tables.



- **Livestock Practices:** Use the Edit List option to enter the list of livestock farming practices (for example, stall-fed/grazing/factory farming, or high intensity/low intensity). The tables are structured to allow you to use this classification of livestock farming practices to enter data on the feed and pasture requirements of different livestock commodities. Your classification of livestock farming practices should reflect available data across all regions and commodities.
- **Cropping Practices:** Use the Edit List option to enter the list of cropping practices (for example, high input, organic, conventional farming, irrigated) that you wish to use in your application. If sufficient data are available, you may wish to include classifications of soil fertility within your cropping practices. The tables are structured to allow you to use your classification of cropping practices to enter data on the yields, crop intensities and seed requirements, and the water and fertilizer inputs of each commodity. Your classification of cropping practices should reflect available data on these subjects across all regions and commodities.
- **Fuels:** Use the Edit List option to choose the group of fuels consumed as inputs in the Agriculture module. Fuel use in the agriculture module includes energy used for irrigation (water pumping), stall heating, soil tilling, etc.
- **Other Inputs:** Use the Edit List option to specify the list of inputs (other than fuels) to agricultural production. The list might include water for irrigation and might also include different types of fertilizers (for example, nitrogen, phosphate, and potash), different pesticides and other important inputs. For each input, enter a relevant unit of measurement (e.g., kt, 10^6 m^3 or 10^6 $). The first input, **Irrigwater,** is used to specify water irrigation requirements. This input cannot be renamed or deleted.
- **Air and Water Pollutants:** Use the Edit List option to choose the pollutants in the Agriculture module. Here, you select pollutants from the master lists of air and water pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window).

6.8.2 Tables



Nutrition

Use this table to enter the calorific intake of each population group in each region of your application. In the Basic Structure, total Calories[3] are supplied by the three categories of commodities: animal, vegetable and other. In the **PopShare** column, allocate total regional population (defined in the Population, GDP and Income module) among the different population groups that you defined in the Disaggregation Structure**:** Population groups dialog box. Shares should sum to 1.0 over groups. The total for each group population (in millions, using the large-scale Basic Structure) will be displayed in the **Population** column. The definition of population groups that you use in this module need not necessarily correspond to the definitions used elsewhere in PoleStar (for example, in the households module).

When building an application based on the Basic Structure, in the **Nutr** column, enter the average daily nutritional intake for each population group in each region (in Calories/capita/day). Finally, in the **VegShare** and **AnimShare** columns, enter the fraction of that caloric intake accounted for by animal and vegetable food commodities. The balance is displayed in the **OthShare** column, such that the values in the three columns sum to 1.0. For each population group, the total daily food demand (in Calories) by commodity category (vegetable, animal and other) is then calculated using the relationships built into the Basic Structure.

Commodity Properties

For applications based on the Basic Structure, use this table to enter the energy content (Calories/kg) of agricultural commodities by region and commodity category (animal, vegetable, other). In the **EnerCont** column enter the calorific content of each commodity (in Cal/kg). These values are used in later tables to convert commodity requirements from Calories to tonnes.

Detailed Diet Structure

Use this table to allocate food requirements by category into commodities you defined in the Disaggregation Structure**:** Commodities dialog box. In the Basic Structure, the **Share of Categ** column contains the fractions of calorie consumption for each category (animal, vegetable, other) in each region and population group met by each commodity. For each of the categories, the shares should sum to 1.0. The share of total calories is then calculated and displayed in the **Share of Total** column. Using these data and the relationships built into the Basic Structure, PoleStar then calculates and displays total food demand in the **Cal FoodDemand** column (in billions of Calories) and the **Food Demand** column (in thousands of tonnes). The conversion of nutritional requirements in Calories into food demands in tonnes is based on the calorific content of different commodities entered in the Commodity Properties table.

Livestock Commodities Balance

Use this table to enter the overall balance between the consumption and supplies (production and trade) of livestock commodities. In the large-scale Basic Structure, amounts in the table are in thousands of tonnes. The columns in the table in the Basic Structure are:

Production: In this column, enter the total indigenous production for each commodity by region.

Tip: In some cases, production statistics are reported in different units for farm outputs (e.g., paddy rice or slaughtered carcass weight) and commodity consumption (e.g., husked rice or total meat weight including offal). If you wish to make this distinction, you can create new columns for production in different units, and a conversion factor to relate production in the two sets of units. You

[3] Throughout PoleStar, the term "Calorie", when used to refer to food energy, conforms to standard usage: 1 Calorie = 1 kcal = 1000 calories.

will also need to modify some of the Basic Structure formulas. For details on creating columns and editing formulas, see Chapter 7.

FoodReq: This column displays total food requirements for the animal products (as calculated in the Detailed Diet Structure table).

FeedReq: In this column, you may account for livestock commodities consumed by livestock (*e.g.*, milk consumed by calves) if you wish.

LossFrac: In this column, enter the fraction of food and feed requirements lost to waste, spoilage and processing for each livestock commodity. Values must be less than 1.0. Total losses are calculated and using the formula entered in the **Losses** column.

TotalReq: This column displays the total domestic requirements of each commodity by region as a total of food requirements, feed requirements and losses.

NetExport: In the Current Accounts, in this column enter the value for net exports (total exports - total imports) of each livestock commodity in each region. In scenarios the value is calculated based on production and demand.

SSR: This column displays the **Self-Sufficiency Ratio** for each commodity, defined as the ratio of the masses of production to total domestic requirements.

Tip: In scenarios, you may wish to specify self-sufficiency ratio or net exports, rather than production. You can rearrange the order of calculations by changing formulas in columns and reordering the columns. See Chapter 7.

Discrepancy: In the Current Accounts in the Basic Structure, this column displays any imbalance between total requirements and production minus net exports. Discrepancies are the sum of stock changes, statistical differences and any other discrepancies between your demand and supply data. Large discrepancies that cannot be explained by stock changes may indicate inconsistencies in your data. For example, differing sources of data may be inconsistent due to differing definitions of variables. In scenarios, the discrepancy column is zero, with net exports calculated as the balance between production and total requirements.

Livestock Practices

In the previous table you entered the production of livestock in each region. In this table you enter information describing **how** those commodities are produced. In the Basic Structure, the livestock practices table contains the following columns:

PracShare: In this column, enter the fraction of total commodity production met by each livestock farming practice. Shares should sum to 1.0 over practices.

Production: This column displays the production of livestock commodities in thousands of tonnes.

ProductCal: This column displays the production of livestock commodities in billions of Calories, using the values entered in the Commodity Properties table.

Feed to Prod Ratio: In this column enter the crop-to-product ratio (Calories of crops consumed for feed to Calories of animal product produced). Since these values represent the inverse of an "efficiency," they would normally be expected to be greater than 1.0. However, when a significant amount of livestock feed comes from grazing, values of less than 1.0 may be appropriate.

CropFeed: Total feed requirements from crops (in billions of Calories, when using the large-scale Basic Structure) are calculated for each practice. In the Basic Structure, feed requirements are calculated by multiplying together total production for the practice, the energy content of the feed (from the Commodity Properties table) and the crop-to-product ratio.

EF: When using the Basic Structure, in this column enter the emissions factors for methane from livestock in kilograms per tonne of livestock produced. Methane from livestock (resulting from enteric fermentation and manure decomposition) can be a significant contributor to greenhouse gas emissions.

Graze Index: In this column (available in scenarios only), enter the ratio of grazing land required in the scenario year per tonne of animal product to the grazing land required in the Current Account year per tonne of animal product. For example, a decrease of 20% in the amount of grazing land required per tonne of animal product would be represented by a Graze index of 0.8. The Graze index indicates the change in efficiency of animal production in the grazing system. An index less than one indicates increasing efficiency. An index greater than one indicates decreasing efficiency.

Pasture: In this column, in Current Accounts, enter the pasture required for grazing in thousands of hectares. In scenarios, the required pasture land is calculated based on the Graze index and production, using the relationships built into the Basic Structure.

Feed from Crops

Use this table to allocate the animal feed requirements of each livestock practice to different crops. When building applications using the Basic Structure, enter in the **Share** column the fraction of total animal feed Calorie requirements provided by crops (as opposed to grazing) that are met by each crop. Shares should sum to 1.0 over all crops. Using the relationships built into the Basic Structure, PoleStar calculates and displays the total animal feed requirement for each crop in the **CropFeedCal** and **CropFeed** columns, first in billions of Calories and second in thousands of tonnes. In the Basic Structure, the conversion of feed requirements from Calories (in the Livestock Practices table) into tonnes is based on the calorific content of commodities (entered in the Commodity Properties table).

Crop Requirements

This table accounts for all crop requirements. All values are displayed and entered in thousands of tonnes. In the Basic Structure, the table contains the following columns:

FoodReq: This column displays total human food requirements for crop commodities (calculated in the Detailed Diet Structure table).

FeedReq: This column displays total animal feed requirements for crop commodities (calculated in the Feed from Crops table).

EnergyReq: This column displays the requirements for biofuel crops, as calculated in the Energy Conversion: Primary Energy Balance table.

OtherReq: In this column enter all other crop requirements, such as cotton used in the textile industry, linseed oil, etc.

FinalReq: This column displays final requirements of crop commodities as the sum of food, feed, energy and other requirements.

LossFrac: In this column, enter the losses (*e.g.*, from waste, pests, and processing) for each crop commodity as a fraction of final requirements. Using the formula entered in the **Losses** column, PoleStar calculates total losses and displays them in the column.

Crop Commodities Balance

Use this table to enter the overall balance between the consumption and supplies of crop commodities. In the Basic Structure, all values are displayed and entered in thousands of tonnes.

Production: In the Current Accounts, this column is calculated from values in the Crop Area and Practices table. In scenarios, in this column enter the total indigenous production for each commodity by region.

SeedFrac: In this column, enter the fraction of **Production** of crop commodities used as seed. Total seed requirements are calculated using the formula entered in column **SeedReq**.

TotRequired: This column displays the total domestic production requirements of each commodity in each region calculated as the total of food, feed, energy and other requirements, plus losses and requirements for seed.

NetExport: In this column, in the Current Accounts enter the net exports (total exports - total imports) of each crop commodity in each region. In scenarios this column is calculated as the difference between production and total requirements.

SSR: This column displays the *Self-Sufficiency Ratio* for each commodity, defined as the ratio of production to total domestic requirements.

Discrepancy: This column displays any imbalance between total requirements and production minus net exports. Discrepancies are the sum of stock changes, statistical differences and any other discrepancies between your demand and supply data. Large values that cannot be explained by stock changes may indicate a problem with your data. In scenarios this column is zero.

Crop Area and Practices

Current Accounts:

In Current Accounts, you enter data to indicate how crops are produced using the crop practices you defined in the Disaggregation Structure. By specifying the land area under each practice and the annual crop yield, you calculate the total production of crops from each practice.

When using the Basic Structure to build an application, in the **Area** column, enter the total land area for each crop and cropping practice by region (in thousands of hectares, for the large-scale Basic Structure). The share of land areas by practice is displayed in the **AreaShare** column, calculated using the formula entered in the column. In the **CropInt** column, enter the crop intensity—the number of harvests per year, averaged over several years. In the **HarvYield** column, enter the kg of crops per hectare per harvest. The product of the harvest yield and the cropping intensity, the annual yield, is displayed in the **AnnYield** column. The production by practice is calculated using the formula entered in the **Production** column, and the share of total production provided by each practice is shown in the **ProductionShare** column.

For applications based on the Basic Structure, in the **EF** column enter methane emission factors per hectare by practice. This would be used, for example, to account for methane emissions from rice cultivation—a significant contribution to greenhouse gas emissions in some places. The resulting methane emissions are calculated using the Basic Structure formulas, and displayed in the **Emission** column.

Scenarios:

In the Basic Structure, the scenario table differs from the Current Accounts table: In scenarios, production is calculated in the Crop Commodities Balance table, and hence the Crop Area and Practices table is used to calculate land practice areas consistent with these production projections.

Enter the share of land areas by practice in the **AreaShare** column. Shares should sum to 1.0 over practices. In the **CropInt** column, enter the crop intensity—the number of harvests per year, averaged over several years. In the **HarvYield** column, enter the kg of crops per hectare per harvest. The annual yield is calculated and displayed in the **AnnYield** column. The production by practice is calculated in using the area shares and annual yields, and displayed in the **Production** column. The **Area** column displays the total land area required for each crop and cropping practice by region (in thousands of hectares).

Input Intensity

Use this table for the water, fertilizer and other agricultural input requirements. When building applications using the Basic Structure, input intensities are entered for each region, crop commodity and cropping practice in the units selected in the Disaggregation Structure**:** Inputs dialog box. In the Basic Structure, areas calculated in the Crop Area and Practices Table are displayed under **HarvArea**. In the **InpInt** column, enter the input intensity of each input per hectare of harvested land. PoleStar will calculate and display total input requirements in the **Input** column. The units that appear in the intensity will depend on the input. For example, for fertilizer the appropriate unit might be ktonnes, or a currency unit. For water the appropriate unit is the volume of water.

Irrigated water is an input to all practices (you cannot delete it from Disaggregation Structure**:** Other Inputs). Set the irrigated water intensity to zero for rainfed practices.

Water Pollution

Use this table to calculate water pollution from the agriculture sector. In the Basic Structure, water pollution is calculated based on agricultural value added. If you wish to use this table, enter **EF**, the pollutant emission factor, in grams/$1000 value added, or customize as you wish (see Chapter 7).

Tip: If you wish to use an agricultural input (e.g., nitrogen fertilizer) to drive water pollution loadings, you can modify the formula that appears in the Basic Structure.

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

Energy Use

In the Basic Structure, agricultural value added drives agricultural energy requirements. The **VA** column displays the value added by agriculture (in terms of the currency specified for the application), as entered in the Population, GDP and Income module. For applications based on the Basic Structure, in the **EI** column in Current Accounts, enter fuel use directly. PoleStar will calculate the energy intensity and fuel shares using the relationships built into the Basic Structure. For scenario years, on the line for TOTAL fuel, enter the energy intensity for each region, expressed as energy consumed for agriculture divided by agricultural value added (in MJ per unit of currency). Next, in the **Share** column, enter the mix of fuels used in each region. Shares should sum to 1.0 over fuels. The total fuel is then calculated and displayed in the **FuelUse** column in Petajoules (for the large-scale Basic Structure).

Combustion Air Emissions

Use this table to calculate air emissions from energy combustion in the agriculture sector. When building an application using the Basic Structure, in the **EF** column**,** enter emission factors (in kg/GJ) for each fuel and each pollutant per unit of fuel use. Total emissions loadings are then calculated and displayed in the **Emission** column (in tonnes of pollutants). PoleStar calculates emissions using the relationships built into the Basic Structure.

6.9 Energy Conversion Module

The table structure in the Energy Conversion module allows you to represent the transformation of primary energy resources (*e.g.*, fossil fuels, uranium, renewables) into final fuels consumed (*e.g.*, electricity, petroleum products).

Note: Unlike most modules, in the Energy Conversion and Energy Resources modules several standard energy accounting relationships are built into PoleStar and cannot be altered. Also, the columns these calculations depend on cannot be deleted, although you can rename them, move them, and change the number of digits they display.

The flow of the energy system is illustrated by the table maps. The essential steps are:

- final energy demands are collected from other modules;
- energy losses are estimated;
- the mix of subsectors and processes for converting primary to secondary energy (*e.g.*, coal to electricity in power stations) are calculated (in the current accounts) or specified (in scenarios);
- requirements for primary resources are calculated (trade in primary resources is assessed in the energy resources module)
- air emissions and water pollution from conversion processes and air emissions from losses and own use of energy are calculated.

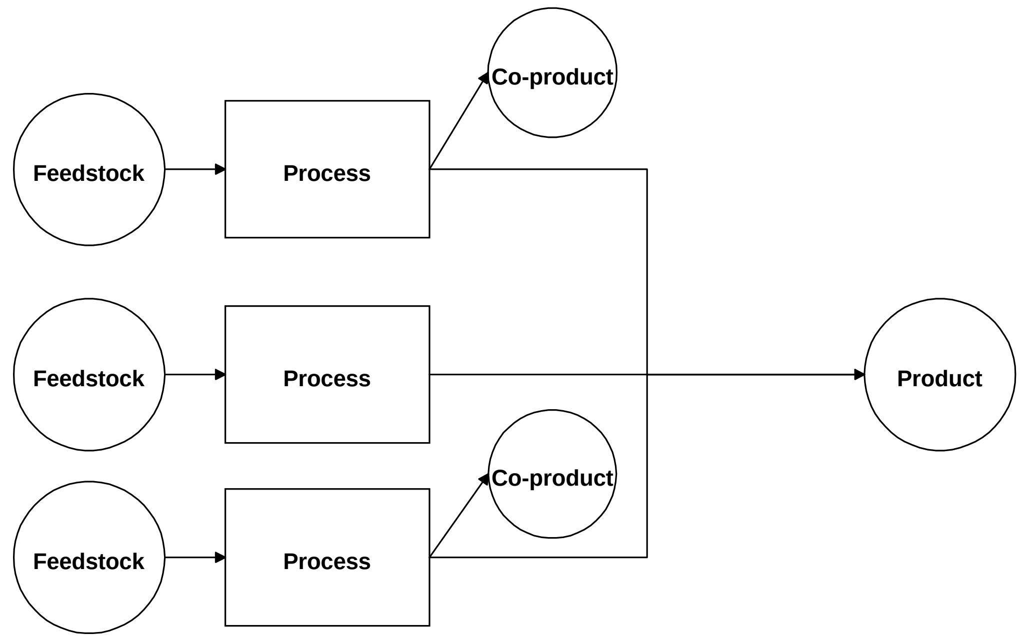
6.9.1 Disaggregation Structure

In the Energy Conversion module you set up data structures at two levels. The *subsector* level represents energy industries such as electricity generation, refining, district heating, cogeneration and charcoal production. The more detailed *process* level describes individual technologies or groups of technologies within a subsector, such as categories of power plants (*e.g.*, coal-fired) and oil refineries, or specific plants. Energy requirements are calculated in the Household, Transport, Services, Agriculture and Industry modules, and in addition, by the energy required for the energy sector itself (*e.g.*, oil for electricity generation).

The Basic Structure comes supplied with default lists of energy system subsectors and processes. These lists can be altered to match the major subsectors and processes in your application. Typically, you will begin by examining the rows in the transformation and conversion section of a national *energy balance* to identify the subsectors for the regions you are studying. You can return later and expand or refine your subsector and process structure.

A subsector is a simplified model of energy flows as illustrated below. Each subsector is made up of any number of processes that are dispatched to satisfy a single *primary product*. Each process in a subsector, is fed by one *feedstock* fuel and may optionally produce one coproduct fuel. Thus, while the different processes in a subsector can consume different feedstock fuels and can produce different coproducts, they are all operated to meet the requirements of a single primary product.

Energy System Subsector Disaggregation Structure



This generalized framework can accommodate a variety of production and conversion subsectors. For example:

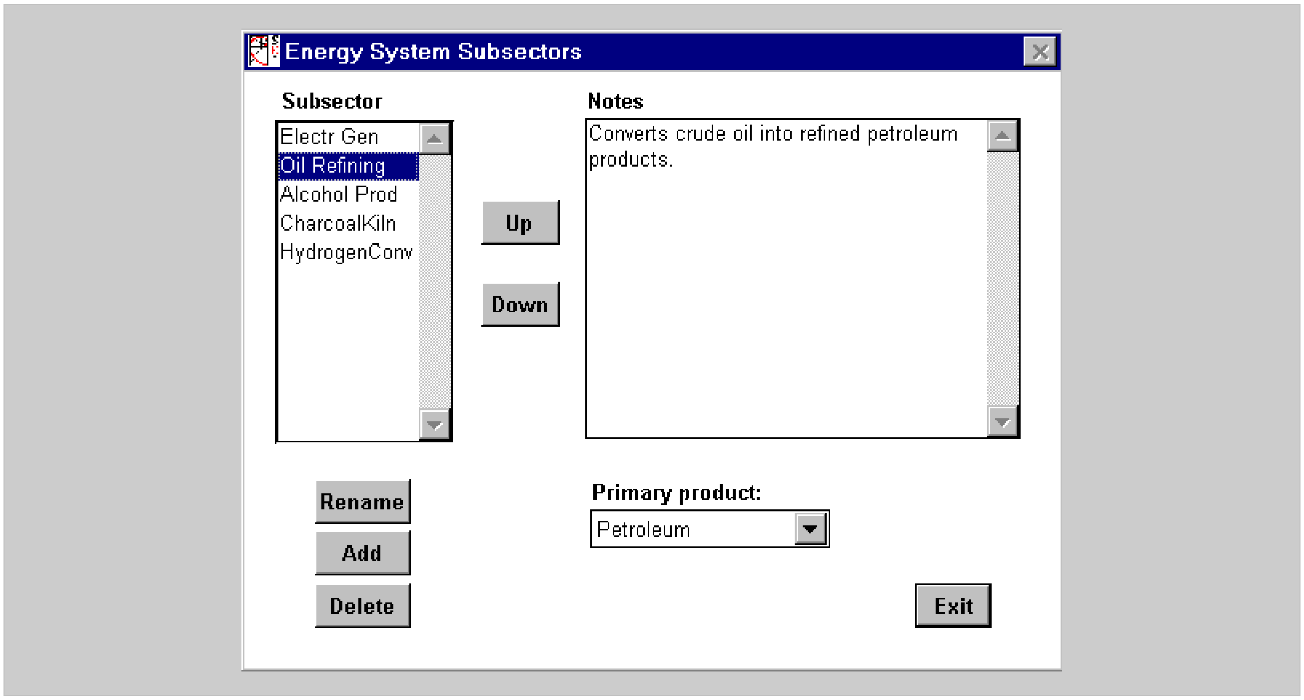
- **Electricity:** The electricity generation subsector processes can be specified as different power plants (or more typically, classes of power plants, *e.g.*, coal generation, hydropower, etc.), all producing electricity as their product, and each using different feedstock fuels (coal, diesel, hydro, nuclear, wind, etc.). Combined heat and power (CHP) plants can be simulated by specifying "heat" as the process coproduct. Conventional steam or gas turbine plants will have no coproducts.

- **Oil Refining:** The refining subsector can be specified as a series of different refinery facilities (or types of facilities) with "Crude Oil" as the feedstock fuel, and a single output including all "Petroleum Products" as the product. Alternatively, by expanding the All Fuels disaggregation and making each petroleum product the output of a separate energy system subsector, separate refinery subproducts, such as gasoline, diesel, LPG, kerosene, etc., can be produced from separate energy system subsectors with different outputs.

By constructing "chains" of subsectors and processes, you can represent the energy system network appropriately for your application. For example, one simple chain might involve one subsector first converting crude oil into petroleum products, followed by another subsector that converts those petroleum products into electricity. At each stage in the energy chain, energy losses and own-use consumption (energy consumed by the process itself, other than feedstock conversion) can be accounted for.

There are four options on the Disaggregation Structure window for Energy Conversion. These are used to define the **Energy System Subsectors**, and **Energy System Processes**, and to choose the **Air** and **Water Pollutants** that apply to the Energy Conversion module.

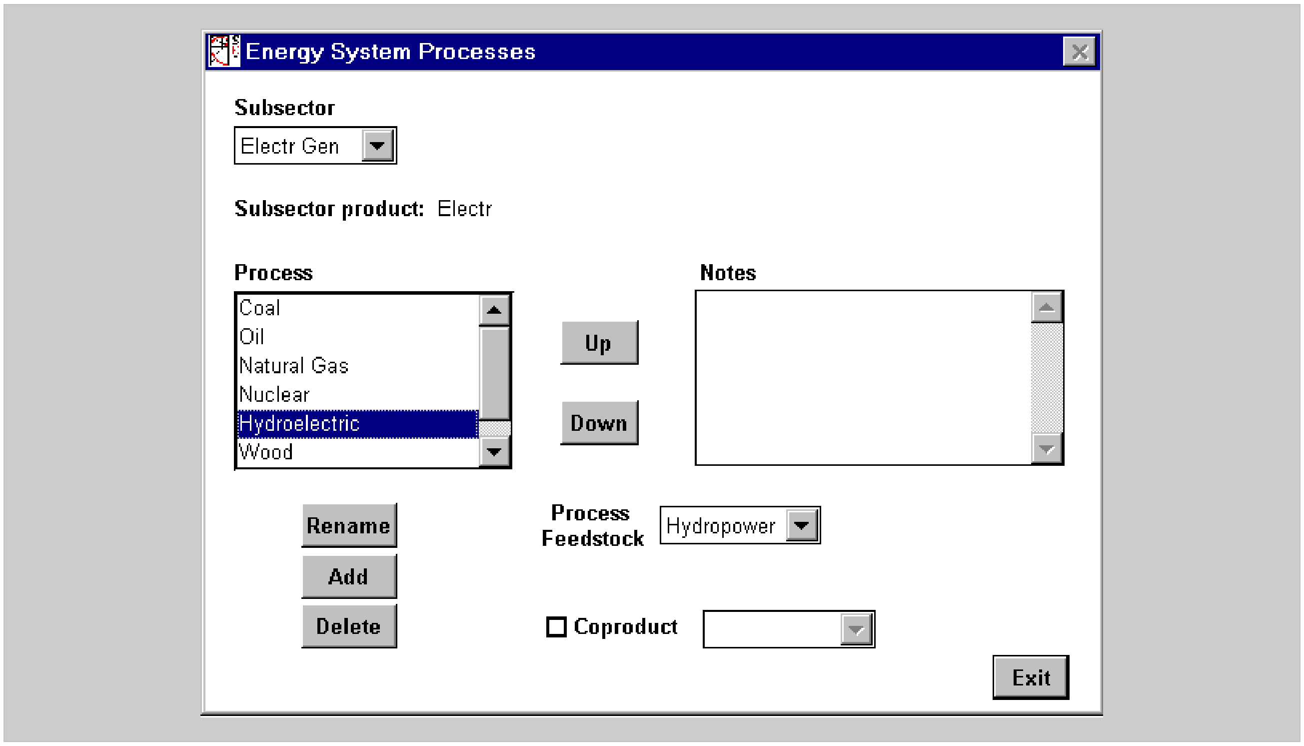
- **Energy System Subsectors:** Use this dialog box to enter the list of Energy system subsectors in your application. Subsectors represent energy industries such as electricity generation, refining, district heating, cogeneration, charcoal production, etc. The choice of categories will depend on the chosen detail and objectives of your study. PoleStar automatically derives the energy requirements that one subsector places on another. For example, oil required for electricity generation will automatically be added to the output requirements for the refinery subsector. The ordering of subsectors in your list will *not* affect calculation results. However, output reports and data entry *are* in this order.



Indicate the **Primary Product** produced by each subsector (*e.g.*, electricity from an Electric Generation subsector). By definition, products are secondary fuels (as defined on the Disaggregation Structure: All Fuels dialog box). The Primary product popup contains only secondary fuels.

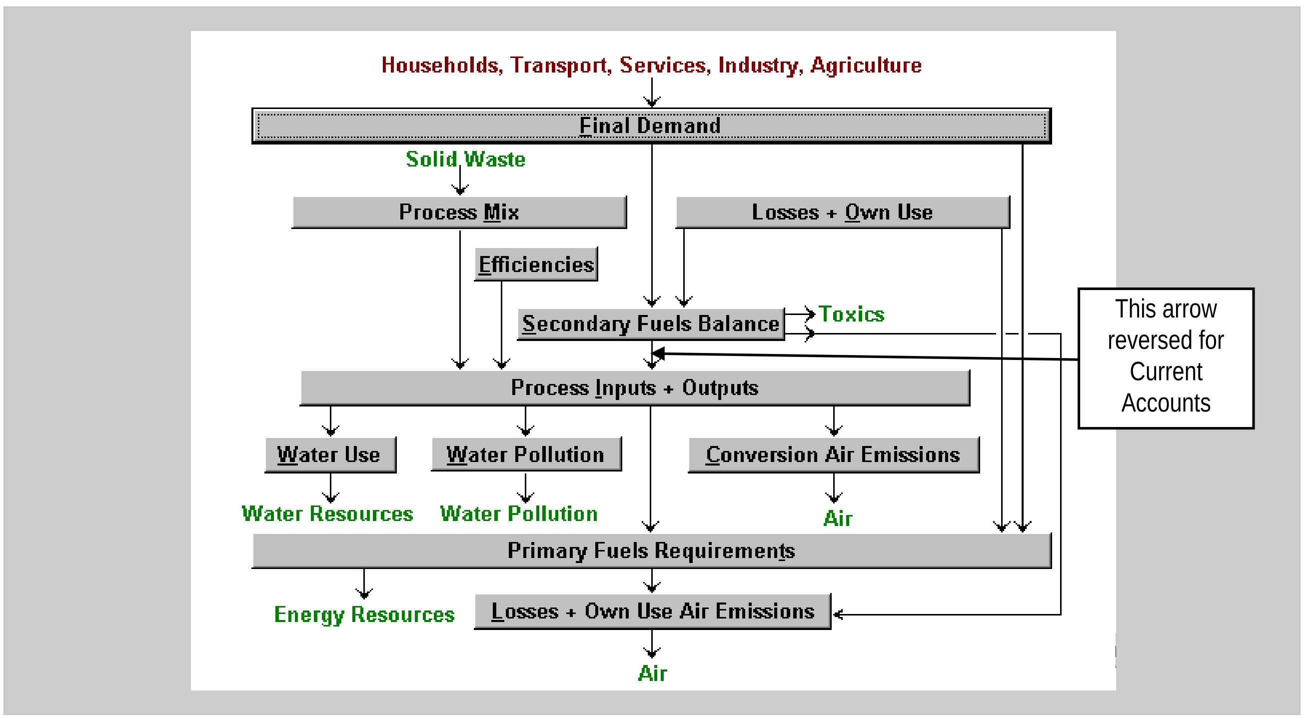
- **Energy System Processes:** Use this dialog box to enter the list of processes in each subsector. The process level describes individual technologies or groups of technologies within a subsector such as particular electric plants or oil refineries.

  Select one subsector at a time using the **Subsector** popup. The dialog list box will then display the list of processes for the selected subsector. For each process, indicate the **Input Fuel**. Keep in mind that within a single subsector, different processes can have different input fuels. If a process produces a coproduct (*e.g.*, heat from a CHP power plant) you must first select the **Coproduct** check box, and then indicate the coproduct fuel in the popup box that appears alongside the checked box. Coproducts must be secondary fuels, not primary resources, as defined on the Disaggregation Structure**:** All Fuels dialog box. Therefore, the coproduct popup contains only secondary fuels.



- **Air and Water Pollutants:** Use these dialog boxes to select the list of pollutants in the Energy Conversion module. Here, you select pollutants from the master lists of air and water pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window).

6.9.2 Tables



The Energy Conversion module uses different calculation approaches when computing Current Accounts and scenarios. In Current Accounts, you can replicate standard energy planning tables such as energy balances by explicitly entering the Base Year production from each conversion process. In Scenarios, production is computed from information on requirements, trade and conversion mix, and technology. In order to reflect the fact that consumption and production information are often derived from different and sometimes conflicting sources, PoleStar allows consumption and production data to be inconsistent, displaying the difference in a calculated “discrepancy” column in the secondary fuels balance.

To balance energy production and demand in scenarios, PoleStar meets fuel requirements by determining required production from all energy conversion subsectors. This calculation (described in the box “Determining Process Inputs and Outputs,” below) takes into account:

- Total final demand from all sectors
- The trade policy variable (fixed production, fixed net exports or fixed self-sufficiency ratio)
- Coproduction
- Production from other sectors (*e.g.*, electricity or heat from solid waste incineration)
- Losses and own use
- Input fuel requirements for conversion processes (*e.g.*, refinery products used for electricity generation)

Note: It is possible that coproduction or production from other sectors exceeds requirements. For example, suppose electrcity demand is met partly from combined heat and power (CHP) plants, and that these plants produce more than enough heat to meet heat demand. In this case the available heat production exceeds required production. Also, there may be demand for a secondary fuel, but no subsector for the fuel (for example, future heat demand might exceed the production from CHP plants). In these situations, an excess or a deficit of available production, compared to required production, will appear in the Secondary Fuels Balance table. You can, of course, alter your assumptions to meet the demand in the scenario.

Determining Process Inputs and Outputs

Process inputs and outputs are determined once total primary fuel production from each subsector has been determined. Primary output from each process is given by

Process Primary Output = Process Share × Subsector Primary Output .

Then, process input fuel requirements are given by

Process Input Requirements = Process Primary Output / Primary Product Efficiency .

Finally, coproduction is given by

Process Coproduction = Process Input Requirements × Coproduct Efficiency .

Some production may also come from other sectors (for example, in the Basic Structure, the Solid Waste module).

Production plus net exports meets total requirements, where in the Basic Structure,

Production = Primary Production + Coproduction + Production from Solid Waste Incineration

and

Total Requirements = Total Final Demand + Process Input Requirements + Losses & Own Use .

Note: Balancing requirements and production can be complex, since the output from one energy conversion process can be used as the input to another process. PoleStar provides a general solution to this problem, by performing a built-in calculation to ensure that production and requirements balance.

Final Demand

This table collects the final fuel demands by sector, as calculated in the Households, Transport, Services, Agriculture, and Industry modules. Use this screen to get a view of total final annual energy demands for the whole application, rather than for just a single sector. The table is used only for displaying results. The **FuelUse** column displays annual final fuel demands in PJ (10^{15} J).

Losses & Own Use

Use this table to enter the losses occurring in the transportation, transmission and distribution of fuels. You also have the option of computing “own use” of fuels in processes, *e.g.*, electricity use in power plants, petroleum products used to run a refinery, etc. In this table you would enter the losses occurring in the transmission and distribution of electricity, the leakage occurring in the distribution of natural gas, and the own-use of fuels such as electricity used in power plants.

In the **LossFrac** column, enter the loss fraction for each fuel and region. In the **OwnUseFrac** column, enter the own-use fraction for each fuel and region. The sum of these two fractions, displayed in the **Total** column, must be less than 1.0. Both the loss fraction and the own-use fraction are applied to total domestic fuel requirements in the economy. Losses are calculated using the formula entered in the column.

Process Mix

This table is used to define the mix of processes dispatched to meet the requirements on each subsector. In Current Accounts, you explicitly enter process outputs from each process (so as to accurately replicate Base Year energy balance data), while shares are computed. In the **SubsectProduct** column, enter the annual energy output of the subsector primary product for each process in PJ (excluding any coproduct fuels). The feedstock for the process is reported in the **ProcFeedstock** column. PoleStar will calculate and display the energy share of each process in the **Share** column. When editing Scenario data, you enter **Shares** explicitly. Shares should sum to 1.0 over subsectors. The **SubsectOutput** column does not appear; it is computed and reported in the Process Inputs and Outputs table.

Efficiencies

Use this table to enter the efficiencies of energy conversion for each process in each subsector and region. Efficiency of a process is the ratio of energy output to energy input. The process feedstock and subsector output are reported in the **ProcFeedstock** and **SubsectProduct** columns. In the **ProductOutputEff** column, enter the fraction of input energy that is recovered as the primary product. If your process has a coproduct, it will be shown in the **Coproduct** column. In the **CoprodOutputEff** column enter the fraction of the input energy that is recovered as the coproduct fuel. The total of these two columns—the overall thermal efficiency of the conversion process—is displayed in the **ProcEff** column. The values in this column must be less than 1.0.

Secondary Fuels Balance

This table provides an energy balance between Final demands and Total Production of Secondary fuels. Secondary fuels are either produced by an energy system subsector, or are imported into the region. All values are displayed in PJ.

Current Accounts

FinalDemand: This column displays total final fuel use (taken from the Final Demand table).

Inputs to Conv Proc: This column displays the sum of all feedstock inputs to energy conversion processes (calculated internally by PoleStar).

Loss&OwnUse: This column displays total system losses and own use of fuels.

Tot Required: This column displays total domestic fuel requirements, as the sum of final demand, feedstock requirements for energy conversion, losses and own use.

Tot Production: This column displays the total indigenous production of secondary fuels in each region based on total requirements and net exports (computed internally by PoleStar from data entered in the Process Mix table and Efficiencies tables), as well as production from other sectors.

NetExport: In this column, enter the net exports (total exports **-** total imports) of secondary fuels in each region.

SSR: This column displays the *Self-Sufficiency Ratio* for each fuel, defined as the ratio of Production to Total Domestic Requirements.

Discrepancy: This column displays any imbalance between total requirements and production minus net exports. Discrepancies are the sum of stock changes, statistical differences and any other discrepancies between your demand and supply data. Large values that cannot be explained by stock changes may indicate inconsistencies with your data. If so, you will need to go back to check data on demand, net exports; outputs, efficiencies and losses, entered in the Energy Conversion and Resources module.

Prod From SW: You can use this column to compute total energy production from processes in non-energy sectors. For example, in the Basic Structure this column includes electricity generated from solid waste incineration.

Prod From En Conv Proc: Production from energy conversion processes (primary outputs plus coproduction) is displayed for information. In the Basic Structure, this equals Total Production minus electricity production from solid waste.

Underproduction: This column reports any difference between the required production of the fuel (determined by total requirements and trade) and the amount produced. Generally this will be zero. A positive value indicates a possible inconsistency, which can usually be corrected by adding an energy subsector with this fuel as the output.

Scenarios:

The fundamental identity relationships defined above hold for both Current Accounts and Scenarios. However, in Current Accounts, you explicitly enter process output data, while in Scenarios, process outputs are calculated on the basis of scenario assumptions for future requirements, process mix and technologies.

Set Production
Set Net Exports
Set SSR

In Scenarios, you explicitly set one of the following variables: **Production**, **Net exports** or **SSR**. An extra column, labeled **Policy**, is used to choose which of these three variables to enter explicitly. You can set a different policy in each scenario year. Position the cursor in this column and click on the arrow next the cell whose value you wish to change. A popup box will appear, listing three choices: **Set production**, **Set net export** or **Set SSR**. After you have chosen the Policy, enter a value in the **Tot Production**, **NetExport**, or **SSR** column.

Process Inputs & Outputs

This table reports process inputs used and outputs produced in the energy system subsectors. The **SubsectProduct** column gives the name of the secondary fuel produced by the process. The **ProcOutput** column gives the quantity of energy produced. The **Share** column displays the share of the total primary product produced by each process. The **ProcFeedstock** column gives the name of the fuel input to the process. The **ProcInput** column displays annual feedstock fuel use. The **Coproduct** and **Coprod[PJ]** columns display the name and output of any coproduced fuels. All fuel values are displayed in PJ.

Primary Fuels Requirements

This table reports the total requirements for primary fuels (as defined on the Disaggregation Structure**:** All Fuels dialog box). The value in the **Inputs to Conv Proc** column is calculated internally by PoleStar, based on the calculated production of secondary fuels by each of the energy conversion processes. The other columns are calculated using the formulas entered in the table.

Water Use in Energy Conversion

This table is used to specify the use of water in energy conversion sectors (for example, cooling water used in fossil and nuclear fired power stations). The **ProcOutput** column displays the process output. In the **WI** column, enter the intensity of water use in each conversion subsector and process in m^3/GJ of production. The total annual water use is calculated and displayed in the **WaterUse** column in millions of m^3, using the formula entered in the column.

Water use can be drawn from freshwater sources, saline sources, or both. In the Basic Structure,freshwater requirements and resources are compiled in the Water Resources module. In this table, freshwater and saline sources are distinguished by specifying the fraction of water withdrawals that are from freshwater sources. The value in the **FreshwaterUse** column is used by the Water Resources module.

Tip: Water use can be specified in terms of consumption, withdrawals, or requirements. You will need to choose an appropriate convention given the concerns of your analysis. Most evaluations of withdrawal or consumption assume zero water use for in-river hydroelectricity facilities.

Conversion Air Emissions

Use this table to calculate the pollutant emissions resulting from the conversion of fuels in the Energy Conversion and Resources module. When building an application using the Basic Structure, in the **EF** column**,** enter conversion emission factors (in kg/GJ of input) for each region, energy system subsector, process and pollutant. These data, together with total input fuel consumption (shown in the **ProcInput** column, calculated in the Secondary Fuels Balance table) are used to calculate total conversion emissions loadings, which are displayed in the **AirEmis** column (in tonnes of pollutants).

Losses and Own Use Air Emissions

Use this table to calculate the pollutant emissions resulting from losses and own use. Losses (in PJ) are displayed in the **Losses** column. In the **LossEF** column**,** enter emission factors for losses (in kg/GJ) for each region, fuel and pollutant. These data are used to calculate total losses emissions loadings, using the formula entered in the **LossEmis** column (in tonnes of pollutants).

Own use energy use (in PJ) is displayed in the **OwnUse** column. In the **OwnUseEF** column**,** enter emission factors for own use energy use (in kg/GJ) for each region, fuel and pollutant. These data are used to calculate total own use emissions loadings, which are displayed in the **OwnUseEmis** column (in tonnes of pollutants).

Water Pollution

Use this table to calculate water pollution levels from the energy conversion sector. When building an application using the Basic Structure, in the **EF** column**,** enter emission factors in kg per GJ of input (feedstock) fuel for each water pollutant, subsector and process. These data are used to calculate total water pollution loadings, using the formula entered in the **WaterPoll** column (in tonnes of pollutants).

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

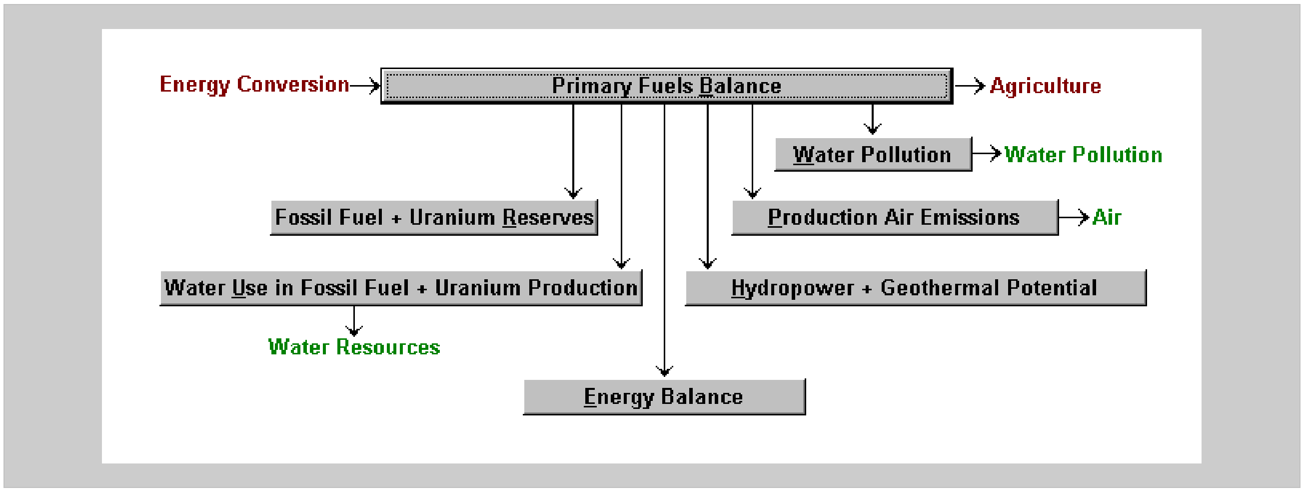
6.10 Energy Resources Module

The Energy Resources module accounts for primary energy resources. As with the Energy Conversion module, some complex calculations are built into PoleStar, and cannot be altered. The module takes primary energy requirements from the Energy Conversion module and, taking account of trade, computes production requirements and compares them to energy resource reserves. In the Basic Structure, water requirements and air pollution associated with energy production are calculated. PoleStar then transfers the totals to appropriate modules.

6.10.1 Disaggregation Structure

There are two buttons on the Disaggregation Structure window for Energy Resources: **Air** and **Water Pollutants**. Use the dialog boxes to select the list of air and water pollutants in the Energy Resources module. Here, you select pollutants from the master lists of air and water pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window).

6.10.2 Tables



Primary Fuels Balance

This table displays the fuels that you defined as primary fuels on the Disaggregation Structure**:** All Fuels dialog box. It shows the balance among requirements, production, and trade. It is calculated using the same fundamental identity relationships described in the Energy Conversion Module: Secondary Fuels Balance (see the previous section). To see the relationships, click on the cells in the table. The formulas connecting them will appear in the Cell Expression box at the top of the table.

In **Current Accounts**, you enter production data directly in the **Production** column, for the total indigenous production of each primary fuel. Enter the net exports in the **NetExport** column. In **Scenarios**, you set a **Policy** for **Production, NetExport** or **SSR,** as for the Secondary Fuels Balance. Then you enter your scenario data in the appropriate column.

Fossil Fuel & Uranium Reserves

Use this table to enter the reserves of each primary fossil fuel resource. This table only displays those fuels that you defined as primary fossil or uranium fuels on the Main Menu**:** Disaggregation Structure: All Fuels dialog box. In the Basic Structure, reserves are entered in the physical units you selected for each fuel (also on the Disaggregation Structure: All Fuels dialog box). The unit is displayed in the

Unit column. The total annual production of each fossil fuel resource is displayed in the **Production** column. This value is calculated from the Primary Fuels Balance table and converted into the fuel's physical units using the conversion factors defined in the Main Menu**:** Disaggregation Structure**:** All Fuels dialog box. (The expression to convert from energy to physical units uses the FUELCONVERSIONFACTOR function, one of the built-in PoleStar functions.) Note that for this table Current Accounts has a different structure than Scenarios.

Current Accounts:
In Current Accounts, when using the Basic Structure, you enter reserves data under two categories: **Proved** and **Probable**. In the **Proved** column, enter the proven finds of the resource as of the Base Year. In the **Probable** column, enter current projections of additional reserves (based, for example, on geological surveys). The total of these two columns is shown in the **CurrRsrvs** column. The number of years of reserves remaining is calculated as the ratio of current reserves to current annual production using the formula entered in the **YrsToGo** column.

Scenarios:
In Scenarios, in the Basic Structure a number of additional columns appear in the table to keep track of resource depletion. When building an application using the Basic Structure, projected reserves in scenario years are entered as a ratio of Current Account reserves (in the **Scen to Curr Ratio** column). This allows you to reflect uncertainty and alternative assumptions on ultimate reserves. Scenario reserves are then calculated in the **ScenRsrvs** column.

The **CumultvProd** column displays the cumulative production since the Base Year. Cumulative production is estimated using a linear interpolation of the rate of resource use between scenario years (the CUMULATIVESINCEBY function shown in the cell expression does this). The **RsrvsLeft** column displays the reserves remaining in each scenario year, calculated as the difference between scenario reserves and cumulative production, using the formula entered in the column. The years of reserves remaining is calculated as the ratio of remaining scenario reserves to annual production in the scenario year, calculated using the formula entered in the **YrsToGo** column. Finally, the **CumultvReq** column displays the cumulative requirements since the Base Year.

Hydropower & Geothermal Potential

Use this table to enter the annual potential energy available from hydropower and geothermal energy resources. Notice that this table allows you to display only those fuels that you defined as primary hydropower & geothermal fuels on the Main Menu**:** Disaggregation Structure: All Fuels dialog box. As with fossil fuel resources, in the Basic Structure you enter this data in a unit other than GJ using the physical units defined for fuels on the Main Menu: Disaggregation Structure: All Fuels dialog box. In the Basic Structure, the physical unit for hydropower is Gigawatt-Hours (GWh). The unit is displayed in the **Unit** column. The total annual production of each resource is displayed in the **Production** column. This value is taken from the Primary Fuels Balance table and converted into the fuel's physical units using the conversion factors defined in the Main Menu**:** Disaggregation Structure: All Fuels dialog box. (The cell expression makes use of PoleStar's FUELCONVERSIONFACTOR function.) In the **Potential** column, enter the annual potential energy available from each resource type. The potential energy should conform to what is technically, economically, and environmentally feasible. The ratio of annual production in the scenario to potential production is shown in the **Prod to Potential Ratio** column.

Water Use in Fossil Fuel & Uranium Production

Use this table to specify the use of water in fossil fuel & uranium production (for example, the use of water for washing coal, or for pressurizing oil wells). When using the Basic Structure, in the **WI** column, enter the intensity of water use in each conversion subsector and process in m^3/GJ of production. The total water use is calculated and displayed using the formula entered in the **WaterUse** column. In the large-scale Basic Structure, total water use is reported in millions of m^3.

Production Air Emissions

Use this table to calculate the pollutant emissions resulting from the production (*i.e.*, extraction) of primary fuels in the Energy Conversion and Resources module (*e.g.*, crude oil, natural gas, and coal production). When building applications using the Basic Structure, in the **EF** column**,** enter emission factors (in kg/GJ of production) for each region, fuel and pollutant. These data, together with total primary fuel production, calculated in the Primary Fuels Balance table, are used to calculate total production emissions loadings, using the formula entered in the **Emission** column. When using the large-scale Basic Structure, totals are reported in tonnes of pollutants.

Water Pollution

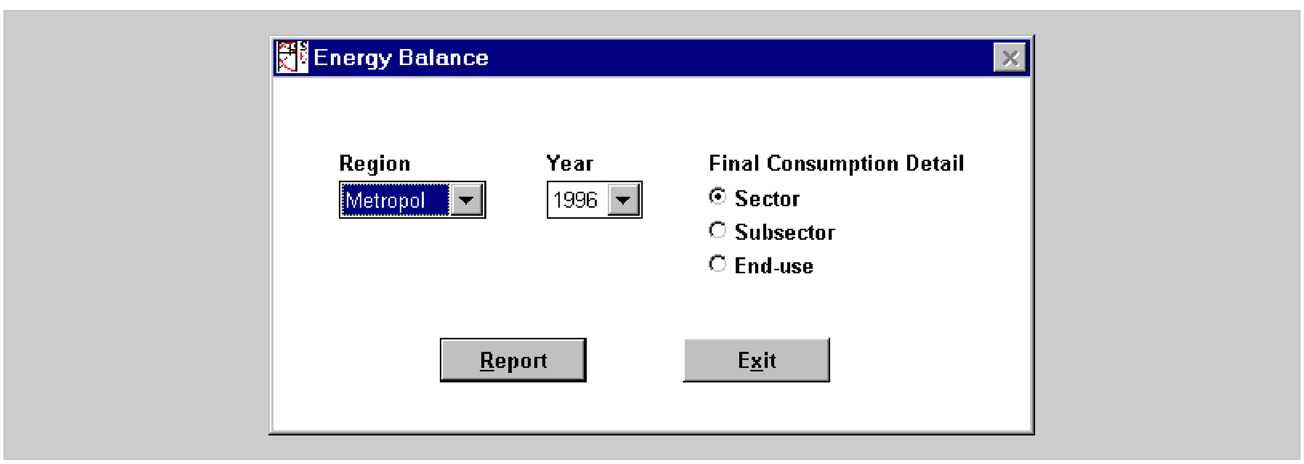
Use this table to calculate water pollution levels from energy resources module. When building applications based on the Basic Structure, in the **EF** column**,** enter emission factors in kg per GJ of resource produced for each region, fuel, water pollutant and year. These data are used to calculate total water pollution loadings, which are displayed in the **WaterPoll** column (in tonnes of pollutants).

Tip: If you do not wish to enter water pollution data by sector, leave this table blank and instead enter data in the Water Pollution module: Other Water Pollution table.

Energy Balance

PoleStar can assemble your energy data to produce a conventional energy balance for any given region and year (only Base Year energy balances are available in Current Accounts). The energy balance summarizes all energy production, transformations, trade, consumption and discrepancies. On the Energy Balance dialog box, select one region (or the total for all regions) and one year for the energy balance. Next select the level of detail for display of energy demand data. Selecting "sector" will generate the most compact report. "Subsector" or "End-Use" will produce a more detailed report.

When you click the Report button, PoleStar will generate an energy balance report in a standard text-editing window. If your application contains more than five fuels, you may need to scroll the report sideways (by pressing the right and left arrow keys) to view all fuels. From this point you can edit, print or save the report to disk.



Tip: If you need to change the screen font to fit your screen or printer, be sure to select a monospaced font such as MS-LINEDRAW or Courier. Non-monospaced fonts will prevent columns in the energy balance from being correctly aligned.

An Energy Balance Report Shown On-Screen in PoleStar

tmp.rpt

Metropol: 1996[PJ] 08/17/99

	Crude Oi	Petroleu	Coal	Nat Gas	Electr	Uranium	Hydropow	Renewabl	Alcohol	Sugarcan	Fuelwood	Charcoal	Hydrogen	Wood	TOTAL
Production	0	0	0	0	0	0	15	0	0	0	11	0	0	0	26
Net Imports	578	-250	609	140	30	76	0	0	0	0	0	3	0	0	1,187
Discrepancies	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Total Requirement	578	-249	609	140	31	76	15	0	0	0	11	3	0	0	1,214
Electr Gen	0	-90	-368	-39	235	-76	-15	0	0	0	0	0	0	0	-353
Oil Refining	-578	520	0	0	0	0	0	0	0	0	0	0	0	0	-58
Alcohol Prod	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CharcoalKiln	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HydrogenConv	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Losses & Own Use	-1	0	-67	-21	-45	0	0	0	0	0	0	0	0	0	-133
Prod from SW[PJ]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Final Demand	0	181	174	80	221	0	0	0	0	0	11	3	0	0	670
Households	0	28	0	29	31	0	0	0	0	0	11	3	0	0	102
Services	0	14	0	10	53	0	0	0	0	0	0	0	0	0	77
Transportation	0	119	4	0	5	0	0	0	0	0	0	0	0	0	129
Industry	0	12	170	41	132	0	0	0	0	0	0	0	0	0	354
Agriculture	0	8	0	0	0	0	0	0	0	0	0	0	0	0	9

6.11 Water Resources Module

6.11.1 Overview

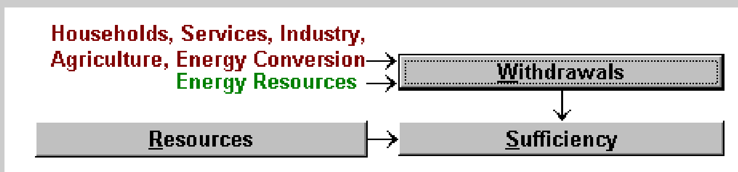
The Water Resources module gathers information on freshwater use from the Households, Services, Industry, Agriculture and Energy modules. The table structure then allow you to compare withdrawals to available resources. In the Basic Structure, you express your water use as freshwater withdrawals from surface and groundwater resources.

6.11.2 Disaggregation Structure

There is one button on the Disaggregation Structure window for Water Resources:

- **Water Sources:** Use this dialog box to define the various renewable sources of water you may wish to distinguish (*e.g.*, rivers, groundwater sources).

6.11.3 Tables



Withdrawals

This table displays a view of freshwater use across sectors, as calculated in the Households, Services, Industry, Agriculture, and Energy modules. Use this table to get a view of total annual water demands for the whole application, rather than for just a single sector. The **WaterUse** column displays annual water use in millions of cubic meters (for the large-scale Basic Structure).

The term "water use" is intentionally ambiguous. You may choose to define and consistently use the term to mean consumption (water rendered unavailable for other uses), requirements, or, more typically, withdrawals. This choice will depend on the data available and focus of your analysis.

In the Basic Structure, withdrawals are related to water use by the reuse rate. The reuse rate is the ratio of total final water use to the total amount of water withdrawn. A reuse rate of 1 means that water is used only once. The higher the reuse rate, the lower the withdrawal per unit of water use. When building applications from the Basic Structure, enter the reuse rate in column **Reuse.** PoleStar will calculate withdrawals using the relationships built into the Basic Structure.

If you entered your irrigation water use data as field application requirements, then the reuse rates take account of water that is collected and reapplied on other irrigated land, thus reducing withdrawal requirements. Similarly, if you entered your industrial water use as process requirements, then the reuse term takes account of water recycling within a plant. On the other hand, wherever you entered your "use" data as withdrawals, set reuse = 1.0.

Resources

Use this table to specify the volume of each region's renewable freshwater resources. When using the Basic Structure to build applications, in the column **Renew**, enter the renewable volume by source. In the column **FracAccess**, enter the fraction of each source that is accessible. The accessibility fraction can be used to make certain physical resources unavailable, if, for example, they are far from demand centers and no water transfer projects are anticipated. The accessible renewable volume is computed using the formula in the column **AccsRenew** as the product of the renewable volume and the fraction that is accessible.

Note: The Basic Structure focuses only on renewable water resources. If you wish to include nonrenewable water resources such as aquifers, simply add a column with appropriate annual supply assumptions (see Chapter 7 for customizing your PoleStar structure).

Sufficiency

This table displays each region's total freshwater resources and use, along with a measure of the pressure on water resources. In the Basic Structure, all of the columns in this table are calculated based on values in other tables. The total and per capita withdrawals are presented in the columns **Withdr** and **WithdrPerCap**, respectively. The renewable water resources are displayed in the column **Renew**. The accessible renewable water resources are displayed in the column **AccsRenew**. Finally, two measures are presented: the ratio of Withdrawals to Renewable Resources is displayed in the column **Withdr_to_Renew Ratio** and the ratio of Withdrawals to Accessible Renewable Resources is displayed in the column **Withdr_to_AccsRenew Ratio**. These measures can be used to give a rough indication of the sufficiency of freshwater resources relative to scenario requirements.

6.12 Land Module

The table structure in the Land module allows you to take information from the Population, GDP, Income and Agriculture modules and additional data to generate land-use change information. In the Basic Structure, the Land module also passes to the Air module estimates of emissions due to land-use change.

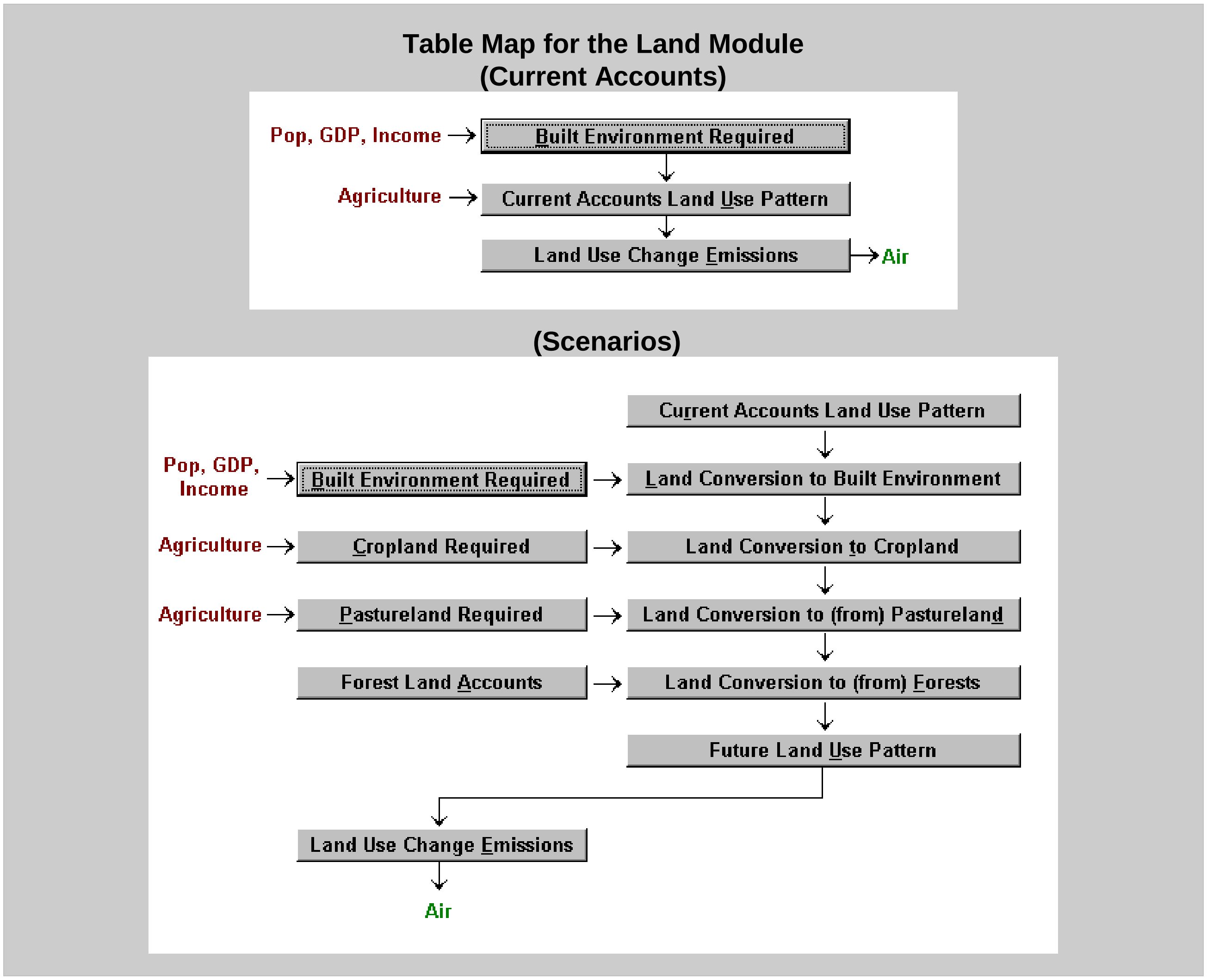
6.12.1 Disaggregation Structure

There is one button option on the Disaggregation Structure window for the Land module:

- **Land-Use Types:** Use the Edit List option to enter the list of land-use types used in the Land module. Four land-use types—**Cropland, BuiltEnvir, Pasture,** and **Other**—have special meaning. They can not be deleted (although you can rename them if you wish). In the Basic Structure the changes in land area assigned to these four land-types are linked directly to population and agriculture data from other modules. To these four land-use types you can add others such as forests, wetlands, grasslands, etc., which you will use to complete your land-use accounts. For land-use type classified as forests, make sure that the **Forest** check box is selected. These types will be the subject of the forest tables. Note that you can define more than one kind of forest (*e.g.*, closed forest, open woodland).

6.12.2 Tables

The Table Maps for the Current Accounts and Scenarios versions of the Land module are somewhat different. The Current Accounts version has only three tables: Built Environment Required, Land-Use Pattern, and Land-Use Change Emissions. Additional tables dealing with cropland, pasture land and forest land conversions are used in scenarios.



Current Accounts Land Use Pattern

In the Current Accounts, this table follows the Built Environment Required Table. In scenarios, it comes before all other tables. In the Current Accounts, use this table to gather all of the land-use information in different modules, and enter any additional Base Year land-use data. In the Basic Structure the Current Accounts table contains four columns, **Area**, **Share**, **ArableFrac** and **AvailArable**. In the **Area** column, areas for built environment, cropland and pasture are gathered from other tables, using formulas entered in those cells. For other land-use types, which you define in Main Disaggregation Structure**:** Land Types, you can enter data directly in the table. If you are building an application using the Basic Structure, enter the area under other land-use types in the remaining cells in the **Area** column. PoleStar then calculates the share of total land area under each land-use type using the formula entered in the **Share** column. Next, enter the fraction of each land-use type that is potentially arable in the **ArableFrac** column. In the Basic Structure, “arable” indicates any land that has the potential to support crops. In the Basic Structure, this will be used in scenarios for allocating land to agriculture. (In the Basic Structure, land that is currently cultivated is not included in this category, so the cell in the Cropland row has been set to “N/A.”) The total area available for cultivation is then calculated using the formula in the **AvailArable** column.

In scenarios this table appears before all others. In the Basic Structure, only the **Area** and **ArableFrac** columns are shown. The cells are set to the values in the Current Accounts table, so you cannot edit the table in scenarios.

Built Environment Required

Use this table to make estimates of the land converted for human settlements, roads, industrial and commercial areas, infrastructure, and other human activities. Areas under the built environment are not available for other land uses, *e.g.*, agriculture, pastures, forests, wetlands, etc. In the Basic Structure, built environment requirements are projected on a per capita basis. The **Pop** column displays regional population values in millions (as specified in the Population, GDP and Income module). In the Current Accounts, enter the total built area in the **Total Required** column. Using the relationships in the Basic Structure, PoleStar will compute average per capita land area devoted to the built environment in each region, and display the result in the **ha per person** column. In scenarios, enter a value in **ha per person**, and PoleStar will compute the total area required using the formula in the scenario **Total Required** column.

In scenarios, there is an additional column in the table. Additional land converted to built area during scenarios is calculated and displayed in the **Additional Required** column (in thousands of hectares, using the large scale Basic Structure). Note that this value is the land converted above and beyond the Base Year amount. A negative number in the **Additional Required** column indicates a reduction in built environment land area.

Land Conversion to Built Environment (Scenario)

This table appears when you are working with a scenario (not in the Current Accounts). In this table you can account for conversion of land to the built environment in the scenario *in addition* to the built environment in the Current Accounts. All values are displayed in thousands of hectares (in the large-scale Basic Structure). When using the Basic Structure to build applications, in the **BY Land Area** column, PoleStar displays land-use area in the Base Year (except BuiltEnvir). Enter the share of the change from each of the land-use types in the **ConvToBuiltEnv [share]** column. Shares should sum to 1.0. The area converted to (or from) the built environment is calculated using the function entered in the column **ConvToBuiltEnv Total**. A negative number in the **ConvToBuiltEnv Total** column means that land is converted from the built environment to other land-use types according to the shares entered. The remaining land is displayed by land-type in the column **Adjusted Area**. Note that the **Adjusted Area** column may contain negative values. This may be a reasonable value, but only if the area of that land-type is increased by conversions specified in subsequent tables.

Cropland Required (Scenario)

This table appears when you are working on a scenario (not Current Accounts). Use this table to compute the total land required to be converted to or from cropland (the additional cropland required in the scenario plus current cropland lost to degradation). All values are displayed in thousands of hectares, when using the large-scale Basic Structure. In the Basic Structure, the **BY Land Area** column displays the total cropland in the Current Accounts. When building applications using the Basic Structure, in the **DegradFrac** column, enter the fraction of Current Accounts cropland that is unavailable in the scenario year due to severe degradation (*e.g.*, erosion, salination, etc.). The total degraded area is calculated using the formula in the **Degraded** column. The **ConvToBuiltEnv** column displays the cropland converted to the built environment (as calculated in the previous table). The **Adjusted Area** column displays the Base Year cropland still available as cropland in scenario years, calculated using the formula entered in the column.

The **Total Required** column displays the total requirements for cultivable land, as calculated in the Agriculture module. Using the formula in the **Additional Required** column, PoleStar calculates and displays the land converted to new cropland. A negative number in the **Additional Required** column means that land is converted from cropland to other land-use types.

Land Conversion to Cropland (Scenario)

This table only appears when you are working on a scenario. It is used to calculate the land converted to cropland from other land types. All values are displayed in thousands of hectares, when using the large-scale Basic Structure. When building applications using the Basic Structure, in the **BY Land Area** column, PoleStar displays the area in Current Accounts for all land-use types except BuiltEnvir and Cropland. Requirements for cropland are derived in the Cropland Required table. The area converted to the built environment by land-use type is taken from the Land Conversion to Built Environment table and is shown in column **ConvToBuiltEnv**. The total available land after conversion to the built environment is shown in the **Adjusted Available** column. The **ArableFract** column shows the fraction of total available land that is arable (from the Base Year Land Use Pattern Table). PoleStar calculates and displays the land available for conversion to cropland using the formula in the column **AvailArable**.

*Tip: The relationships built into the Basic Structure assume that some arable land is lost when land is converted to the Built Environment, and that all subsequent conversions do not affect the amount of arable land available. You can incorporate different assumptions in your application by editing the formula in the **AvailArable** column. See chapter 7 for details.*

The total new Cropland is calculated on the previous table, Cropland Required. Enter the share of new cropland from each of the land-use types in the **ConvToCropland [share]** column. Shares should sum to 1.0. PoleStar then calculates and displays the land required for conversion to cropland using the formula in the column **ConvToCropland Total**. A negative number in the **ConvToCropland Total** column means that land is converted from cropland to other land-use types according to the shares you enter here. In column **ConvFromDegraded [share]**, give the share of degraded cropland that is converted to the other land-use types. For example, degraded cropland may become grazing land or be put in the "Other" category. The additional land from degraded cropland is calculated using the formula in the **ConvFromDegraded Total** column. The remaining land is displayed by land-use type in column **Adjusted Area**. These values may be negative. This may be reasonable, but only if the area of that land-type is increased by conversions specified in subsequent tables.

Pastureland Required (Scenario)

This table is used to calculate the amount of land to convert to pastureland. This equals requirements minus the current pastureland still available after all previous conversions (current value minus the amount converted to the built environment and cropland). All values are displayed in thousands of hectares, in the large-scale Basic Structure. For applications based on the Basic Structure, the **BY Land Area** column displays the total pastureland in the Current Accounts. The **ConvToBuiltEnv** column displays the pastureland converted to the built environment (from the Land Conversion to Built Environment table). The **ConvToCropland** column displays the net conversion of pastureland to cropland, taking cropland degradation into account (taken from the previous table). The **Adjusted Area** column displays the Base Year pastureland still available in scenario years, and is calculated using the formula entered in the column. The **Total Required** column displays the total requirements for pastureland, as calculated in the Livestock Practices table of the Agriculture module. Using the formula entered in the **Additional Required** column, PoleStar calculates the land converted to pasture. A negative number in the **Additional Required** column means that land is converted from pastureland to other land-use types.

Land Conversion to Pastureland (Scenario)

This table is used to calculate the quantity of land converted to pastureland from other land types. All values are displayed in thousands of hectares, when using the large-scale Basic Structure. When building applications using the Basic Structure, in the **BY Land Area** column, PoleStar displays the area in Current Accounts for all land-use types except BuiltEnvir, Cropland and Pastureland. Requirements for cropland and the built environment are derived above. The area converted to the built environment by land-use type is taken from the Land Conversion to Built Environment table and is shown in column **ConvToBuiltEnv**. The net area converted to cropland by land-use type, taking cropland degradation into account, is taken from the Land Conversion to Cropland table and is shown in column **ConvToCropland.** The total available land after conversions to the built environment and to cropland is shown in the column **Adjusted Available**. The total change to pastureland was calculated on the previous table. Enter the share from where additional pastureland comes—or to where pastureland goes—in the **ConvToPasture [share]** column. Shares should sum to 1.0. PoleStar then calculates and displays the land required for conversion to pasture using the formula entered in the column **ConvToPasture Total**. A negative number in the **ConvToPasture Total** column means that land is converted from pastureland to other land-use types. The remaining land by land-use type is calculated using the formula in column **Adjusted Area**.

Forests Land Accounts (Scenario)

The Forest Land Accounts table is used to enter and display changes in forested area. All values are displayed in thousands of hectares, when using the large-scale Basic Structure. Only land-use types specified as "Forests" on the Disaggregation Structure**:** Land-Use Types dialog box are displayed in this table. When building applications using the Basic Structure, the **BY Land Area** column displays the area in Current Accounts for each forest land-use type. The **ConvToBuiltEnv** column displays the forest area converted to the built environment. The **ConvToCropland** column displays the forest area converted to cropland. The **ConvToPasture** column displays the forest area converted to pasture. The **Adjusted Area** column displays the Base Year forest still in existence in scenario years, calculated using the formula entered in the column. In the **Afforestation** column you may explicitly add afforestation targets for your scenario. (A negative figure here would account for any additional deforestation beyond the land conversions already captured in other columns.) Using the formula entered in the **Total Forest Area** column, PoleStar calculates total forest land.

Land Conversion to Forests (Scenario)

This table is used in a scenario to calculate the quantity of land converted to forests from other land types. All values are displayed in thousands of hectares, when using the large-scale Basic Structure. In the **BY Land Area** column, PoleStar displays the forest area in Current Accounts for all land-use types except BuiltEnvir, Cropland, Pastureland, and Forests. Requirements for these land types are calculated in the preceding tables. In the Basic Structure, the area converted to the built environment is shown in the column **ConvToBuiltEnv**. The area converted to cropland is displayed in the column **ConvToCropland**. The total area converted to pastureland is shown in the column **ConvToPasture.** The total available land remaining after conversion to the built environment, cropland and pasture is shown in the column **Adjusted Available**. When building applications using the Basic Structure, in the **Afforestation [share]** column enter the fraction of land converted to new forest from each land use type. PoleStar then calculates and displays the land required for conversion to forest area in the column **Afforestation**, using the total from the Forest Land Accounts table. A negative number in the **Afforestation** column means that land is converted from forests to other land-use types. The remaining land is calculated using the formula entered in column **Adjusted Area**.

Future Land Use Pattern

This table gathers data from the previous tables to display summary land-use patterns. Also, it provides a summary of all conversions between land-use types calculated on the preceding tables. The area under each land-use type in the base year is displayed in the **BY Land Area** column. In the **BltEnv Changes**, **Crop Changes**, **Past. Changes** and **Forest Changes** columns, an accounting of the net conversions to and from these land-use types is provided. All values are displayed in thousands of hectares, when using the large-scale Basic Structure. The **Area** column displays the area under each land-use type. The share of total land by land-use type is calculated using the formula in the **Share** column. The **ChangeSinceBY** column shows the difference between the land area in the scenario and in the base year. The **Available Arable Land** column displays the arable land not in production—this provides a measure of the arable land available for conversion to cropland in the future.

*Tip: This table is very useful for identifying invalid or inconsistent scenario assumptions regarding land requirements and allocations. Both the **Area** and **Available Arable Land** columns should be non-negative in valid and consistent scenarios.*

Land-Use Change Emissions

Current Accounts

Use this table to account for carbon dioxide emissions due to changes in land-use patterns. When building applications based on the Basic Structure, enter the rate of net change in hectares per year, by land-use type, in the **Change** column. A positive number implies a net increase in land area, while a negative number implies a net decrease in land area. For internal consistency, the net changes of land use should sum to zero over all land-use types. Next, in the **Biomass** column, enter the total amount of carbon in the ecosystem measured in tonnes of carbon per hectare, by land-use type. Using the formula entered in the **Emission** column PoleStar displays the resulting emissions of carbon dioxide.

Scenarios:

Similar calculations are used in scenarios, except that the average annual net change in land area for each land-use is calculated (instead of being entered), using the formula entered for scenarios in the **Change** column.

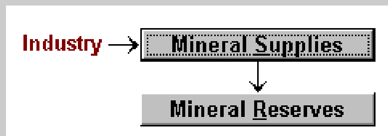
6.13 Mineral Resources Module

The table structure in the Mineral Resources module allows you to collect data concerning *non-energy* mineral requirements from the Industry module. The Basic Structure then generates information on mineral supplies and reserves (energy minerals such as fossil fuel deposits are treated in the Energy Resource module).

6.13.1 Disaggregation Structure

There are no buttons on the Disaggregation Structure window for Minerals. Lists of minerals are specified in the Industry module.

6.13.2 Tables



Mineral Supplies

Use this table to enter the overall balance between the consumption and supply (production and trade) of minerals. All values are displayed and entered in tonnes, in the large-scale Basic Structure.

Current Accounts

Requirements: This column displays the calculated mineral demand from the Industry module. Unlike most columns in PoleStar, the formula in this column cannot be changed by the user, and the column cannot be deleted (all other properties can be changed, such as the column title, number of digits to display, etc.).

Production: Enter the total domestic mineral production in this column.

NetExport: In this column, enter the net exports (total exports - total imports) of minerals in each region. By convention, a net export has a positive value, and a net import has a negative value.

SSR: Using the formula entered in this column, PoleStar computes the **Self-Sufficiency Ratio** for each mineral, defined as the ratio of Production to Total Requirements.

Discrepancy: This column displays any imbalance between total requirements and production minus net exports. Discrepancies are the sum of stock changes, statistical differences and any other discrepancies between your requirements and supply data. Large discrepancies that cannot be explained by stock changes may indicate inconsistencies in your data. For example, differing sources of data may be inconsistent due to differing definitions of variables.

Scenarios:

Set production
Set net export
Set SSR

In Scenarios you explicitly choose to enter data for one of the mutually dependent **Production**, **Net exports** or **SSR** columns. The other two will be calculated with the discrepancy set to zero. In scenarios, an extra column labeled **Policy** is used to set the variable that will be entered explicitly. You can set a different policy in each scenario year. Use the popup box listing the three choices: **Set**

production, **Set net export** or **Set SSR**. The **Requirements**, **Policy**, **Production**, **Net exports** and **SSR** columns cannot be deleted.

Mineral Reserves

Use this table to enter the reserves of each mineral. The total annual production of each mineral is displayed in the **Production** column. In the large-scale Basic Structure, all values are displayed and entered in thousands of tonnes.

Tip: You may encounter a wide range of values among different minerals within a single application. To accommodate this, you may wish to add a column containing a scale factor (e.g., none, thousands, millions, etc.). You could then use the factor entered in the scale factor column to scale the values in the rest of the table. See chapter 7 for information on how to add columns.

Current Accounts:
In the Basic Structure, in Current Accounts, you may enter reserves data under two categories: **Proved** and **Probable**. In the Proved column, enter the proven reserves of the resource. (Reserves generally refer to resources that may be economically extracted). In the Probable column, enter projections of reserves (based, for example, on geological surveys or past trends of new discoveries). The total of these two columns is calculated using the formula entered in the **CurrRsrvs** column. The number of years of reserves remaining is calculated as the ratio of current reserves to annual production and is shown in the **YrsToGo** column.

Scenarios:
In Scenarios, a number of additional columns appear in the version of this table used in the Basic Structure. The additional columns help keep track of resource depletion. You may define "scenario reserves" which are above and beyond current reserves (proven plus probable). Projected reserves in scenario years are entered as a ratio to Current Account reserves (in the **Scen to Curr Ratio** column). The total is calculated as the product of Current Account reserves and the Scen to Curr Ratio, using the formula in the **ScenResrvs** column. The **CumulProd** column displays the cumulative production after the Base Year. Cumulative production is estimated using a linear interpolation of the rate of resource use between scenario years (the CUMULATIVESINCEBY function shown in the cell expression does this). The **RsrvsLeft** column displays the remaining reserves in the scenario year. Finally, the number of years of reserves remaining is calculated as the ratio of remaining scenario reserves to annual production in the scenario year and is shown in the **YrsToGo** column. Years To Go are the number of years until the resource is exhausted, assuming constant rate of use. The **CumultvReq** column displays the cumulative requirements after the Base Year.

6.14 Air Pollution Module

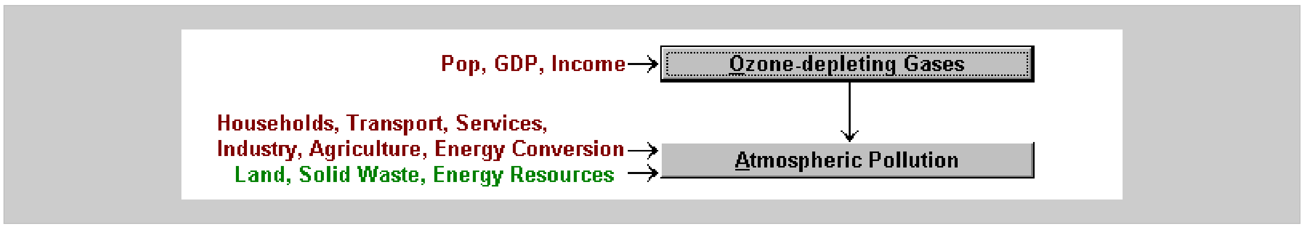
6.14.1 Overview

The table structure in the Air Pollution module allows you to collect and analyze aggregate atmospheric pollution loads.

6.14.2 Disaggregation Structure

There is one button on the Disaggregation Structure window for Air Pollution: **Ozone Depleting Gases.** Note that greenhouse gases and ground-level air pollutants are defined separately using the **All Air Pollutants** button, while toxic pollutants are defined within the Toxics module.

6.14.3 Tables



Ozone Depleting Gases

Use this table to enter emissions of ozone depleting gases for each region. PoleStar displays the total GDP in the **GDP** column. When using the Basic Structure to build an application, in the Current Accounts in the **Emission** column enter the total emission for each ozone depleting gas in tonnes (for the large-scale Basic Structure). Two different emission factors are calculated and displayed in the **EF** columns: grams/$GDP and grams/$ Value Added in the Industry sector, calculated using the formulas entered in those columns. In scenarios, enter **EF** in g/$GDP, and PoleStar will calculate total emissions and g/$ Value Added in the Industry sector.

Atmospheric Pollution

This table displays total atmospheric pollution loadings across sectors: (households, transport, services, industry, agriculture, energy, and solid waste). Pollution loadings are displayed in the **Emission** column in tonnes (for the large-scale Basic Structure).

6.15 Water Pollution Module

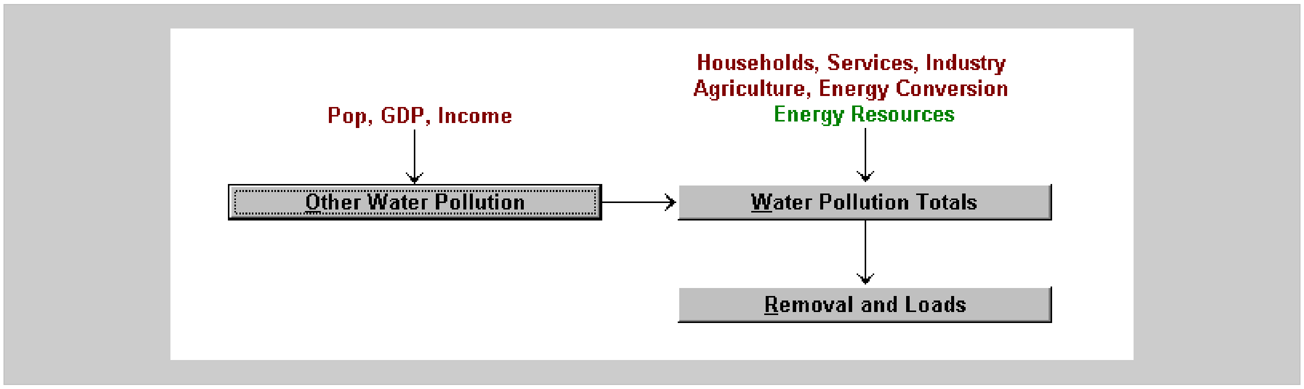
6.15.1 Overview

The Water Pollution module gathers water pollution loads specified in the Households, Services, Industry, Agriculture and Energy modules. The table structure in the module allows the user to easily add other (*i.e.*, non-point) sources of water pollution. One table allows you to introduce additional relationships to analyze treatment and removal of water pollutants, and hence the level of final water pollutant loads.

6.15.2 Disaggregation Structure

The list of water pollutants is specified using the All Water Pollutants button on the Disaggregation Structure window.

6.15.3 Tables



Other Water Pollution

Use this table to enter additional non-point sources of water pollution — those that cannot conveniently be associated with one of the sectors mentioned above. When using the Basic Structure to build applications enter the emission factor in kg/$1000 GDP (in the **EF** column). Total loadings are then calculated using the formula entered in the **WaterPoll** column.

Tip: If you do not wish to enter water pollution data by sector, you may enter TOTAL water pollution loads in this table. In this case leave blank the individual water pollution tables in each sector (Households, Services, Industry, Agriculture and Energy).

Water Pollution Totals

This table displays total water pollution loadings across sectors: (Households, Services, Industry, Agriculture and Energy). Loadings are displayed in the **WaterPoll** column in tonnes, when using the large-scale Basic Structure. Unlike most other columns in PoleStar, the formula in this column cannot be changed by the user, and the column cannot be deleted (all other properties can be changed, such as the column title, number of digits to display, etc.).

Removal and Loads

This table displays total water pollution loadings (the sum of sectoral and other loadings). You may then enter the fraction removed for each pollutant by water treatment plants. This fraction is used to calculate final water pollutant loads using the formula entered in the **WaterLoad** column.

6.16 Toxics Module

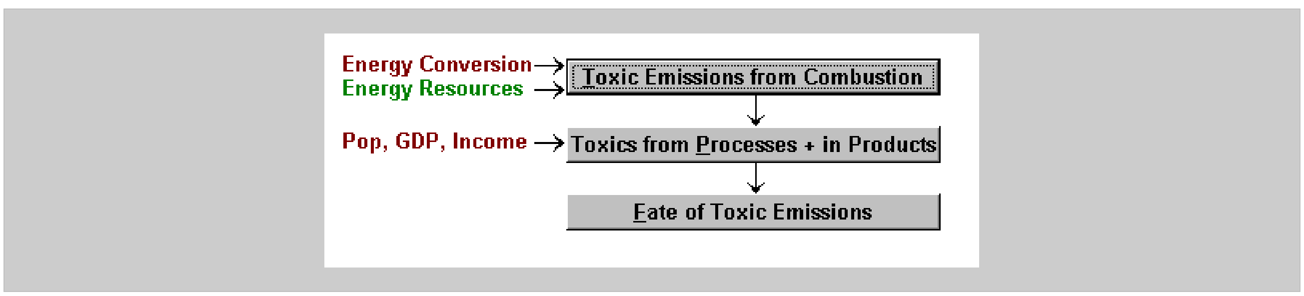
Toxics refer to heavy metals, trace chemicals and waste (other than solid waste) that are hazardous to the environment and humans. These might include cadmium, lead, dioxin and radioactive materials. Accounting for toxics is quite difficult since much of the toxic load is dispersed in indirect ways through products after their disposal (*e.g.*, lead paint, batteries, and so on). In the Basic Structure, the Toxics module computes toxic emissions from energy combustion (driven by data from the Energy Conversion module), processes and products. Within the Basic Structure structure, you may also account here for the environmental fate of toxic waste loads.

6.16.1 Disaggregation Structure

There is one button on the Disaggregation Structure window for Toxics: **Toxic Substances.**

- **Toxic Substances:** Use this dialog box to enter the list of toxic substances, such as Cadmium, Lead and Mercury, for which you want to track emissions. These toxics are released either through fuel combustion, from industrial processes (*e.g.*, iron & steel, cement, or fertilizer production), or from product use and disposal (*e.g.*, batteries, paint, tires). For each toxic, use the **Energy-related** check box to indicate if the toxic is emitted during fuel combustion. If so, it will appear on the Toxic Emissions from Combustion table. To avoid double counting, the list of Toxics and the list of Atmospheric Pollutants should **not** have any items in common. Also, use the **Subdivide by Fate** check box option to select those toxics you wish to enter data for regarding their ultimate fate (atmosphere, waters, landfill/dumping, or agricultural application). Finally, you need to enter the proper **Unit** for each toxic, e.g., t or CU (Curie is used for radioactive substances). As in other dialog boxes, you can **Rename**, **Add,** and **Delete** toxics using the dialog box buttons, and reorder the list using the **Up** and **Down** buttons. You can also document each toxic using the **Notes** text box.

6.16.2 Tables



Toxic Emissions from Combustion

Use this table to enter toxic emissions from fuel combustion for each toxic and fuel. Only those toxics that have been marked as energy-related on the Toxics Disaggregation Structure dialog box will be included in the table. The **TotConsumpt** column is a measure of the amount of energy combusted in the region. The calculation for the value in this column is built up in the table in stages. It can be expressed as total requirements for fuels, for both primary and secondary fuels. However, since some of the primary fuel consumption is as inputs to secondary fuel production, simply adding primary and secondary fuel requirements leads to double-counting of primary fuels used in conversion processes. So, the appropriate equation is: *primary fuel requirements + secondary fuel requirements – domestic secondary fuel production*. The last term corrects for double-counting of primary fuels used as feedstocks in energy conversion processes. When building an application using the Basic Structure, in the **EF** column, enter the emission factor, in units/PJ, where the unit (displayed in the **Unit** column) was set for each pollutant on the

Toxics Disaggregation Structure dialog box. The total emission is then calculated and displayed in the **Emission** column. PoleStar calculates emissions from each fuel using the formula entered in the **Emission** column.

Toxics from Processes & in Products:

Use this table to enter toxic emissions from industrial processes (*e.g.*, iron & steel, cement, or fertilizer production) and from the release of toxics contained in products, following their use and disposal (*e.g.*, batteries). To these releases are added the toxic emissions from fuel combustion totaled from the previous table. In Current Accounts, total product and process emissions are entered and the implied process and product emission factors are calculated and displayed in the **Ind Proc EF** and **Prod EF** columns respectively. Process emission factors are calculated per dollar of industrial value added, while product emission factors are calculated per unit of total GDP. In scenarios, these emission factors can be entered directly, and are then used to project the total process and product toxic loads. The last column in the table calculates total toxic emissions as the sum of emissions from energy, process and product emissions.

Fate of Toxic Emissions

This table is optional and is used to specify the fates of toxic pollutants. The four major pathways of toxics into the environment are Atmosphere, Waters, Landfill/Dumping, and Agricultural Application. You need only use this table if you have chosen to subdivide at least one of the toxic pollutants by fate in your analysis. This table summarizes the total toxic emissions from the previous table. In addition, if the **Subdivide by Fate** box was checked on the Toxics Disaggregation Structure dialog box, for a given toxic, then PoleStar breaks down the toxic by fate. Toxics which are not subdivided have a single row for **Total**. When using the Basic Structure to build applications, in the **FateShare** column, apportion the toxic emission by its ultimate fate. Shares should sum to 1.0 over all fates. The load for each fate is calculated using the formula in the **Load** column.

6.17 Solid Waste Module

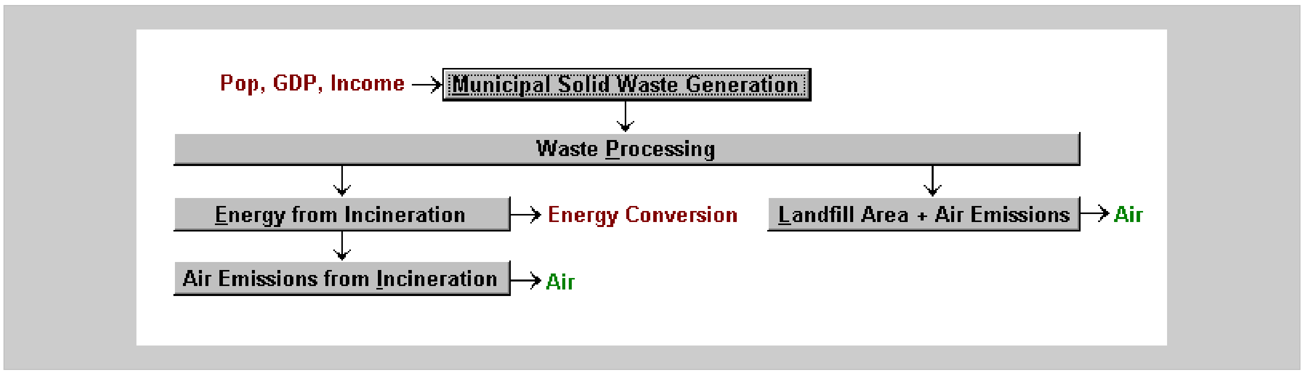
The table structure in the Solid Waste module allows you to build an analysis of the solid waste system. Relationships built into the Basic Structure cover waste generated and processed, landfill area and methane emissions, waste-to-energy conversion, and emissions from incineration.

6.17.1 Disaggregation Structure

There is one button on the Disaggregation Structure window for Solid Waste**: Air Pollutants**.

- **Air Pollutants:** Use this dialog box to select the list of air pollutants in the Solid Waste module. Here, you select pollutants from the master list of air pollutants (which you may expand by going back to the Main Menu: Disaggregation Structure window).

6.17.2 Tables



Municipal Solid Waste Generation

Use this table for total municipal solid waste generated by each region. When building an application based on the Basic Structure, in Current Accounts enter total waste generated in **Waste[kt]** and PoleStar will compute two waste generation rates, in kg/cap/day (**GenRate[kg/cap/day]**) and kg/1000$ (**GenRate[kg/1000$]**). In scenario years, enter the waste generated as a generation rate in the column **GenRate[kg/cap/day]**. The other columns are calculated using the formulas entered in them.

Waste Processing

Use this table to specify how waste is processed in each region. The disposal types are: Landfill, Incineration, Recycling, and Other. When using the Basic Structure to build an application, in the **ProcShare** column, enter the share of the region's waste handled by each processing option. Shares should sum to 1.0 over disposal types. The total waste processed is calculated using the formula in the **TotProc** column. The process share assumption for incineration should include both direct incineration and solid waste energy facilities (see the Energy from Incineration table).

Landfill Area and Air Emissions

Use this table to calculate area used for landfills and methane generated by waste decomposition in landfills (methane is an important greenhouse gas). In the Basic Structure, the **WasteLF** column displays the waste landfilled in a given year, as calculated on the Waste Processing table. The landfill area can be entered in column **LFInt** as an intensity (t/ha). The total additional landfill area needed is then calculated using the formula in column **AddLFArea** (in ha, for the large-scale Basic Structure). In scenarios an additional column **CumulAddArea** is displayed. The **CumulAddArea** column contains the *cumulative* additional landfill area needed (in hectares). Cumulative area is calculated using a linear interpolation for the rate of increase in area between scenario years (using PoleStar's CUMULATIVESINCEBY function). In the **EF** column enter the rate of methane emissions from landfills. The method for calculating emissions does not include time lags, but assumes that methane is released in the year in which the waste is placed in the landfills. Thus, emission factors should account for the cumulative future methane released by a tonne of waste in the landfill. The total methane generated is calculated using the formula in the **Generated** column. In the **RecapFract** column, enter the fraction of methane generated that is recaptured. The quantity of methane released is displayed in the **Released** column, using the relationships built into the Basic Structure.

Energy from Incineration

Use this table to calculate the usable energy produced from waste incineration, in the forms of electricity and/or district heat. In the Basic Structure, the **WasteInc** column displays the waste incinerated, as calculated by the Waste Processing table. In the **ElecShr** and **DHShr** columns, enter the shares of waste incinerated which goes towards the production of electricity and district heat, respectively. In the **ExtrRate(GJ elec/t)** and **ExtrRate(GJ DH/t)** columns enter the energy extraction rates for electricity and district heat. The electricity and heat outputs are calculated using the equations in the columns **Electr** and **DistHeat** respectively.

*Note: Electricity and heat output from the Solid Waste module can be linked to the Energy Conversion module by entering a formula in the **Prod from Other Sectors** column of the **Secondary Fuels Balance** table in the **Energy Conversion** module. The Basic Structure already has this link for electricity from incineration. See chapter* 7 *for information on entering formulas.*

Emissions from Incineration

This table is used to calculate the pollutant emissions from waste incineration. The **WasteInc** column displays the waste incinerated, as calculated on the Waste Processing table. Enter the emission factor (kg of pollutant per Tonne of waste incinerated) in the **EF** column. The Emissions are calculated using the formula entered in the **Emission** column.

7 BUILDING CUSTOMIZED STRUCTURES

The Basic Structure described in Chapter 6 provides an initial framework for building current accounts and scenarios. PoleStar allows you to modify the Basic Structure by adding variables and changing modeling relationships. In this manner, you can customize PoleStar to match the goals of your application. Some examples of how the Basic Structure might be changed include:

- **Social Variables:** You may wish to expand the Basic Structure to incorporate additional social indicators—*e.g.*, health, literacy, access to safe water, etc. Such variables could be added to one of the tables in the Pop, GDP, Income module, and thereafter used as driving variables in sectoral analyses. (For example, household water demand may be driven in part by a variable specifying access to safe water.)

- **Macroeconomic Variables:** In the Basic Structure, GDP is an exogenous driving variable. You may wish to decompose economic activity, for example, into employment and productivity data and assumptions.

- **Demographic Variables:** In the Basic Structure, population is used as an exogenous driving variable. Users may instead wish to explicitly manipulate demographic variables, such as fertility and mortality rates.

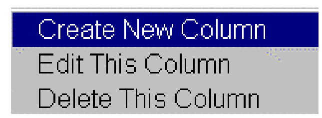
- **Incorporating Price and Income:** In the Basic Structure, many activity levels and intensities are specified exogenously. You may wish to link consumption patterns to price by introducing new variables in your PoleStar model. Depending on the needs of the study, these might be introduced in individual sector modules or in the Pop, GDP, Income module.

- **Beyond Emissions:** The Basic Structure allows you to examine pollutant loadings. However, changes in loadings do not necessarily lead to a proportional change in environmental impact. The links between the two are often studied using complex models that cover issues such as pollutant transport, chemical modification, population exposure and dose-response effects. While such complex approaches would be difficult to incorporate into PoleStar, it is possible to include parameterized versions of such models relating emission loads to environmental and health impacts.

7.1 Customizing Tables

You can **create**, **delete** and **edit** table columns, including the title of each column. (Note that columns in a table, the *variables* in your model, are distinct from the table *dimensions*. The cells in variable columns are either blue, where data is entered, or gray, where values are computed. Table dimensions are the left-most columns of tables, and the cells have a white background. They are governed by the pop-ups at the top of your screen. Generally, dimension values can be changed by editing the disaggregation structure.) Creating a column is equivalent to adding a new PoleStar variable. Deleting a column is equivalent to removing a PoleStar variable. When you delete a column, it is removed from the Current Accounts and all scenario tables.

Warning: You should be cautious when deleting a column, since the values in that column may be needed in another column's formula.



To edit a column in a table, *right-click on the column title* and from the popup menu choose **Edit This Column**. The **Edit Column** dialog will appear. You can then change the column title, and the entries on any of the tabs. Edit the column title in the **Variable Name** box at the top of the dialog. The name must be unique among other columns in the table, as it will be used to refer to the column in formulas. The title can contain any combination of letters, spaces, underscores and periods, up to 25 characters in length. If the values in the column have a scale or unit associated with them, like "PJ" (for "Petajoules"), these should be placed in **Scale** and **Unit** boxes. The popup box for scale lists numerical scales (*e.g.,* 10^6)—if you prefer a non-numerical scale (e.g., M, million, or mega), you may enter it in the Unit box. The scale and unit are for your information when building equations and to inform users who are looking at your application.

Note: Some columns are used internally by PoleStar. When you edit these columns, some features in the Edit Column dialog will be unavailable.

Similarly, to add a column, right-click on any column and choose **Create New Column**. Again, the **Edit Column** dialog will appear. Again, adding a new column is equivalent to adding a new variable. When deciding in which table you want to add a new variable, keep two things in mind.

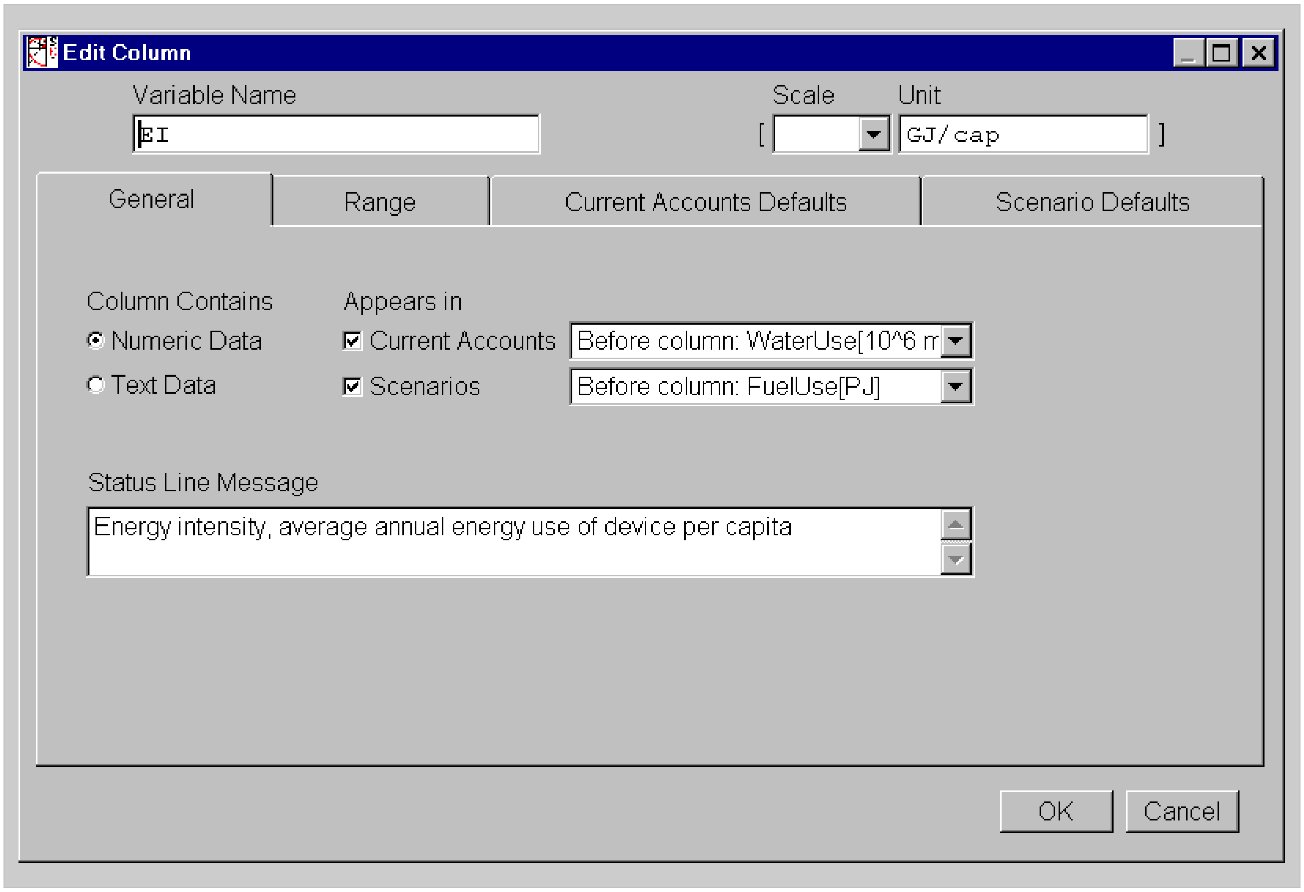
- The variable you create will have the same dimensions as the table to which it is added. **Dimensions** in PoleStar are the columns on the left in tables with white backgrounds, *e.g.,* region, year, fuel. Therefore, the dimensions of the table should match the dimensions you need for your variable. For example, if specifying different oil prices for each region in a study, you should put them in a table with regions and years as dimensions, such as the Gross Domestic Product table.

- The new variable must appear *before* other variables that depend on it. The arrows on the Table Maps show the order of calculation among tables, while the arrows on the Main Menu show the order of calculation among modules. Within tables, evaluation order of columns is left to right.

The tabs of the **Edit Column** are:

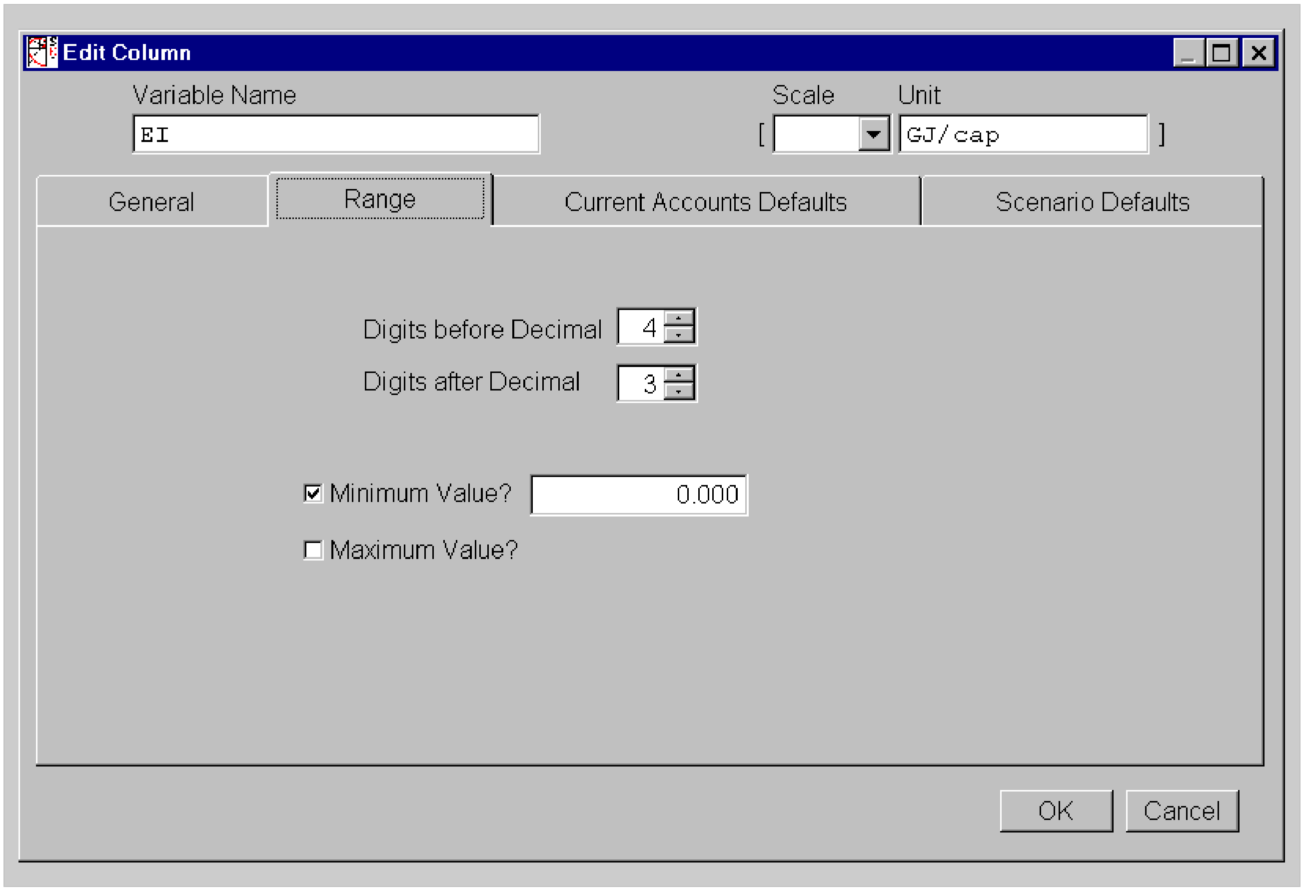
- **General:** Use this tab to specify whether the **Column Contains Numeric** or **Text** data (you may change this only when a variable is first created), whether the column **Appears in** either **Current Accounts** or **Scenarios,** or in both, and its order in relation to other columns on the table. When setting the order of the column, which can be different in Current Accounts and scenarios, keep in mind that the column must lie to the left of any other columns that reference it, and to the right of any columns you want it to refer to. Finally, you can enter an explanatory status line message, which will appear on the PoleStar status bar when you click on a cell in that column.

In the example shown below, the column is **EI[GJ/cap]** in the Household module, Energy & Water Use table. The column is set to appear in both Current Accounts and scenarios tables and contains numeric data. Note that the column appears in different positions in the Current Accounts and Scenarios tables.



- **Range** or **Size:** If the column contains numeric data, the **Range** tab allows you to specify how the number is displayed, by specifying the number of **digits** displayed **before** and **after** the **decimal** point. (PoleStar keeps track of the full precision internally regardless of the precision displayed.) You may also set **minimum** and **maximum values** (for example, a percentage value might be checked to ensure it is between 0% and 100%). When entering data in a cell, it will be checked to ensure its value lies within the valid range. If the cell contains text data, the **Size** tab appears instead, which allows you to specify the maximum number of characters that can be entered in the cell.

  In the example shown below for the Household **Energy Intensity** variable, the column is set to display with 4 digits before and 3 digits after the decimal point, and the column is constrained to have a minimum value of zero, since the energy intensity must be positive. No maximum value has been set.



*Tip: If there are not enough digits before the decimal place to view a number, the cell will fill with asterisks (e.g., ******.**). If this occurs, edit the column and increase the number of digits before the decimal.*

- **Current Accounts Defaults:** When you are in Current Accounts mode (selected from the Main Menu), use this tab to specify which cells are entered as data (blue) and which are calculated (gray), as well as the formulas to use for the calculated cells. These specifications determine the *default behavior* of the column's cells, *which can be overridden for any given cell*. For instance, you may specify a default formula to use in computing values for cells in a column, but override it in a few specific cells with a different formula or a specific value.

  Note: Items on the Current Accounts Defaults tab cannot be edited in scenario tables. However, both the Current Accounts Defaults and the Scenario Defaults can be edited in current accounts tables.

  The defaults are separated into two categories: **non-total rows** and **total rows**. You set non-total rows to be data, calculated as an expression, or as blank ("N/A"). In addition, total rows may be set as a sum of the non-total rows for each dimension of the table, an expression, or blank.

  Start by specifying the default behavior for **non-total rows**. Default behavior can be set to "**entered as data**," "**calculated by expression**" or "**set to N/A**" (not applicable). If you specify "entered as data," then when you exit the Edit Column dialog, cells in the column will appear blue by default, and you will be expected to enter data for each non-total Current Accounts cell. If you specify "calculated by expression," an edit box will appear into which you should enter the formula used to compute the values for all non-total row cells in the column. In the example shown below, the formula is simply the population divided by the number of households. Creating formulas is discussed in more detail in the next section. If you specify "set to N/A," no values will be calculated by default for each non-total Current Accounts cell and they will appear gray and blank.

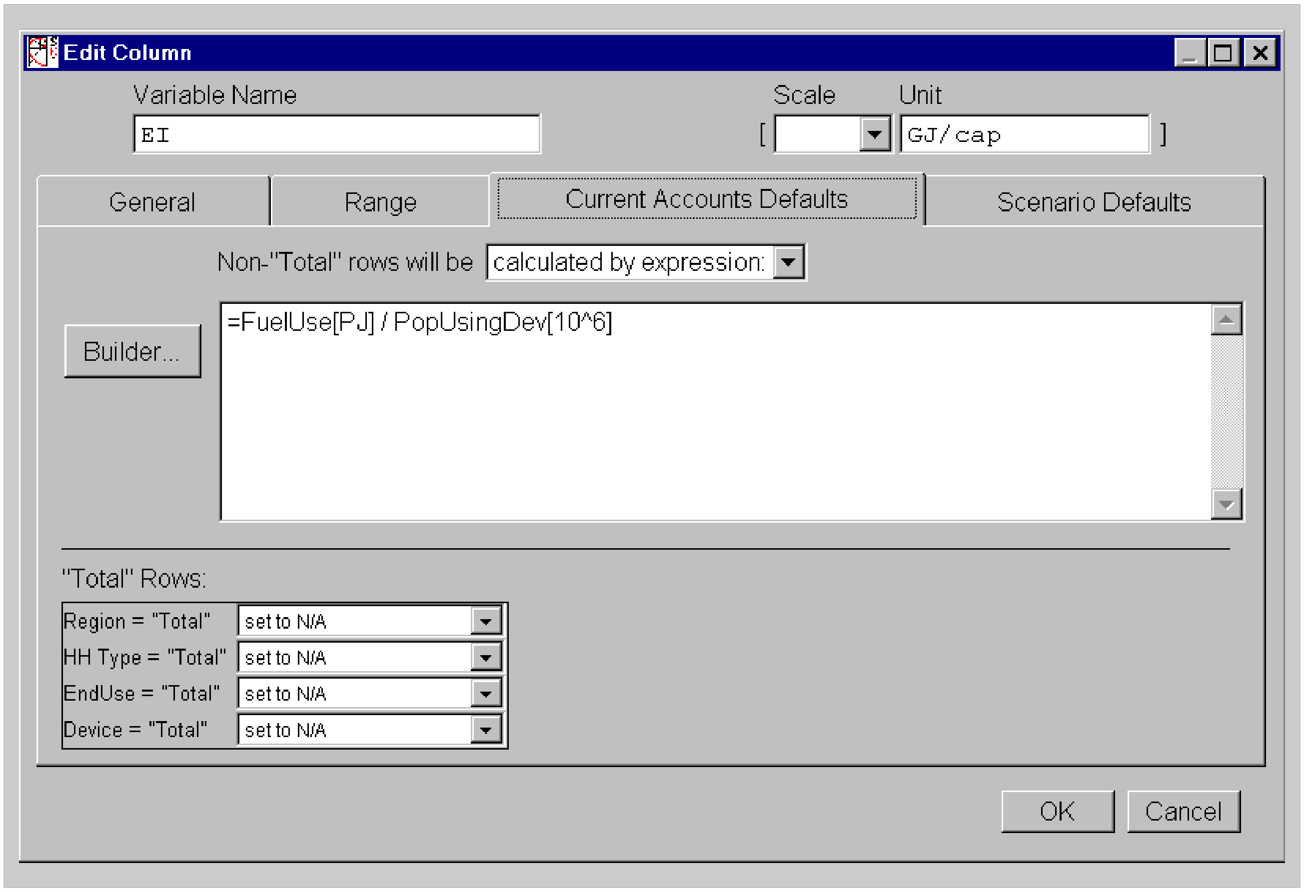
Tip: You can resize the Edit Column window to aid in viewing long formulas.

Next, specify how PoleStar deals with **"Total" rows**. If the values in a column are additive and can sensibly be summed, you can set the behavior to "**sum**" for each "totals" row. In other cases (for example columns containing ratios or intensities) no sum should be calculated. For these cells you normally set the "Total" row behavior to " **set to N/A**" (not applicable) directly or "**entered as data**." In some cases, you may wish to calculate a weighted average for the "Totals" row. To do this, set the default "totals" row behavior to "**calculated by expression**". Then, in the adjoining edit box, enter a formula to calculate an average for the cells weighted across another variable (see Section 7.2.3 for information about the AVERAGE() function). In the example shown below for the Household **EI** column, all totals are "set to N/A." If the average energy intensity were needed either for later calculations or as an indicator, it could be calculated using the "AVERAGE()" function.

You can independently set the "Total" behavior for each dimension (*e.g.*, Region, HH Type). For instance, a column containing shares that are to add up to one would typically be summed only at the lowest disaggregation level and set to N/A at all other levels. Note: you may not specify different expressions for different dimension totals—all disaggregation levels for a given variable that are "calculated by expression" will use the same expression.

In some cases, you may not wish to enter data for the full disaggregation structure, but rather specify "totals" rows as "**entered as data**" In these cases, you should normally set the non-totals rows and any total rows at lower levels of disaggregation to "**Set to N/A**".

Note: To keep tables from becoming cluttered, PoleStar displays total values for only the inmost dimension shown. You will see different totals when you filter table data using the popup controls in modules.



- **Scenario Defaults:** use this tab to enter or set the Scenario default properties for the column. This tab works just like the **Current Accounts Defaults** tab described above.

  *Note: **scenario default selections and formulas apply to all PoleStar scenarios** in your application. You can override these column defaults by creating different cell-specific expressions in each scenario.*

7.2 Creating Formulas

Formulas are standard mathematical expressions used to calculate variables in Polestar. All PoleStar formulas begin with the "=" character (to distinguish them from a number), and are composed of numeric values; standard mathematical operators (+, - , * , /, ^); references to other PoleStar variables (earlier columns in the current table or in an earlier module/table); and a set of standard functions. See Section 7.2.1 for an explanation of PoleStar's Builder tool for creating formulas, Section 7.2.2 for information on how to reference other PoleStar variables in a formula, and Section 7.2.3 for information on the functions available in PoleStar.

Formulas can also refer to scenario years as though they were variables. The current year is referred to as Y (or Year), the previous scenario year is PY (or PrevYr or PrevYear) and the Base Year (Current Accounts year) is BY (or BaseYr or BaseYear). For example, the formula "= X * (Y-PY)" multiplies the variable X by the number of years from the previous scenario year. (Note: PrevYear equals the Base Year when the current year is the first scenario year.)

You can add comments to formulas—any text following a semicolon (;) is displayed by PoleStar but ignored when evaluating the formula. For example, a cell could contain:

    = GROWTHBY(0.05)   ;   5% annual growth from the Base Year.

Formulas in PoleStar 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, PoleStar will put the names in a standard format—capitalizing the function names and setting the variables names as they appear in their column titles. For example, if you enter growthby(0.05) to calculate a 5% annual growth relative to the Base Year, PoleStar will change the function name to its standard form, so the formula reads GROWTHBY(0.05).

Two types of formulas can be defined in PoleStar: **column default** formulas, which apply to all the cells in a column and **cell-specific** formulas, which apply to the cell in which it is entered (and override the column default for that cell). The format of the formulas is the same in either case. In general, if it is possible to enter a column default formula, you should do so to save work and to ease the process of managing your PoleStar model. However, in some cases the same formula cannot apply to all cells in a column. If this is the case, use a cell-specific formula (see below). (Refer to Annex 2: Rules for Computing Cells for more information on how PoleStar determines the value of a cell.)

- **Setting Column Default Formulas:** To enter a column default formula, click with the right mouse button on the column title and select **Edit This Column** from the right-click menu. In the **Edit Column** dialog, enter formulas in the **Current Accounts Defaults** and **Scenario Defaults** tabs (see Section 7.1 for more information on using the Edit Column dialog). You may type in a formula directly in the box, or use the Builder tool (see section 7.2.1), by pressing the **Builder…** button.

- **Entering Cell-Specific Formulas:** Click on the cell to select it, then enter the formula into the **Cell Expression** box at the top of the table or with the Builder tool by pressing the **Builder…** button.

Two principles that should be kept in mind while creating formulas:

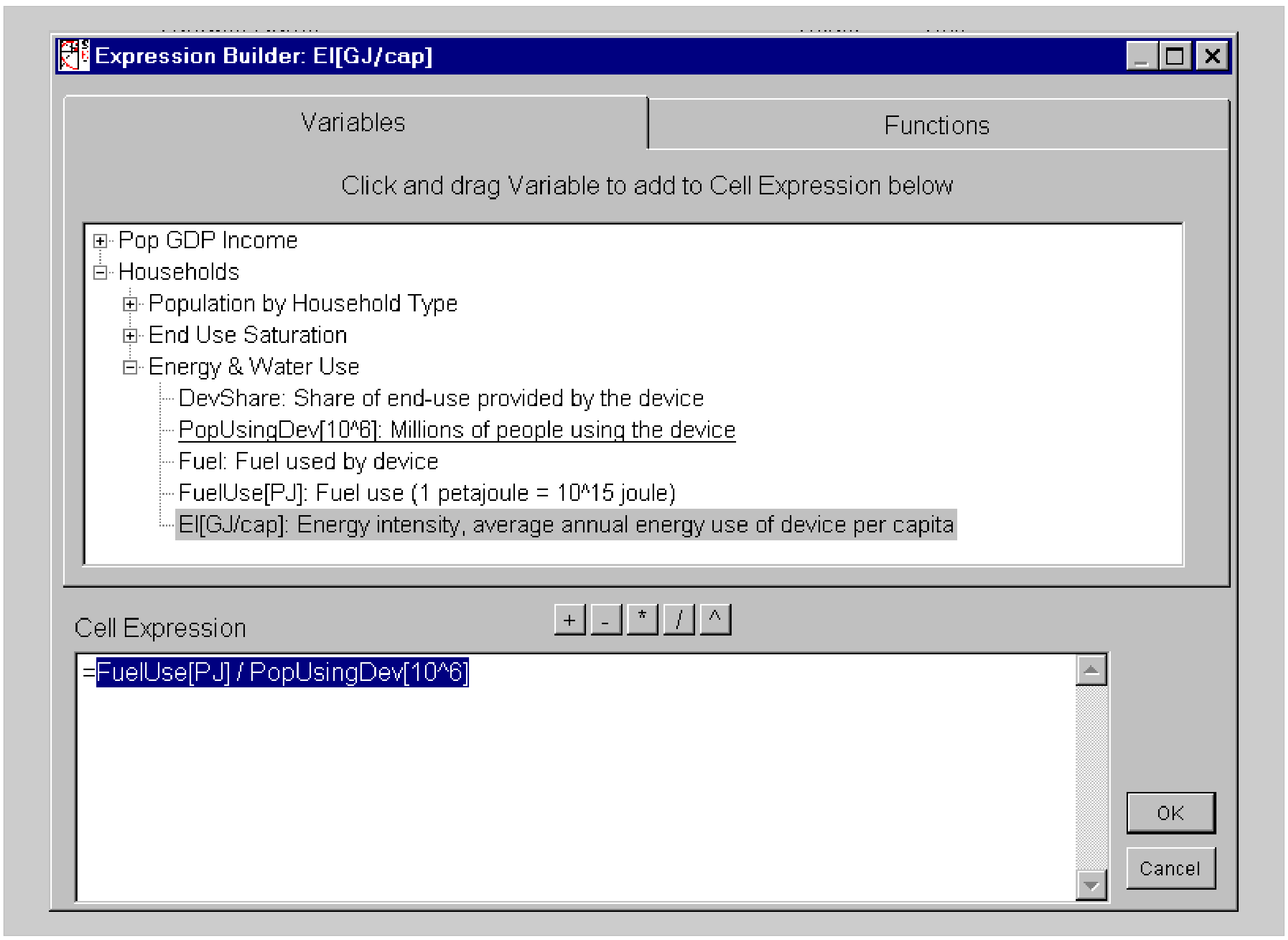
- **Keep formulas simple:** If your formula is complex, consider creating one or more intermediate variables (columns) to build up the computation stages. This will help make your model transparent. Use the status line message to document the purpose of each variable.

- **Keep formulas and data separate:** PoleStar's cell-coloring feature allows you to draw attention to the cells where data should be entered. Values that might be changed later by you or another user should not be embedded in formulas. Keeping data and formulas separate also helps when importing data using PoleStar's **import** feature, since only blue (data) cells are imported when using this feature.

  Tip: If a formula has a parameter (for example, a growth rate) that can vary between scenarios, create a new data column for the parameter, and refer to the column in the formula (rather than putting the growth rate value directly in the formula). This ensures that the same formula can be used in all scenarios where the growth rates differ.

7.2.1 Using the Expression Builder to Create Formulas

The **Expression Builder** (shown below) is a tool for creating formulas. It can be accessed at any point in PoleStar where an expression is defined (either when entering or editing a column default expression or when entering or editing a cell-specific expression). The Builder window gives you quick access to the complete list of variables, functions and operators that can be used in building formulas in PoleStar, saving you having to remember their names or type them in.



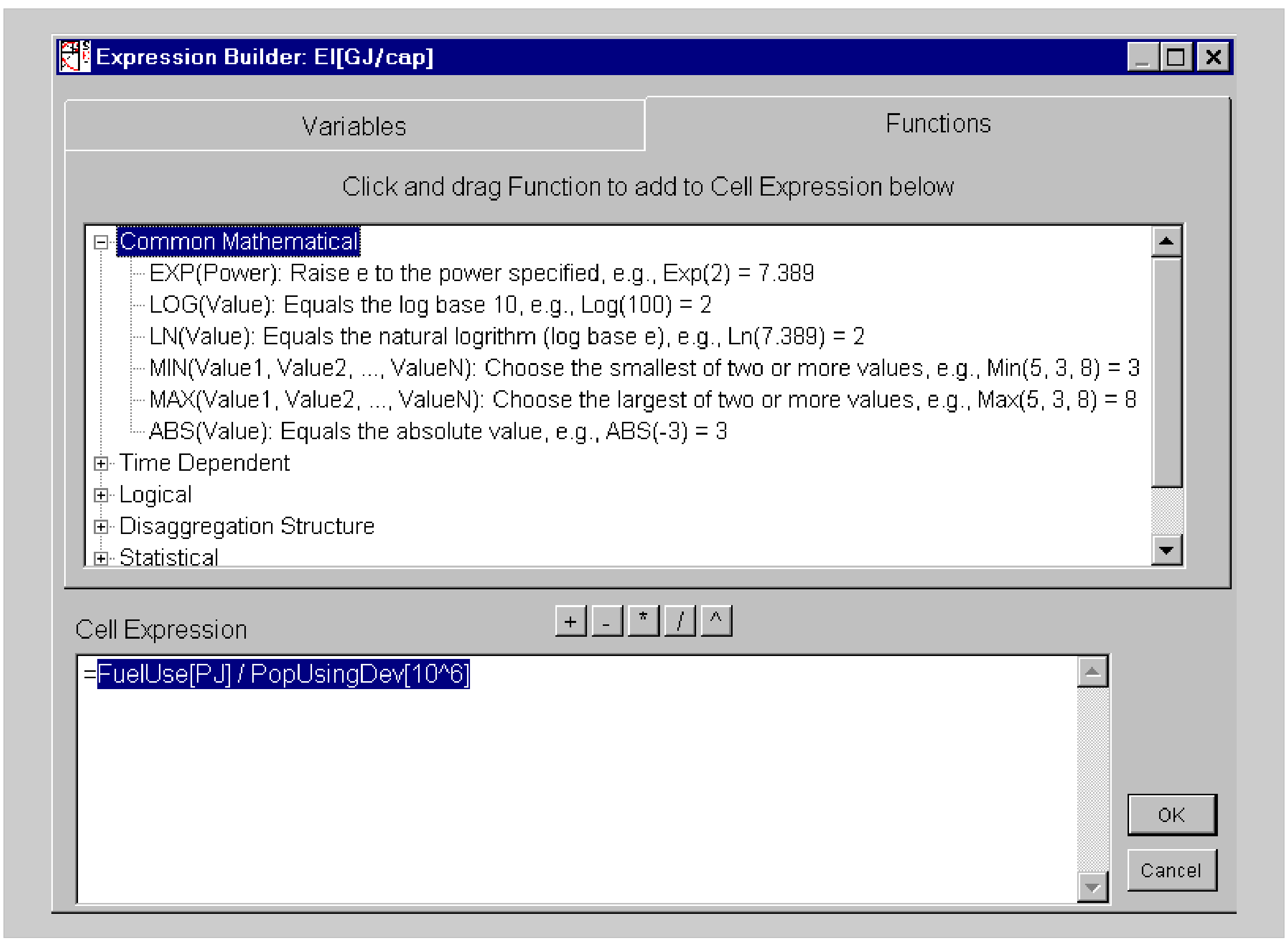
The **Cell Expression** box at the bottom of the Builder is where formulas are built. If there is already a formula in the cell or column default expression box you are editing, the formula is shown in the Cell

Expression box when you open the Builder. The standard mathematical operators (+, -, *, /, ^) are also shown as a row of buttons. The operators are shown in the following table

Operator	Operation
+	Add
-	Subtract
*	Multiply
/	Divide
^	Raise to a power (*e.g.*, 3^2 = 3^2 = 9)

The Builder window contains two tabs. When the Builder dialog first opens, the **Variables** tab is shown. All of the variables available to you (*i.e.*, upstream of the function you are entering) are accessible within this tab. Variables are shown in a hierarchical outline structure, with the top level being modules, the second level tables with each module, and the third level variables within each table. Initially, the outline is expanded to show variables in the current table. To see the variables in another table or module, click on the plus sign next to the table or module name to expand the outline. To include a variable in your formula, either drag the variable with the mouse from the tab to the Cell Expression box, or double-click on the variable name. In either case, the variable will appear in the Cell Expression box.

To see the list of functions you may use in your formula, select the **Functions** tab (see below). To include a function in your formula, you may either drag the function with the mouse from the Function tab to the Cell Expression box, or double-click on the function name. In either case, the function will appear in the Cell Expression box. Functions are described in Section 7.2.3.



If you make an error typing in a formula—for example, if all open parentheses "(" are not matched by close parentheses ")"—PoleStar will give a warning message, and allow you to correct the formula.

When you refer to a variable in another table, it is possible that the dimensions between the two tables will be incompatible. In that case, PoleStar will alert you that you need to supply more information in your formula, and give an indication of the kind of information required. You will then be able to correct the formula. The topic of referring to variables in other tables is discussed in the next section.

Tip: You can resize the Expression Builder window to aid in viewing long formulas.

7.2.2 Variables

When referring to a variable in the same table, simply type its name in the formula you are editing. When you refer to a variable in another table in the same module, give the table name, followed by an exclamation point (!) and the variable name:

    Table Name ! Variable Name

If the variable is in a different module, give the module name as well:

    Module Name ! Table Name ! Variable Name

Alternatively, if you create formulas using the Builder (see section 7.2.1), PoleStar will insert the module and table names for you.

If the dimensions for the variable match the dimensions in the table with the formula you are editing, PoleStar matches up all dimensions automatically for each cell. (For example, the **Population** table in the Pop, GDP, Income module has the same dimensions as the **GDP** table: region and year. Thus, if you enter a column default formula for GDP in the GDP table as the product of population and GDP per capita, PoleStar will apply the formula in each cell in the column for the appropriate region and year.) If the variable you wish to use has more dimensions than the table with the formula you are editing, or if you want a variable from a particular row, then you must specify which dimension label you want. For example, if you want the TOTAL over some dimension, use the notation

    Module Name ! Table Name ! Variable Name(Dimension Name = "TOTAL")

Or, if the variable is in the same module,

    Table Name ! Variable Name(Dimension Name = "TOTAL")

Tip: If you do not specify the dimension name when the variable has more dimensions than the table with the formula you are editing, PoleStar will prompt you to add the information.

Some examples:

- **GDP per capita growth:** To calculate GDP per capita using average annual growth rates over base-year GDP per capita values, add a scenario column to the left of the GDP per capita column called, *e.g.*, "Growth Rate from BY." Then, to calculate GDP per capita in scenarios, enter the formula

      = GROWTHBY(Growth Rate from BY)

  as the column default expression for GDP per capita (the GROWTHBY function is explained in section 7.2.3).

- **GDP from Population and GDP per capita:** In the Basic Structure, in the **Gross Domestic Product** (GDP) table of the **Pop, GDP, Income** module, GDP is calculated as a product of GDP per capita and population. GDP per capita appears on the GDP table, while population appears on the Total Population table. The column default expression for the "GDP" column is

  =0.001 * Total Population ! Pop[10^6] * GDPPerCap[$/cap]

- **Allocating a total by shares:** suppose that you wish to allocate total energy consumption, given in the TOTAL row of column **EnergyTot** across a variety of end-uses by specifying shares in column **Share**, to calculate energy by end-use in column **EnergyByEndUse**. Then in column **EnergyByEndUse** you would enter the column default formula

  = Share * EnergyTot(End-Use = "TOTAL")

- **Allocating a value from another table by shares:** In the sample application Xland, which is included with PoleStar, dietary intake in the **Agriculture** module is given separately in table **Nutrition** for three different population groups—Low Income, Mid Income and Hi Income. The population groups appear in the Nutrition table as labels for the dimension **PopGroup**. The share of total population in each group is given in the column "PopShare" in the table, and total populations in each group are calculated in the column "Population [10^6]" using the formula

  =PopShare * Pop GDP Income ! Total Population ! Pop[10^6]

  Note: The Nutrition table has the same dimensions as the Total Population table except for the additional PopGroup dimension. PoleStar assumes that since the variable "Pop[10^6]" does not have the PopGroup dimension, its value is the same for all population groups.

- **Extracting Value Added for a particular sector:** In the Basic Structure, in the **Industry** module, value added in the **Value Added by Subsector** table is specified by entering shares of industrial value added, which are multiplied by total industrial value added from the Pop, GDP, Income module. The "Value Added [10^9$]" column contains the formula

  =Share * Pop GDP Income ! Value Added by Sector ! VA[10^9$](Sector = "Industry")

7.2.3 Functions

To use a function in a formula, type the function name, followed by the function parameters in parentheses:

FunctionName(parameter_1, parameter_2, …)

Some functions take no parameters, while others can take different numbers of parameters for different calculations. If a function takes no parameters it is not necessary to add the parentheses, although parentheses will be added by PoleStar to distinguish it from a variable name. The functions available in PoleStar are listed below, grouped by type.

Common Mathematical

- **EXP(Power)**

  Equals *e* raised to the power **Power**, where *e* = 2.71828… is the base of the natural logarithm. For example,

  Exp (2.0) equals a value of $e^2 = 7.389$

- **LOG(Value)**

  Equals the base 10 logarithm of **Value**. For example,

Log(100)	equals a value of 2.0

- **LN(Value)**

  Equals the natural logarithm (the base *e* logarithm) of **Value**. For example,

Log(7.389)	equals a value of 2.0

- **MIN(Value1, Value2, ... ValueN)**

  Equals the minimum of the values **Value1, Value2, … ValueN**. You can use any number of values. For example,

Min(2, 1, 5, 3)	equals a value of 1
Min(-1.6, 15.3)	equals a value of –1.6

- **MAX(Value1, Value2, ... ValueN)**

  Equals the maximum of the values **Value1, Value2, … ValueN**. You can use any number of values. For example,

Max(2, 1, 5, 3)	equals a value of 5
Max(-1.6, 15.3)	equals a value of 15.3

- **ABS(Value)**

  Equals the absolute value, *i.e.*, the distance a number is from zero, without regard to sign. For example,

Abs(2.1)	equals a value of 2.1
Abs(-2.1)	equals a value of 2.1

<u>Time Dependent</u>

- **BYValue()**

  Equals the Base Year value of a PoleStar variable. This function is only available in scenarios. If you do not specify a variable, the function will return the Base Year value of the variable for the column in which the function appears. For example,

BYValue()	equals the Base Year value of the variable for the column in which this function appears
BYValue(Production)	equals the Base Year value of a variable named Production

- **PYValue()**

  Equals the value of a PoleStar variable in the previous scenario year. This function is only available in scenarios. If you do not specify a variable, the function will return the previous year's value of the variable for the column in which the function appears. For example,

PYValue()	equals the previous year's value of the variable for the column in which this function appears
PYValue(Production)	equals the previous year's value of a variable named Production

- **GROWTH(InitVal, Rate, NumYears)**

Calculates a future value given an initial value **InitVal**, an annual growth rate **Rate** and a number of years **NumYears**. It is equivalent to entering the formula

InitVal * (1 + Rate) ^ NumYears

For example,

GROWTH(2, 0.05, 25) equals 2 * (1 + 0.05) ^ 25 = 6.77

- **GROWTHBY(Rate)**

When entered in a scenario column for a PoleStar variable, equals the future value, by applying the annual growth rate **Rate** to the base-year value. For example, if the year corresponding to the cell where the function being evaluated is 2010 and the Base Year (1995) value is 10.5, then

GROWTHBY(0.05) equals 10.5 * (1 + 0.05) ^ (2010 - 1995) = 21.83

- **GROWTHPY(Rate)**

When entered in a scenario column for a PoleStar variable, equals the future value, by applying the annual growth rate **Rate** to the value in the previous scenario year. For example, if the year corresponding to the cell where the function being evaluated is 2010 and the Previous Year's (2000) value is 15, then

GROWTHPY(0.05) equals 15 * (1 + 0.05) ^ (2010 - 2000) = 24.43

- **INTERP(Year1, Value1, Year2, Value2, ...YearN, ValueN)**

Calculates the value in a year by performing a linear interpolation between the *N* year-value pairs. For example, if the year corresponding to the cell where the function being evaluated is 2010, then

INTERP(1996, 0.1, 2005, 0.3, 2012, 0.52, 2025, 1.02)

$$= 0.3 + (0.52 - 0.3)\left(\frac{2010 - 2005}{2012 - 2005}\right) = 0.46$$

Note: For years before the earliest year listed, the value for the earliest year is used. Similarly, for years after the latest year listed, the value for the latest year is used (i.e., values are not extrapolated).

- **CUMULATIVESINCEPY(Variable)**

Calculates the cumulative value of the variable (*e.g.*, cumulative production) since the end of the previous scenario year, where the annual rate (*e.g.*, production rate) for scenario years is specified by **Variable**. The rate is assumed to change linearly between scenario years. The value during the "active" year (the year of the row being computed) is included, while the previous scenario year's value is excluded. This function is computed using the following formula:

CumulativeSincePY = (Y – PY + 1) * (ActiveYearValue + PYValue) / 2 - PYValue

The formula gives the average rate times the number of years between the previous scenario year and the active year (including both years in the total number of years) minus the annual rate in the previous scenario year. Subtracting PYValue excludes the previous scenario year from the total.

For example, if the previous year is 1995 and the active year is 2000, then CumulativeSincePY will sum the interpolated values from 1996-2000. If the value in the active year is 15, and the previous year value is 10, then

CumulativeSincePY = (2000 - 1995) * (15 + 10) / 2 + (15 - 10) / 2 = 65

which corresponds to the sum of linearly interpolated values over the period 1996-2000:

11 + 12 + 13 + 14 + 15 = 65

To include production from the previous scenario year, use the formula "PYValue(Variable) + CumulativeSincePY(Variable)."

- **CUMULATIVESINCEBY(Variable)**
  Calculates, *e.g.*, cumulative production since the end of the Base Year, where the annual production rate for scenario years is specified by **Variable**. For this calculation, the production rate is assumed to change linearly between years. The Base Year's value is not included in the sum, while the value in the "active" year (the year of the row being computed) is included. The sum is computed by successively applying the CumulativeSincePY function on each of the previous scenario years and summing the results. For example, if the values in the Base Year and scenario years of the variable to be cumulated are: 1995 (Base Year) = 10, 2000 = 15, 2005 ("Active" year) = 25, then

CUMULATIVESINCEBY = CUMULATIVESINCEPY (with 2005 as the active year)
+ CUMULATIVESINCEPY (with 2000 as the active year)

= (2005 - 2000) * (25 + 15) / 2 + (25 - 15) / 2
+ (2000 - 1995) * (15 + 10) / 2 + (15 - 10) / 2

= 105 + 65 = 170

which corresponds to the sum of linearly interpolated values over the period 1996-2005:

$$\underbrace{11+12+13+14+15}_{\text{1996 through 2000}}+\underbrace{17+19+21+23+25}_{\text{2001 through 2005}}=170$$

To include production from the Base Year, use the formula

BYValue(Variable) + CumulativeSinceBY(Variable).

- **PY**
  Equals the previous scenario year. For example,

IF(PY = 2000, 1, 0) equals 1 if the previous scenario year is 2000, 0 otherwise.

Note: Also, BY equals the Base Year, and Y equals the year being evaluated. For example,

IF(Y = BY, 0, (Y - PY) * 0.10) equals 0 in the Base Year, the number of years in the preceding interval times 0.10 otherwise.

Logical

- **IF(Test, ValueIfTrue, ValueIfFalse)**
  In the **IF** function, **Test** is an expression that is either true or false. The following are all valid tests:

GDPPerCap [$/cap] > 9000	True if GDP per capita exceeds $9,000.
Year = 2030	True if the scenario year is 2030.
Year <> 2010	True if the year is not 2010.
BYValue() > 1	True if the Base Year's value exceeds 1.

The **IF** function equals **ValueIfTrue** if **Test** is true, and **ValueIfFalse** if **Test** is false. For example,

IF(Year > 2025, 2, 1)	equals 2 if the year is after 2025, 1 if on or before 2025.

Note: If you have several tests to perform, you may nest several IF functions together, for example,

IF(Fuel = "Coal", 1.20, IF(Fuel = "Nat Gas", 1.35, 1.10))

*However, be aware that overly complex expressions might be difficult for other users of your application to understand. Readability can be enhanced through the use of carriage returns and spaces in the Builder window to indent the **Test, ValueIfTrue** and **ValueIfFalse** clauses, for example,*

```
IF(Fuel = "Coal",
   1.20,
   IF(Fuel = "Nat Gas",
      1.35,
      1.10))
```

- **AND(Test1, Test2, … TestN)**
  Equals true only if *all* of the listed tests are true. Use in conjunction with the **IF** function. For example,

IF(AND(Year > 2025, BYValue() > 100), 2, 1)	equals 2 only if both the year is after 2025 *and* the Base Year's Value is greater than 100, 1 otherwise.

- **OR(Test1, Test2, … TestN)**
  Equals true if *any* of the listed tests are true. Use in conjunction with the **IF** function. For example,

IF(OR(Year > 2025, BYValue() > 100), 2, 1)	equals 2 if either the year is after 2025 *or* the Base Year Value is greater than 100, 1 neither condition is true.

- **NOT(Test)**
  Equals true if test is false, or false if test is true. Use in conjunction with the **IF** function. For example,

IF(NOT(Region = "Metropol"), 2, 1)	equals 2 if the region is *not* equal to "Metropol", 1 if it is.

- **XOR(Test1, Test2, … TestN)**
  Equals true if one and only one of the tests is true (an "exclusive or"). Use in conjunction with the **IF** function. For example,

IF(XOR(Year > 2025, BYValue() > 100), 2, 1)	equals 2 if the year is after 2025 and the Base Year Value is less than or equal to 100, or if the year is on or before 2025 and the Base

Year Value is greater than 100, 1 if neither or both conditions are true.

- **INLIST(Dimension, “Value1”, “Value2”, … “ValueN”)**
  Equals true if one of the listed values matches the value of the **Dimension**. (Every table is organized by one or more dimensions, such as region, year, fuel, air pollutant.) Use in conjunction with the **IF** function. For example,

  IF(INLIST(Fuel, “Coal”, “Crude Oil”, “Nat Gas”), 1, 0) — equals 1 for the listed fuels, 0 for all other fuels.

- **=, <>, <, >, <=, >=**
  Comparison operators for logical tests. Use in conjunction with the IF function.

Operator	**Definition**	**Example**
=	Equal to	FUELUSED = “Biomass”
<>	Not equal to	Region <> “Metropol”
<	Less than	HH Size < 3
<=	Less than or equal to	Year <= 2010
>	Greater than	Year > 2010
>=	Greater than or equal to	CO2 Emission >= BYValue() * 2

For example,

IF(CO2 Emission >= BYValue() * 2, “High”, “Low”)

would read “High” if the value in the variable CO2 Emissions had doubled from the Base Year level, “Low” otherwise.

Disaggregation Structure

- **UNITNAME()**
  Where units are specified in the disaggregation structure (fuels, toxics and agricultural inputs), this function equals the unit name. For example, water inputs may be in millions of cubic meters, whereas fertilizer inputs are in thousands of tonnes. This function would return “M m^3” for irrigation water, and “kt” for fertilizer. This function is normally used to display the unit in a text column (for information only). The empty parentheses ( ) after the function name implicitly refers to the relevant fuel, toxic or agricultural input.

- **FUELUSED()**
  Equals the name of the fuel consumed by a particular device or vehicle. This function is only available in tables where a device or vehicle is one of the dimensions. Fuels used by devices and vehicles are set in the disaggregation structure of the sector modules. This function is normally used to display the fuel in a text column (for information only). The empty parentheses ( ) after the function name implicitly refers to the relevant device or vehicle.

- **FEEDSTOCK(), PRODUCT(), COPRODUCT()**
  Equals the names of the fuels consumed or produced by an energy conversion process. This function is only available in tables where an energy conversion process is one of the dimensions. Input and output fuels from energy conversion processes are set in the disaggregation structure for the energy conversion module. This function is normally used to display the fuel in a text column (for information only). The empty parentheses ( ) after the function name implicitly refers to the relevant energy conversion process.

- **PRODUCT()**
  See **FEEDSTOCK**

- **COPRODUCT()**
  See **FEEDSTOCK**

- **PRIMARYFUELCONVERSIONFACTOR()**
  Equals the conversion factor for a primary fuel in GJ/physical unit (e.g., GJ/tonne). Use this function to convert between energy units and physical units. For example, if the physical unit for a fuel is in tonnes, the following expression

  Production[PJ] / PRIMARYFUELCONVERSIONFACTOR()

  would convert the primary fuel production value from the variable named Production[PJ] from PJ to Mt. The empty parentheses ( ) after the function name implicitly refers to the relevant primary fuel.

- **CROPFUELCONVERSIONFACTOR()**
  This function takes the crop commodity on the row of the cell being evaluated, determines which primary fuel of type "Crop" is linked to that crop (*e.g.,* Sugarcane), and returns the conversion factor in GJ/tonne of that linked primary fuel (see Section 6.8 for information on linking crops to fuels). This function is normally used in conjunction with BIOFUELREQ function, described below in the section titled "Miscellaneous". The empty parentheses ( ) after the function name implicitly refers to the relevant crop.

  Note: A fuel is specified of type "Crop" on the All Fuels disaggregation screen. A crop is linked to a fuel on the Agricultural Commodities disaggregation screen, by first specifying that it is a biofuel, then by linking it to a fuel of type "Crop".

- **ISFOREST()**
  In the Land module, equals true if the Land-Use Type (on the row on which the expression is evaluated) is a forest type, as specified in the land-use types disaggregation structure. This function is useful when distinguishing forest types from other land-use types in the Land-Use Patterns tables. Use in conjunction with the **IF** function. For example,

  IF(ISFOREST(), 1, 0) equals 1 if the land use type is a forest type, 0 otherwise.

  The empty parentheses ( ) after the function name implicitly refers to the relevant land use.

Statistical

- **AVERAGE(WeightingVariable1, WeightingVariable2, … WeightingVariableN)**
  Equals the average value of a PoleStar variable, optionally weighted by the specified variables. It applies to the column where the function appears. For example, in the sample Xland application, in the total row of column GDPPerCap in the Gross Domestic Product table (found in the Pop, GDP, Income module), the average GDP per capita for all of Xland is calculated using the formula:

  AVERAGE(Total Population ! Pop[10^6])

  Note: This function can only be used for specifying "totals" rows.

- **NORMDIST(x, mean, sd)**
  Equals the value for the density function at the point **x**, for a normal distribution with mean **mean** and standard deviation **sd**. The normal distribution is discussed in the next section.

- **NORMCUM(x, mean, sd)**
  Equals the value for the cumulative distribution at the point **x**, for a normal distribution with mean **mean** and standard deviation **sd**. The normal distribution is discussed in the next section.

- **NORMCUMINV(p, mean, sd)**
  Equals the value of the inverse cumulative normal distribution, for probability **p**, for a normal distribution with mean **mean** and standard deviation **sd**. The normal distribution is discussed in the next section.

- **LOGNORMDIST(x, mu, sigma)**
  Equals the value for the density function at the point **x**, for a lognormal distribution with parameters μ (**mu**) and σ (**sigma**). The lognormal distribution is discussed in the next section.

- **LOGNORMCUM(x, mu, sigma)**
  Equals the value for the cumulative lognormal distribution at the point **x**, for a lognormal distribution with parameters μ (**mu**) and σ (**sigma**). The lognormal distribution is discussed in the next section.

- **LOGNORMCUMINV(p, mu, sigma)**
  Equals the value of the inverse cumulative normal distribution, for probability **p**, for a normal distribution with parameters μ (**mu**) and σ (**sigma**). The lognormal distribution is discussed in the next section.

- **SDLOGNORM(Gini)**
  Equals the parameter σ (**sigma**) for a lognormal distribution corresponding to a Gini coefficient of **Gini**. Use this function when modeling income distributions with lognormal curves. The Gini coefficient is defined in Section 6.3, and the lognormal distribution is discussed in the next section.

- **MEDIANLOGNORM(mean, Gini)**
  Equals the median value (*e.g.*, of income) from the mean value and the Gini coefficient, when values are distributed according to a lognormal distribution. Use this function when modeling income distributions with lognormal curves. The Gini coefficient is defined in Section 6.3, and the lognormal distribution is discussed in the next section.

Miscellaneous

- **SUMACROSS(Dimension)**
  Equals the total of the variable, summed across the given dimension. ("Dimensions" in PoleStar are the columns on the left in tables with white backgrounds, *e.g.*, region, year, fuel.) For example, in the Value Added by Sector table in the Pop, GDP and Income module, the **VA** variable is independently summed across the dimensions Sector and Region. This means that for rows where Region = "TOTAL", the expression for the cell is SUMACROSS(Region), while for rows where Sector = "TOTAL", the expression for the cell is SUMACROSS(Sector). For cells where more than one dimension equals "TOTAL", the expression for the left-most dimension (in this case, Region) is used.

  Note that in this example, for **VA**, SUMACROSS(Sector) equals the total value added across all sectors for a region (*i.e.*, that region's GDP); SUMACROSS(Region) equals the total value added for a sector across all regions. (So, *e.g.*, if you put SUMACROSS(Region) on the row where Sector = "Industry," the computed value equals the total Industrial value added for all regions. If you put the function on the row Sector = "Transport," then the value equals the total Transportation value added for all regions. Finally, if you put the function on the row Sector = "TOTAL," the value equals the total value added for all regions and all sectors.)

Typically, the SUMACROSS function is specified as a column default, rather than a cell-specific expression. In the Edit Column dialog, you can choose which dimensions a variable should be summed across. See Section 7.1 for details.

- **REMAINDER()**

  Equals the value on the TOTAL row minus the sum of all the non-total rows (other than the current row). For example, this function can be used in calculating the value of a share as a remainder of the other shares, so that the total equals one. In this case, you would enter as data a value of 1 in the total row cell. The empty parentheses ( ) after the function name implicitly refers to the relevant dimension.

  Note: When using the REMAINDER *function, the total row expression should not be* SUMACROSS*. If the* SUMACROSS *function is entered in the total row, then the total row expression and the non-total row expression will be mutually dependent. This circular calculation could lead to incorrect results.*

- **BIOFUELREQ()**

  This function can be used where a crop commodity appears. For crop commodities that are linked to a fuel (*e.g.*, sugarcane for alcohol production), it equals the energy requirement from the Primary Fuels Balance table for the fuel of type "Crops" that is linked to the crop. The link between crops and fuels is made in the disaggregation structure for the Agriculture module. The units are the same as those in the Primary Fuels Balance table. (For example, in the large-scale Basic Structure, BIOFUELREQ() returns the energy in PJ.) The empty parentheses ( ) after the function name implicitly refers to the crop commodity.

  Note: A fuel is specified of type "Crop" on the All Fuels disaggregation screen. A crop is linked to a fuel on the Agricultural Commodities disaggregation screen, by first specifying that it is a biofuel, then by linking it to a fuel of type "Crop".

The Normal and Lognormal Distributions

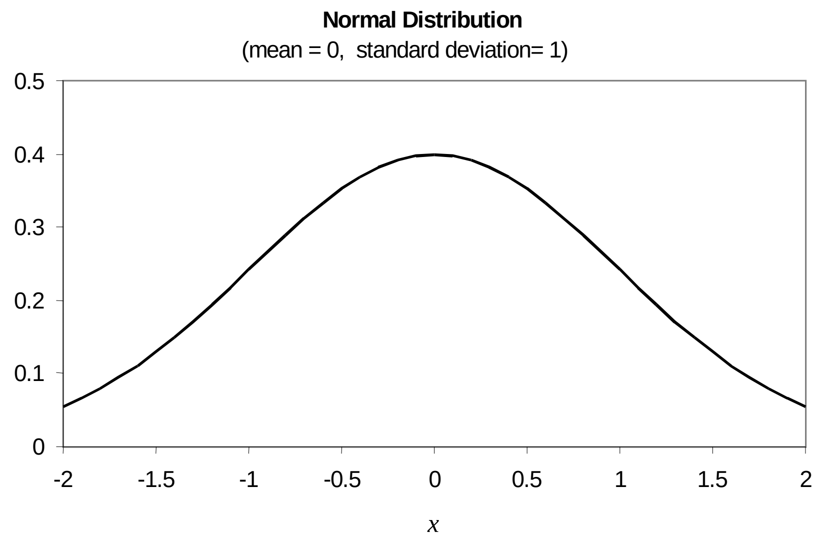
PoleStar supplies two standard statistical distribution functions, along with some related functions. One, the *normal distribution*, is frequently encountered in statistical analysis. The other, the *lognormal distribution*, is sometimes used to represent income distributions. The Basic Structure uses lognormal distributions to approximate income distribution functions. In addition to the distribution (*i.e.*, the density function), PoleStar supplies the *cumulative distribution function* and the *inverse cumulative distribution*. The normal and lognormal distributions are shown in the boxes below. Note the characteristic "bell" shape of the normal density function.

Probabilities (or fractions of a total value) are given by the cumulative distribution functions. The cumulative distributions are computed as the accumulated area under the curves described by the density function (shown in the boxes below). The value of the cumulative distributions increases steadily from 0 to 1 as *x* increases. With the cumulative function, you can answer the question, "What is the probability that a variable is above or below a particular value?" For example, the cumulative lognormal can be used to estimate the fraction of the population with income below the poverty line. With the inverse function you can answer the opposite question. For example, if you are given the fraction of the population with income below the poverty line, then you can use the inverse lognormal distribution to estimate the poverty line.

Normal Distribution Function

The normal distribution $f_{\text{normal}}(x, \text{mean}, \text{sd})$ has two parameters, the mean and the standard deviation (sd). It has the form

$$f_{\text{lognorm}}(x, \text{mean}, \text{sd}) = \frac{1}{\sqrt{2\pi} \cdot \text{sd}} \exp\left[-\frac{1}{2 \cdot \text{sd}^2}(x - \text{mean})^2\right]$$

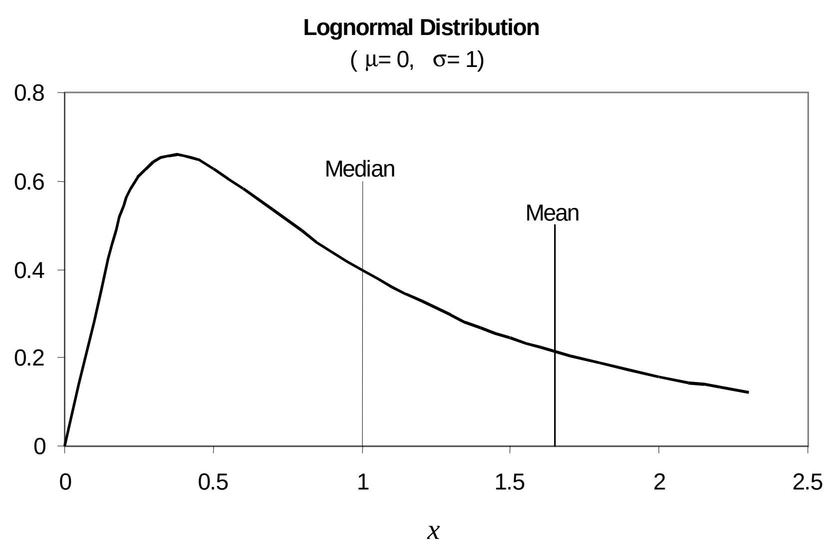


Lognormal Distribution Function

The lognormal distribution $f_{\text{lognorm}}(x, \mu, \sigma)$ has two parameters, μ (mu) and σ (sigma). It has the form

$$f_{\text{lognorm}}(x, \mu, \sigma) = \frac{1}{\sqrt{2\pi}\sigma x} \exp\left[-\frac{1}{2\sigma^2}\left(\ln(x) - \mu\right)^2\right]$$

The curve is asymmetric, which is reflected in the fact that the median, the mean and the mode (*i.e.*, the peak) appear at different values of *x*.



ANNEX 1: SELECTED CONVERSION FACTORS

Unit Prefixes

k	kilo	10^3
M	Mega	10^6
G	Giga	10^9
T	Tera	10^{12}
P	Peta	10^{15}
E	Exa	10^{18}

Energy

1 British Thermal Unit (BTU)	= 1054 Joules (J)
1 kilocalories (kcal) = 1 Calorie (C)	= 4184 J
1 kilowatt-hour (kWh)	= 0.0036 Gigajoules (GJ)
1 Gigawatt-hour (GWh)	= 3600 GJ
1 cubic feet of natural gas = 1000 BTU	= 0.001054 GJ
1 metric Tonne coal equivalent (TCE)	= 29.3076 GJ
1 metric Tonne oil equivalent (TOE)	= 41.868 GJ
1 barrel crude oil equivalent (bbl)	= 5.8147 GJ
1 horsepower-hour (hp-h)	= 0.002686 GJ

Power

1 megawatt	= 31500 GJ/year

Mass

1 pound (lb)	= 0.4536 kilograms (kg)
1 short ton (ton)	= 0.9087 metric tonnes (t)

Volume

1 barrel (bbl) = 42 gallons	= 0.159 cubic meter (m^3)
1 cubic yards (yd^3)	= 0.7646 m^3
1 gallons (gal)	= 0.003785 m^3
1 liter (l)	= 0.001 m^3

Area

1 acres	= 0.4047 hectares (ha)
1 square kilometer = 10^6 square meters	= 100 ha
1 square mile	= 259 ha

Length

1 foot	= 0.3048 meters (m)
1 mile	= 1.609 kilometers (km)

ANNEX 2: RULES FOR COMPUTING CELLS