Energy Technology Systems Analysis Programme

http://www.iea-etsap.org/web/Documentation.asp

Documentation for the TIMES Model

PART V

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Authors: Evelyn Wright
Amit Kanudia
Richard Loulou
Gary Goldstein

General Introduction

This documentation is composed of five Parts.

Part I provides a general description of the TIMES paradigm, with emphasis on the model's general structure and its economic significance. Part I also includes a simplified mathematical formulation of TIMES, a chapter comparing it to the MARKAL model, pointing to similarities and differences, and chapters describing new model options.

Part II constitutes a comprehensive reference manual intended for the technically minded modeler or programmer looking for an in-depth understanding of the complete model details, in particular the relationship between the input data and the model mathematics, or contemplating making changes to the model's equations. Part II includes a full description of the sets, attributes, variables, and equations of the TIMES model.

Part III describes the organization of the TIMES modeling environment and the GAMS control statements required to run the TIMES model. GAMS is a modeling language that translates a TIMES database into the Linear Programming matrix, and then submits this LP to an optimizer and generates the result files. Part III describes how the routines comprising the TIMES source code guide the model through compilation, execution, solve, and reporting; the files produced by the run process and their use; and the various switches that control the execution of the TIMES code according to the model instance, formulation options, and run options selected by the user. It also includes a section on identifying and resolving errors that may occur during the run process.

Part IV provides a step-by-step introduction to building a TIMES model in the VEDA-Front End (VEDA-FE) model management software. It first offers an orientation to the basic features of VEDA-FE, including software layout, data files and tables, and model management features. It then describes in detail twelve Demo models (available for download from the ETSAP website) that progressively introduce VEDA-TIMES principles and modeling techniques.

Part V describes the VEDA Back-End (VEDA-BE) software, which is widely used for analyzing results from TIMES models. It provides a complete guide to using VEDA-BE, including how to get started, import model results, create and view tables, and create and modify user sets, and step through results in the model Reference Energy System. It also describes advanced features and provides suggestions for best practices.

PART V: VEDA Back-End

TABLE OF CONTENTS FOR PART V

1 Introduction

Part V of the TIMES documentation provides a user manual for the **VE**rsatile **D**ata **A**nalyst **B**ack-**E**nd (VEDA[1]-BE) software, which is widely used for analyzing results from TIMES models. VEDA-BE is a flexible, user-friendly tool for the construction of analyst tables and graphs from structured datasets of any kind.

VEDA-BE is particularly suitable for analyzing results from GAMS-based models built on the concepts of *sets* for identifying and grouping model components and *parameters* for the management of numeric values, including those obtained from the model solution (e.g. the primal and dual solution values obtained from optimization). Any GAMS-based model can be linked to VEDA-BE by means of the GDX2VEDA utility and the associated <application>.VDD VEDA data definition file (see Appendix B for more).

VEDA-BE has additional features to work with the TIMES family of models that rely on a Reference Energy System (RES) network structure, where nodes in the network represent processes, and the arcs linking these nodes represent commodities produced and/or consumed by these processes. By means of the GDX2VEDA utility, VEDA-BE is made aware of a TIMES model's network topology, allowing the user to trace flows of commodities through the network by means of process inputs and outputs.

VEDA-BE may be used in conjunction with TIMES models built and managed in either the VEDA Front-End or ANSWER-TIMES model management systems. This document describes how to use VEDA-BE with both systems. It uses the VEDA-TIMES DemoS model described in Part IV as an example throughout; however, the instructions are general, and use of this demo model is not required in order to follow along.

Part V is organized as follows:

Chapter 1 Introduction and installation: introduces VEDA-BE and provides instructions to download and install the software.

Chapter 2 Getting started: provides an overview of the user environment, describes how to create a new database and how to import TIMES results, and introduces how to view results in ExRES and table views.

Chapter 3 Sets: describes the role of sets in viewing results in VEDA-BE. Explains how to construct and modify sets, how to use them in tables, and how to move them between VEDA-BE databases.

Chapter 4 Tables: describes how to build, customize, and manage tables; how to move tables between VEDA-BE databases; and some advanced features for working with tables.

Chapter 5 Units handling: describes the VEDA-BE units handling facility.

Chapter 6 Working with Excel and producing reports: describes ways to use VEDA-BE to produce analysis reports, including using VEDA-BE in conjunction with Excel and using the VEDA-BE batch mode.

Chapter 7 Best practices: provides some best practice suggestions.

Appendix A VEDA-BE Attribute Reference Guide.

Appendix B The GDX2VEDA utility and the VEDA data definition file.

[1] Veda [Sanskrit,=knowledge, cognate with English wit, from a root meaning know], oldest scriptures of Hinduism and the most ancient religious texts in an Indo-European language. [The Columbia Encyclopedia, 6th ed. New York: Columbia University Press, 2000.]

1.1 Software installation

Instructions for installing VEDA-BE are available at http://support.kanors-emr.org/.

2 Getting started with VEDA-BE for TIMES modeling

This section provides a guide to getting started with VEDA-BE for TIMES modeling, including creating a new database, importing results into an existing database, and viewing simple tables and graphs.

2.1 Bringing TIMES results into VEDA-BE

VEDA-BE requires as input four text files containing full information on each model run that the user wishes to process and examine. These files are produced from model run GAMS Data eXchange (GDX) files by the GAMS GDX2VEDA utility (see Appendix B). The generic names and role of these files are as follows:

- <scenarioname>.VD, containing the application VEDA-BE header directives (controlling the appearance of the main VEDA-BE table specification form) and actual model data;
- <scenarioname>.VDE, containing the list of individual set member elements for each index managed by VEDA-BE with their descriptions;
- <scenarioname>.VDS, where the set grouping information is provided for the various sub-sets associated with each index managed by VEDA-BE, and
- <scenarioname.VDT>, containing the topology (RES) information, for MARKAL/TIMES models only.

These files are deposited by the GDX2VEDA utility in the user's GAMS Work folder. (The default path is \VEDA\VEDA-FE\GAMS_WrkTIMES for VEDA-FE users, and \AnswerTIMESv6\GAMS_WrkTI for ANSWER users, but the user may choose to set up different Work folders, for example, for different projects.)

Following a model run, in order to analyze results in VEDA-BE, these files must first be brought into VEDA-BE. This may be done (occasionally, for example, when starting a new project) by creating a new VEDA-BE database from the run results, or (far more often) by importing run results into an existing database. Both operations are described in this section, along with other results management facilities, after quick instructions on how to follow along with the DemoS example database used in this document.

2.1.1 The DemoS working example

Throughout Part V, we will work with the TIMES DemoS_012 model as an example. The user may choose to follow along by downloading the Demo model package.[2] The ETSAP_DemoS_VFE folder should be copied into the user's /VEDA/Veda_Models directory, and the DemoS_VBE folder should be copied into the user's /VEDA/VEDA-BE/Databases folder.

To create an example run, we have run the DemoS_012 case, changing the run name so that we can compare the results to the DemoS_012 run already in the DemoS_VBE database, as shown in Figure 1. We have also created the Gams_WrkDEMO folder to receive our results files. (See Part IV for more on running the Demo models in VEDA-FE.)

[2] Available on the ETSAP website along with the TIMES documentation at http://iea-etsap.org/index.php/documentation.

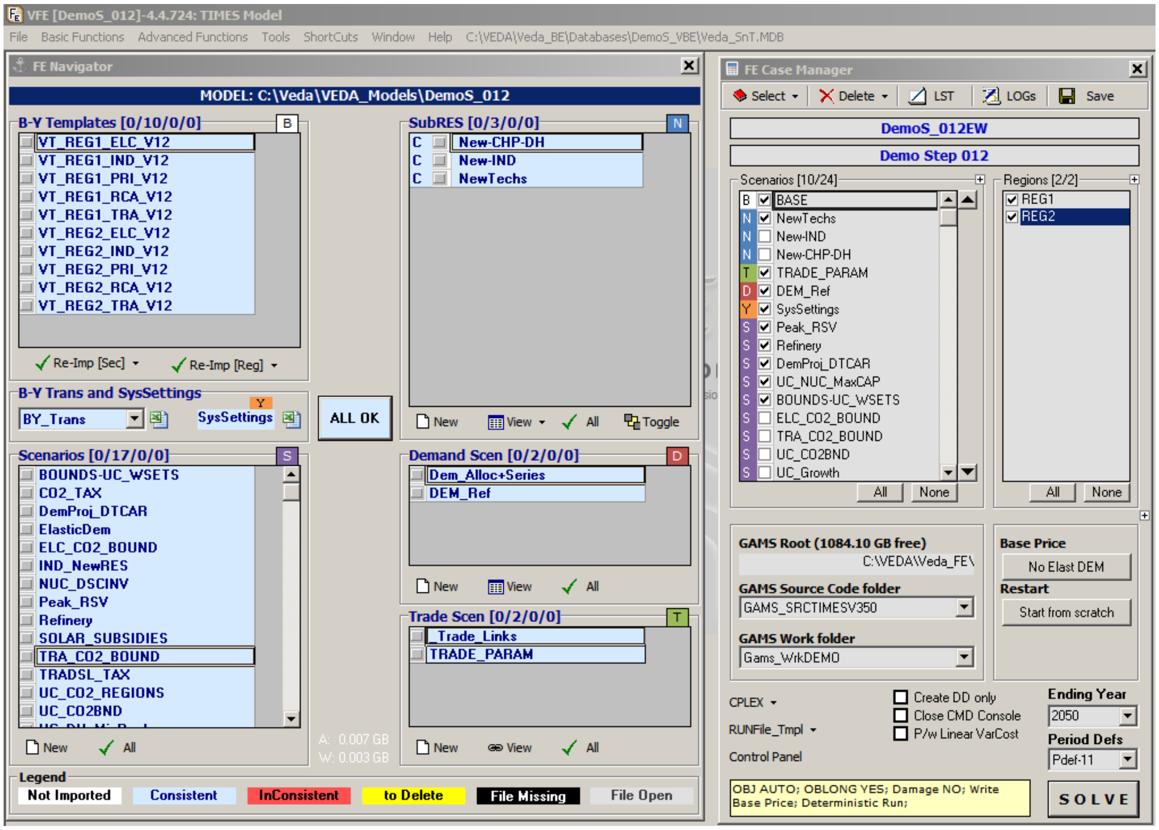
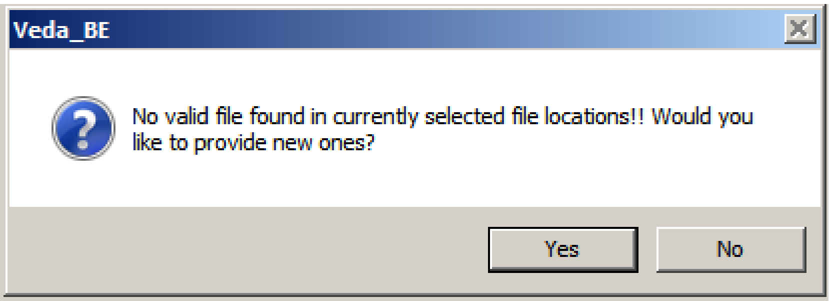


Figure 1: Creating an example DemoS_012 run

2.1.2 Creating a new VEDA-BE database

To create a new VEDA-BE database, from the **File** menu choose **New Database** and then select **Local**. Depending on your set-up, you may now see a window titled "**Flavors**". If so, see instructions starting at Figure 5 below. You may also see the following message:



No valid file found in currently selected file locations!! Would you like to provide new ones?

Figure 2: Prompt to set file locations

Click "**Yes**", and you will be delivered to the **Input Files Locations** window:

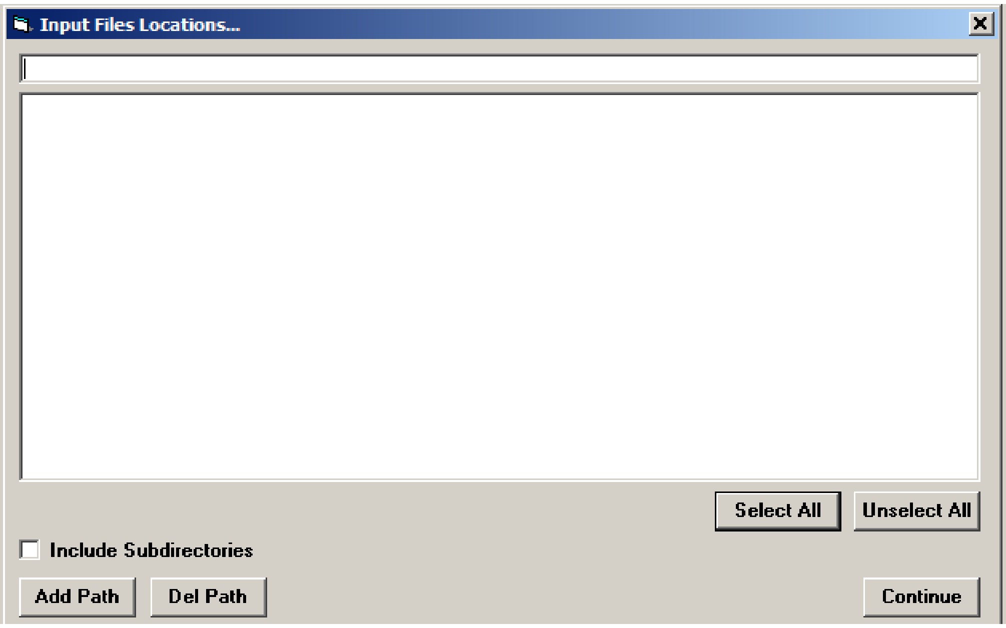


Figure 3: The Input Files Locations window

Click **Add Path**, which will bring up a folder **Browse** window. Scroll to the Veda_FE folder and click the "+" next to it. Then select the GAMSWrk folder you have used in your model run, as shown in Figure 4, and click **OK**[3].

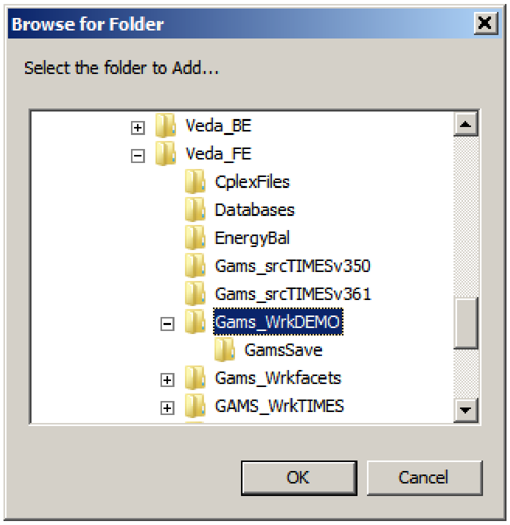
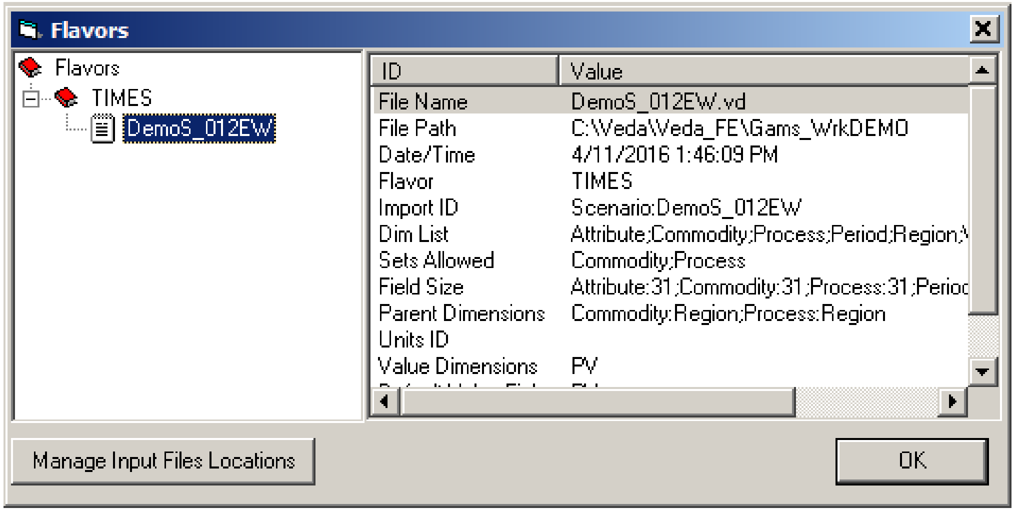


Figure 4: Selecting your GAMSWrk folder in the folder Browse

[3] If you use ANSWER to produce TIMES model runs, the Input Files Location path is set by navigating in this browse to your GAMS Work folder (default GAMS_WrkTI) within your AnswerTIMESv6 folder. Although the DemoS_012 model is a VEDA-TIMES model, you may follow along with the examples in this guide using the pre-existing DemoS_VBE database.

This should return you to the **Input Files Locations** window, where clicking **Continue** will bring you to the **Flavors** window:



ID	Value
File Name	DemoS_012EW.vd
File Path	C:\Veda\Veda_FE\Gams_WrkDEMO
Date/Time	4/11/2016 1:46:09 PM
Flavor	TIMES
Import ID	Scenario:DemoS_012EW
Dim List	Attribute;Commodity;Process;Period;Region;
Sets Allowed	Commodity;Process
Field Size	Attribute:31;Commodity:31;Process:31;Perioc
Parent Dimensions	Commodity:Region;Process:Region
Units ID	
Value Dimensions	PV

Figure 5: Selecting the run to create a new database in the Flavors window

In the **Flavors** window, click the "+" next to TIMES (the "flavor" of VEDA model that we will be working with), and your model run should appear. Select your run and Click **OK**. You will be prompted for a database name (e.g., *DemoS_VBE* here), whereupon VEDA-BE will create the new database and import your run. When the import is complete, you should see your scenario listed on the **Scenarios** tab.

A note on terminology: In VEDA-FE and ANSWER, model runs are called *cases*, and are assembled from one or more *scenarios* consisting of input data that are layered to form the input assumptions for a particular case. However, in VEDA-BE, the model runs upon import are referred to as *scenarios*. Because VEDA-BE is generally used only to review TIMES model output data, this change in terminology should not cause any (lasting) confusion.

2.1.3 Importing results into an existing database

It is generally more convenient to work from an existing database, if one has been previously created for your model/project, because it will likely be already populated with Sets and Tables that are useful for analyzing your model. (Throughout this document, we will work with the DemoS_VBE database that is distributed with the DemoS model.)

Upon starting, VEDA-BE will open the last used database, if any. To open a desired database, choose **Open Database** from the **File** menu. You will see a folder Browse of all the databases (folders) in the (default) /VEDA/VEDA-BE/Databases folder, from which you can select the desired database[4].

[4] You may store your databases in any location. Each "database" will always be a folder consisting of several Access databases, as described in Section 2.1.5.

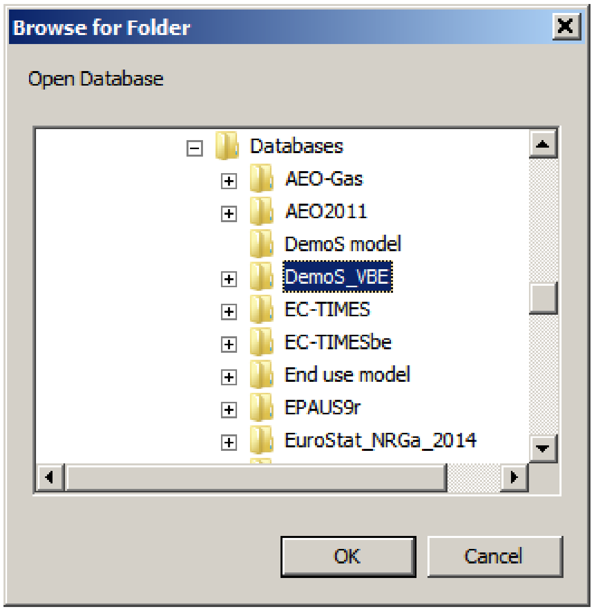
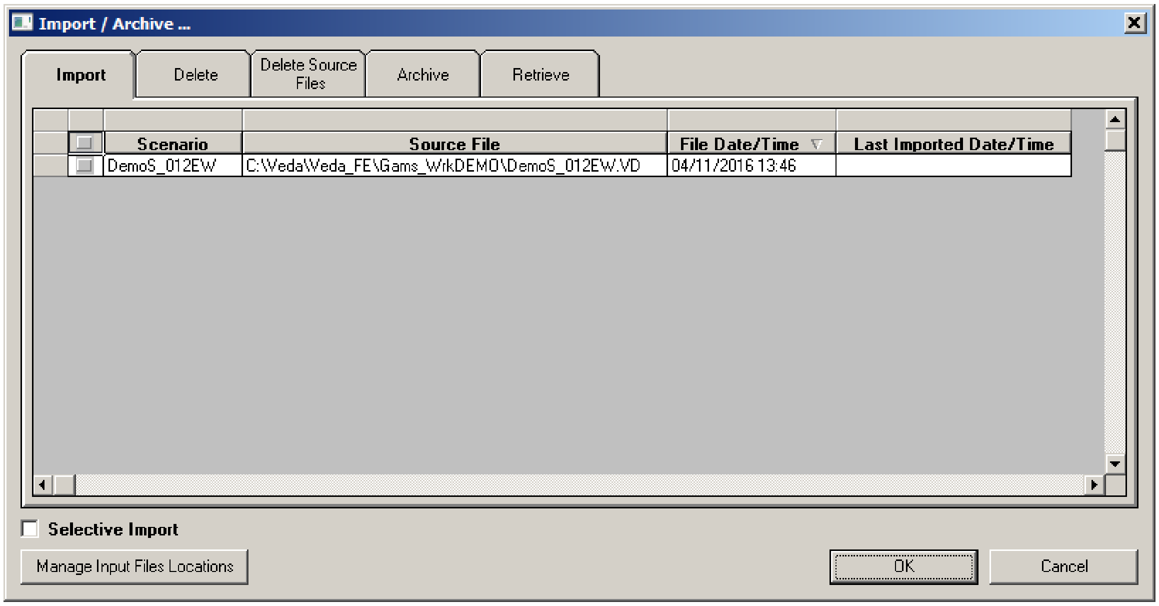


Figure 6: Opening a database

To import a run or runs into an existing database, from the **Results** menu choose **Import/Archive**. This brings up the following window:



□	Scenario	Source File	File Date/Time	Last Imported Date/Time
□	DemoS_012EW	C:\Veda\Veda_FE\Gams_WrkDEMO\DemoS_012EW.VD	04/11/2016 13:46	

☐ Selective Import

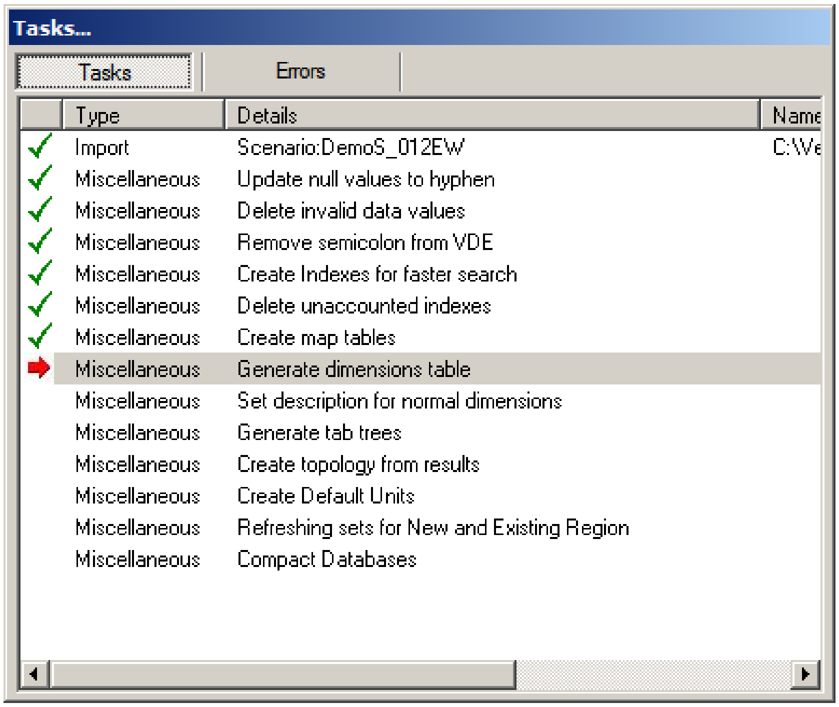
Figure 7: The Import/Archive window

You may see your model run listed here. If so, click on the checkbox next to its name to select it, and click **OK**.

Alternatively, the Import file list may be blank, because the path to the GAMSWrk folder has not been set yet. In this case, click **Manage Input Files Locations**. This will take you to the **Input Files Locations** window shown in Figure 3, where you can click **Add Path** and navigate to and select your GAMSWrk folder as described in Section 2.1.2. This should be a one-time operation, unless you change GAMSWrk folders, and the Import file list should be populated with new results as you conduct runs from now on.

Note that the **Input Files Locations** box can also be used to remove a path from a VBE database, if desired (for example, if you decide to create separate GAMSWrk folders for different projects later on.)

Once you have selected your run(s) to import and clicked **OK**, the **Tasks** window should appear, showing you the progress of the import process. Depending on the size of your model, this process may take a few seconds (for the DemoS model) up to several minutes for very large models.



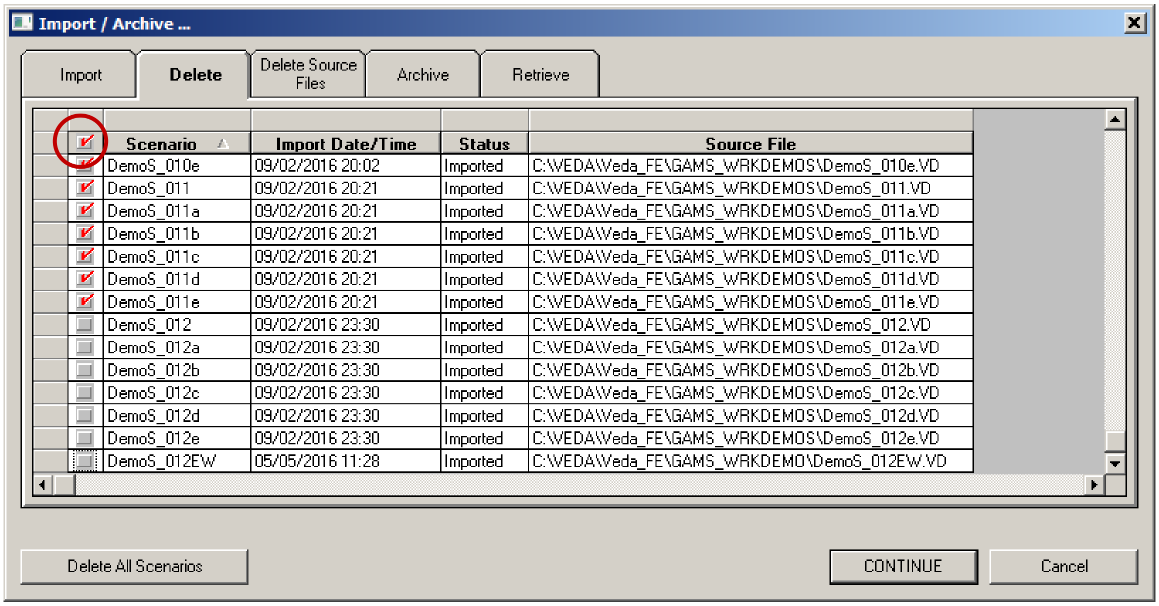
	Type	Details	Name
✓	Import	Scenario:DemoS_012EW	C:\Ve
✓	Miscellaneous	Update null values to hyphen	
✓	Miscellaneous	Delete invalid data values	
✓	Miscellaneous	Remove semicolon from VDE	
✓	Miscellaneous	Create Indexes for faster search	
✓	Miscellaneous	Delete unaccounted indexes	
✓	Miscellaneous	Create map tables	
➡	Miscellaneous	Generate dimensions table	
	Miscellaneous	Set description for normal dimensions	
	Miscellaneous	Generate tab trees	
	Miscellaneous	Create topology from results	
	Miscellaneous	Create Default Units	
	Miscellaneous	Refreshing sets for New and Existing Region	
	Miscellaneous	Compact Databases	

Figure 8: The Tasks window for importing and deleting scenarios

2.1.4 Managing scenarios in a VEDA-BE database

From the **Import/Archive** window, one may perform additional tasks to manage the scenarios stored in your VEDA-BE database. Clicking on the **Delete** tab will bring up a list of all the scenarios that are currently in the database. Select the scenarios you want to delete by checking the checkboxes next to their names and click **CONTINUE**. This will bring you back to the **Import** tab, where you can select scenarios for Import, if desired, and then click **OK** to start the Delete (and Import, if any) process.

To streamline the DemoS_VBE database for our use, we'll delete all the scenarios from DemoS 1-11. With the **Import/Archive** window open, click on the **Delete** tab to bring up the list of all scenarios in the database. Clicking on the checkbox next to "Scenario" (see the circled area in Figure 9) will select *all* scenarios in the list. You may sort the list by scenario name by clicking on **Scenario**, then scroll to the bottom and unselect the DemoS_012 scenarios by clicking on each of their checkboxes to clear the checks. Click **CONTINUE** and then **OK** to start the delete.



☑	Scenario	Import Date/Time	Status	Source File
☑	DemoS_010e	09/02/2016 20:02	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_010e.VD
☑	DemoS_011	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011.VD
☑	DemoS_011a	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011a.VD
☑	DemoS_011b	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011b.VD
☑	DemoS_011c	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011c.VD
☑	DemoS_011d	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011d.VD
☑	DemoS_011e	09/02/2016 20:21	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_011e.VD
□	DemoS_012	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012.VD
□	DemoS_012a	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012a.VD
□	DemoS_012b	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012b.VD
□	DemoS_012c	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012c.VD
□	DemoS_012d	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012d.VD
□	DemoS_012e	09/02/2016 23:30	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMOS\DemoS_012e.VD
□	DemoS_012EW	05/05/2016 11:28	Imported	C:\VEDA\Veda_FE\GAMS_WRKDEMO\DemoS_012EW.VD

Figure 9: Deleting scenarios from the database

From the **Import/Archive** window, you may also delete old VD* files from your GAMSWrk folder, by clicking on the **Delete Source Files** tab and selecting the scenarios for deletion. Once you have imported scenarios into your VEDA-BE database, the VD* files are no longer needed and should be periodically deleted to save disk space.

Note that if, upon opening the **Import/Archive** window, VEDA-BE finds results files with the same name but a later time stamp than a scenario already in the database, indicating that you have run a new version of a previously imported scenario, it will automatically select that scenario for import. You may deselect it, if desired, by clearing the checkbox next to its name. If you request the import to proceed, it will first delete the previous version of the scenario.

2.1.5 The structure of a VEDA-BE database

A VEDA-BE database is a folder residing by default in the /VEDA/VEDA-BE/Databases folder, containing several Microsoft Access databases (.mdb files). These include:

- One Access database named VEDA_R_<scenarioname> corresponding to each scenario that is currently in the VEDA-BE database;
- Access databases named VEDA-R and VEDA-Y. These hold the structure of the scenario-specific files, and the scenario and table dimensions, and are meant for the internal use of the application. Users should never modify these files; and
- An access database named VEDA_SnT.

The SnT file is of particular importance, as it can be used to transfer Sets and Tables from one VEDA-BE database to another, as described in Sections 3.4 and 4.4. **The other Access files should not be moved or copied by the user from one location to another.**

2.1.6 Moving/sharing a VEDA-BE database

The recommended procedure to move an existing VEDA-BE database from one computer to another and/or share it with a colleague is to create a new database from one model run, and then import any needed scenarios, sets, and tables as follows:

Select a model run on the old machine, locate the four VD* files from that run in your GAMSWrk folder, and compress and move them to the GAMSWrk folder on the other machine. Also locate the VEDA_SnT file in the VEDA-BE database folder and copy it to a known location on the other machine, such as the Desktop. Next create a new database on this machine from the VD* files, following the procedure described in Section 2.1.2. Finally, import desired sets and tables from the SnT file, following the procedures described in Sections 3.4 and 4.4. Additional scenarios may be imported into the new database by copying their VD* files to the new machine's GAMSWrk folder and using the **Import/Archive** window.

Merging scenarios, sets, and/or tables from existing one database into another may be accomplished by following the same procedure, minus the creation of a new database.

Note that it is not recommended to short-cut this procedure by moving the entire database folder and/or the SnT file to the new machine. Differences in VEDA-FE settings between the two machines may cause the required SnT file format to be slightly different, resulting in incompatibilities.

2.2 Orientation to the main VEDA-BE window

If you have imported and deleted scenarios from the DemoS_VBE database as described in Section 2.1, your screen should now look something like that shown in Figure 10.

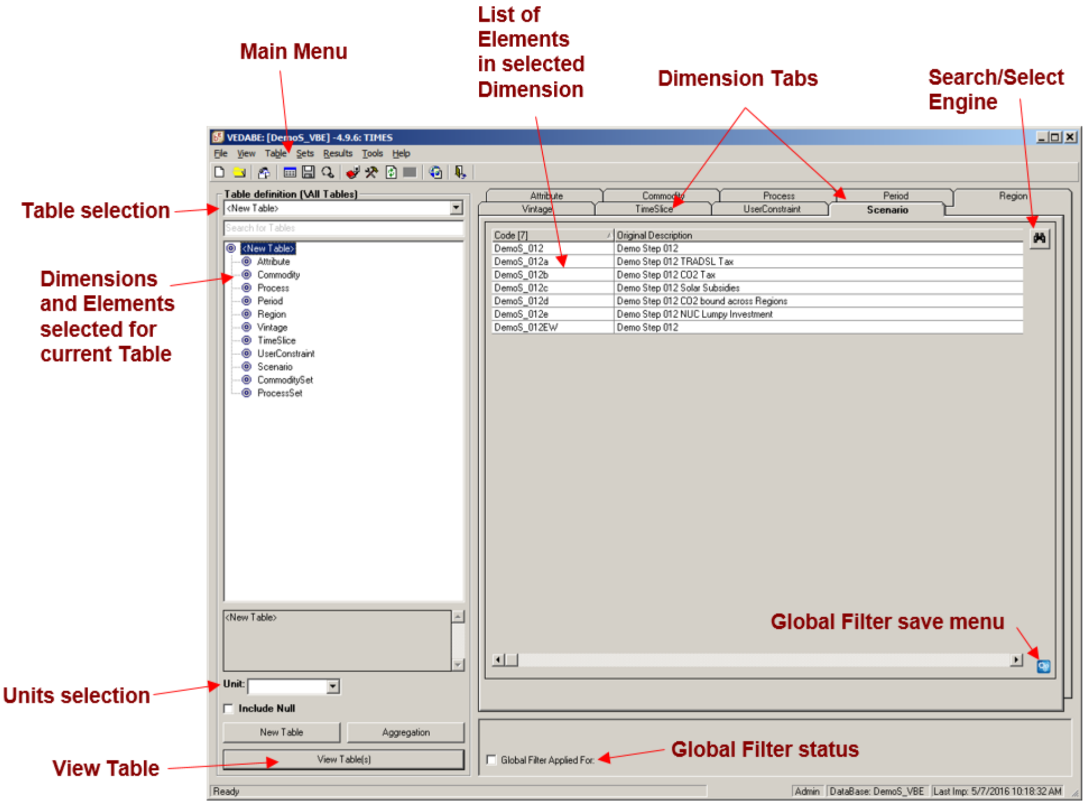
The arrows in Figure 10 call out the primary features of the main VEDA-BE window. Below the **Main menu** bar (described in Section 2.2.2), the window is divided in two. The left panel is the **Table definition** panel, which contains at its top a dropdown list of existing tables (if any have been previously defined). The drop-down menu also contains the option to define a new table, as shown in Figure 10. Underneath the menu is the list of dimensions and elements that describe the selected table (if any). The user can choose (and then optionally modify) a pre-defined table from the list, or create a new one altogether. Note that the list of tables shown is the one in the folder that has been selected under *\View\Open folder(s)* in the main menu (see Section 4.4). If no folder has been selected, all tables are shown. The table definition process is described in Section 4.1.

The right panel holds the **Dimension Tabs**, which display the detailed lists of all elements in the database. The available dimensions for TIMES models are described in Section 2.2.1.

Additional features of note in the main window include:

- The **Units** drop-down menu allows the user to specify the native model units that are associated with the table. If the user has defined custom units and conversion factors (discussed in Section 5), the display units of the table may be modified inside the table view.
- The **View table(s)** button processes the table definition, and produces the tabular cube view (see Section 2.3) according to the specified criteria.
- The **Global Filter** status bar at the bottom indicates whether global filters have been set, and if so, for which dimensions and elements. This feature allows the user to set filters that will apply to *all* tables viewed and then later to easily remove them for all tables,

without having to redefine the tables. See Section 2.3.5 for instructions on this extremely useful feature.



Code [7]	Original Description
DemoS_012	Demo Step 012
DemoS_012a	Demo Step 012 TRADSL Tax
DemoS_012b	Demo Step 012 CO2 Tax
DemoS_012c	Demo Step 012 Solar Subsidies
DemoS_012d	Demo Step 012 CO2 bound across Regions
DemoS_012e	Demo Step 012 NUC Lumpy Investment
DemoS_012EW	Demo Step 012

Figure 10: The main VEDA-BE window

2.2.1 The dimension tabs and items lists

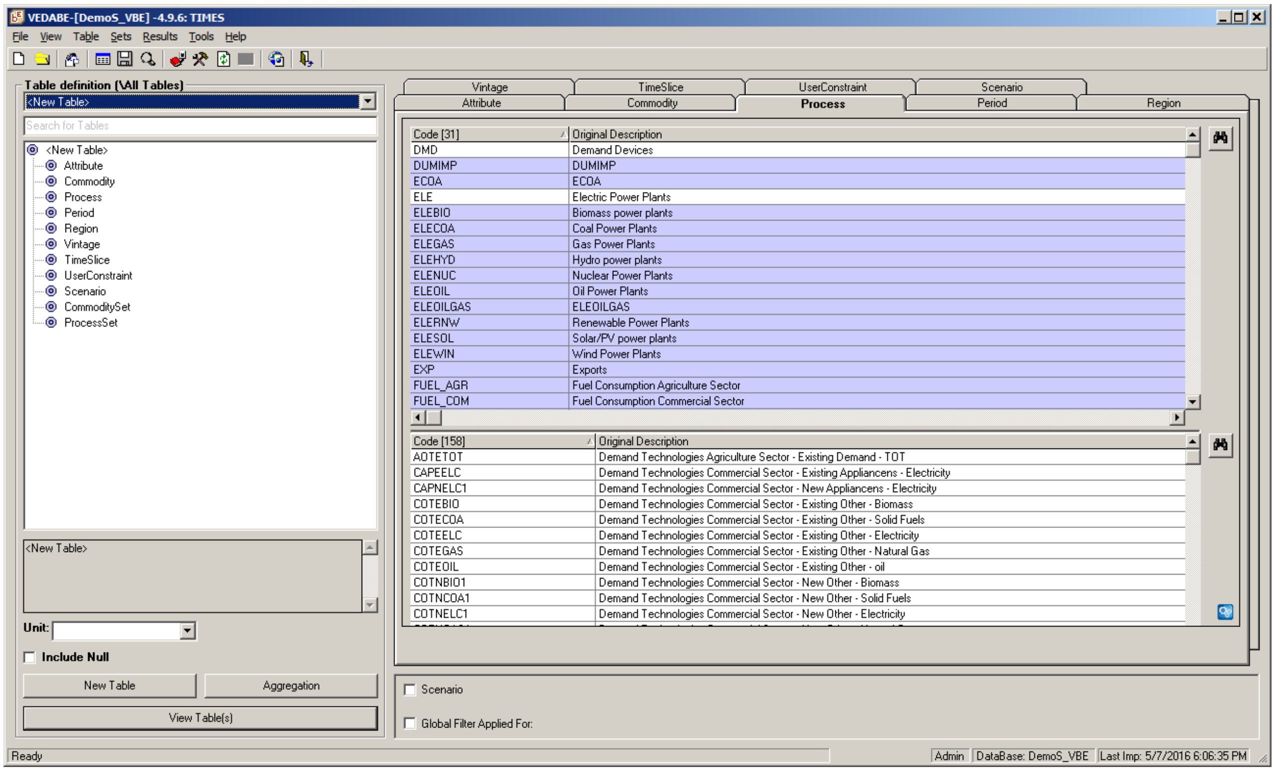
The **Dimension tabs** organize all the items that are available to view in the VEDA-BE database. Each tab lists the available elements corresponding to that dimension. Note that for the **Process** and the **Commodity** dimensions, the tab is divided into lists of *sets* of items that TIMES and/or the user have defined (above) and the items themselves (below), as shown in Figure 11.

Each element in a dimension has a *code* and a *description*. The description comes in two flavors: the original description provided from the model, and the Veda description. You may toggle between the Veda and Original descriptions by right-clicking with the cursor in the description column and selecting **Display Type** from the pop-up menu. Initially, these two descriptions are identical, but the user may change the Veda description at will by selecting **Edit description** from this pop-up menu. This feature is particularly useful for scenario descriptions, and may also by useful for set descriptions or region names, in order to adapt the heading of table columns or rows to the terminology of a particular report.

For the TIMES models, the 9 dimensions are:

- **Attribute**: describing the kind of results data to be displayed. There are many VEDA attributes handled for the TIMES models, including process capacities and investments, commodity flows, costs, and marginals. See Appendix A for a full listing.

- **Commodity and Commodity Set**: a *commodity* is an energy form, a material, an emission, or a demand category. In short, a commodity represents a link in the RES network (whereas a process, as described below, represents a node of the RES). A *commodity set* is a group of commodities defined by the model or by the user. Commodity sets are convenient ways to avoid having to list many commodities when defining a table. They will be discussed in detail in Section 3.
- **Process and Process Set (**Figure 11): a *process* is the generic name for a technology or an energy source or energy/emission sink. A *process set* is a group of processes defined by the model itself or by the user. Process sets are a convenient way to avoid having to list many processes when defining a table. They will be discussed in detail in Section 3.



Code [31]	Original Description
DMD	Demand Devices
DUMIMP	DUMIMP
ECOA	ECOA
ELE	Electric Power Plants
ELEBIO	Biomass power plants
ELECOA	Coal Power Plants
ELEGAS	Gas Power Plants
ELEHYD	Hydro power plants
ELENUC	Nuclear Power Plants
ELEOIL	Oil Power Plants
ELEOILGAS	ELEOILGAS
ELERNW	Renewable Power Plants
ELESOL	Solar/PV power plants
ELEWIN	Wind Power Plants
EXP	Exports
FUEL_AGR	Fuel Consumption Agriculture Sector
FUEL_COM	Fuel Consumption Commercial Sector

Code [158]	Original Description
AOTETOT	Demand Technologies Agriculture Sector - Existing Demand - TOT
CAPEELC	Demand Technologies Commercial Sector - Existing Appliancens - Electricity
CAPNELC1	Demand Technologies Commercial Sector - New Appliancens - Electricity
COTEBIO	Demand Technologies Commercial Sector - Existing Other - Biomass
COTECOA	Demand Technologies Commercial Sector - Existing Other - Solid Fuels
COTEELC	Demand Technologies Commercial Sector - Existing Other - Electricity
COTEGAS	Demand Technologies Commercial Sector - Existing Other - Natural Gas
COTEOIL	Demand Technologies Commercial Sector - Existing Other - oil
COTNBIO1	Demand Technologies Commercial Sector - New Other - Biomass
COTNCOA1	Demand Technologies Commercial Sector - New Other - Solid Fuels
COTNELC1	Demand Technologies Commercial Sector - New Other - Electricity

Figure 11: The *Process* tab, showing *process sets* above and *processes* below

- **Period**: lists all the periods in the model, by milestone year.
- **Region**: the various regions represented in the model.
- **Vintage**: the vintage year corresponds to the period in which a process was initially installed, as opposed to the period in which activity occurs. This view may be useful for technologies whose characteristics change with vintage. This dimension also contains the reserved tags 0, -, and ¤ for use in characterizing capacity additions and retirements (see Appendix A).
- **Time Slice**: sub-divisions of model periods according to seasons and time-of-day.
- **User Constraint**: lists all user constraints in the model, along with reserved TIMES tags that distinguish objective function components (see Appendix A).
- **Scenario**: all model runs currently imported in the database, as described in Section 2.1.

2.2.2 VEDA-BE main menus and toolbar

This section summarizes the features available under each of the main menus, as follows.

- **File**: contains commands to create a ***New*** database and ***Open*** an existing one; to ***Backup*** all files in the current database as a single Zip archive and to ***Restore*** a database from such an archive; and to ***Quit*** VEDA-BE.
- **View**: besides the usual view choices such as showing or hiding parts of the screen, this menu has two important functions: a) to allow the user to select subsets of tables in specific ***folders***, and b) to choose the ***execution mode*** (interactive or batch). See Sections 4.4 and 6.2 for these advanced features.
- **Tables**: this menu allows the user to define a ***new*** table, to ***save*** or ***delete*** a table, to ***import*** tables defined in another database and ***export*** tables to share with another database, to erase ***Cube files*** (the final form in which a table is organized), and to open the ***Table Master***. See Section 4 for defining and managing tables.
- **Sets**: this menu allows the user to create ***new*** sets, to ***edit, delete***, or ***refresh*** existing sets, to ***import*** sets defined by another user, and to ***export*** sets to another location. See Section 3 for all operations on sets.
- **Results**: this menu allows ***importing*** and ***deleting*** results, as well as defining the directory where result files are stored, as described in Section 2.1.
- **Tools**: this menu offers a diverse array of tools, including user ***Options*** for setting default table layouts and formats (discussed in Section 4.2) and settings for working with ***Exports*** and ***Batch Mode*** (Section 6); operations on ***Cube Files*** (Section 2.3.7); the ***Units*** facility (Section 5); and the ability to ***Update Excel files*** containing calculations and graphs based on VEDA-BE tables (Section 6.3).
- **Help**: this menu provides links to the KanORS Veda Support website and Veda Support Forum. The Forum has an active user community and is a very good source of information for beginners as well as advanced users.

2.3 Viewing tables

We are now ready to work with the tables that have been defined in the DemoS_VBE database. We'll begin by verifying that our test run of the DemoS_012 scenario has succeeded in duplicating the same solution, by selecting the ***_SysCost*** table from the drop-down menu in the **Table definition** panel, as shown in Figure 12. Note that this table is so useful in initial assessment of model runs that its creator has chosen to begin its name with an underscore (**_**) character, so that it will always sort at the beginning of the table list.

The **Table definition** panel now shows us how this table is constructed. Its specifications consist of only a single entry: the attribute ***Reg_obj***. Clicking on the **Attributes** tab shows us the description of this item: *Regional total discounted system cost*, as shown in Figure 13. Note that this item appears in bold, because it is part of the currently selected table's definition.

Below the **Table Definition** form, we see the table's description, assigned by its creator: *Objective Function Value*. We also see that the table's creator has set the Units for this table to M Euro. These are the *native* units in the model for the costs shown in this table. Having set the native units in the table definition process allows the user to make use of the Units function to later change the *display* units of the table to any units of their choosing.

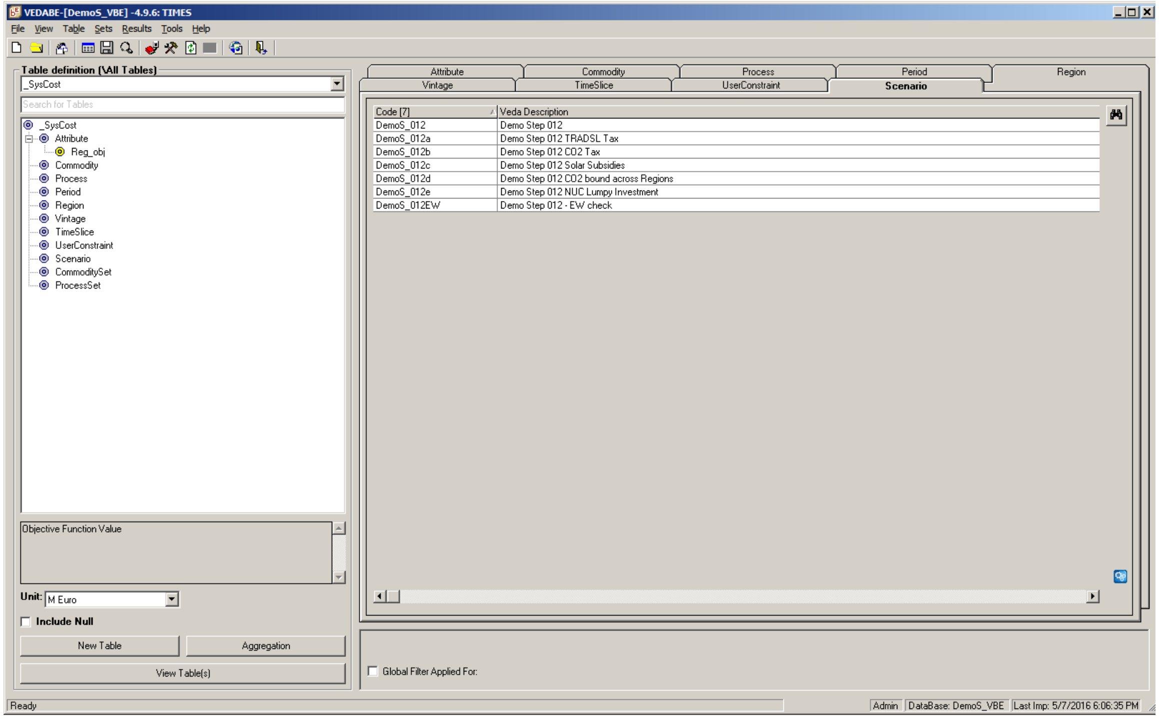


Table definition (\All Tables): _SysCost

Code [7]	Veda Description
DemoS_012	Demo Step 012
DemoS_012a	Demo Step 012 TRADSL Tax
DemoS_012b	Demo Step 012 CO2 Tax
DemoS_012c	Demo Step 012 Solar Subsidies
DemoS_012d	Demo Step 012 CO2 bound across Regions
DemoS_012e	Demo Step 012 NUC Lumpy Investment
DemoS_012EW	Demo Step 012 - EW check

Objective Function Value

Unit: M Euro

☐ Include Null

☐ Global Filter Applied For:

Figure 12: The _*SysCost* table definition

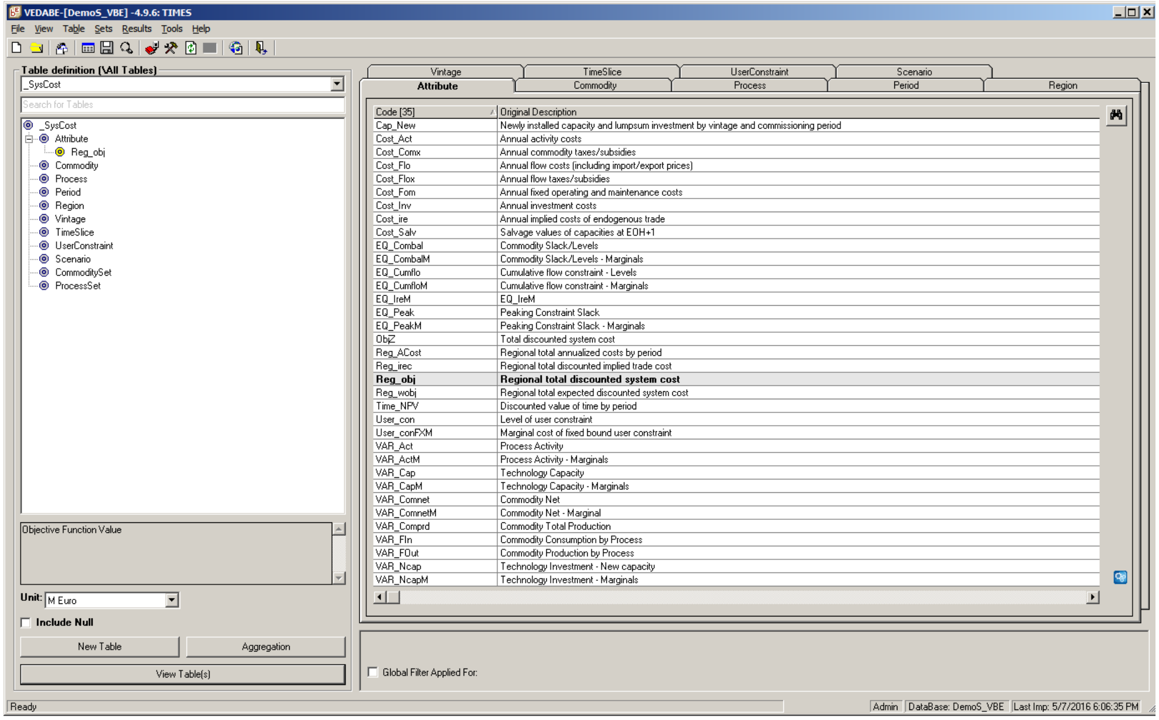


Table definition (\All Tables): _SysCost

Code [35]	Original Description
Cap_New	Newly installed capacity and lumpsum investment by vintage and commissioning period
Cost_Act	Annual activity costs
Cost_Comx	Annual commodity taxes/subsidies
Cost_Flo	Annual flow costs (including import/export prices)
Cost_Flox	Annual flow taxes/subsidies
Cost_Fom	Annual fixed operating and maintenance costs
Cost_Inv	Annual investment costs
Cost_ire	Annual implied costs of endogenous trade
Cost_Salv	Salvage values of capacities at EOH+1
EQ_Combal	Commodity Slack/Levels
EQ_CombalM	Commodity Slack/Levels - Marginals
EQ_Cumflo	Cumulative flow constraint - Levels
EQ_CumfloM	Cumulative flow constraint - Marginals
EQ_IreM	EQ_IreM
EQ_Peak	Peaking Constraint Slack
EQ_PeakM	Peaking Constraint Slack - Marginals
ObjZ	Total discounted system cost
Reg_ACost	Regional total annualized costs by period
Reg_irec	Regional total discounted implied trade cost
Reg_obj	**Regional total discounted system cost**
Reg_wobj	Regional total expected discounted system cost
Time_NPV	Discounted value of time by period
User_con	Level of user constraint
User_conFXM	Marginal cost of fixed bound user constraint
VAR_Act	Process Activity
VAR_ActM	Process Activity - Marginals
VAR_Cap	Technology Capacity
VAR_CapM	Technology Capacity - Marginals
VAR_Comnet	Commodity Net
VAR_ComnetM	Commodity Net - Marginal
VAR_Comprd	Commodity Total Production
VAR_FIn	Commodity Consumption by Process
VAR_FOut	Commodity Production by Process
VAR_Ncap	Technology Investment - New capacity
VAR_NcapM	Technology Investment - Marginals

Objective Function Value

Unit: M Euro

☐ Include Null

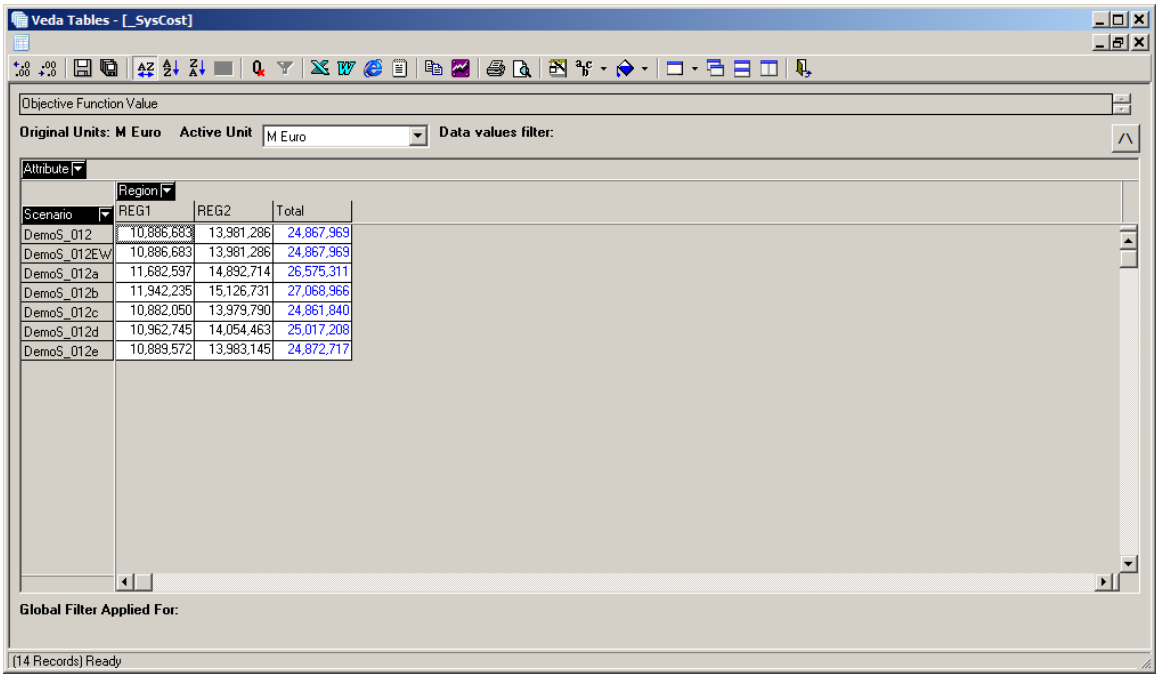
☐ Global Filter Applied For:

Figure 13: The Attributes tab

Clicking on **View Table(s)** brings us into the table **View window**, as shown in Figure 14. VEDA-BE tables are highly dynamic data *cubes* that may be readily rearranged. Table dimensions are shown in either rows (as for *Scenario* in this example), columns (*Region*), or "on the page", meaning sitting at the top, as *Attribute* is here. Dimensions in rows or columns are enumerated there, while dimensions on the page are summed over. In this case, there is only one *Attribute* in the table (***Reg_obj***), so having it on the page merely gets it out of the way without changing the results shown.

Hovering the cursor over any (black) dimension header will cause a cross-hair to appear, allowing you to hold down the cursor (left-mouse) and drag this dimension to any other position in the table (where a green line will appear). Dragging *Region* to the top will remove the enumerated *Region* data from the table and show only the sum across regions, as shown in Figure 15. Note that the *Region* header is now enclosed in asterisks (*), to alert us that multiple values are being summed over.

The user must take care that dimensions on the page are only those that it is meaningful to sum over. For example, it rarely makes sense to sum over *Attribute* (with the exception of the ***Cost_*** components), so when there is more than one *Attribute* in a table, it should be shown in a row or column. Similarly, summing over *Scenario* is never meaningful, and so *Scenario* should always be in a row or column (with the exception of tables used in single scenario Excel workbooks for update using the features described in Section 6.3, to be used with the Global Filter selecting a single scenario.)



Objective Function Value

Original Units: M Euro   Active Unit: M Euro   Data values filter:

Attribute

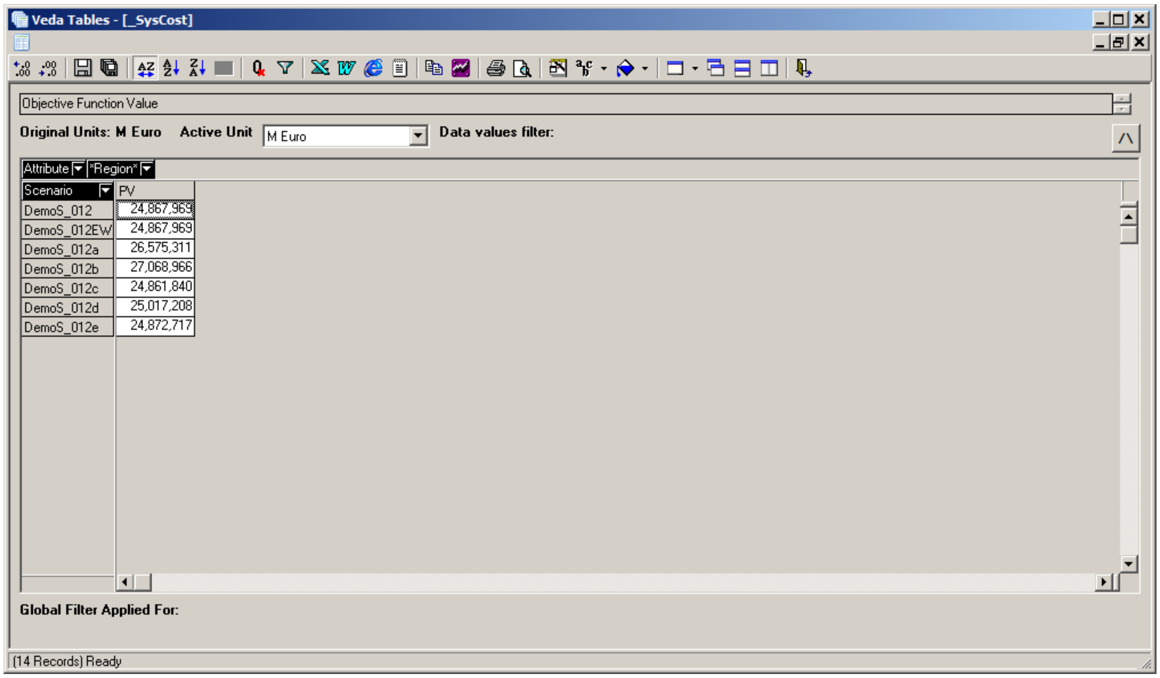
Scenario	REG1	REG2	Total
DemoS_012	10,886,683	13,981,286	24,867,969
DemoS_012EW	10,886,683	13,981,286	24,867,969
DemoS_012a	11,682,597	14,892,714	26,575,311
DemoS_012b	11,942,235	15,126,731	27,068,966
DemoS_012c	10,882,050	13,979,790	24,861,840
DemoS_012d	10,962,745	14,054,463	25,017,208
DemoS_012e	10,889,572	13,983,145	24,872,717

Global Filter Applied For:

(14 Records) Ready

Figure 14: Viewing the _*SysCost* table

The order of multiple dimensions in row and column positions determines the order in which data is nested. (See Section 2.3.6 for an example.)



Objective Function Value

Original Units: M Euro   Active Unit: M Euro   Data values filter:

Scenario	PV
DemoS_012	24,867,969
DemoS_012EW	24,867,969
DemoS_012a	26,575,311
DemoS_012b	27,068,966
DemoS_012c	24,861,840
DemoS_012d	25,017,208
DemoS_012e	24,872,717

Global Filter Applied For:

(14 Records) Ready

Figure 15: The _*SysCost* table with *Region* summed

With this table, we can verify that our test run of DemoS_012 has produced the same objective value, and hence the same solution as the original run. However, let us use this simple table to explore a few more features in the View window.

2.3.1 Sub-totals

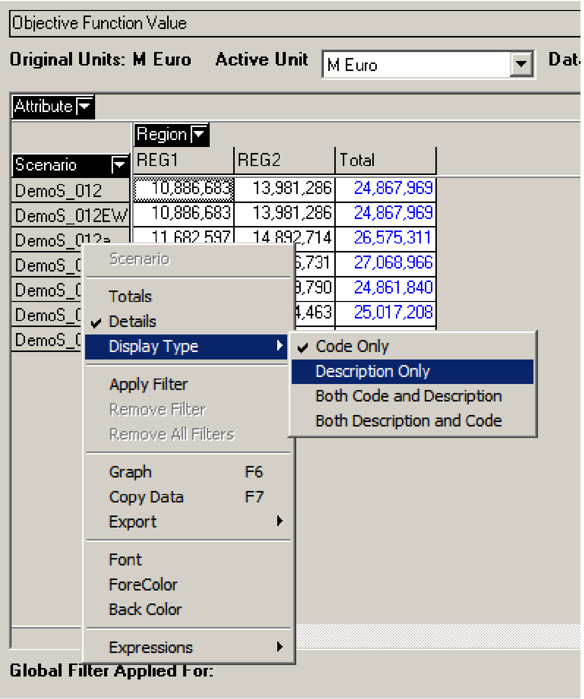
Dragging *Region* back to its original column position allows us to see (as in Figure 14) that the creator of this table opted to have the displayed values summed over *Region*. This option is toggled by right-clicking while the cursor lies in the row or column listing for the desired dimension (in this case, on one of the region names) and selecting **Totals** from the menu that appears. As with dimensions held on the page (rather than in rows or columns), the user must take care that the items summed produce a meaningful total.

2.3.2 Changing item display from name to description

From the same menu, one may choose the **Display Type** for the selected dimension. As shown in Figure 16, the **Display Type** menu offers the option to view items in the selected dimension by their *Code* (short name), *Description*, or both, in either order. Switching *Scenarios* here to a display type that includes the description may help us keep track of which scenario is which, for example. Note that when only the *Code* or *Description* is selected, the unselected option appears as a tooltip when you hover over a scenario entry.

2.3.3 Unit conversion

If a table's native *units* and relevant *unit conversion factors* have been specified, a table's display units can be converted in the cube (and saved, if desired). Clicking on the drop-down menu next to **Active Unit** above the top of the table reveals that, in addition to the table's native *M Euro* unit, another relevant unit (and its conversion factor with MEuro) has been defined: *B Euro*.



Objective Function Value

Original Units: M Euro   Active Unit M Euro   Dat

Scenario	REG1	REG2	Total
DemoS_012	10,886,683	13,981,286	24,867,969
DemoS_012EW	10,886,683	13,981,286	24,867,969
DemoS_012a	11,682,597	14,892,714	26,575,311
DemoS_(		5,731	27,068,966
DemoS_(		3,790	24,861,840
DemoS_(		4,463	25,017,208
DemoS_(			

Global Filter Applied For:

Figure 16: Choosing the display type

Selecting *B Euro* from the drop-down menu converts all data in the table. Defining units and conversion factors is discussed in Section 5.

2.3.4 View window toolbar

The view window has a toolbar with several icons. The name of each button is shown when the cursor is hovered over the corresponding button. Moving from left to right, here is a brief description of the tool bar buttons:

- Decrease or increase the number of digits after decimal;
- Save table changes. The first button saves the highlighted table only, and the next button saves all tables currently on screen (in the case of multiple tables). If changes were made while in view mode, the user is asked to provide a new name or to use the old name for the table (writing over its previous specifications). If you begin entering a new name, a checkbox will appear to allow you to retain the old table (with its original name) or substitute the new name for the old. Note that these save options save the *definition* of the table, as modified in view mode, as well as any layout modifications. They do not save the *data values* in the table. These are regenerated from the table definition each time the table is opened by choosing **View Table(s)** in the main window, unless the **Save Cube Files** user option has been selected, as described in Section 2.3.7.
- Sort the table. **Ascending** and **Descending** sort table rows by the data in the first column (only), while **Default** returns to sort by the row name. This feature can be useful when trying to identify the largest flows/costs in a table;
- Hide/Show blank/zero values;

- Export table (four options are provided: Excel, Word, Html, Text, of which Excel is the recommended option) or copy a portion of the table on to the clipboard. When the table is exported to a file, the date and time are appended to the table's name to constitute the name of the saved file. See Section 6 for more on using VEDA-BE in conjunction with Excel.
- Produce a graph of a selected table area: first block the table cells desired, then press the graph button (discussed further in Section 2.3.8);
- Print and Preview the current table;
- Set layout preferences (appearance, font, colors);
- Set the way multiple windows are shown (cascade, horizontally, vertically). These options are useful when several tables are viewed simultaneously.
- Close the view window. (You may also close individual tables by clicking on the X in the upper righthand corner of that table's window).

The /\ button located on the far right below the toolbar toggles showing and hiding the table's description in the header.

2.3.5 Global Filtering

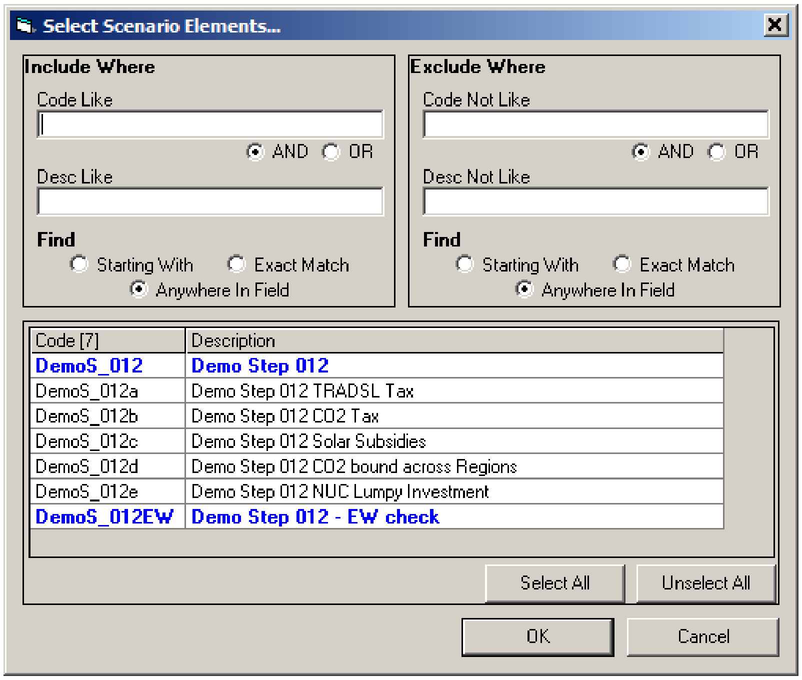
While we could easily verify, in this simple table, that the objective function values for the two scenarios we wished to compare were identical, in fact we made this task harder for ourselves by including four extraneous scenarios in the table. In general, efficient model results analysis is all about controlling *and limiting* what you see to only the essential items. The ***global filter*** feature supports this practice.

Global filters are set in the main VEDA-BE window. Close the current table (by clicking on the **X** in the upper right corner of the window or by clicking the **Exit** icon). Because we have modified the table layout, we are prompted to choose whether to **Save** our changes, **Exit** without saving, or **Cancel** and keep the table open. As with the Save toolbar buttons described in Section 2.3.4, clicking the **Save** button will give you the further choice of saving with a new name (optionally retaining the original table) or writing over the original table.

Back in the main window, there are two methods to set a global filter. Both start from the **Scenarios** tab:

- Option 1: hold down the **Control** key, and click on the desired scenarios in the scenarios list. Their rows will turn yellow, to indicate that they have been set within the global filter.
- Option 2: right click anywhere within the scenarios list, and choose **Global Filter** from the menu that appears. This brings up the selection window shown in Figure 17. Here you may select individual scenarios by clicking on them (turning them **bold blue**), filter scenarios by code or description, and **Select** or **Unselect All** from the filtered list.

Setting the global filter for the original and re-run *DemoS_012* scenarios results in the window appearance in Figure 18. The global filter status at the bottom now shows us that the global filter has been applied for the selected scenarios. The checkboxes allow you to remove the filters by dimension (if filters have been set for one or more dimensions) while retaining their specifications. The filters may be reengaged later by re-checking the box.



Include Where

Code Like:

● AND ○ OR

Desc Like:

Find

○ Starting With ○ Exact Match
● Anywhere In Field

Exclude Where

Code Not Like:

● AND ○ OR

Desc Not Like:

Find

○ Starting With ○ Exact Match
● Anywhere In Field

Code [7]	Description
DemoS_012	**Demo Step 012**
DemoS_012a	Demo Step 012 TRADSL Tax
DemoS_012b	Demo Step 012 CO2 Tax
DemoS_012c	Demo Step 012 Solar Subsidies
DemoS_012d	Demo Step 012 CO2 bound across Regions
DemoS_012e	Demo Step 012 NUC Lumpy Investment
DemoS_012EW	**Demo Step 012 - EW check**

Figure 17: Selecting scenarios for a global filter

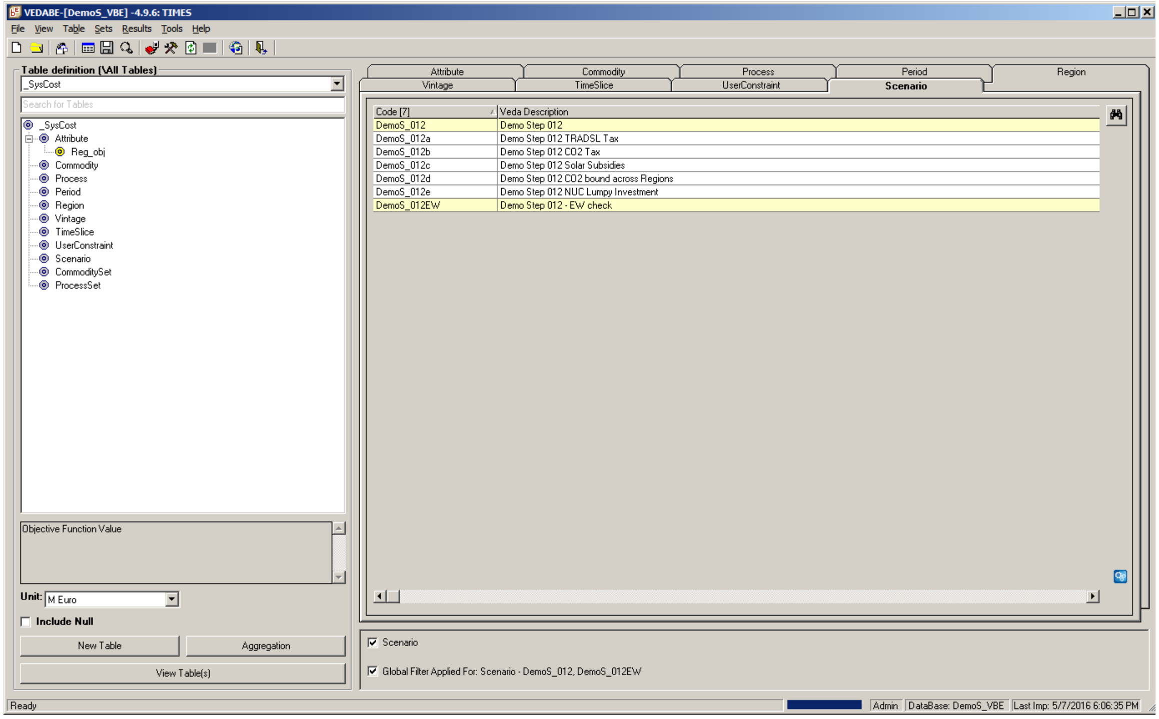


Table definition: _SysCost

Code [7]	Veda Description
DemoS_012	Demo Step 012
DemoS_012a	Demo Step 012 TRADSL Tax
DemoS_012b	Demo Step 012 CO2 Tax
DemoS_012c	Demo Step 012 Solar Subsidies
DemoS_012d	Demo Step 012 CO2 bound across Regions
DemoS_012e	Demo Step 012 NUC Lumpy Investment
DemoS_012EW	Demo Step 012 - EW check

Unit: M Euro

☐ Include Null

☑ Scenario

☑ Global Filter Applied For: Scenario - DemoS_012, DemoS_012EW

Ready | Admin | DataBase: DemoS_VBE | Last Imp: 5/7/2016 6:06:35 PM

Figure 18: Main window with global filter set on scenarios

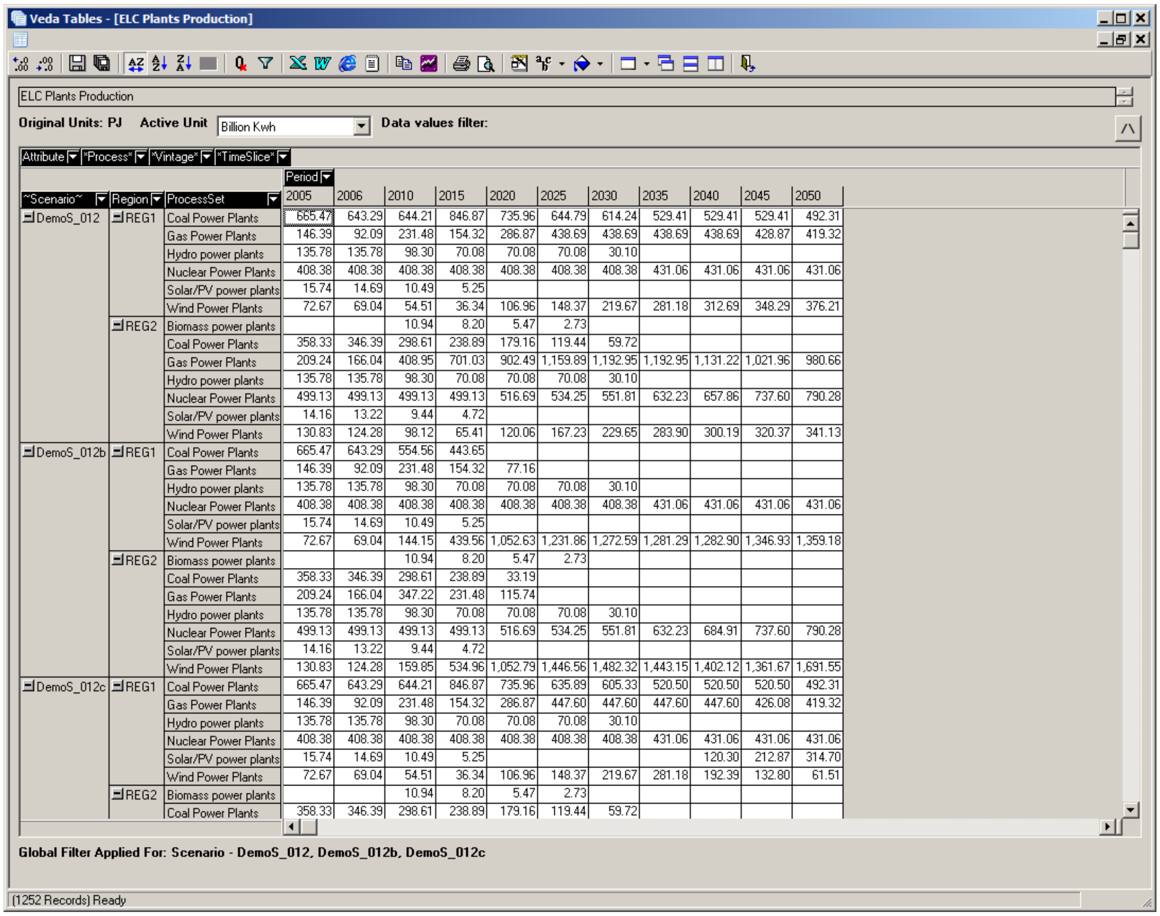
When we click **View Table(s)** with the filter engaged, we now see only the two selected scenarios. This filter will remain active for any subsequent tables created, until it is removed. Tables already open will not be affected.

Because scenarios and scenario names change often, and the global filter facilitates viewing only the scenarios you choose, it is recommended to *never* include scenarios in a table definition, and to simply use the global filter to select scenarios for viewing as you work. Global filters may also be set for other dimensions: *Region* may be convenient for analyzing results in large multi-region models, and *Attribute* can be useful in conjunction with the ExRES feature described in Section 2.4, to limit results shown in the full attributes mode.

To save a global filter for later re-use, click on the **Gear** icon in the lower right corner of the main window. Choose **New**, enter a name for the filter, and click the "check" icon. The filter may now be selected at any time by clicking on its name from the drop-down menu under the Gear icon.

2.3.6 Additional functions in the table view

To fully appreciate the power of the VEDA-BE table viewer, we need to work with a more complex table. Set a global filter for scenarios *DemoS_012*, *DemoS_012b* (carbon tax), and *DemoS_012c* (solar subsidy), and select the ***ELC Plants Production*** table. This table consists of the attribute ***Var_Act***, or process activity, and several process sets, each named *ELExxx*. Click **View Table(s)** to open the table view. When we first open the table, it looks like Figure 19.



ELC Plants Production

Original Units: PJ Active Unit Billion Kwh Data values filter:

Attribute *Process* *Vintage* *TimeSlice*

			Period										
~Scenario~	Region	ProcessSet	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
DemoS_012	REG1	Coal Power Plants	665.47	643.29	644.21	846.87	735.96	644.79	614.24	529.41	529.41	529.41	492.31
		Gas Power Plants	146.39	92.09	231.48	154.32	286.87	438.69	438.69	438.69	438.69	428.87	419.32
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		Solar/PV power plants	15.74	14.69	10.49	5.25							
		Wind Power Plants	72.67	69.04	54.51	36.34	106.96	148.37	219.67	281.18	312.69	348.29	376.21
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	179.16	119.44	59.72				
		Gas Power Plants	209.24	166.04	408.95	701.03	902.49	1,159.89	1,192.95	1,192.95	1,131.22	1,021.96	980.66
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	499.13	499.13	499.13	499.13	516.69	534.25	551.81	632.23	657.86	737.60	790.28
		Solar/PV power plants	14.16	13.22	9.44	4.72							
		Wind Power Plants	130.83	124.28	98.12	65.41	120.06	167.23	229.65	283.90	300.19	320.37	341.13
DemoS_012b	REG1	Coal Power Plants	665.47	643.29	554.56	443.65							
		Gas Power Plants	146.39	92.09	231.48	154.32	77.16						
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		Solar/PV power plants	15.74	14.69	10.49	5.25							
		Wind Power Plants	72.67	69.04	144.15	439.56	1,052.63	1,231.86	1,272.59	1,281.29	1,282.90	1,346.93	1,359.18
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	33.19						
		Gas Power Plants	209.24	166.04	347.22	231.48	115.74						
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	499.13	499.13	499.13	499.13	516.69	534.25	551.81	632.23	684.91	737.60	790.28
		Solar/PV power plants	14.16	13.22	9.44	4.72							
		Wind Power Plants	130.83	124.28	159.85	534.96	1,052.79	1,446.56	1,482.32	1,443.15	1,402.12	1,361.67	1,691.55
DemoS_012c	REG1	Coal Power Plants	665.47	643.29	644.21	846.87	735.96	635.89	605.33	520.50	520.50	520.50	492.31
		Gas Power Plants	146.39	92.09	231.48	154.32	286.87	447.60	447.60	447.60	447.60	426.08	419.32
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		Solar/PV power plants	15.74	14.69	10.49	5.25					120.30	212.87	314.70
		Wind Power Plants	72.67	69.04	54.51	36.34	106.96	148.37	219.67	281.18	192.39	132.80	61.51
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	179.16	119.44	59.72				

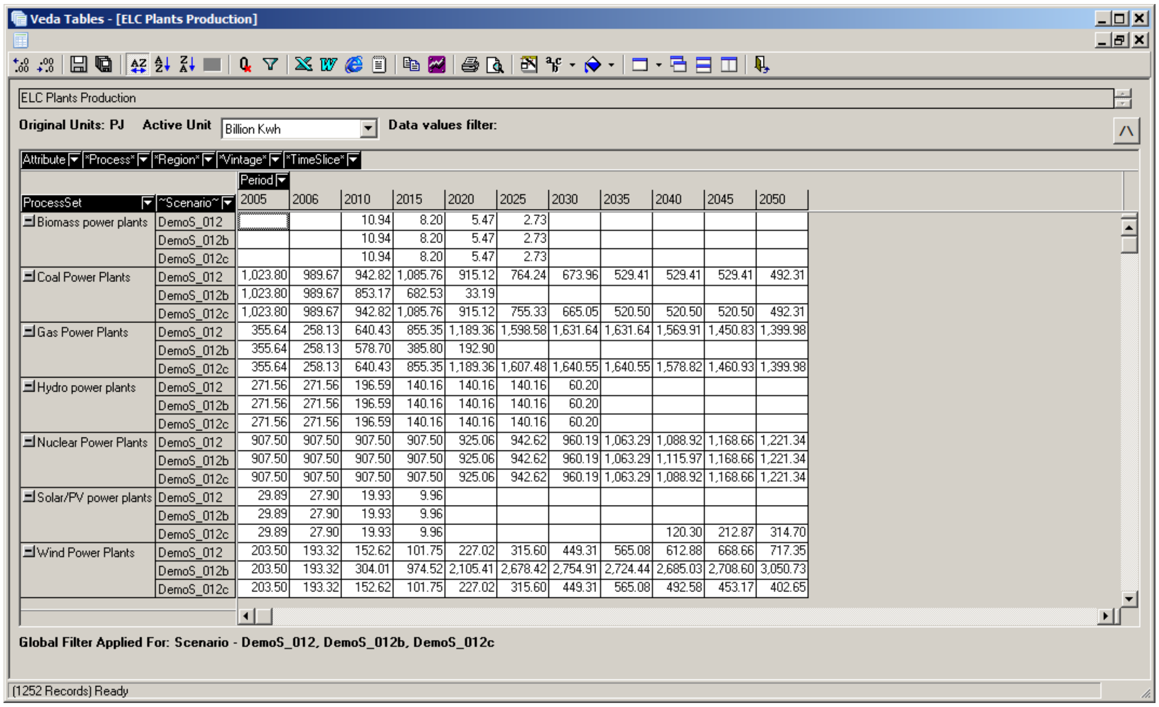
Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(1252 Records) Ready

Figure 19: The *ELC Plants Production* table, as first opened

We have *Scenario*, *Region*, and *ProcessSet* on rows, and *Period* on columns. The *ProcessSet* display has been set to *Description Only*, and the units have been set to *Billion Kwh*, from their original *PJ*.

Let us first drag *Region* up above to simplify the table. Then drag *Scenario* to the right of *ProcessSet.* This makes the table appear as in Figure 20 and allows us to compare power plant activity by type across scenarios more easily. We see, for example, that coal and gas plants entirely shut down by 2025 in the *DemoS_012b* (carbon tax) scenario, replaced by wind and solar plants, and that in the *DemoS_012c* (solar subsidy) scenario, solar plants take market share primarily away from wind plants, leaving the others largely unchanged.



ELC Plants Production

Original Units: PJ   Active Unit Billion Kwh   Data values filter:

ProcessSet	~Scenario~	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
Biomass power plants	DemoS_012			10.94	8.20	5.47	2.73					
	DemoS_012b			10.94	8.20	5.47	2.73					
	DemoS_012c			10.94	8.20	5.47	2.73					
Coal Power Plants	DemoS_012	1,023.80	989.67	942.82	1,085.76	915.12	764.24	673.96	529.41	529.41	529.41	492.31
	DemoS_012b	1,023.80	989.67	853.17	682.53	33.19						
	DemoS_012c	1,023.80	989.67	942.82	1,085.76	915.12	755.33	665.05	520.50	520.50	520.50	492.31
Gas Power Plants	DemoS_012	355.64	258.13	640.43	855.35	1,189.36	1,598.58	1,631.64	1,631.64	1,569.91	1,450.83	1,399.98
	DemoS_012b	355.64	258.13	578.70	385.80	192.90						
	DemoS_012c	355.64	258.13	640.43	855.35	1,189.36	1,607.48	1,640.55	1,640.55	1,578.82	1,460.93	1,399.98
Hydro power plants	DemoS_012	271.56	271.56	196.59	140.16	140.16	140.16	60.20				
	DemoS_012b	271.56	271.56	196.59	140.16	140.16	140.16	60.20				
	DemoS_012c	271.56	271.56	196.59	140.16	140.16	140.16	60.20				
Nuclear Power Plants	DemoS_012	907.50	907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,088.92	1,168.66	1,221.34
	DemoS_012b	907.50	907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,115.97	1,168.66	1,221.34
	DemoS_012c	907.50	907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,088.92	1,168.66	1,221.34
Solar/PV power plants	DemoS_012	29.89	27.90	19.93	9.96							
	DemoS_012b	29.89	27.90	19.93	9.96							
	DemoS_012c	29.89	27.90	19.93	9.96					120.30	212.87	314.70
Wind Power Plants	DemoS_012	203.50	193.32	152.62	101.75	227.02	315.60	449.31	565.08	612.88	668.66	717.35
	DemoS_012b	203.50	193.32	304.01	974.52	2,105.41	2,678.42	2,754.91	2,724.44	2,685.03	2,708.60	3,050.73
	DemoS_012c	203.50	193.32	152.62	101.75	227.02	315.60	449.31	565.08	492.58	453.17	402.65

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

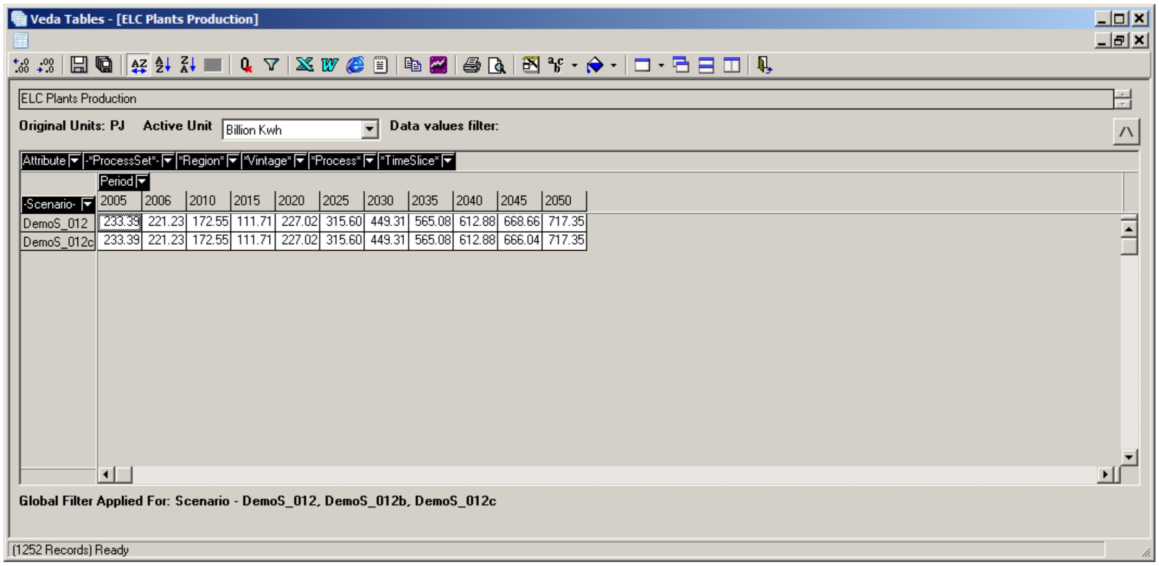
(1252 Records) Ready

Figure 20: The *ELC Plants Production* table, as rearranged

To get additional detail, pull *Process* down to the row headers, between *ProcessSet* and *Region*, so that we may still compare scenarios directly against each other. We see that most of the process sets in the table contain more than one process that operates in these scenarios, generally an existing process that retires partway through the model horizon, and a new process whose activity grows over time. (We will see in Section 3 how these process sets are created.)

We can focus the view further by removing some items temporarily from view. Each (black) dimension header contains a triangle revealing a drop-down menu of all items under that dimension in the table definition when clicked. Individual items can be deselected and reselected by clearing and re-checking the checkbox next to their names, and the entire list can be selected or cleared by holding down the **Control** key while clicking a single checkbox.

For example, by selecting only *Solar/PV* and *Wind power plants* from the *ProcessSet* list, and only *DemoS_012* and *DemoS_012c* from the *Scenarios* list, and then pulling both *ProcessSet* and *Process* up above, we now see the total generation from wind and solar plants in these two scenarios, and can see just how close the totals are (Figure 21).



Veda Tables - [ELC Plants Production]

ELC Plants Production

Original Units: PJ Active Unit Billion Kwh Data values filter:

Attribute -*ProcessSet*- *Region* *Vintage* *Process* *TimeSlice*

Period	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
-Scenario-											
DemoS_012	233.39	221.23	172.55	111.71	227.02	315.60	449.31	565.08	612.88	668.66	717.35
DemoS_012c	233.39	221.23	172.55	111.71	227.02	315.60	449.31	565.08	612.88	666.04	717.35

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(1252 Records) Ready

Figure 21: The *ELC Plants Production* table, rearranged to show total solar and wind plant activity

Note that if you choose to **Save** the table after these modifications, both the process set selections and the scenario selections will be saved in the table definition, because explicit choices have been made for both.

An alternative to removing items from a table while managing the volume of information displayed is to selectively collapse and open sections of the table using the "+" and "-" icons next to elements that have dimensions nested beneath them. For example, returning to the original ***ELC Plants Production*** view shown in Figure 19 and clicking "-" icon next to *DemoS_012* in the Scenarios column collapses all the results for that scenario, showing just the total over all collapsed rows. You may collapse all the table sections associated with a particular dimension by right clicking on any item in that dimension and choosing **Details** from the drop-down menu that appears. You may then selectively reopen desired sections by clicking on the relevant "+" icon.

2.3.7 Saving data cubes

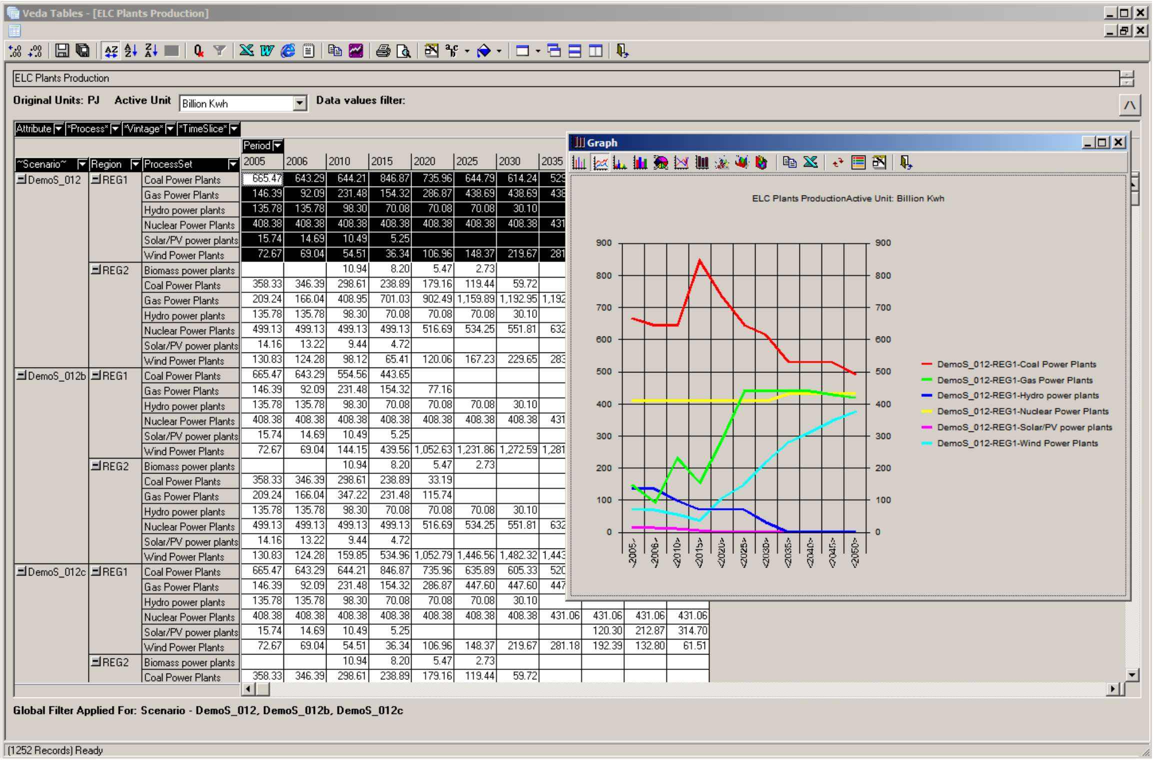
The table **Save** operation described in the previous section saves the *definitions* and *layout options* for tables, which will be recreated from these saved specifications the text time the table is viewed. Another kind of "save" operation is possible: saving the *data cube* itself as it has been created. The option to do so is a global user preference, set by choosing **Options** from the **Tools** menu in the main window, and then checking the box labeled **Save Cube Files**. If selected, this option will reopen an existing table almost instantly, as long as the content of the table has not changed since the last request. VEDA-BE keeps track of any potential changes and recreates the cube when necessary. This option can greatly speed up work if you expect to view the same tables repeatedly.

When viewing saved cube files, the pivot, select and deselect, and subtotal options are all available, but swapping code and description is not. All cubes are deleted whenever scenarios are imported or deleted. Choosing **Delete Cube File(s)** from the **Tools** menu will manually force a delete of all saved cubes.

2.3.8 The VEDA-BE graphing function

A final feature available in the view window is the graphing function. An entire data table or any portion thereof may be graphed by selecting the desired data points and either right clicking and choosing **Graph** from the drop-down menu or clicking the graph button on the toolbar. (If no data is selected, the entire table will be graphed.) For example, returning the *ELC Plants Production* table to its original Figure 19 configuration, selecting all the data rows for *REG1* in scenario *DemoS_012*, and clicking the **Graph** button yields the graph shown in Figure 22.

The toolbar at the top of the **Graph** window contains options to change the type of graph, switch rows and columns, copy to the clipboard or export to Excel, and toggle the legend, as well as a **Graph Settings window** with numerous options to format the graph, as well as to hide or remove individual series. These simple graphs can help the user quickly get a visual feel for one or more data series, but for creating and maintaining more complex or customized graphs for presentations and reports, the **Update Excel File** feature discussed in Section 6.3 is recommended.


Veda Tables - [ELC Plants Production]
Graph
ELC Plants ProductionActive Unit: Billion Kwh
900
800
700
600
500
400
300
200
100
0
<2005>
<2006>
<2010>
<2015>
<2020>
<2025>
<2030>
<2035>
<2040>
<2045>
<2050>
DemoS_012-REG1-Coal Power Plants
DemoS_012-REG1-Gas Power Plants
DemoS_012-REG1-Hydro power plants
DemoS_012-REG1-Nuclear Power Plants
DemoS_012-REG1-Solar/PV power plants
DemoS_012-REG1-Wind Power Plants

ELC Plants Production

Original Units: PJ Active Unit Billion Kwh Data values filter:

Attribute *Process* *Vintage* *TimeSlice*

~Scenario~	Region	ProcessSet	2005	2006	2010	2015	2020	2025	2030	2035			
DemoS_012	REG1	Coal Power Plants	665.47	643.29	644.21	846.87	735.96	644.79	614.24	529			
		Gas Power Plants	146.39	92.09	231.48	154.32	286.87	438.69	438.69	438			
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431			
		Solar/PV power plants	15.74	14.69	10.49	5.25							
		Wind Power Plants	72.67	69.04	54.51	36.34	106.96	148.37	219.67	281			
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	179.16	119.44	59.72				
		Gas Power Plants	209.24	166.04	408.95	701.03	902.49	1,159.89	1,192.95	1,192			
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	499.13	499.13	499.13	499.13	516.69	534.25	551.81	632			
		Solar/PV power plants	14.16	13.22	9.44	4.72							
		Wind Power Plants	130.83	124.28	98.12	65.41	120.06	167.23	229.65	283			
DemoS_012b	REG1	Coal Power Plants	665.47	643.29	554.56	443.65							
		Gas Power Plants	146.39	92.09	231.48	154.32	77.16						
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431			
		Solar/PV power plants	15.74	14.69	10.49	5.25							
		Wind Power Plants	72.67	69.04	144.15	439.56	1,052.63	1,231.86	1,272.59	1,281			
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	33.19						
		Gas Power Plants	209.24	166.04	347.22	231.48	115.74						
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	499.13	499.13	499.13	499.13	516.69	534.25	551.81	632			
		Solar/PV power plants	14.16	13.22	9.44	4.72							
		Wind Power Plants	130.83	124.28	159.85	534.96	1,052.79	1,446.56	1,482.32	1,443			
DemoS_012c	REG1	Coal Power Plants	665.47	643.29	644.21	846.87	735.96	635.89	605.33	520			
		Gas Power Plants	146.39	92.09	231.48	154.32	286.87	447.60	447.60	447			
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		Solar/PV power plants	15.74	14.69	10.49	5.25					120.30	212.87	314.70
		Wind Power Plants	72.67	69.04	54.51	36.34	106.96	148.37	219.67	281.18	192.39	132.80	61.51
	REG2	Biomass power plants			10.94	8.20	5.47	2.73					
		Coal Power Plants	358.33	346.39	298.61	238.89	179.16	119.44	59.72				

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

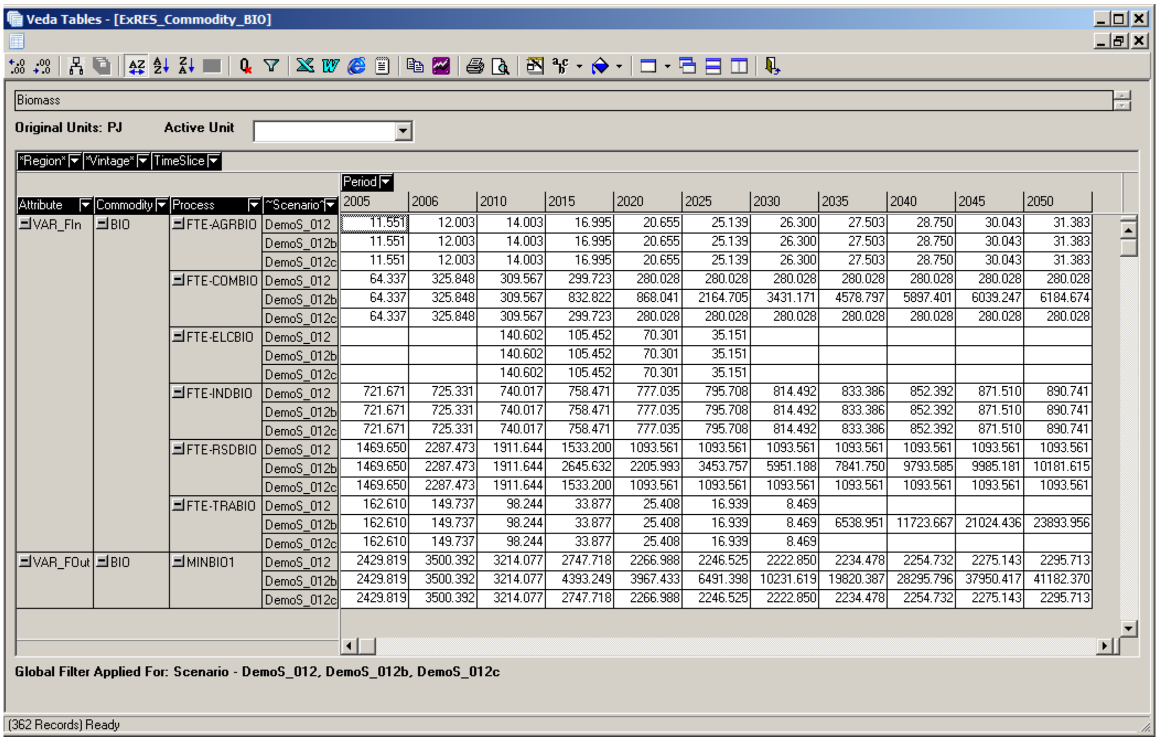
(1252 Records) Ready

Figure 22: Creating a simple graph in VEDA-BE

2.4 Viewing results in the ExRES

It is not necessary to define a table every time you wish to view results. Another equally powerful, but quite different method for viewing results is the **ExRES** (for “Extended RES”). This tool lets you zero in on model results *as they are connected in the model’s Reference Energy System (RES).* Starting from the main window, the ExRES can be invoked for any process or process set, commodity or commodity set, or user constraint to rapidly get results information for that item or set.

For example, to view results data for commodity *BIO (Biomass)*, right click on its listing on the *Commodity* tab and choose **ExRES** from the menu that appears. This will create the table shown in Figure 23 for all scenarios in the currently set global filter. It shows all data associated with the ***VAR_Fin*** (*Commodity Consumption by Process*, or uses) and ***VAR_Fout*** (*Commodity Production by Process*, or sources) attributes for the selected commodity. (Had we launched the ExRES from a process, *VAR_Fin* and *VAR_Fout* would still be the displayed attributes, now representing all inputs to and outputs from the selected process.)



Veda Tables - [ExRES_Commodity_BIO]

Biomass

Original Units: PJ   Active Unit

Region *Vintage* TimeSlice

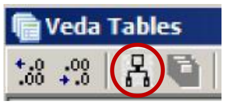
Attribute	Commodity	Process	~Scenario~	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
VAR_FIn	BIO	FTE-AGRBIO	DemoS_012	11.551	12.003	14.003	16.995	20.655	25.139	26.300	27.503	28.750	30.043	31.383
			DemoS_012b	11.551	12.003	14.003	16.995	20.655	25.139	26.300	27.503	28.750	30.043	31.383
			DemoS_012c	11.551	12.003	14.003	16.995	20.655	25.139	26.300	27.503	28.750	30.043	31.383
		FTE-COMBIO	DemoS_012	64.337	325.848	309.567	299.723	280.028	280.028	280.028	280.028	280.028	280.028	280.028
			DemoS_012b	64.337	325.848	309.567	832.822	868.041	2164.705	3431.171	4578.797	5897.401	6039.247	6184.674
			DemoS_012c	64.337	325.848	309.567	299.723	280.028	280.028	280.028	280.028	280.028	280.028	280.028
		FTE-ELCBIO	DemoS_012			140.602	105.452	70.301	35.151					
			DemoS_012b			140.602	105.452	70.301	35.151					
			DemoS_012c			140.602	105.452	70.301	35.151					
		FTE-INDBIO	DemoS_012	721.671	725.331	740.017	758.471	777.035	795.708	814.492	833.386	852.392	871.510	890.741
			DemoS_012b	721.671	725.331	740.017	758.471	777.035	795.708	814.492	833.386	852.392	871.510	890.741
			DemoS_012c	721.671	725.331	740.017	758.471	777.035	795.708	814.492	833.386	852.392	871.510	890.741
		FTE-RSDBIO	DemoS_012	1469.650	2287.473	1911.644	1533.200	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561
			DemoS_012b	1469.650	2287.473	1911.644	2645.632	2205.993	3453.757	5951.188	7841.750	9793.585	9985.181	10181.615
			DemoS_012c	1469.650	2287.473	1911.644	1533.200	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561
		FTE-TRABIO	DemoS_012	162.610	149.737	98.244	33.877	25.408	16.939	8.469				
			DemoS_012b	162.610	149.737	98.244	33.877	25.408	16.939	8.469	6538.951	11723.667	21024.436	23893.956
			DemoS_012c	162.610	149.737	98.244	33.877	25.408	16.939	8.469				
VAR_FOut	BIO	MINBIO1	DemoS_012	2429.819	3500.392	3214.077	2747.718	2266.988	2246.525	2222.850	2234.478	2254.732	2275.143	2295.713
			DemoS_012b	2429.819	3500.392	3214.077	4393.249	3967.433	6491.398	10231.619	19820.387	28295.796	37950.417	41182.370
			DemoS_012c	2429.819	3500.392	3214.077	2747.718	2266.988	2246.525	2222.850	2234.478	2254.732	2275.143	2295.713

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(362 Records) Ready

Figure 23: The ExRES for commodity *BIO*

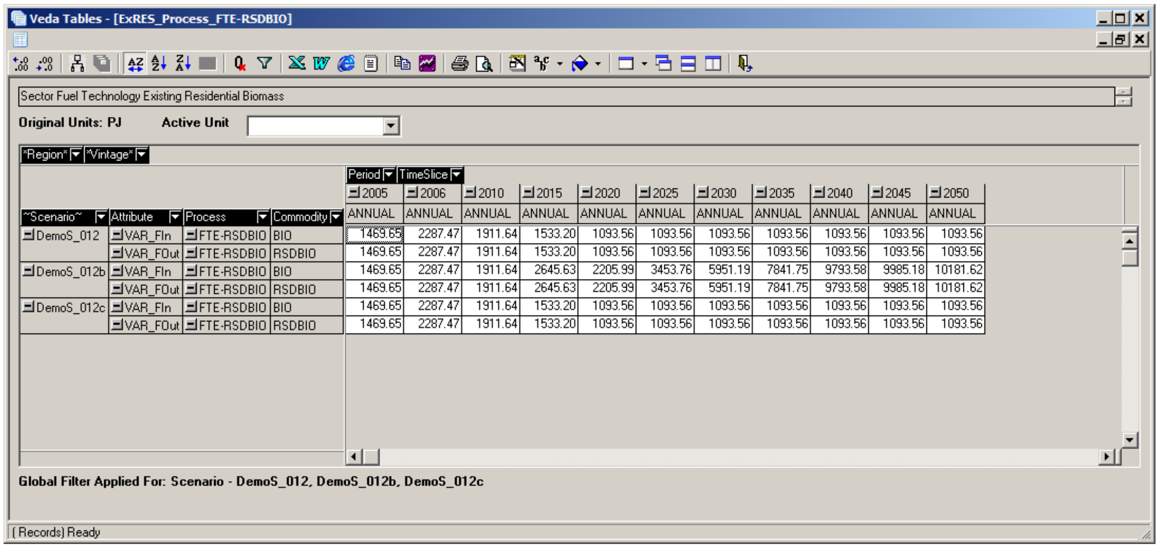
This input-and-output-flows view of the ExRES may be toggled with a full results details view by clicking the third icon from left in the view window menu bar.



Doing so will display *all* the results data associated with the selected item. Clicking the icon (which changes appearance in this mode to indicate that additional data is being shown) again will return to the flows-only view. The full results ExRES view may be refined by setting a global filter on desired attributes. For example, setting a global filter on ***EQ_CombalM***, ***VAR_Fin***, and ***VAR_FOut*** can aid in fuel chain debugging by allowing you to see only commodity production, consumption, and prices.

The ExRES view allows you to move up and downstream in the model RES to trace the sources and/or uses of commodities, making it a key tool for model debugging. Clicking on any process or commodity name in the table view will launch an ExRES window for that item. This may be pursued as far up or down the RES network as needed.

For example, clicking on *FTE-RSDBIO* in the table shown in Figure 23 reveals that this process merely changes the name of *BIO* to *RSDBIO* for purposes of sector fuel accounting (Figure 24). Clicking on *RSDBIO* then allows us to see that the primary use of increased residential biomass in the carbon tax scenario is a new space heating technology (where the tooltip of the process description has been shown in Figure 25 by hovering over the process name *RSHNBIO1*).



Veda Tables - [ExRES_Process_FTE-RSDBIO]

Sector Fuel Technology Existing Residential Biomass

Original Units: PJ   Active Unit

Region *Vintage*

~Scenario~	Attribute	Process	Commodity	2005 ANNUAL	2006 ANNUAL	2010 ANNUAL	2015 ANNUAL	2020 ANNUAL	2025 ANNUAL	2030 ANNUAL	2035 ANNUAL	2040 ANNUAL	2045 ANNUAL	2050 ANNUAL
DemoS_012	VAR_FIn	FTE-RSDBIO	BIO	1469.65	2287.47	1911.64	1533.20	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56
	VAR_FOut	FTE-RSDBIO	RSDBIO	1469.65	2287.47	1911.64	1533.20	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56
DemoS_012b	VAR_FIn	FTE-RSDBIO	BIO	1469.65	2287.47	1911.64	2645.63	2205.99	3453.76	5951.19	7841.75	9793.58	9985.18	10181.62
	VAR_FOut	FTE-RSDBIO	RSDBIO	1469.65	2287.47	1911.64	2645.63	2205.99	3453.76	5951.19	7841.75	9793.58	9985.18	10181.62
DemoS_012c	VAR_FIn	FTE-RSDBIO	BIO	1469.65	2287.47	1911.64	1533.20	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56
	VAR_FOut	FTE-RSDBIO	RSDBIO	1469.65	2287.47	1911.64	1533.20	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56	1093.56

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(Records) Ready

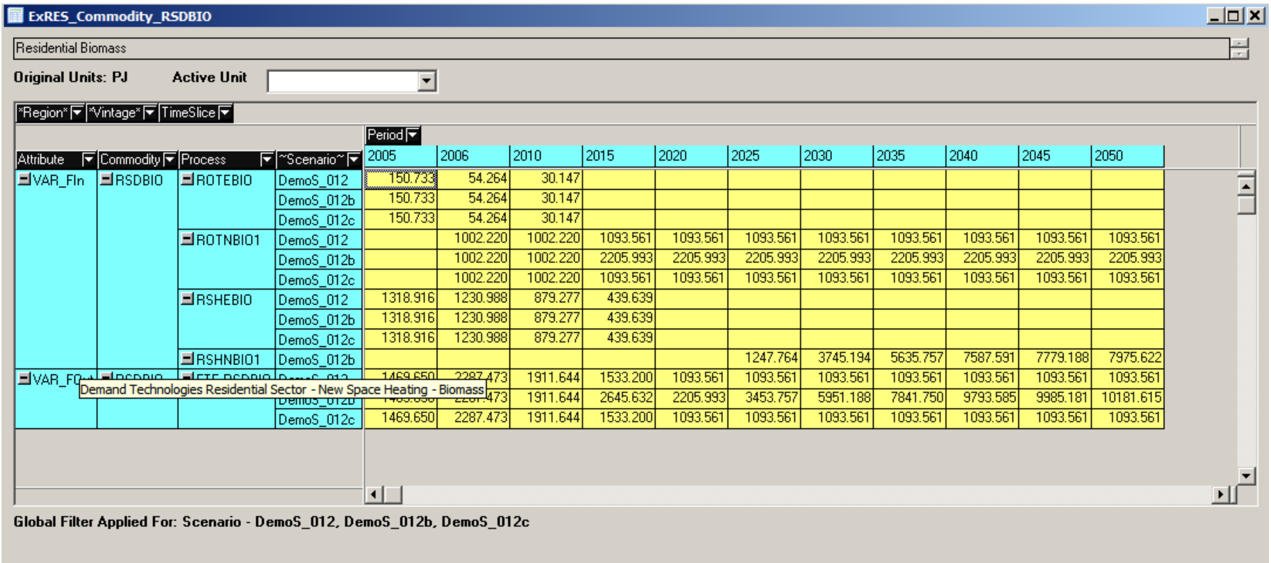
Figure 24: The ExRES for *FTE-RSDBIO*

To make it readily apparent when you are using an ExRES rather than table view, it is recommended to use the **view window** formatting tool, available from the **paint bucket icon** in the view window toolbar to make the formatting of ExRES views distinct from table views. Figure 25 shows an example, where the table body (**Back Color** menu option) and items lists (**Headings Back Color** menu option) background color defaults have been changed. Once set in a single ExRES view, these formats will be active for all future ExRES views launched in the database.

The ExRES can also be invoked within the table view mode, by right clicking on any process, commodity, process set, or commodity set name in the table and choosing **ExRES** from the menu that appears (see Figure 26). This is an excellent way to further investigate the results you see in any table.

From the main window there is an additional ExRES function available by right clicking on any commodity, process, or user constraint name: the **Related ExRES**. This menu item allows you to generate an ExRES as follows:

- If selected for a commodity, all *Processes* consuming or producing that commodity, or all *User constraints* involving that commodity;
- If selected for a process, all *Commodities* being consumed or produced by that process, or all *User constraints* involving that process; and
- If selected for a user constraint, all *Commodities* or *Processes* involved in that user constraint.


ExRES_Commodity_RSDBIO

Residential Biomass

Original Units: PJ   Active Unit

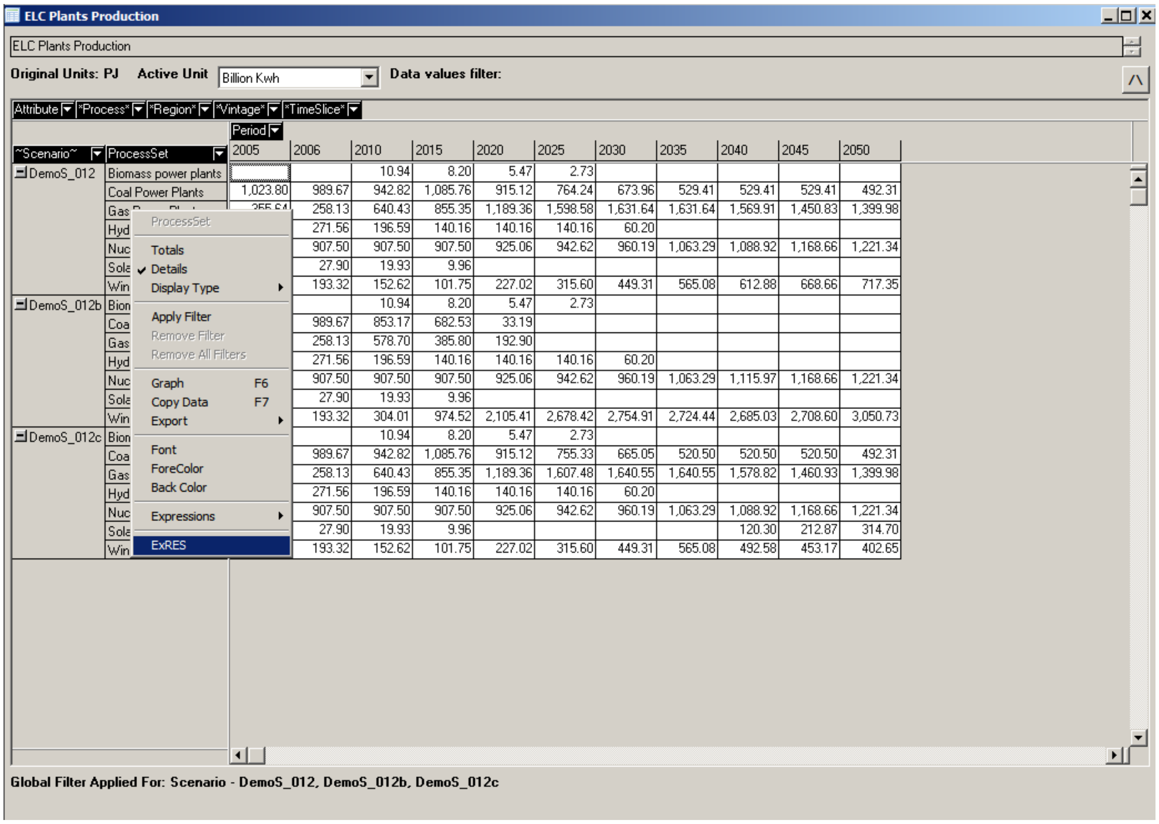
Region | *Vintage* | TimeSlice

Attribute	Commodity	Process	~Scenario~	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
VAR_FIn	RSDBIO	ROTEBIO	DemoS_012	150.733	54.264	30.147								
			DemoS_012b	150.733	54.264	30.147								
			DemoS_012c	150.733	54.264	30.147								
		ROTNBIO1	DemoS_012		1002.220	1002.220	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561
			DemoS_012b		1002.220	1002.220	2205.993	2205.993	2205.993	2205.993	2205.993	2205.993	2205.993	2205.993
			DemoS_012c		1002.220	1002.220	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561
		RSHEBIO	DemoS_012	1318.916	1230.988	879.277	439.639							
			DemoS_012b	1318.916	1230.988	879.277	439.639							
			DemoS_012c	1318.916	1230.988	879.277	439.639							
		RSHNBIO1	DemoS_012b						1247.764	3745.194	5635.757	7587.591	7779.188	7975.622
VAR_FOut	RSDBIO	FTE-RSDBIO	DemoS_012	1469.650	2287.473	1911.644	1533.200	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561
			DemoS_012b	1469.650	2287.473	1911.644	2645.632	2205.993	3453.757	5951.188	7841.750	9793.585	9985.181	10181.615
			DemoS_012c	1469.650	2287.473	1911.644	1533.200	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561	1093.561

Demand Technologies Residential Sector - New Space Heating - Biomass

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

Figure 25: The ExRES for RSDBIO, with background coloring options set


ELC Plants Production

ELC Plants Production

Original Units: PJ   Active Unit: Billion Kwh   Data values filter:

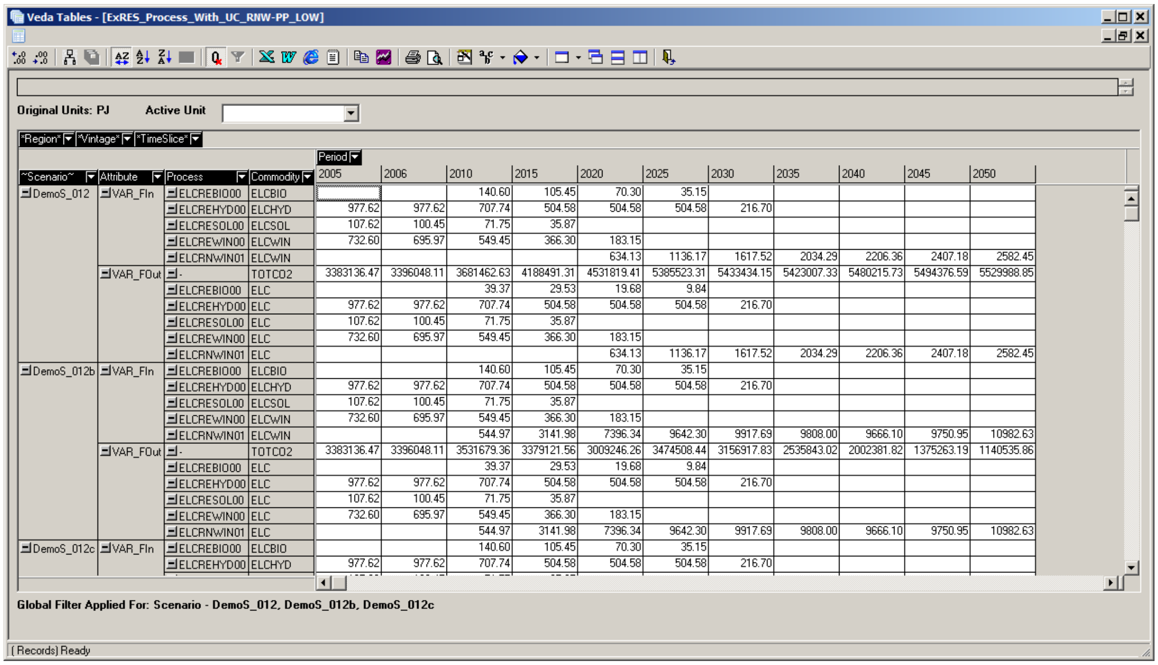
Attribute | *Process* | *Region* | *Vintage* | *TimeSlice*

~Scenario~	ProcessSet	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
DemoS_012	Biomass power plants			10.94	8.20	5.47	2.73					
	Coal Power Plants	1,023.80	989.67	942.82	1,085.76	915.12	764.24	673.96	529.41	529.41	529.41	492.31
	Gas P... Pl...	255.64	258.13	640.43	855.35	1,189.36	1,598.58	1,631.64	1,631.64	1,569.91	1,450.83	1,399.98
	Hyd		271.56	196.59	140.16	140.16	140.16	60.20				
	Nuc		907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,088.92	1,168.66	1,221.34
	Sola		27.90	19.93	9.96							
	Win		193.32	152.62	101.75	227.02	315.60	449.31	565.08	612.88	668.66	717.35
DemoS_012b	Bion			10.94	8.20	5.47	2.73					
	Coa		989.67	853.17	682.53	33.19						
	Gas		258.13	578.70	385.80	192.90						
	Hyd		271.56	196.59	140.16	140.16	140.16	60.20				
	Nuc		907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,115.97	1,168.66	1,221.34
	Sola		27.90	19.93	9.96							
	Win		193.32	304.01	974.52	2,105.41	2,678.42	2,754.91	2,724.44	2,685.03	2,708.60	3,050.73
DemoS_012c	Bion			10.94	8.20	5.47	2.73					
	Coa		989.67	942.82	1,085.76	915.12	755.33	665.05	520.50	520.50	520.50	492.31
	Gas		258.13	640.43	855.35	1,189.36	1,607.48	1,640.55	1,640.55	1,578.82	1,460.93	1,399.98
	Hyd		271.56	196.59	140.16	140.16	140.16	60.20				
	Nuc		907.50	907.50	907.50	925.06	942.62	960.19	1,063.29	1,088.92	1,168.66	1,221.34
	Sola		27.90	19.93	9.96					120.30	212.87	314.70
	Win		193.32	152.62	101.75	227.02	315.60	449.31	565.08	492.58	453.17	402.65

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

Figure 26: Invoking the ExRES within a table view

For example, right clicking on *UC_RNW-PP_LOW* on the *UserConstraint* tab and choosing **Related ExRES of → Process** generates the ExRES shown in Figure 27, displaying all inputs and outputs of the processes involved in that user constraint.



Veda Tables - [ExRES_Process_With_UC_RNW-PP_LOW]

Original Units: PJ Active Unit

~Scenario~	Attribute	Process	Commodity	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
DemoS_012	VAR_FIn	ELCREBIO00	ELCBIO			140.60	105.45	70.30	35.15					
		ELCREHYD00	ELCHYD	977.62	977.62	707.74	504.58	504.58	504.58	216.70				
		ELCRESOL00	ELCSOL	107.62	100.45	71.75	35.87							
		ELCREWIN00	ELCWIN	732.60	695.97	549.45	366.30	183.15						
		ELCRNWIN01	ELCWIN					634.13	1136.17	1617.52	2034.29	2206.36	2407.18	2582.45
	VAR_FOut	-	TOTCO2	3383136.47	3396048.11	3681462.63	4188491.31	4531819.41	5385523.31	5433434.15	5423007.33	5480215.73	5494376.59	5529988.85
		ELCREBIO00	ELC			39.37	29.53	19.68	9.84					
		ELCREHYD00	ELC	977.62	977.62	707.74	504.58	504.58	504.58	216.70				
		ELCRESOL00	ELC	107.62	100.45	71.75	35.87							
		ELCREWIN00	ELC	732.60	695.97	549.45	366.30	183.15						
		ELCRNWIN01	ELC					634.13	1136.17	1617.52	2034.29	2206.36	2407.18	2582.45
DemoS_012b	VAR_FIn	ELCREBIO00	ELCBIO			140.60	105.45	70.30	35.15					
		ELCREHYD00	ELCHYD	977.62	977.62	707.74	504.58	504.58	504.58	216.70				
		ELCRESOL00	ELCSOL	107.62	100.45	71.75	35.87							
		ELCREWIN00	ELCWIN	732.60	695.97	549.45	366.30	183.15						
		ELCRNWIN01	ELCWIN			544.97	3141.98	7396.34	9642.30	9917.69	9808.00	9666.10	9750.95	10982.63
	VAR_FOut	-	TOTCO2	3383136.47	3396048.11	3531679.36	3379121.56	3009246.26	3474508.44	3156917.83	2535843.02	2002381.82	1375263.19	1140535.86
		ELCREBIO00	ELC			39.37	29.53	19.68	9.84					
		ELCREHYD00	ELC	977.62	977.62	707.74	504.58	504.58	504.58	216.70				
		ELCRESOL00	ELC	107.62	100.45	71.75	35.87							
		ELCREWIN00	ELC	732.60	695.97	549.45	366.30	183.15						
		ELCRNWIN01	ELC			544.97	3141.98	7396.34	9642.30	9917.69	9808.00	9666.10	9750.95	10982.63
DemoS_012c	VAR_FIn	ELCREBIO00	ELCBIO			140.60	105.45	70.30	35.15					
		ELCREHYD00	ELCHYD	977.62	977.62	707.74	504.58	504.58	504.58	216.70				

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(Records) Ready

Figure 27: The Related ExRES for *UC_RNW-PP_LOW*

3 Sets: A powerful tool

A key building block in the construction of VEDA-BE tables is the ability to create user-defined sets of model processes and commodities. While simple tables, such as the *_SysCost* table viewed in Section 2.3, do not require them, most VEDA-BE tables make use of process and/or commodity sets. A set is a group of like items grouped *by rule* in order to view their results together (and in VEDA-FE, to apply common input data.) Upon creation, a VEDA-BE database contains only those sets passed from the model by the GDX2VEDA utility, such as process sets *ELE* (electric power plants), *DMD* (demand devices), and *PRE* (energy processes), and commodity sets *DEM* (demands), *ENV* (emissions), and *NRG* (energy carriers).

Because a TIMES model may contain hundreds, or even thousands, of processes, the ability to group items into sets using logical rules becomes an essential component in the analysis of large models.

Remark: Note that the importance of sets has implications for model *design*. Structured naming conventions for items must be developed *and scrupulously adhered to* in order to make use of the ability to create sets using rules based on item names. Item descriptions may also be used in set creation, and so should not be overlooked for holding, in carefully structured form, information needed – or information that may be useful in the future – to create sets[5].

3.1 The set definition window

Set definitions can be viewed, edited, and created in the **set definition** window, which can be accessed for an existing set by selecting **Edit Set** from the **Sets** menu or right clicking on a set name on the **Process** tab and selecting **Edit/View Set** from the menu that appears, or, for a new set, by choosing **New Set(s)** from the **Sets** menu. A combo box in the upper lefthand corner of the allow the user to switch between working with commodity and process sets.

The set definition window allows sets to be defined through rules that include and/or exclude items based on:

- membership in other sets,
- characters in the item name and/or description, and
- for process sets, input and output commodities.

In specifying rules for item names and descriptions, the wildcards "?", "_", and "*" may be used to specify a single character wildcard (question mark and underscore[6]) and a general wildcard (asterisk) for any number of characters, respectively.

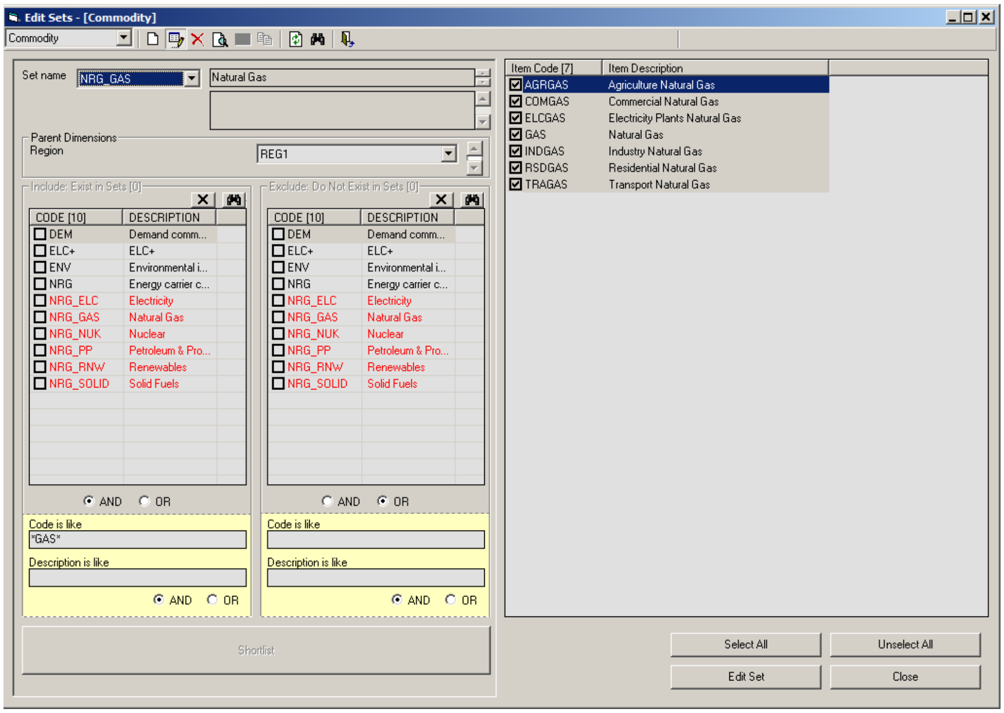
The rules that define any existing set, and its resulting members, can most easily be examined by right clicking on its listing on the **Commodity** or **Process** tab and choosing **Edit/View Set** from the menu that appears. Note that to manipulate the set definition form in any way, including

[5] See Wright and Kanudia (2015), "Highly Detailed TIMES Modeling to Analyze Interactions between Air Quality and Climate Regulations in the United States," in Giannakidis, G., Labriet, M., Ó Gallachóir, B., Tosato, G. (Eds.), *Informing Energy and Climate Policies using Energy Systems Models: Insights from Scenario Analysis Increasing the Evidence Base*, Springer, for one example of how item descriptions have been packed with information in the FACETS model. Available at: http://facets-model.com/mats/.

[6] Note that to filter for a underscore in an item name or description, it is necessary to enclose it in square brackets ("[ ]") so that it will be interpreted as a literal character, rather than a wildcard.

to scroll through the *Exist in Sets* lists, you must press the **Edit Set** button in the lower righthand corner of the window. Within the window, you may move to view another set by selecting its name from the **Set name** drop-down menu in the upper lefthand corner of the window.

Figures 28-30 show several examples of how these rules may be combined to create sets. Figure 28 shows how this window is used to specify a very simple set definition: all commodities that contain the string "GAS" in their names.



Edit Sets - [Commodity]

Commodity

Set name: NRG_GAS — Natural Gas

Parent Dimensions
Region: REG1

Include: Exist in Sets [0]

CODE [10]	DESCRIPTION
□ DEM	Demand comm...
□ ELC+	ELC+
□ ENV	Environmental i...
□ NRG	Energy carrier c...
□ NRG_ELC	Electricity
□ NRG_GAS	Natural Gas
□ NRG_NUK	Nuclear
□ NRG_PP	Petroleum & Pro...
□ NRG_RNW	Renewables
□ NRG_SOLID	Solid Fuels

● AND ○ OR

Code is like: *GAS*

Description is like:

● AND ○ OR

Exclude: Do Not Exist in Sets [0]

CODE [10]	DESCRIPTION
□ DEM	Demand comm...
□ ELC+	ELC+
□ ENV	Environmental i...
□ NRG	Energy carrier c...
□ NRG_ELC	Electricity
□ NRG_GAS	Natural Gas
□ NRG_NUK	Nuclear
□ NRG_PP	Petroleum & Pro...
□ NRG_RNW	Renewables
□ NRG_SOLID	Solid Fuels

○ AND ● OR

Code is like:

Description is like:

● AND ○ OR

Item Code [7]	Item Description
☑ AGRGAS	Agriculture Natural Gas
☑ COMGAS	Commercial Natural Gas
☑ ELCGAS	Electricity Plants Natural Gas
☑ GAS	Natural Gas
☑ INDGAS	Industry Natural Gas
☑ RSDGAS	Residential Natural Gas
☑ TRAGAS	Transport Natural Gas

Figure 28: The *NRG_GAS* set definition

Figure 29 shows an example of a definition making use of the Exist in and Input Commodity criteria: all items in the set *ELE* that take input commodities having any of four specified strings in their names.

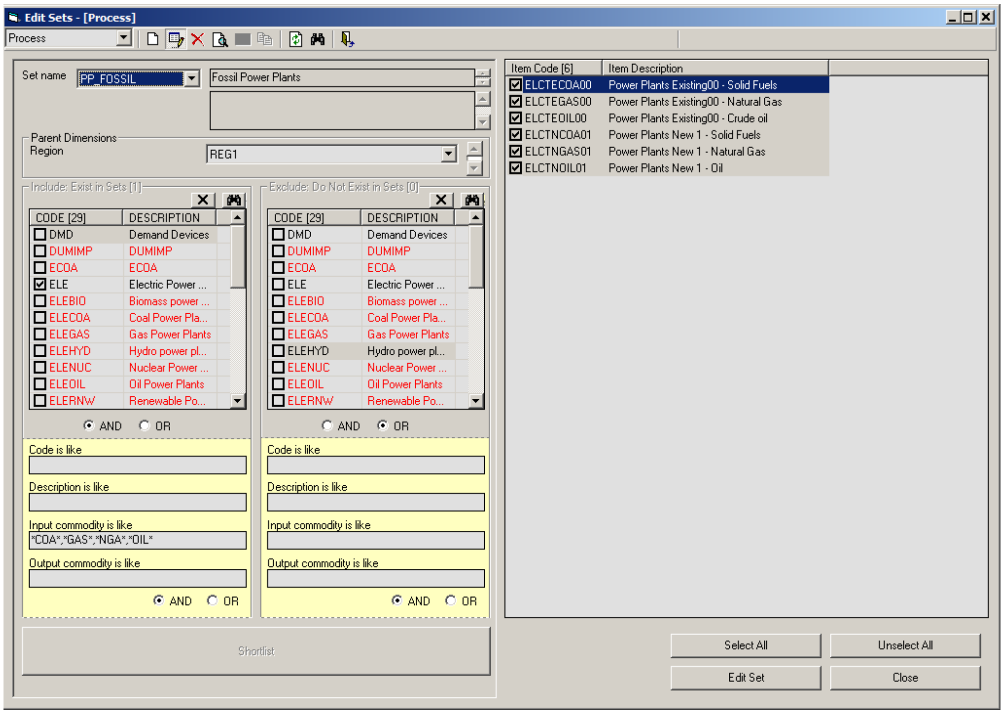
Figure 30 shows a combination of inclusion and exclusion rules to create a very useful type of set: all items that exist in the set *NRG* but not in any of six user-defined commodity sets. This set is looking for energy carriers that have been missed in defining the *NRG_** user-defined sets, and should be empty when all these sets have been properly defined.

3.2 Creating and editing sets

Sets may be created either by modifying an existing set from the **Edit/View Set** function described in Section 3.1 or by selecting **New Set(s)** from the **Sets** menu. Both methods use the set definition window described in the previous section to enter the rules to define the set.

Rules for *Inclusion* and *Exclusion* of items can be defined separately in the left and right halves of the left panel. The top portion of each half provides checkboxes for inclusion/exclusion based upon set membership (***Exist/Do Not Exist in Sets*** boxes). Above these boxes, the binoculars icon 🔍 opens a search window that may be used to search for sets by name and/or description. The “X” icon to the left of the binoculars clears all selections made. Multiple set choices made here are combined with an OR logic. That is, if multiple sets are selected for

Inclusion or *Exclusion*, an item must be a member of only one such set to be included or excluded.



Process

Set name: PP_FOSSIL — Fossil Power Plants

Parent Dimensions
Region: REG1

Include: Exist in Sets [1]

CODE [29]	DESCRIPTION
□ DMD	Demand Devices
□ DUMIMP	DUMIMP
□ ECOA	ECOA
☑ ELE	Electric Power ...
□ ELEBIO	Biomass power ...
□ ELECOA	Coal Power Pla...
□ ELEGAS	Gas Power Plants
□ ELEHYD	Hydro power pl...
□ ELENUC	Nuclear Power ...
□ ELEOIL	Oil Power Plants
□ ELERNW	Renewable Po...

● AND ○ OR

Code is like:
Description is like:
Input commodity is like: *COA*,*GAS*,*NGA*,*OIL*
Output commodity is like:

● AND ○ OR

Exclude: Do Not Exist in Sets [0]

CODE [29]	DESCRIPTION
□ DMD	Demand Devices
□ DUMIMP	DUMIMP
□ ECOA	ECOA
□ ELE	Electric Power ...
□ ELEBIO	Biomass power ...
□ ELECOA	Coal Power Pla...
□ ELEGAS	Gas Power Plants
□ ELEHYD	Hydro power pl...
□ ELENUC	Nuclear Power ...
□ ELEOIL	Oil Power Plants
□ ELERNW	Renewable Po...

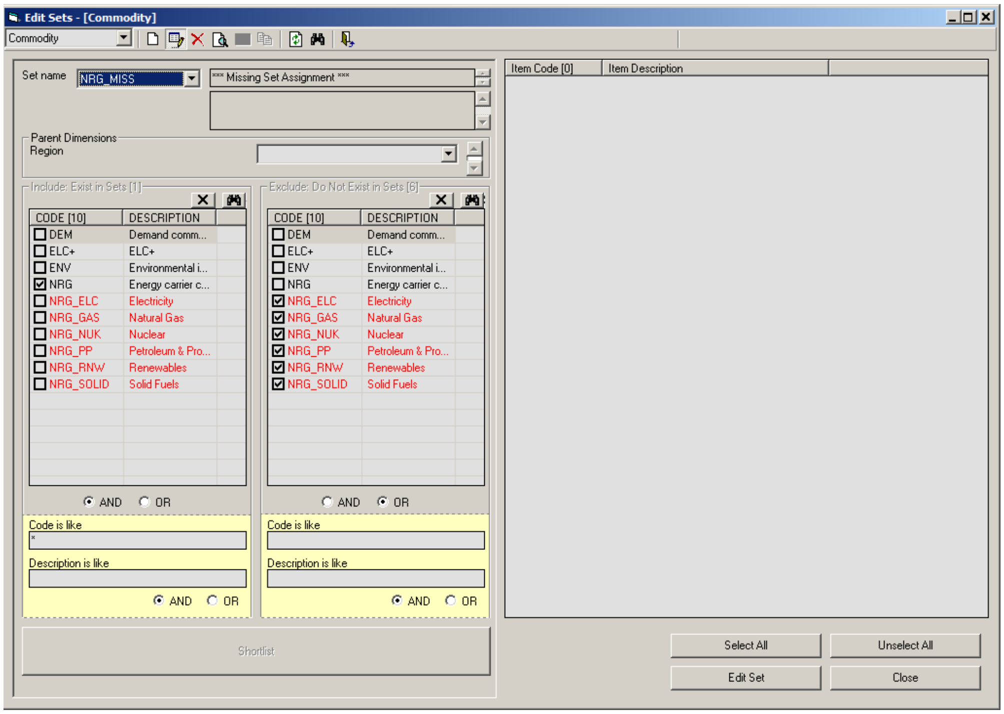
○ AND ● OR

Code is like:
Description is like:
Input commodity is like:
Output commodity is like:

● AND ○ OR

Item Code [6]	Item Description
☑ ELCTECOA00	Power Plants Existing00 - Solid Fuels
☑ ELCTEGAS00	Power Plants Existing00 - Natural Gas
☑ ELCTEOIL00	Power Plants Existing00 - Crude oil
☑ ELCTNCOA01	Power Plants New 1 - Solid Fuels
☑ ELCTNGAS01	Power Plants New 1 - Natural Gas
☑ ELCTNOIL01	Power Plants New 1 - Oil

Figure 29: The *PP_FOSSIL* set definition



Commodity

Set name: NRG_MISS — *** Missing Set Assignment ***

Parent Dimensions
Region:

Include: Exist in Sets [1]

CODE [10]	DESCRIPTION
□ DEM	Demand comm...
□ ELC+	ELC+
□ ENV	Environmental i...
☑ NRG	Energy carrier c...
□ NRG_ELC	Electricity
□ NRG_GAS	Natural Gas
□ NRG_NUK	Nuclear
□ NRG_PP	Petroleum & Pro...
□ NRG_RNW	Renewables
□ NRG_SOLID	Solid Fuels

● AND ○ OR

Code is like: *
Description is like:

● AND ○ OR

Exclude: Do Not Exist in Sets [6]

CODE [10]	DESCRIPTION
□ DEM	Demand comm...
□ ELC+	ELC+
□ ENV	Environmental i...
□ NRG	Energy carrier c...
☑ NRG_ELC	Electricity
☑ NRG_GAS	Natural Gas
☑ NRG_NUK	Nuclear
☑ NRG_PP	Petroleum & Pro...
☑ NRG_RNW	Renewables
☑ NRG_SOLID	Solid Fuels

○ AND ● OR

Code is like:
Description is like:

● AND ○ OR

Item Code [0]	Item Description

Figure 30: The *NRG_MISS* set definition

Below the set checkboxes are rows in which inclusion/exclusion criteria may be entered based upon item name, description, and, for process sets, input and output commodity. Multiple criteria may be specified on the name/description/input/output lines, separated by commas (and without spaces. These commas *within a single line* are always interpreted as logical OR. That is, to belong in the set specified in Figure 29, the process input commodity must fit only one of the four criteria entered into the ***Input commodity is like*** line on the *Include* side of the form.

Two sets of ***AND/OR*** radio buttons are found on each of the *Include/Exclude* sides. The upper one allows the user to control how the set membership and remaining conditions are combined. ***AND*** here means that *both* the set membership and the other conditions must hold, while ***OR*** means that only one is required. For example, again in Figure 29, the choice of ***AND*** in upper left ***AND/OR*** selection means that an item must be in the set *ELE* and meet one of the four stated input commodity conditions in order to belong.

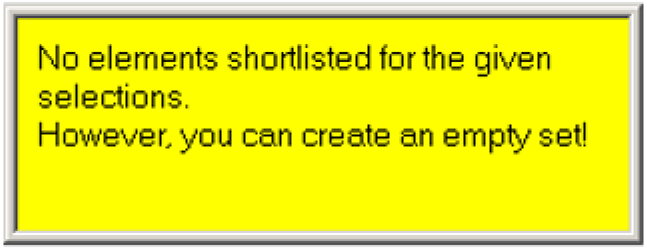
The bottom set of ***AND/OR*** radio buttons on each side controls how conditions on the remaining four (two for commodity sets) rows are combined. ***AND*** means that conditions stated on different rows must all hold, while ***OR*** means that only one such condition must hold.

All of the inclusion and exclusion conditions are logically combined separately, and the final set consists of all those items that meet the inclusion conditions and do not meet the exclusion conditions. For example, the set shown in Figure 30 includes all items that exist in the set *NRG* **and** do not exist in all six specified commodity sets.

Note that sets that are based upon including/excluding members of user-defined sets may not be themselves used as *Exist/Do Not Exist in Sets* criteria, because such nesting of set memberships would cause ambiguity in set update processing.

There are often many possible ways to define a particular set of items. When choosing rules for set definition, consider which definition will be easier to maintain as your model evolves over time. In general, when choosing between rules based upon name/description or commodity input/output, it is recommended to choose the topology-based option wherever it is equally parsimonious, because it is more likely to be robust to future model development.

Once rules have been specified, press the **Shortlist** button to view the qualifying items. The right panel will list qualifying items in the region selected from the **Parent Dimensions Region** menu above the Include/Exclude panels on the lefthand side (by default, the alphabetically first region). If items may vary by region, you may wish to check the lists of qualifying items in other regions by selecting them from the menu and pressing **Shortlist** again. If your criteria do not yield any items, the following message will appear. Once it fades, you may create an empty set or modify your criteria.



No elements shortlisted for the given selections.
However, you can create an empty set!

Figure 31: No elements shortlisted message

Although it is possible at this point to remove some of the shortlisted items from the set definition by manually clearing the checkboxes next to their names, this is not recommended. If needed, you may enter exclude conditions for particular items based upon their names/descriptions.

Once the set criteria have been satisfactorily defined, press the **Create Set** button (or, if you have been modifying a previous set's definition, the **Update Set** button), and a window opens to let you name the set (up to 10 characters) and provide a description. If you leave the description blank, it will be automatically set identical to the name. A comment for the set (such as its intended use) may also be entered at this time, and will appear in the set definition window under the description.

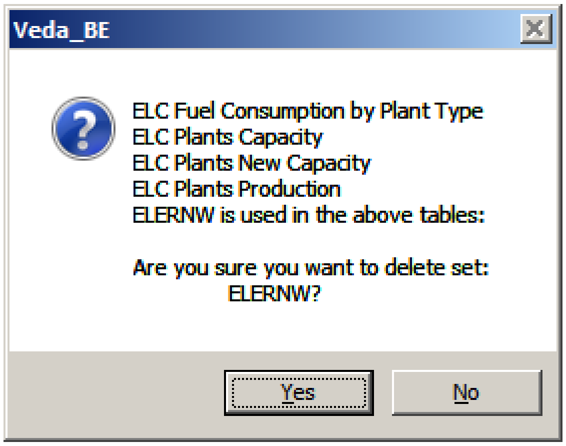
When editing a previously existing set, entering a new name will create a new set with that name, leaving the old one unchanged, whereas clicking **OK** without changing the set name will result in overwriting the old definition with the new.

You may define and/or edit multiple sets in the window before choosing **Close** when you are ready to return to the main window.

Set memberships are refreshed from their definitions whenever new results or sets are imported and when tables using them are viewed.

3.3 Managing sets

Individual sets may be deleted by right clicking on the set's name listing on the **Commodity** or **Process** tab and selecting ***Delete Set*** from the menu that appears. You will be prompted by a window similar to that shown in Figure 32, letting you know which tables the set is used in and asking you to confirm or cancel the delete.



Veda_BE

ELC Fuel Consumption by Plant Type
ELC Plants Capacity
ELC Plants New Capacity
ELC Plants Production
ELERNW is used in the above tables:

Are you sure you want to delete set:
ELERNW?

Figure 32: Confirm set deletion window

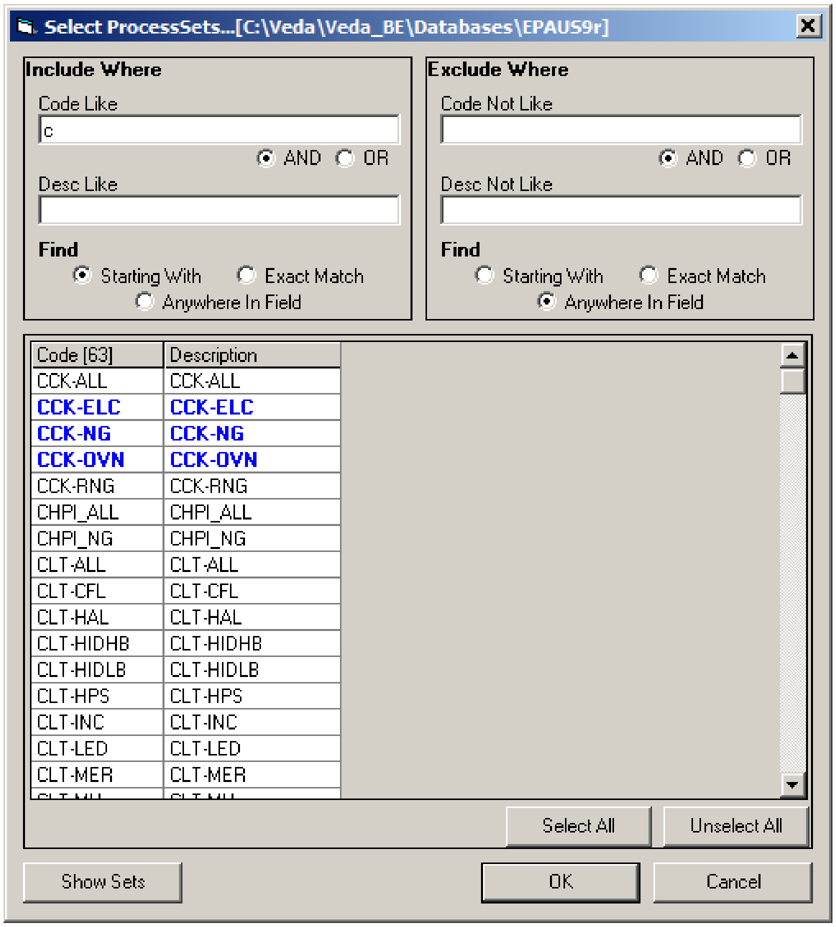
Multiple sets can be deleted by choosing **Delete Set(s)** from the **Sets** menu. This brings up a window in which sets may be searched for by name/description, and their membership and table usage viewed before choosing to delete them.

The following actions can be performed on sets by choosing the relevant item from the menu that appears upon right clicking on a set listing on the **Commodity** or **Process** tab:

- ***Copy set***: prompts you to enter a name for the new set. You may then modify the new set as needed;
- ***Rename set***;
- ***Edit description***;
- ***Copy set elements to clipboard***: puts the names of all set members in the clipboard for pasting wherever needed;
- ***Used in tables***: brings up a window showing which tables the set is used in;
- ***Comment for set***: allows you to enter a comment which will be visible when the set is viewed/edited in the set definition window.

3.4 Sharing sets

To share set definitions to another database/user/computer, there are two options. *All* sets in the database may be shared by saving the SnT file found in the database folder of the source computer to a known location on the second computer. Open the desired destination database and choose **Import Set(s)** from the **Sets** menu, and then select **Access** from the dropdown menu that appears. This will bring up a **Browse** window. Locate and select the folder containing the SnT file. (Note that the SnT file itself will not become visible in this browse, only the enclosing folder.) Next choose *Commodity* or *Process* sets from the **Select Dimension** window that appears. This will bring up the **Select** window shown in Figure 33.



Include Where

Code Like: c

● AND ○ OR

Desc Like:

Find: ● Starting With ○ Exact Match ○ Anywhere In Field

Exclude Where

Code Not Like:

● AND ○ OR

Desc Not Like:

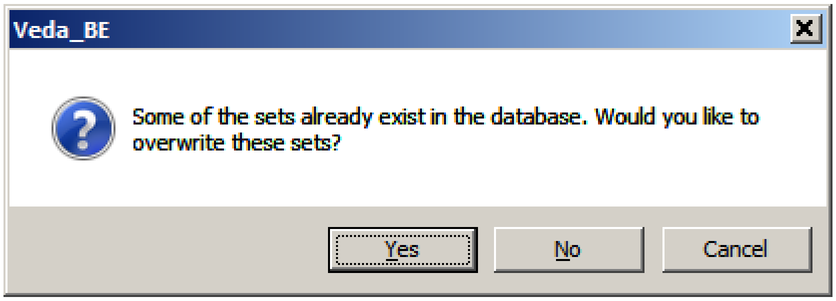
Find: ○ Starting With ○ Exact Match ● Anywhere In Field

Code [63]	Description
CCK-ALL	CCK-ALL
CCK-ELC	**CCK-ELC**
CCK-NG	**CCK-NG**
CCK-OVN	**CCK-OVN**
CCK-RNG	CCK-RNG
CHPI_ALL	CHPI_ALL
CHPI_NG	CHPI_NG
CLT-ALL	CLT-ALL
CLT-CFL	CLT-CFL
CLT-HAL	CLT-HAL
CLT-HIDHB	CLT-HIDHB
CLT-HIDLB	CLT-HIDLB
CLT-HPS	CLT-HPS
CLT-INC	CLT-INC
CLT-LED	CLT-LED
CLT-MER	CLT-MER

Figure 33: Select sets window for importing sets

You may enter desired criteria, if any, based on code and/or description. Select/deselect individual sets by clicking on their names (which will turn them **bold blue**), and/or Select All/Unselect All with the buttons in the bottom righthand corner. All selected (**bold blue**) sets will be imported into the destination database when you click **OK**.

If a set or sets are selected for import with names matching ones already in the database, the following window will appear. You can choose to import and overwrite, or skip these sets.



Some of the sets already exist in the database. Would you like to overwrite these sets?

Figure 34: Import set overwrite prompt

The SnT file may also be used to share sets created in VEDA-BE with VEDA-FE for use in specifying inputs – for example, to identify qualifying renewable electricity generation processes for a portfolio standard – by pointing VEDA-FE to the VEDA-BE database folder, using the **File Locations** tab of the VEDA-FE **User Options** window.

To share only some of the sets from the source database, choose **Export Set(s)** from the **Sets** menu, and **Excel** or **Text** from the dropdown menu that appears. Next select *Commodity* or *Process* sets, and provide a name and location for the export file in the window that appears. This will bring up a search window similar that shown in Figure 33, where you may search for and select sets for export. Sets may then be imported into the destination database by choosing **Import Set(s)** and selecting **Excel** or **Text**, as relevant, from the dropdown menu, and then following the search and select procedure described above.

4 Working with tables

This section describes how to define and modify tables, how to set default table layout and formatting options, how to use the ***aggregation rules*** function to create some advanced table types, and some tools for managing and sharing tables.

4.1 Defining a new table

As introduced in Section 2.3, tables are defined in VEDA-BE by specifying which elements from each available dimension are to be included. You may think of table creation as a *filtering* process. The VEDA-BE database contains *all* the results information from the currently imported scenarios. Each table selects from and *limits* that information into a particular view, which can then be further shaped in the **View Window**.

Table definition takes place in the VEDA-BE main window. You may start the process by:

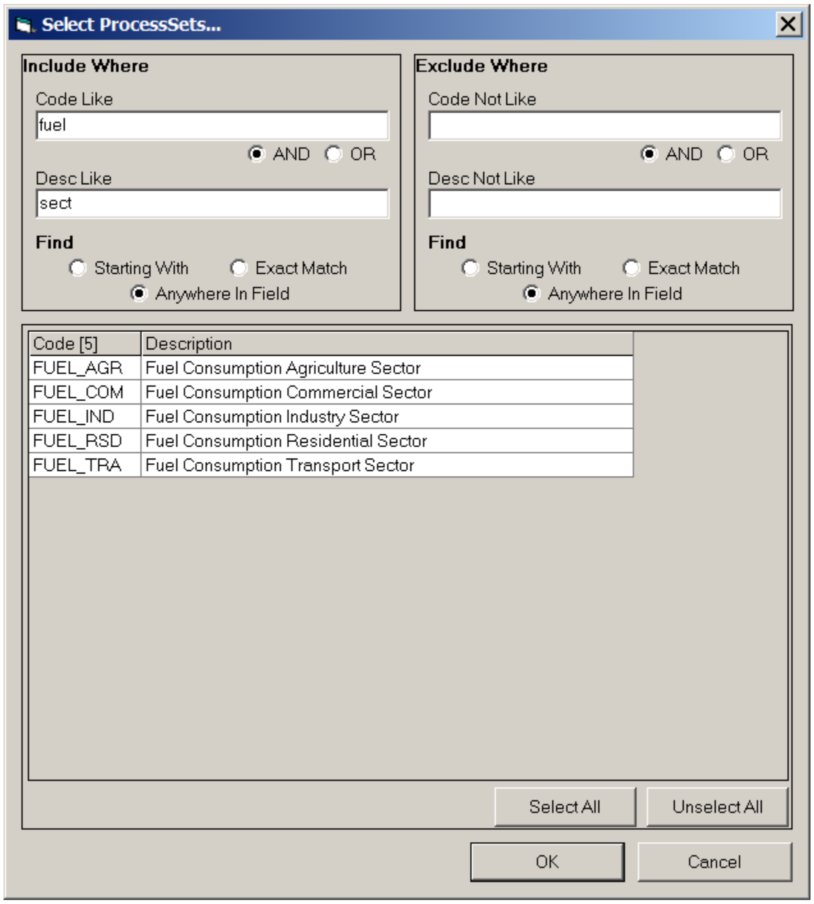
- Choosing **<New Table>** from the top of the **Table Selection** drop-down menu in the upper lefthand corner of the **Table Definition** form (see Figure 10);
- Choosing **New Table** from the **Table** menu; or
- Pressing **Crtl+N**.

All three options will give you a blank table definition form, which you may begin filling with specifications. Elements may be added to the definition form manually or via the *search engine*, as described below. On some occasions, you may find it more convenient to begin creating a new table by selecting and modifying an existing, similar table. When you request the table view, you will be given the opportunity to save the modified table with a new name, optionally retaining the old table, or to overwrite the previous table definition.

Manual filtering: Select the desired dimension tab in the right panel and locate the desired element in the appropriate list. (Having clicked on any element on a dimension tab, you may quickly jump to another element by typing the first letters of its name.) *Double-click* on the selected element (or press the *space bar*, or press the *Insert key*) to add it to the left-side table definition form. The chosen element is now displayed under the dimension heading in the window on the left, while in the right panel its entry turns **bold** to indicate that it is part of the current table definition. This operation can be reversed by highlighting the selected element in the left panel and *double clicking* on it (or pressing the *space bar*, or pressing the *Delete* key).

Filtering via the Search Engine: in the case of dimensions containing many elements, manual filtering may quickly become very awkward and time-consuming, due to the sheer number of elements. The search tool, launched by clicking the binoculars icon next to each dimension listing, allows filtering via a combination of inclusions and exclusions based on the names (short or long) of the elements in the dimension being considered. The list of elements in the bottom part of the window will be filtered as you type, showing the results of the search. Individual items may now be selected from this list by clicking on their names, turning them **bold blue** to show that they are selected, or the entire list may be selected/deselected using the **Select All/Unselect All** buttons. The **OK** button transfers the selected items to the table definition form. (Note that in doing so, they *overwrite* any items of the same dimension that are already on the table definition form.)

For example, Figure 35 shows one way in which the search engine can be used to select all the sector fuel process sets in the DemoS_VBE database. These may then be added to the table definition form (replacing any process sets already loaded onto it) by clicking **Select All** and then **OK**.



Include Where

Code Like: fuel

● AND ○ OR

Desc Like: sect

Find

○ Starting With ○ Exact Match

● Anywhere In Field

Exclude Where

Code Not Like:

● AND ○ OR

Desc Not Like:

Find

○ Starting With ○ Exact Match

● Anywhere In Field

Code [5]	Description
FUEL_AGR	Fuel Consumption Agriculture Sector
FUEL_COM	Fuel Consumption Commercial Sector
FUEL_IND	Fuel Consumption Industry Sector
FUEL_RSD	Fuel Consumption Residential Sector
FUEL_TRA	Fuel Consumption Transport Sector

Figure 35: Using the search feature to add elements to the table definition

Dimensions for which no elements are specified for a given table are processed as follows:

- Dimensions that are not relevant to a given table are left off the table. (For example, the **_SysCost** table shown in Figure 14 lacks the process and commodity dimensions because these are not relevant dimensions of the **Reg_obj** attribute.)
- For relevant dimensions for which no specifications have been provided, *all* available elements are presented in the table, subject to any *global filter* currently in place (see Section 2.3.5).
- The exception to the previous rule is that processes and commodity sets are not added to a table when not specified. This is because any given process or commodity can belong to any number of process/commodity sets, and so no unambiguous procedure can be used to select sets to be added to such a table.

If you wish to make use of the units conversion feature for this table, select the appropriate native model units from the drop-down menu in the lower lefthand corner of the table definition form. (These units must have been previously defined, as described in Section 5.)

The **Include Null** checkbox in the lower lefthand corner of the screen allows combining attributes that have different relevant dimensions. For example, Figure 36 shows a table definition form that puts electricity generation and capacity, by fuel type, into the same table. Because ***VAR_FOut*** takes the commodity index (in this case, we want output of *ELC* only) and ***VAP_Cap*** does not, if **Include Null** was not checked, ***VAR_Cap*** would be absent from the created table. **Include Null** allows ***VAR_Cap*** to be included although its commodity is null.

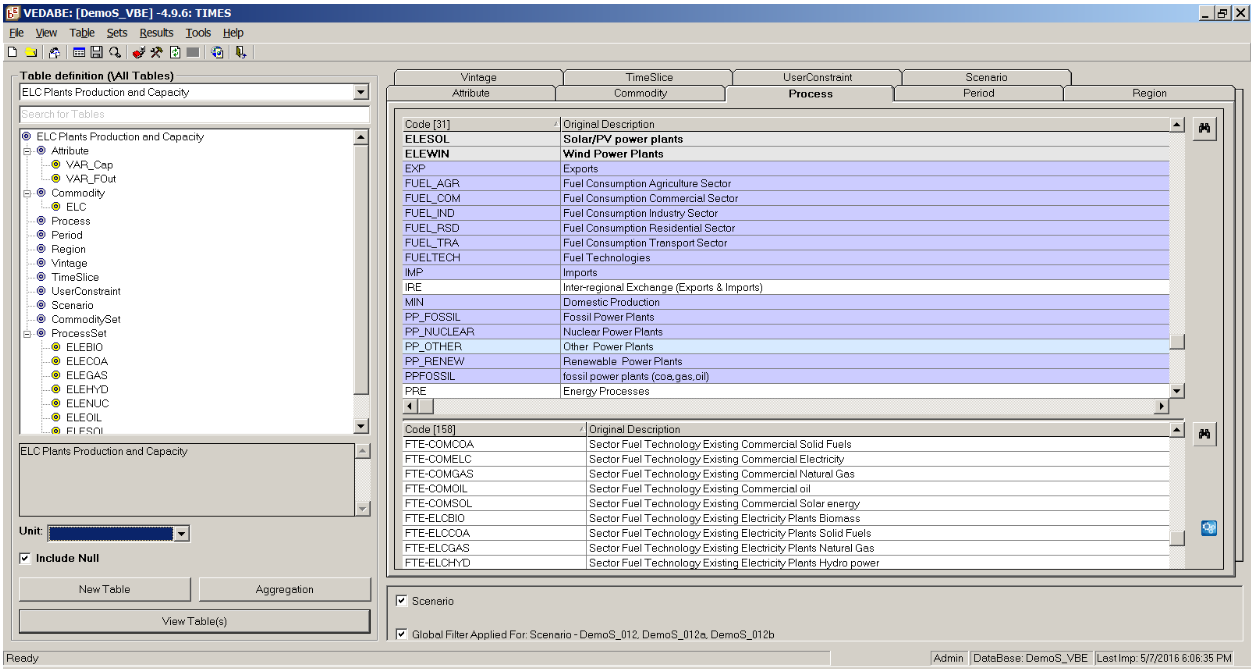


Table definition (All Tables): ELC Plants Production and Capacity

Search for Tables

- ELC Plants Production and Capacity
  - Attribute
    - VAR_Cap
    - VAR_FOut
  - Commodity
    - ELC
  - Process
  - Period
  - Region
  - Vintage
  - TimeSlice
  - UserConstraint
  - Scenario
  - CommoditySet
  - ProcessSet
    - ELEBIO
    - ELECOA
    - ELEGAS
    - ELEHYD
    - ELENUC
    - ELEOIL
    - ELESOL

ELC Plants Production and Capacity

Unit:

☑ Include Null

Code [31]	Original Description
ELESOL	**Solar/PV power plants**
ELEWIN	**Wind Power Plants**
EXP	Exports
FUEL_AGR	Fuel Consumption Agriculture Sector
FUEL_COM	Fuel Consumption Commercial Sector
FUEL_IND	Fuel Consumption Industry Sector
FUEL_RSD	Fuel Consumption Residential Sector
FUEL_TRA	Fuel Consumption Transport Sector
FUELTECH	Fuel Technologies
IMP	Imports
IRE	Inter-regional Exchange (Exports & Imports)
MIN	Domestic Production
PP_FOSSIL	Fossil Power Plants
PP_NUCLEAR	Nuclear Power Plants
PP_OTHER	Other Power Plants
PP_RENEW	Renewable Power Plants
PPFOSSIL	fossil power plants (coa,gas,oil)
PRE	Energy Processes

Code [158]	Original Description
FTE-COMCOA	Sector Fuel Technology Existing Commercial Solid Fuels
FTE-COMELC	Sector Fuel Technology Existing Commercial Electricity
FTE-COMGAS	Sector Fuel Technology Existing Commercial Natural Gas
FTE-COMOIL	Sector Fuel Technology Existing Commercial oil
FTE-COMSOL	Sector Fuel Technology Existing Commercial Solar energy
FTE-ELCBIO	Sector Fuel Technology Existing Electricity Plants Biomass
FTE-ELCCOA	Sector Fuel Technology Existing Electricity Plants Solid Fuels
FTE-ELCGAS	Sector Fuel Technology Existing Electricity Plants Natural Gas
FTE-ELCHYD	Sector Fuel Technology Existing Electricity Plants Hydro power

☑ Scenario

☑ Global Filter Applied For: Scenario - DemoS_012, DemoS_012a, DemoS_012b

Admin | DataBase: DemoS_VBE | Last Imp: 5/7/2016 6:06:35 PM

Figure 36: Using the Include Null checkbox

When you have completed specifying your table definition, click the **View Table(s)** button. You will be prompted to save the table by providing a name and description. (If you leave the description field blank, it will be set equal to the name.)

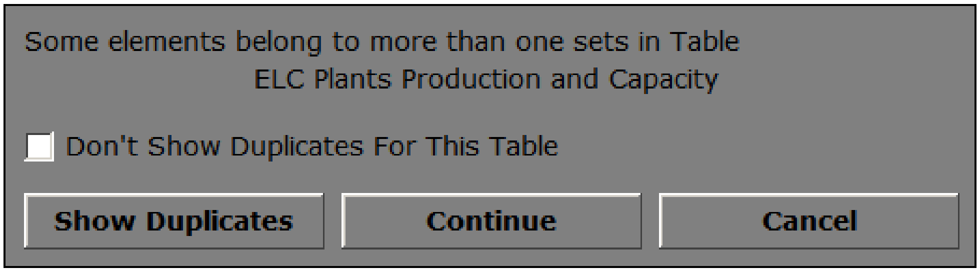
Note that if you have modified the definition of an existing table, rather than starting from a blank table, you will be presented with the table's original name here. If you click **Save** without providing a new name, the table's previous definition will be overwritten with the new one (and you will see a message telling you that the old definition has been removed). If you provide a new name, you will be presented with an option to **Retain Old Table**.

Clicking **Save** prompts VEDA-BE to construct the table by applying the filtering criteria specified for the table, according to the default layout specified using the user options described in the following section. You may then further modify the layout by pivoting, rearranging, and deselecting or collapsing items, adding or removing subtotals, and changing display types, as described in Section 2.3.

During the table construction process, a number of quality control feature checks take place. If a specified element is now missing from the database, you will seeing a message asking if you wish to continue. To remedy this situation for subsequent requests, simply remove the missing element from the table definition.

If the table includes process and/or commodity sets, and any element appears in more than one of these sets, an error message similar to that shown in Figure 37 will appear. The **Show**

Duplicates option will open a text file listing all elements that appear in multiple sets and halt the table creation process. **Continue** continues with creating the table, and **Cancel** halts the operation. The **Don't Show Duplicates For This Table** checkbox prevents this error message from being shown in the future. When this message first appears for a given table, it is recommended that you choose the **Show Duplicates** option and inspect the text file to confirm that there are no errors in the requested set specifications before proceeding.

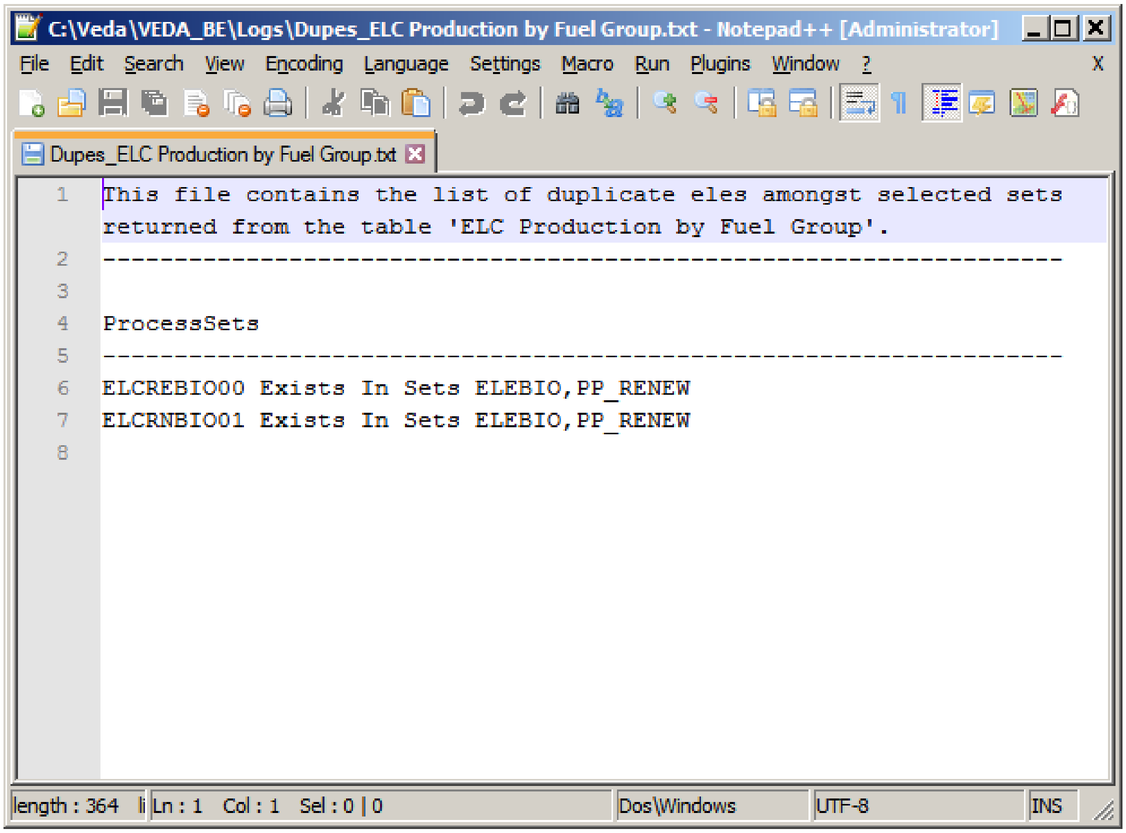


Some elements belong to more than one sets in Table
ELC Plants Production and Capacity

□ Don't Show Duplicates For This Table

Figure 37: Duplicate elements error message

Figure 38 shows an example of the *Dupes* file listing duplicate elements found.



C:\Veda\VEDA_BE\Logs\Dupes_ELC Production by Fuel Group.txt - Notepad++ [Administrator]
File Edit Search View Encoding Language Settings Macro Run Plugins Window ?
Dupes_ELC Production by Fuel Group.txt
length : 364
Ln : 1 Col : 1 Sel : 0 | 0
Dos\Windows
UTF-8
INS

```
This file contains the list of duplicate eles amongst selected sets returned from the table 'ELC Production by Fuel Group'.
-----------------------------------------------------------------

ProcessSets
-----------------------------------------------------------------
ELCREBIO00 Exists In Sets ELEBIO,PP_RENEW
ELCRNBIO01 Exists In Sets ELEBIO,PP_RENEW

```

Figure 38: Example of Dupes text file listing duplicate elements

4.2 Setting table defaults

The **Options** function available from the **Tools menu** offers a number of table layout and formatting defaults that may be set, as follows:

- On the **General** tab, the default number of decimal places shown may be set;
- The **Dimensions** tab allows the default display type, location (row, column, or page), and use of subtotals to be set for each dimension;
- The **Auto Format** tab allows the default format of each portion of the table to be adjusted; and
- The **My Sort** tab allows the sort order for each dimension to be altered from its alphanumeric default.

Changes to the default table settings will be active for new tables, but will not affect existing tables.

4.3 Aggregation rules

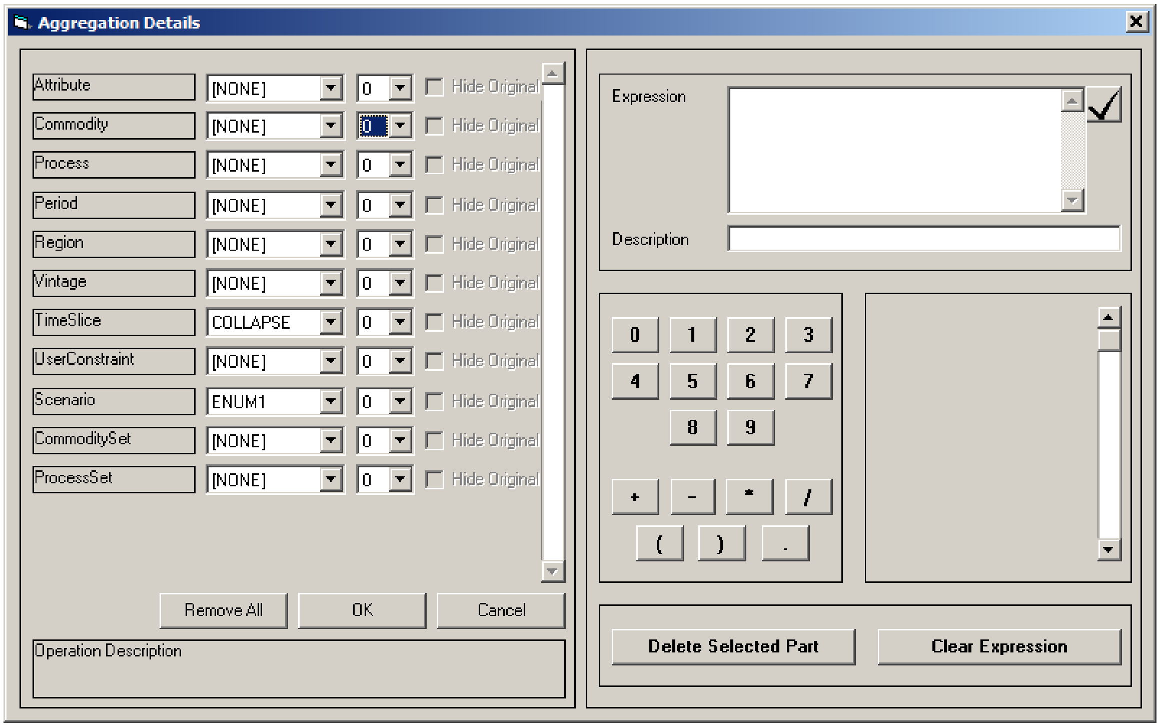
The aggregation window, available by clicking the **Aggregation** button at the bottom of the table definition form, allows some simple operations to be requested on tables. Two of the most useful are the **enumerate** and **collapse** functions.

Enumerate directs that separate tables be produced for each element in the requested dimension. In the example shown in shown in Figure 39, separate tables will be created for each available scenario (limited by any scenarios specified in the table definition or by an applied global filter.) Up to three dimensions may be enumerated, with the order of table creation set by the suffix ***x*** on *ENUMx* when more than one dimension is enumerated.

If Export to Excel is requested when enumerated tables are open, each table will be placed on a different sheet within the same workbook. This can be very useful, for example, to create the same report table for each region in a large multi-region model.

Collapse directs that the selected dimension be summed over all available elements when the table is created. The effect is similar to that when the dimension is placed on the page of a table, rather than in a row or a column, except that when Collapse is used, the collapsed element is no longer available to be dragged back into a row or column and the details revealed. Collapse can thus greatly reduce table size, and in large models can make some tables much faster to create. (For example, power plant activity and output are tracked by timeslice, so tables containing these results may grow quite large. Collapsing by timeslice may make them far more manageable, if the timeslice detail is not required.)

The other options available within the aggregation window should be considered experimental. In general, they have been superseded by the ability to update Excel workbooks, which may contain any desired calculations and operations, with new results data (see Section 6.3).



Attribute	[NONE]	0	□ Hide Original
Commodity	[NONE]	0	□ Hide Original
Process	[NONE]	0	□ Hide Original
Period	[NONE]	0	□ Hide Original
Region	[NONE]	0	□ Hide Original
Vintage	[NONE]	0	□ Hide Original
TimeSlice	COLLAPSE	0	□ Hide Original
UserConstraint	[NONE]	0	□ Hide Original
Scenario	ENUM1	0	□ Hide Original
CommoditySet	[NONE]	0	□ Hide Original
ProcessSet	[NONE]	0	□ Hide Original

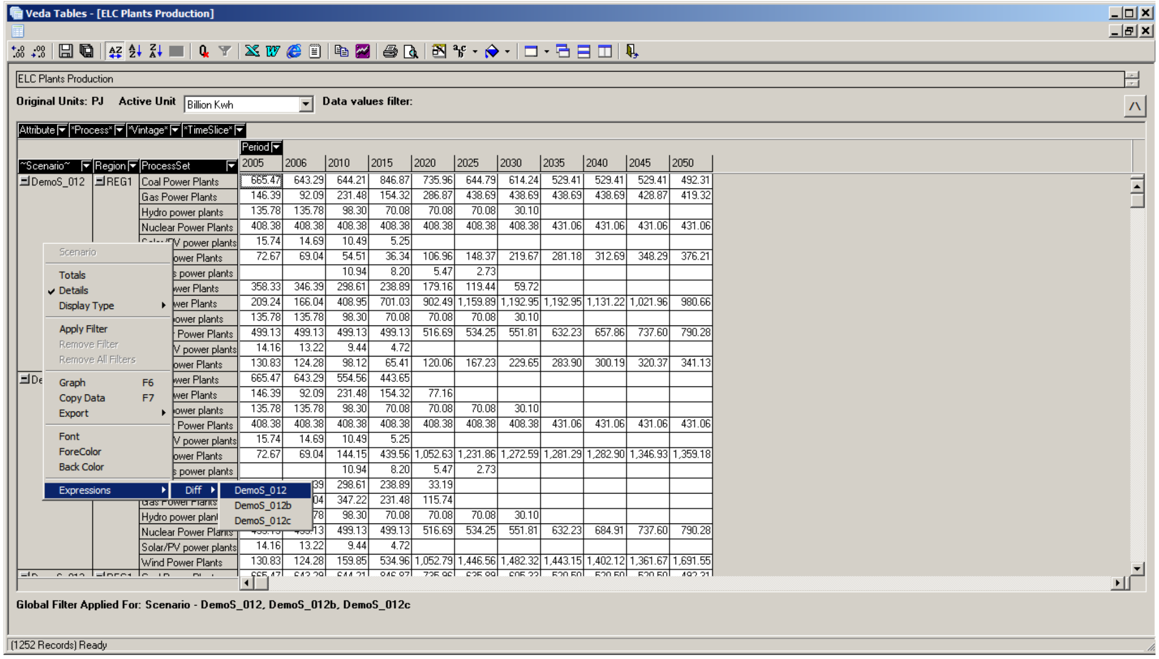
Figure 39: The aggregation window

A third type of aggregation – the difference in result values between scenarios – is easier to create from within a table view. Within the desired table, right click on the scenario column and select **Expression**, then **Diff**, and then the scenario from which you want differences calculated (see Figure 40). You will be asked if you want to hide the original table. **Yes** puts only the scenario differences in the new table, while **No** keeps the absolute scenario data in the table along with the new scenario differences. You will then be prompted to save the original table, or exit without saving any layout or definition changes you have made since opening it. Figure 41 shows the resulting table, when the original table was hidden.

You may save the scenario difference table for later use in the same way as for any other table: click the **SaveTable** icon at the top of the table window, or choose **Save** when closing the table. (Note that if you do not provide a new name and select **Retain Oil Table**, your original table will be overwritten.) The **Diff** expression can be used for other dimensions than scenario, but care must be taken to choose a difference that is meaningful.

When an aggregation rule has been set for a table, the **Aggregation** button on its table definition form will turn bold and receive asterisks (*) to show that a rule is in place, as shown:

.



ELC Plants Production

Original Units: PJ Active Unit Billion Kwh Data values filter:

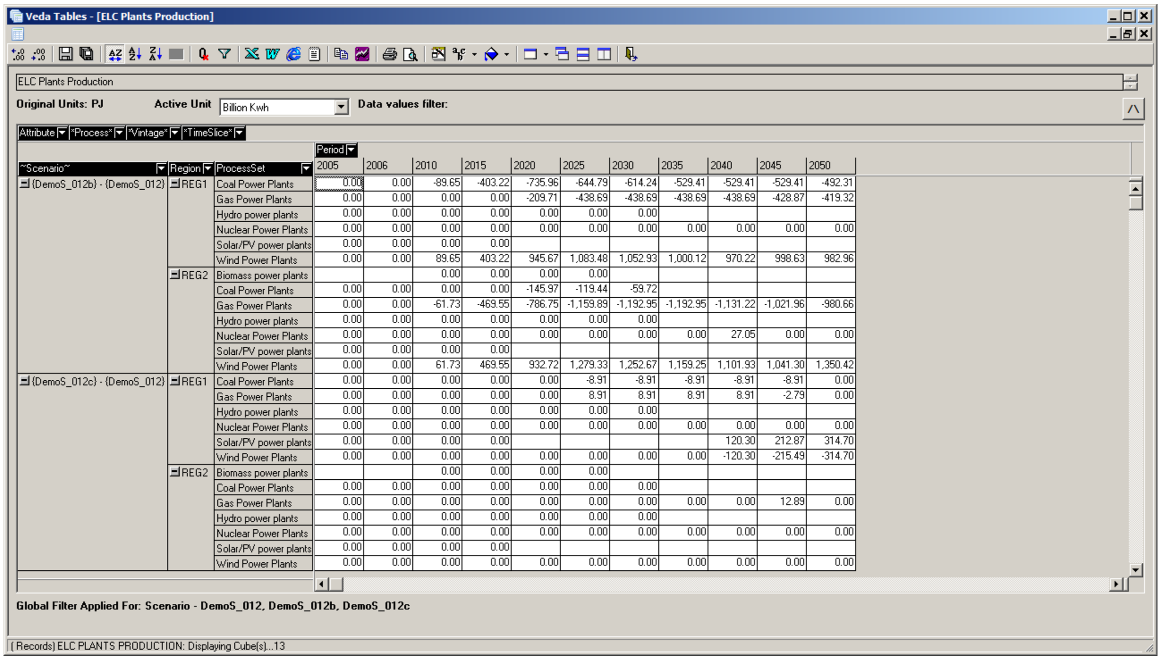
Attribute *Process* *Vintage* *TimeSlice*

~Scenario~	Region	ProcessSet	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
DemoS_012	REG1	Coal Power Plants	665.47	643.29	644.21	846.87	735.96	644.79	614.24	529.41	529.41	529.41	492.31
		Gas Power Plants	146.39	92.09	231.48	154.32	286.87	438.69	438.69	438.69	438.69	428.87	419.32
		Hydro power plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		V power plants	15.74	14.69	10.49	5.25							
		ower Plants	72.67	69.04	54.51	36.34	106.96	148.37	219.67	281.18	312.69	348.29	376.21
		s power plants			10.94	8.20	5.47	2.73					
		wer Plants	358.33	346.39	298.61	238.89	179.16	119.44	59.72				
		wer Plants	209.24	166.04	408.95	701.03	902.49	1,159.89	1,192.95	1,192.95	1,131.22	1,021.96	980.66
		ower plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Power Plants	499.13	499.13	499.13	499.13	516.69	534.25	551.81	632.23	657.86	737.60	790.28
		V power plants	14.16	13.22	9.44	4.72							
		ower Plants	130.83	124.28	98.12	65.41	120.06	167.23	229.65	283.90	300.19	320.37	341.13
De		wer Plants	665.47	643.29	554.56	443.65							
		wer Plants	146.39	92.09	231.48	154.32	77.16						
		ower plants	135.78	135.78	98.30	70.08	70.08	70.08	30.10				
		Power Plants	408.38	408.38	408.38	408.38	408.38	408.38	408.38	431.06	431.06	431.06	431.06
		V power plants	15.74	14.69	10.49	5.25							
		ower Plants	72.67	69.04	144.15	439.56	1,052.63	1,231.86	1,272.59	1,281.29	1,282.90	1,346.93	1,359.18
		s power plants			10.94	8.20	5.47	2.73					
				39	298.61	238.89	33.19						
				04	347.22	231.48	115.74						
		Hydro power plant		78	98.30	70.08	70.08	70.08	30.10				
		Nuclear Power Plants		13	499.13	499.13	516.69	534.25	551.81	632.23	684.91	737.60	790.28
		Solar/PV power plants	14.16	13.22	9.44	4.72							
		Wind Power Plants	130.83	124.28	159.85	534.96	1,052.79	1,446.56	1,482.32	1,443.15	1,402.12	1,361.67	1,691.55

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(1252 Records) Ready

Figure 40: Requesting a difference across scenarios



ELC Plants Production

Original Units: PJ Active Unit Billion Kwh Data values filter:

Attribute *Process* *Vintage* *TimeSlice*

~Scenario~	Region	ProcessSet	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
{DemoS_012b} - {DemoS_012}	REG1	Coal Power Plants	0.00	0.00	-89.65	-403.22	-735.96	-644.79	-614.24	-529.41	-529.41	-529.41	-492.31
		Gas Power Plants	0.00	0.00	0.00	0.00	-209.71	-438.69	-438.69	-438.69	-438.69	-428.87	-419.32
		Hydro power plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
		Nuclear Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Solar/PV power plants	0.00	0.00	0.00	0.00							
		Wind Power Plants	0.00	0.00	89.65	403.22	945.67	1,083.48	1,052.93	1,000.12	970.22	998.63	982.96
	REG2	Biomass power plants			0.00	0.00	0.00	0.00					
		Coal Power Plants	0.00	0.00	0.00	0.00	-145.97	-119.44	-59.72				
		Gas Power Plants	0.00	0.00	-61.73	-469.55	-786.75	-1,159.89	-1,192.95	-1,192.95	-1,131.22	-1,021.96	-980.66
		Hydro power plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
		Nuclear Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.05	0.00	0.00
		Solar/PV power plants	0.00	0.00	0.00	0.00							
		Wind Power Plants	0.00	0.00	61.73	469.55	932.72	1,279.33	1,252.67	1,159.25	1,101.93	1,041.30	1,350.42
{DemoS_012c} - {DemoS_012}	REG1	Coal Power Plants	0.00	0.00	0.00	0.00	0.00	-8.91	-8.91	-8.91	-8.91	-8.91	0.00
		Gas Power Plants	0.00	0.00	0.00	0.00	0.00	8.91	8.91	8.91	8.91	-2.79	0.00
		Hydro power plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
		Nuclear Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Solar/PV power plants	0.00	0.00	0.00	0.00					120.30	212.87	314.70
		Wind Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-120.30	-215.49	-314.70
	REG2	Biomass power plants			0.00	0.00	0.00	0.00					
		Coal Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
		Gas Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.89	0.00
		Hydro power plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00				
		Nuclear Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		Solar/PV power plants	0.00	0.00	0.00	0.00							
		Wind Power Plants	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(Records) ELC PLANTS PRODUCTION: Displaying Cube(s)...13

Figure 41: The resulting scenario difference table

4.4 Managing and sharing tables

From the **Table** menu of the main VEDA-BE window, one may access the following table management functions:

- Create a **New Table**;

- **Save** a table definition without launching the table view;
- Open a table **View;**
- **Delete**, **Rename**, and **Copy** tables. Note that **Delete Table** deletes only the currently selected table. To delete multiple tables at once, enter **Batch Mode** (described in Section 6.2) from the **View** menu, by selecting **Execution Mode** and then **Batch Mode**. This will provide checkboxes next to each table, which can be used to multi-select tables. Choosing **Delete Table** from the **Table** menu will then allow all the selected tables to be deleted.
- **Import** and **Export** tables using Excel or text format or the Access SnT file, in a manner precisely analogous to the import and export of sets described in Section 3.4;
- **Sort Tables** alphabetically in ascending or descending order, or by modification date;
- **Delete** saved **Cube File(s)**, which forces recreation of tables from their definitions, if they have been saved as described in Section 2.3.7. This option may be requested if you suspect a cube is not refreshing appropriately; and
- Open the **Table Master** window, described below.

The **Table Master** provides a functionality for organizing tables into folders (Figure 42). Upon opening the Table Master window, you will be shown a folder structure with the uppermost level called ***All Tables***, which always holds, as the name implies, all tables. You may add and delete folders and subfolders at will, creating a tree structure. The folders may be used in the main window to restrict the list of tables shown in the table definition window, by using the **Open Folder(s)** option from the **View** menu[7]. They may also be used to process (open for viewing) multiple or all tables within a folder from the Table Master window.

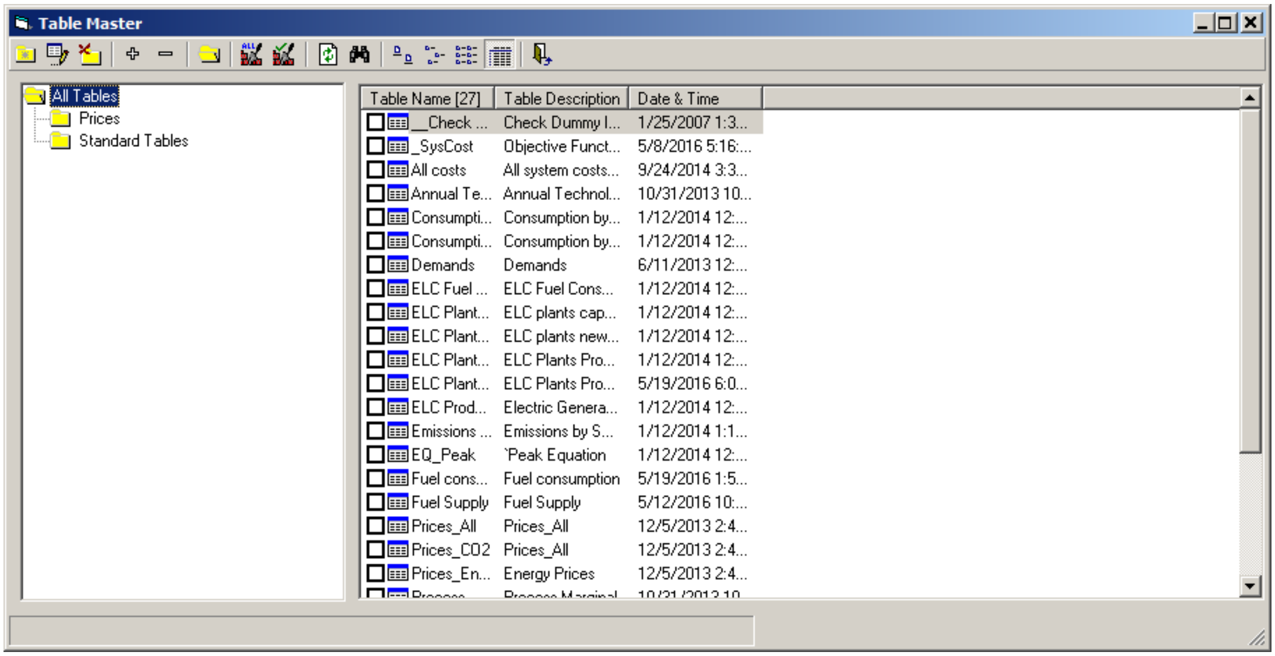


	Table Name [27]	Table Description	Date & Time
□	__Check ...	Check Dummy I...	1/25/2007 1:3...
□	_SysCost	Objective Funct...	5/8/2016 5:16:...
□	All costs	All system costs...	9/24/2014 3:3...
□	Annual Te...	Annual Technol...	10/31/2013 10...
□	Consumpti...	Consumption by...	1/12/2014 12:...
□	Consumpti...	Consumption by...	1/12/2014 12:...
□	Demands	Demands	6/11/2013 12:...
□	ELC Fuel ...	ELC Fuel Cons...	1/12/2014 12:...
□	ELC Plant...	ELC plants cap...	1/12/2014 12:...
□	ELC Plant...	ELC plants new...	1/12/2014 12:...
□	ELC Plant...	ELC Plants Pro...	1/12/2014 12:...
□	ELC Plant...	ELC Plants Pro...	5/19/2016 6:0...
□	ELC Prod...	Electric Genera...	1/12/2014 12:...
□	Emissions ...	Emissions by S...	1/12/2014 1:1...
□	EQ_Peak	`Peak Equation	1/12/2014 12:...
□	Fuel cons...	Fuel consumption	5/19/2016 1:5...
□	Fuel Supply	Fuel Supply	5/12/2016 10:...
□	Prices_All	Prices_All	12/5/2013 2:4...
□	Prices_CO2	Prices_All	12/5/2013 2:4...
□	Prices_En...	Energy Prices	12/5/2013 2:4...
□	Process	Process Marginal	10/31/2013 10

Figure 42: The Table Master window

[7] Note that the table list in the table definition form turns yellow when the open folder is set to anything other than ***All Tables*** to remind you that a filter has been set.

The toolbar at the top of the Table Master window offers the following tools:

- New folder
- Rename folder
- Delete folder
- Add tables to folder (opens a search window to find and select desired tables)
- Remove selected tables from folder
- Remove all tables from folder
- Process (open for view) all tables in the selected folder
- Process (open for view) selected tables in the selected folder
- Refresh tables (if you have made changes to tables while the form was open)
- Search for folder to open (useful if you have many folders)
- Display options for tables (Large Icons, Small Icons, List, and Details)
- Exit Table Master Window

For example, to group all the price-related tables into a folder, use the following steps:

- Click the **New folder** icon
- Click the **Rename** folder icon, and enter “Prices”
- Click the Plus-sign icon, which brings up a search window. Enter “pri” into the **Include Where Code Like** box, then click **Select All**, followed by **OK.**

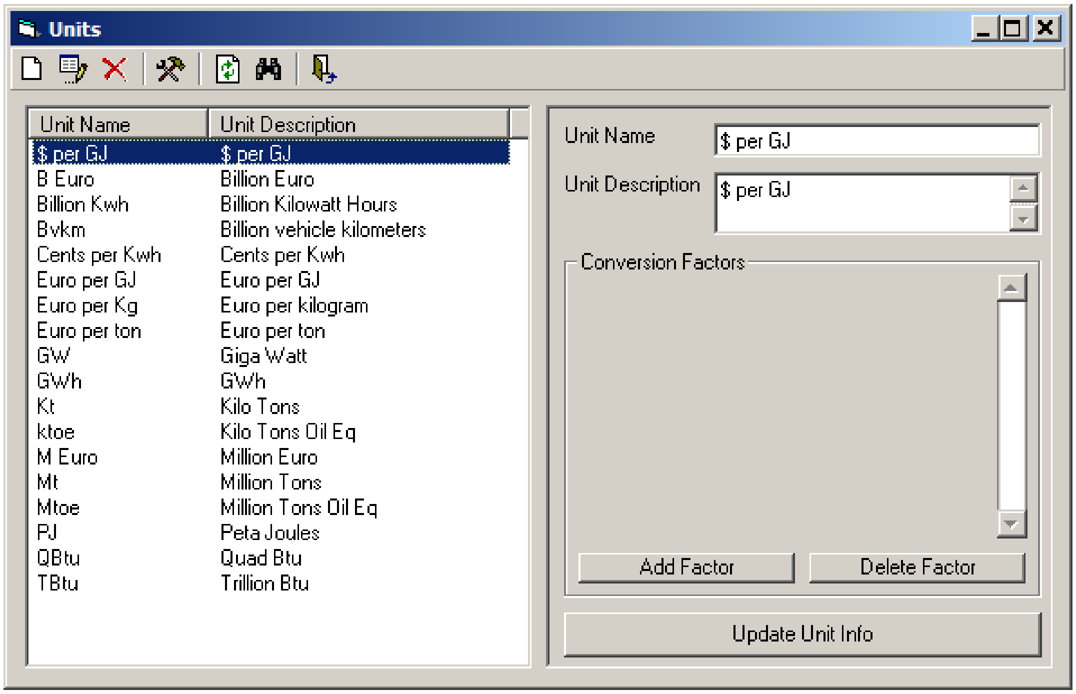
One may now open all of the Prices tables by choosing the appropriate icon from the toolbar.

5 VEDA-BE units handling

VEDA-BE offers a simple yet powerful means for handling *units*. The user must identify the units to be used, provide each alternate unit *conversion factor*, and specify the native model units for each table. Once this is done, the resulting tables may be presented in any desired alternate units instead of the native model units. For example, we saw in Section 2.3.6 (Figure 19) that *ELC Plants Production* table is displayed in *billion kilowatt-hours* (*Billion KWh*), although the native energy carrier units for the DemoS_012 model are *petajoules* (*PJ*).

To create, edit, and delete units and to specify unit conversion factors between them, select **Units** and then **Create/Edit/Delete** from the **Tools** menu to bring up the **Units** window (Figure 43). The window offers the following tools:

- To specify a new unit, click on the **New Unit** icon 🗋. This clears the **Unit Name** and **Unit Description** textboxes on the right panel. Enter a name and, if desired, a description for the new unit, and click **Update Unit Info**.
- To edit a unit's name and/or description, select the unit from the list in the left panel. Make the desired changes to the name and/or description, and click **Update Unit Info**.



Unit Name	Unit Description
$ per GJ	$ per GJ
B Euro	Billion Euro
Billion Kwh	Billion Kilowatt Hours
Bvkm	Billion vehicle kilometers
Cents per Kwh	Cents per Kwh
Euro per GJ	Euro per GJ
Euro per Kg	Euro per kilogram
Euro per ton	Euro per ton
GW	Giga Watt
GWh	GWh
Kt	Kilo Tons
ktoe	Kilo Tons Oil Eq
M Euro	Million Euro
Mt	Million Tons
Mtoe	Million Tons Oil Eq
PJ	Peta Joules
QBtu	Quad Btu
TBtu	Trillion Btu

Unit Name: $ per GJ

Unit Description: $ per GJ

Figure 43: The Units window in the DemoS_VBE database

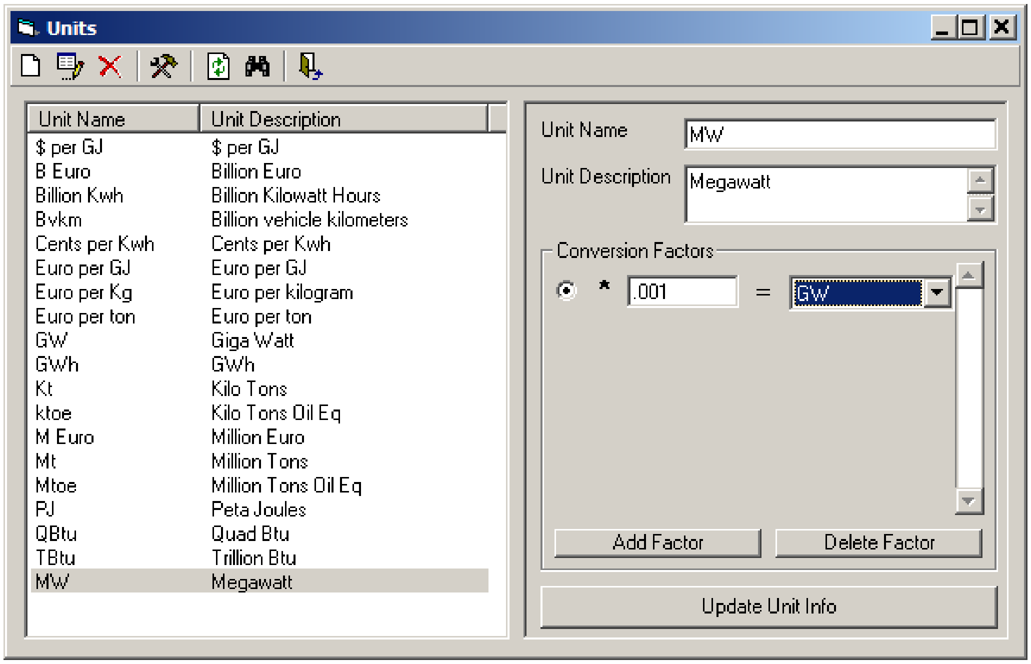
- To delete a unit, select it from the list in the left panel, and click on the **Delete Unit** icon ✕. Click the **Yes** button when a message appears asking you to confirm the deletion of the unit.
- To add a new *unit conversion factor* between two units, both must first be defined as described above. Then, select one of the two units from the list in the left panel. Click on **Add Factor**. This provides a textbox into which one may type what the *currently active* unit should be multiplied by to get the resulting unit. Enter the desired conversion factor

and then choose the resulting unit from the drop-down menu immediately to the right. Finally, click **Update Unit Info**.

Conversions are automatically defined for the *reciprocal* relationship for each conversion factor created. However, additional conversions implied by this relationship with additional units are not automatically created and must be manually defined.

For example, to define a new unit for megawatts (MW) and specify that it is 1/1000 of a GW, use the following steps:

- Click on the **New Unit** icon.
- Enter “MW” in the **Unit Name** textbox and “Megawatt” in the **Unit Description** textbox. Click **Update Unit Info**.
- Click **Add Factor**. Type “.001” into the text box that appears.
- Select “GW” from the drop-down menu to the right.
- Click **Update Unit Info**. The **Units** window should now appear as shown in Figure 44.



Unit Name	Unit Description
$ per GJ	$ per GJ
B Euro	Billion Euro
Billion Kwh	Billion Kilowatt Hours
Bvkm	Billion vehicle kilometers
Cents per Kwh	Cents per Kwh
Euro per GJ	Euro per GJ
Euro per Kg	Euro per kilogram
Euro per ton	Euro per ton
GW	Giga Watt
GWh	GWh
Kt	Kilo Tons
ktoe	Kilo Tons Oil Eq
M Euro	Million Euro
Mt	Million Tons
Mtoe	Million Tons Oil Eq
PJ	Peta Joules
QBtu	Quad Btu
TBtu	Trillion Btu
MW	Megawatt

Unit Name: MW

Unit Description: Megawatt

● * .001 = GW

Figure 44: The Units window after adding MW

Note that selecting “GW” in the left panel should now reveal that the conversion

*** 1000 = MW**

has been added to it.

Units may be moved between VEDA-BE databases by using the units import/export function. To export units, select **Export Unit(s)** from the **Tools** menu. This will produce a prompt to name and provide a location in which to save a text (.UII) file. After you have clicked **Save**, a search form will come up allowing you to select the units to export in a very similar manner to the export of sets described in Section 3.4.

Choosing **Import Unit(s)** from the **Tools** menu will prompt you to locate and open a .UII file, and then allow you to search for and select the units to import.

The user should carefully observe the following notes on using the units handling facility:

- VEDA-BE does not know anything about native model units as they have been defined in VEDA-FE or ANSWER. The user must specify the native units in which results come to VEDA-BE from model using the table definition form, for each table where unit conversion is desired. These original units will be saved as part of the table definition. The units that appear when the table is viewed (the Active Units) may then be changed (and saved) within the view window.
- It is not necessary to provide native units as part of the table definition if no unit conversion is desired. Thus this step in the table definition may be postponed until such time that conversion is desired.
- Care needs to be taken when different attributes are mixed in a single table as they may be in different units. No native units should be provided for such a table, and the unit conversion facility should not be used, as the resulting values will be meaningless for the incompatible attribute(s).

6 Working with Excel and preparing reports

This section addresses two key capabilities for conducting a TIMES analysis: moving results data out of VEDA-BE into Microsoft Excel for further processing, and preparing analysis reports.

Results analysis often involves two distinct modes. One is exploratory in nature, where the analyst examines key results in the ExRES view and/or with a limited number of tables, drills into model details with the ExRES, exports selected pieces of data to Excel for further calculations, and designs new result tables to uncover new features of the results. There is a second mode, which may be called “production mode.” Here the table definitions and layouts have been stabilized, and it is desired to produce a set of tables and graphs without further user interference. After discussing two options for moving data into Excel, this section describes tools that may be used in production mode to produce analysis reports.

6.1 Moving results data into Excel

Two methods are available for moving data from the current table view into Excel.

First method – Copy/Paste: In any open table view, right click in the numerical area of the table, and choose **Copy Data** from the menu that appears. (Optionally, select any portion of the data by dragging through the desired cells first.) Switch to Excel and use **Edit->Paste** or **Ctrl-V** to paste the data in the desired location. The VEDA-BE table and appropriate row/column headers will be pasted along with the data. If no data was selected before choosing **Copy Data**, the entire table will be copied. This method allows you to rapidly select desired data and place it exactly where you want it.

Second method – Export: To move data from multiple tables to Excel automatically, use the **Export** method. First set user options for the handling of exported tables by choosing **Options** from the **Tools** menu of the main VEDA-BE window and going to the **Export Options** tab. Here you may set the path, file naming convention (add date/time stamp), and handling of multiple tables. Note that Excel is the recommended file type, and that **Show Exported Data** may not result in the exported files automatically opening after export, due to differences in how Excel may be configured on different machines. (On this tab you may also set behavior for **Batch** mode operations, as discussed in Section 6.2.)

To export data, in any open table view, click the **Export to Excel** icon in the toolbar, or right click in the numerical area of the table, and choose **Export** from the menu that appears. All open tables will be placed in one or multiple Excel files in the designated destination folder, according to the **Export Location** option selected.

6.2 The batch mode

The **batch mode** provides an option for processing multiple tables automatically without user intervention. This choice is available under the **View** menu, **Execution Mode** command. All we have seen up until now about VEDA-BE has been in the **Interactive** mode of operation.

If you choose the batch mode, the table definition window of the main screen is replaced by a list of existing tables, each preceded by a check box The user may then check any number of boxes, and VEDA-BE will process them as a batch when you click **View Table(s)**. Figure 45 shows an example of using the batch mode with four tables selected.

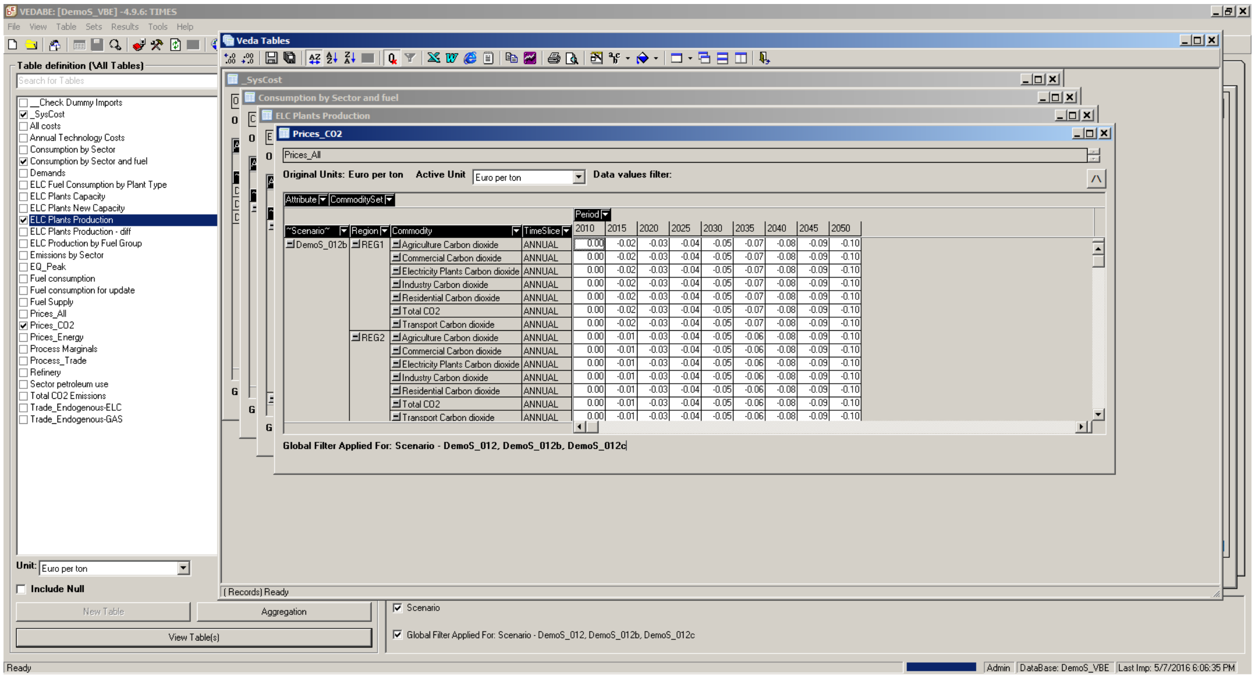

VEDABE: [DemoS_VBE] -4.9.6: TIMES
File View Table Sets Results Tools Help
Veda Tables
_SysCost
Consumption by Sector and fuel
ELC Plants Production
Prices_CO2
New Table
Aggregation
View Table(s)

Table definition (\All Tables)

Search for Tables

- □ __Check Dummy Imports
- ☑ _SysCost
- □ All costs
- □ Annual Technology Costs
- □ Consumption by Sector
- ☑ Consumption by Sector and fuel
- □ Demands
- □ ELC Fuel Consumption by Plant Type
- □ ELC Plants Capacity
- □ ELC Plants New Capacity
- ☑ ELC Plants Production
- □ ELC Plants Production - diff
- □ ELC Production by Fuel Group
- □ Emissions by Sector
- □ EQ_Peak
- □ Fuel consumption
- □ Fuel consumption for update
- □ Fuel Supply
- □ Prices_All
- ☑ Prices_CO2
- □ Prices_Energy
- □ Process Marginals
- □ Process_Trade
- □ Refinery
- □ Sector petroleum use
- □ Total CO2 Emissions
- □ Trade_Endogenous-ELC
- □ Trade_Endogenous-GAS

Unit: Euro per ton

□ Include Null

Prices_All

Original Units: Euro per ton Active Unit Euro per ton Data values filter:

Attribute CommoditySet

~Scenario~	Region	Commodity	TimeSlice	2010	2015	2020	2025	2030	2035	2040	2045	2050
DemoS_012b	REG1	Agriculture Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Commercial Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Electricity Plants Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Industry Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Residential Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Total CO2	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
		Transport Carbon dioxide	ANNUAL	0.00	-0.02	-0.03	-0.04	-0.05	-0.07	-0.08	-0.09	-0.10
	REG2	Agriculture Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Commercial Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Electricity Plants Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Industry Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Residential Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Total CO2	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10
		Transport Carbon dioxide	ANNUAL	0.00	-0.01	-0.03	-0.04	-0.05	-0.06	-0.08	-0.09	-0.10

Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

(Records) Ready

☑ Scenario

☑ Global Filter Applied For: Scenario - DemoS_012, DemoS_012b, DemoS_012c

Ready | Admin | DataBase: DemoS_VBE | Last Imp: 5/7/2016 6:06:35 PM

Figure 45: The batch mode

The operation(s) VEDA-BE performs on the requested tables depends on the **Batch Mode Options** set on the **Export Options** tab of the user options form, available by choosing **Options** from the **Tools** menu of the main VEDA-BE window. The user may request either or both of these options:

- **View Cube**: will open each requested table into view mode.
- **Export**: will export the requested tables according to the export options set as described in Section 6.1.

With the batch mode and its options, the user can easily reconstruct standard sets of tables as runs are refined and new runs performed.

The batch mode may also be used for database cleanup operations, to delete multiple tables at once. Choosing **Delete Table** from the **Table** menu while in batch mode will produce a prompt to confirm deletion of all tables with their checkboxes selected.

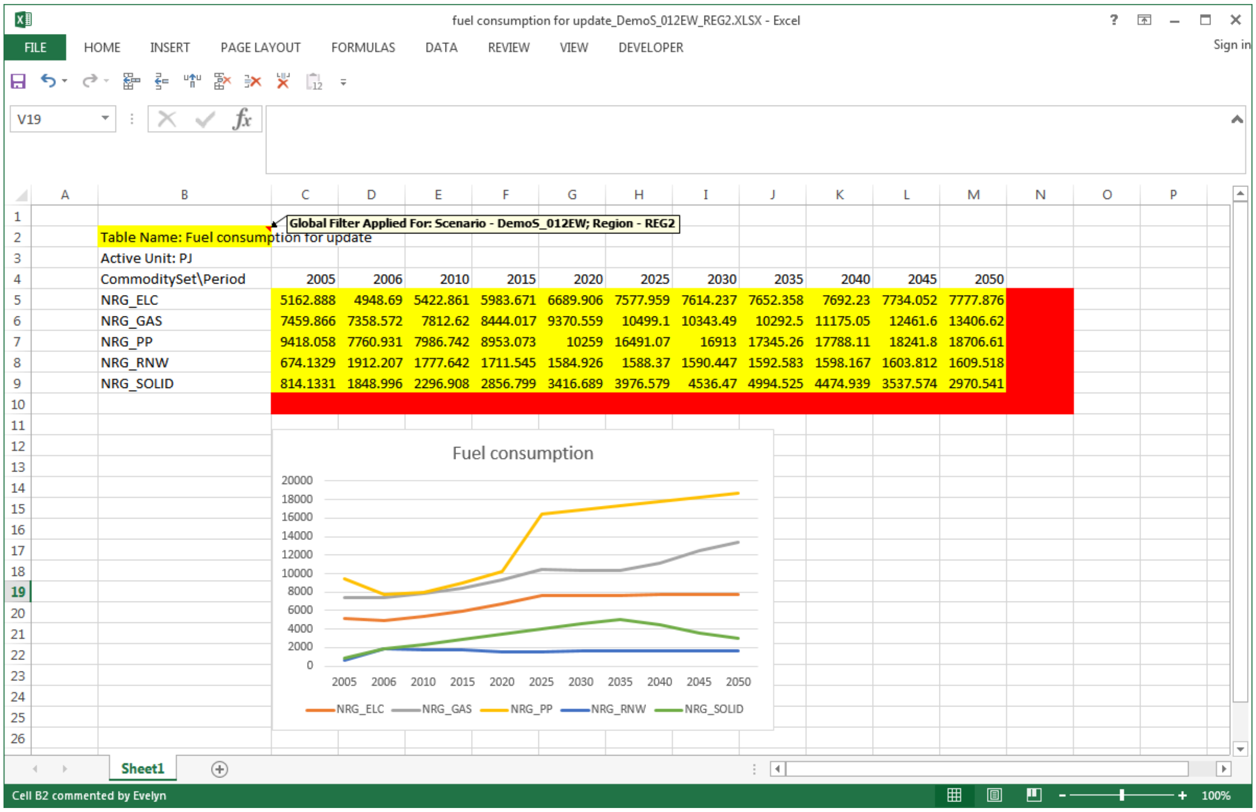
An alternative way to open multiple tables simultaneously for viewing is from the **Table Master** window (see Section 4.4). Here the user can request that all or selected tables from a Table Master folder be processed. The open tables can then be exported as described in Section 6.1.

6.3 Updating VEDA-BE results in Excel workbooks

Any Excel .xls format workbook containing tables that have been copy/pasted and/or exported using the methods described in Section 6.1 can be *updated* using the **Update Excel file** option from the **Tools** menu. When this tool is invoked, VEDA-BE will search the workbook for VEDA-BE tables corresponding to those in the open database, and then examine each data row/column, updating the data entries to the values currently in the associated tables. VEDA-BE will highlight (in yellow) all processed values, and indicate any problems encountered (in red). A comment will be placed in the table name cell, indicating any global filters used in the processing. A log file is also created (by default in the \VEDA_BE\Logs folder) that can be viewed at the end of the update request. It will list tables successfully updated along with table names found in the workbook that could not be matched (usually because of some difference in configuration) to those in the database.

This tool allows any calculations, graphs, etc. that are based upon results in a VEDA-BE table to be automatically updated with new results. The only restriction is that blank rows and columns should always be left on all four sides of tables that are to be updated by VEDA-BE, and blank rows/columns must not be inserted within the table. However, you can insert calculations such as growth rates/subtotals/shares within tables so long such row/column labels start with an asterisk (*).

Figure 46 shows a simple version of such a workbook, where a line graph has been made which will be updated each time the results are updated.



fuel consumption for update_DemoS_012EW_REG2.XLSX - Excel

Global Filter Applied For: Scenario - DemoS_012EW; Region - REG2

Table Name: Fuel consumption for update

Active Unit: PJ

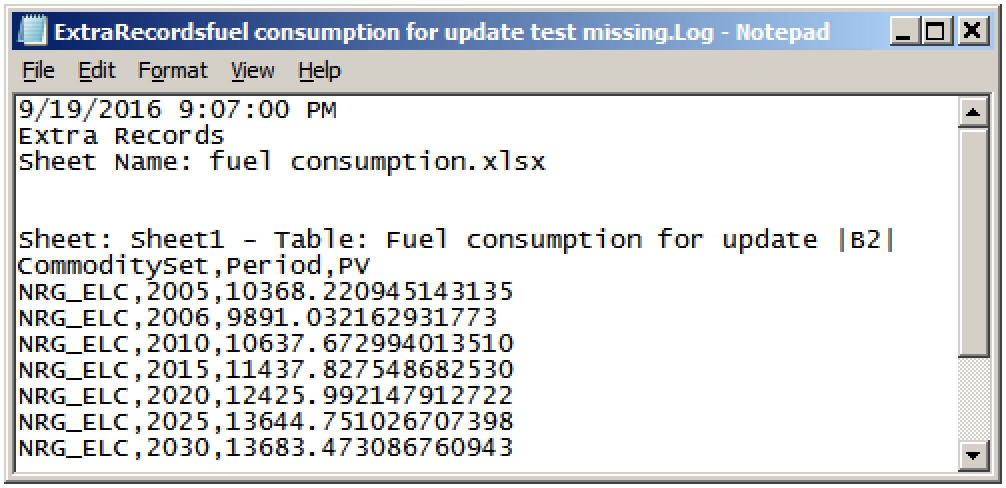
CommoditySet\Period	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
NRG_ELC	5162.888	4948.69	5422.861	5983.671	6689.906	7577.959	7614.237	7652.358	7692.23	7734.052	7777.876
NRG_GAS	7459.866	7358.572	7812.62	8444.017	9370.559	10499.1	10343.49	10292.5	11175.05	12461.6	13406.62
NRG_PP	9418.058	7760.931	7986.742	8953.073	10259	16491.07	16913	17345.26	17788.11	18241.8	18706.61
NRG_RNW	674.1329	1912.207	1777.642	1711.545	1584.926	1588.37	1590.447	1592.583	1598.167	1603.812	1609.518
NRG_SOLID	814.1331	1848.996	2296.908	2856.799	3416.689	3976.579	4536.47	4994.525	4474.939	3537.574	2970.541

Cell B2 commented by Evelyn

Figure 46: An Excel workbook updated with VEDA-BE results

This is a powerful tool, but one that must be used with care and attention. VEDA-BE will update those data entries for which it finds a match in the table/row/column specifications. Therefore, the user must ensure that tables currently available in VEDA-BE match exactly in format those in the target workbook. That is, table definitions and formats must not have changed, and VEDA-BE must be able to find the intended data upon processing the table, taking into account any global filters that may be currently set. VEDA-BE helps the user take care not to change the definition of tables that have been used in updates by highlighting the table name in red in the table definition form. It will also prompt you to reconsider if you attempt to save a change to the table definition.

In addition, the user should bear in mind that *only* the rows/columns listed in the target workbook table will be updated. VEDA-BE will not *add* additional rows/columns that may appear in currently available tables that were not pasted/exported into the target workbook. This can pose a problem if items (e.g., processes, fuels) that were not active in the scenarios used to create the Excel tables become active in later scenarios. If VEDA-BE does encounter extra records in a database table that are not listed in an Excel table updated, an *ExtraRecords* text file will be produced in the log folder listing these values (see Figure 47).


ExtraRecordsfuel consumption for update test missing.Log - Notepad
File
Edit
Format
View
Help

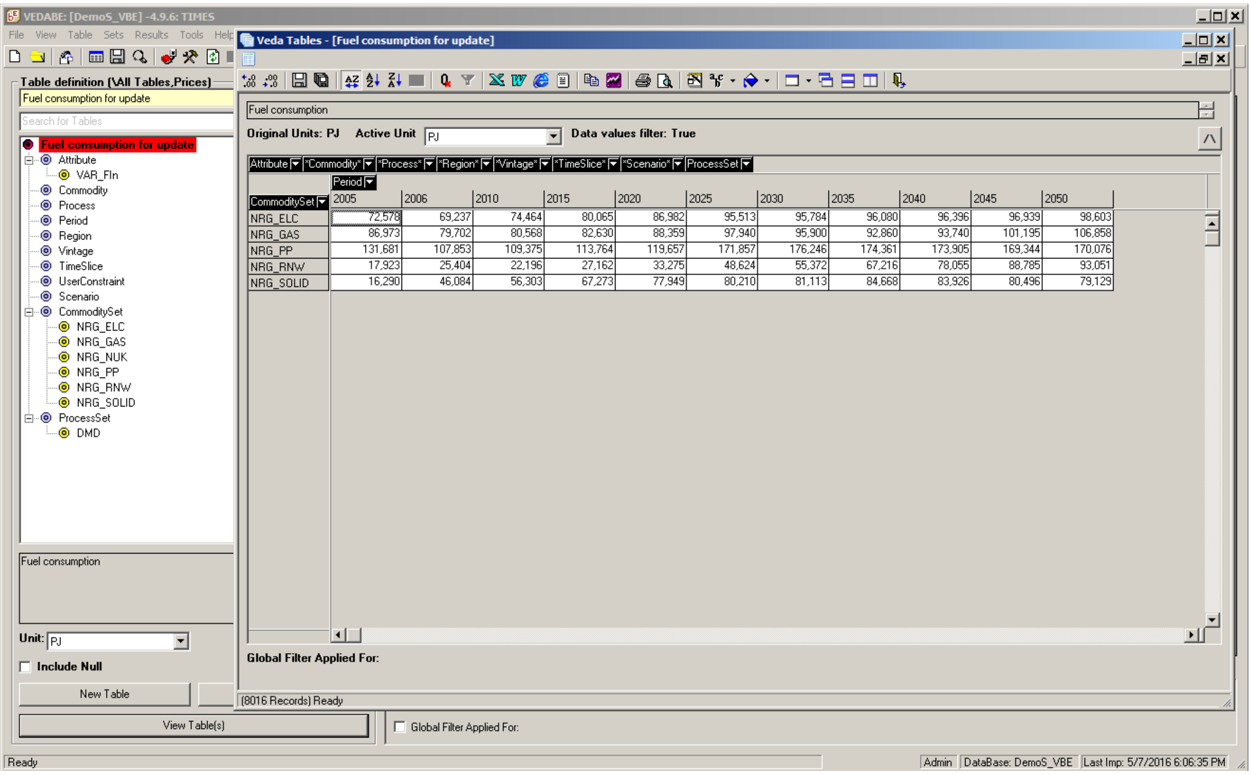
```
9/19/2016 9:07:00 PM
Extra Records
Sheet Name: fuel consumption.xlsx


Sheet: Sheet1 - Table: Fuel consumption for update |B2|
CommoditySet,Period,PV
NRG_ELC,2005,10368.220945143135
NRG_ELC,2006,9891.032162931773
NRG_ELC,2010,10637.672994013510
NRG_ELC,2015,11437.827548682530
NRG_ELC,2020,12425.992147912722
NRG_ELC,2025,13644.751026707398
NRG_ELC,2030,13683.473086760943
```

Figure 47: Sample ExtraRecords log file

In order to ensure intended results, the following best practices are suggested:

- Use sets rather than individual commodities/processes in tables wherever possible, as they are less likely to be omitted from some scenarios but appear in others.
- Prepare tables for copying/exporting to Excel by summing over the widest possible range of scenarios. (Run the full range of anticipated scenarios, place the scenario dimension on the page of all tables, and do not include scenarios in the table definition.) This will help ensure that surprise items do not show up later in the analysis.
- If elements are clearly missing, manually expand the target table to include them.
- Check the log file (and the *ExtraRecords* file, if any) in the VEDA_BE\Logs folder after updates for any possible issues.

Figure 48 shows how the *Fuel consumption* table was modified to prepare it for use in a workbook update. Process, commodity, scenario, and region have all been moved to the page. The desired scenario for any update will be selected using a global filter or through using the batch mode (described below). Individual regions may also be selected using a global filter or batch mode, or the table may be used to report the sum of results across regions. Finally, the table was saved with a different name ("*for update*") so that the original table may continue to be used within VEDA-BE.



VEDABE: [DemoS_VBE] -4.9.6: TIMES
File View Table Sets Results Tools Help
Veda Tables - [Fuel consumption for update]
Table definition (\All Tables,Prices)
Search for Tables
Fuel consumption for update
Attribute
VAR_FIn
Commodity
Process
Period
Region
Vintage
TimeSlice
UserConstraint
Scenario
CommoditySet
NRG_ELC
NRG_GAS
NRG_NUK
NRG_PP
NRG_RNW
NRG_SOLID
ProcessSet
DMD
Include Null
New Table
View Table(s)
Global Filter Applied For:
Ready
Admin
DataBase: DemoS_VBE
Last Imp: 5/7/2016 6:06:35 PM
Attribute *Commodity* *Process* *Region* *Vintage* *TimeSlice* *Scenario* ProcessSet
Period
(8016 Records) Ready

Fuel consumption

Unit: PJ

Original Units: PJ   Active Unit PJ   Data values filter: True

CommoditySet	2005	2006	2010	2015	2020	2025	2030	2035	2040	2045	2050
NRG_ELC	72,578	69,237	74,464	80,065	86,982	95,513	95,784	96,080	96,396	96,939	98,603
NRG_GAS	86,973	79,702	80,568	82,630	88,359	97,940	95,900	92,860	93,740	101,195	106,858
NRG_PP	131,681	107,853	109,375	113,764	119,657	171,857	176,246	174,361	173,905	169,344	170,076
NRG_RNW	17,923	25,404	22,196	27,162	33,275	48,624	55,372	67,216	78,055	88,785	93,051
NRG_SOLID	16,290	46,084	56,303	67,273	77,949	80,210	81,113	84,668	83,926	80,496	79,129

Figure 48: The Fuel consumption table as modified for use in update

The **Update Excel File** command offers three options:

- **All Tables** will prompt you to locate the desired workbook and update all properly formatted tables found in the workbook.
- **Selected Tables** will provide a checklist of all properly formatted tables found in the selected workbook and prompt you to choose the desired ones.
- **Batch Mode** will prompt you to select desired scenarios and regions, and then iterate the update process, producing separate workbooks for each scenario/region combination requested. If no regions are selected, the process will sum over all regions, subject to any global filter on regions in place at the time of update. (There is no option to sum over scenarios.)

This function can be combined with Excel functions and macros to generate quite complex reports and graphics.

7 Best practices for using VEDA-BE

This section provides a recap of advanced features and best practices discussed elsewhere in this manual that both new and experienced users are recommended to include in their repertoire.

- Use the **ExRES** for model debugging and quick result viewing without building new tables. Set a default coloring scheme for the ExRES view, to help readily distinguish it from table views (Section 2.4). The ExRES view can also be an excellent way to introduce new users to model results, as it presents a deep dive into the currently active portion of the model RES.
- When building and viewing tables, make use of **global filters.** Table definitions are meant to change only when you want to change the underlying logic of the table, not when you are just focused on a particular part of the results. Keep items that can better be applied to tables using global filters out of table definitions. Most commonly, this advice applies to scenarios and regions. Also, make use of the option to save and reuse global filter definitions (Section 2.3.5).
- When **defining sets**, consider set maintenance. How well will your definitions hold up over time? Use model topology, or rigorously adhered to naming conventions, as the basis for set definitions. And consider how you can use intersections between processes, commodities and process and commodity sets to build tables. You may need fewer sets than you think. For example, to view final energy by end use and fuel in a sector, combine process sets for devices satisfying each end use with the attribute ***Var_FIn*** and commodity sets for types of fuels (e.g., *all coal*, *all petroleum products*, etc). Separate sets by sector/end use and fuel are not needed.
- Use the **units** facility (Section 5) to readily convert tables from native model units to desired units for reporting.
- Select the user option to **save cube files** (Section 2.3.7). This speeds up the presentation of repeatedly selected analysis tables (when no information has changed in the table since the last request).
- Explore using **Batch mode** and **Excel export** and **update** operations to facilitate results reporting (Section 6).
- Join the **Veda Support Forum** (link available from the **Help** menu).

Appendix A
VEDA-BE TIMES Attributes

Table A-1 provides a list of VEDA-BE TIMES attributes produced by the **gdx2veda** GAMS utility from a TIMES run **GDX** file, according to the **times2veda.vdd** directives (see Appendix B) and the reporting options (see Part III, Section 3.10) invoked with the run. Not all attributes listed will appear in every VEDA-BE database. Many attributes will not appear if the driving input attributes were not used in the model input. See Part II, Section 3.3.1 for more details on the TIMES reporting parameters.

Table A-1 VEDA-BE attributes

VEDA-BE attribute	Dimensions involved*	Description
Cap_New	p	New capacity and lumpsum investment costs. (UC tags INSTCAP and LUMPINV, respectively.)
Cost_Act	p	Annual variable activity costs of processes. Undiscounted.
Cost_Com	c	Annual commodity costs. Undiscounted.
Cost_Comx	c	Annual commodity taxes/subsidies. Undiscounted.
Cost_Dam	c	Annual undiscounted commodity related damage costs, generated by DAM_COST.
Cost_Dec	p	Annualized decommissioning costs for a process. Undiscounted.
Cost_Els	c	Annual elastic demand costs (losses) due to elastic demand changes. Undiscounted.
Cost_Fixx	p	Annual fixed taxes/subsidies associated with process installed capacity. Undiscounted.
Cost_Flo	p,c	Annual flow costs (including exogenous import/export prices). Undiscounted.
Cost_Flox	p,c	Annual undiscounted flow-related tax/subsidy costs (caused by FLO_TAX, FLO_SUB) in period (t) associated with a commodity (c) flow in/out of a process (p) with vintage period (v) as well as capacity related commodity flows.
Cost_Fom	p	Annual fixed operating and maintenance costs. Undiscounted.
Cost_Inv	p	Annualized investment costs. Undiscounted.
Cost_Invx	p	Annual undiscounted investment taxes/subsidies, spread over the economic process lifetime.
Cost_ire	p	Annual implied costs of endogenous trade, valued according to the marginal(s) of the trade equation of process p. Undiscounted
Cost_NPV	p,c	Total discounted costs by component. See Table A-2 below for components, and Part III, Section 3.10 for reporting options.
COST_Salv	p	Salvage value of investment cost, taxes and subsidies of process (p) with vintage period (v), for which the technical lifetime exceeds the end of the model horizon, value at year EOH+1.

Dual_Clic	c	Climate module results for the duals of constraint related to climate variable (c) in period (t).
EQ_Combal	c	Commodity Slack/Levels: commodity production minus consumption.
EQ_CombalM	c	Commodity shadow price
EQ_Cumflo	p,c	Level of cumulative constraint for flow of commodity (c) of process (p) between the year range (v–t).
EQ_CumfloM	p,c	Shadow price of cumulative constraint for flow of commodity (c) of process (p) between the year range (v–t). Not undiscounted.
EQ_IreM	p,c	Inter-regional trade equation marginal. The undiscounted shadow price can be interpreted as the import/export price of the traded commodity.
EQ_Peak	c	Peaking constraint slack
EQ_PeakM	c	Peaking Constraint shadow price (price premium for consumption during peak timeslice paid by the consumer in addition to COMBAL price).
ObjZ	none	Total discounted present value of system cost
PAR_CapLO	p	Capacity lower limit
PAR_CapUP	p	Capacity upper limit
Reg_ACost	r	Regional total annualized costs by period and cost category. (See Table A-2 below for categories.)
Reg_irec	r	Regional total discounted implied trade cost, derived by multiplying the shadow prices of the trade equations by the trade volumes. The sum of REG_IREC over regions is zero.
Reg_obj	r	Regional total discounted system cost
Reg_wobj	r	Regional total discounted system cost by cost type (uc_n). (See Table A-2 below for cost types.)
Time_NPV		Present value of the time in each model period (t) by region (r), with s='ANNUAL' and uc_n='COST'/'LEVCOST' depending on whether the $SET ANNCOST LEV reporting option has been used.
User_Con		Level of user constraint (or its slack). Only reported when the VAR_UC variables are used.
User_ConFXM		User constraint shadow price. Undiscounted only if the constraint is defined by region and period.
User_DynbM		Undiscounted shadow price of dynamic process-wise bound constraint, identified with name uc_n, for variable c (CAP / NCAP / ACT), in period t and timeslice s.
Val_Flo	p,c	Annual commodity flow values: Flows of process (p) multiplied by the commodity balance marginals of those commodities (c), which can be interpreted as the market values of the process inputs and outputs.
VAR_Act	p	Process activity level
VAR_ActM	p	Process activity marginal. Annual undiscounted reduced cost of process activity variable.
VAR_Cap	p	Process capacity. The vintage tags 0, -, and ¤ are used to indicate residual capacity, new capacity, and retired

		capacity, respectively.
VAR_CapM	p	Process capacity marginal. Undiscounted reduced cost of process capacity variable, when generated.
VAR_Climate		Climate module results for the levels of climate variable (c) in period (t).
VAR_Comnet	c	Commodity net quantity (consumption minus production); only generated when bound is specified by the user (COM_BNDNET).
VAR_ComnetM	c	Dual variable of bound put on the net production of a commodity.
VAR_Comprd	c	Commodity total production; only generated when bound is specified by the user (COM_BNDPRD).
VAR_ComprdM	c	Dual variable of constraint related to the bound on the production of a commodity.
VAR_CumCst		Cumulative costs by type (if constrained).
VAR_Eout		Electricity output of electricity supply processes by energy source. (Opted out by default – set RPT_OPT('FLO','5')=1 to activate; see Part III, Section 3.10).
VAR_Fin	p,c	Commodity consumption by process
VAR_Fout	p,c	Commodity production by process
VAR_Ncap	p	Technology investment
VAR_NcapM	p	Technology investment marginal. Undiscounted reduced cost of process investment variable.
VAR_NcapR	p	Technology Investment – BenCost + ObjRange (see Part II, Section 3.3.3 and Part III, Section 3.10 for more details): Cost-benefit and ranging indicators for process (p) in period (t), where uc_n is the name of the indicator: • COST - the total unit costs of VAR_NCAP (in terms of an equivalent investment cost) • CGAP - competitiveness gap (in terms of investment costs), obtained directly from the VAR_NCAP marginals (and optional ranging information) • GGAP - competitiveness gap (in terms of investment costs), obtained by checking also the VAR_ACT, VAR_FLO and VAR_CAP marginals, in case VAR_NCAP is basic at zero • RATIO - benefit / cost ratio, based on CGAP • GRATIO - benefit / cost ratio, based on GGAP • RNGLO - ranging information (LO) for VAR_NCAP (if ranging is activated; in terms of investment costs) • RNGUP - ranging information (UP) for VAR_NCAP (if ranging is activated; in terms of investment costs)

* p = *process*, c= *commodity*, r = *region*, t = *period*, s = *timeslice*, and v = *vintage*
In addition, the r,t,s,v dimensions are involved for attributes involving processes, and the r,t,s dimensions for attributes involving commodities only.

Table A-2: Acronyms used in the cost reporting parameters.

Cost parameter	**Component acronyms**
COST_NPV	Total discounted costs by commodity/process: COM Commodity-related costs, taxes and subsidies ELS Losses in elastic demands DAM Damage costs INV Investment costs, taxes and subsidies, excluding portions attributable to hurdle rates in excess of the general discount rate INV+ Investment costs, taxes and subsidies, portions attributable to hurdle rates in excess of the general discount rate FIX Fixed costs, taxes and subsidies ACT Activity costs FLO Flows costs taxes and subsidies (including exogenous IRE prices) IRE Implied trade costs minus revenues
REG_ACOST	Regional total annualized costs by period: INV Annualized investment costs INVX Annualized investment taxes and subsidies FIX Annual fixed costs FIXX Annual fixed taxes and subsidies VAR Annual variable costs VARX Annual variable taxes and subsidies IRE Annual implied trade costs minus revenues ELS Annual losses in elastic demands DAM Annual damage costs
REG_WOBJ	Regional total discounted system cost by component: INV Investment costs INVX Investment taxes and subsidies FIX Fixed costs FIXX Fixed taxes and subsidies VAR Variable costs VARX Variable taxes and subsidies ELS Losses in elastic demands DAM Damage costs

Appendix B
GDX2VEDA and the VEDA data definition file

To get results from the GAMS solution (found in the GDX file) to VEDA-BE, the GDX2VEDA utility processes the GAMS GDX file according to the directives contained in the TIMES2VEDA.VDD (VEDA data definition) file, and produces the results files to be imported into VEDA-BE. The VDD file specifies which sets and model results are to be included and how to prepare this information for VEDA-BE. Thus the GDX2VEDA GAMS utility allows anyone familiar with a particular model to specify what information should be extracted from the GAMS model and passed to VEDA-BE. The call to the GDX2VEDA routine is embedded in the VTRUN / ANSRUN.CMD command routines.

For those working with TIMES, an appropriate initial VDD file is distributed in the source code folder (one for conventional TIMES (and MACRO/MCA), and another for Stochastics), which requests the dumping of the information summarized in Appendix A. However, with a proper understanding of the VDD file, after saving the standard VDD, a knowledgeable user may carefully augment the VDD to request additional information be moved from GAMS to VEDA-BE.

> The user is encouraged to first examine (via the **GAMSIDE**, see Section 2.3.3 of Part III) what information is found in the TIMES GDX file, including its structure (indexes), to determine what and how to introduce additional information to be dumped to the VDD. Furthermore, the process of changing the VDD should be done in consultation with someone fully familiar with the GAMS GDX file for TIMES and the basics of the GDX2VEDA utility.

In this Appendix we first simply reproduce the Command Prompt `GDX2VEDA --help` echoed help file, annotated with explanatory footnotes. The help file explains the way to call GDX2VEDA, as well as the various options available to the user in the VEDA Data Definition (VDD) file that control how and what gets dumped. The next section provides the initial TIMES2VEDA.VDD file for the core TIMES model distributed with the TIMES source code. The final section provides examples of the VD* results files.

B.1 The GDX2VEDA help file

```
>gdx2veda gdx vdd [run]

   gdx  GAMS GDX file
   vdd  VEDA Data Definition file
   run  VEDA Run identifier (optional)

The VEDA data file name and run identifier are either taken from the gdx file
name or specified with the run name. Use "token with blanks" if needed.

>gdx2veda mygdx    //  will dump the gdx symbols
>gdx2veda          //  prints this message
>gdx2veda --help   //  prints more detailed help message[8]

Add .csv to the run name to write in csv format.
```

[8] This message!

```
VDD File Summary
----------------
[DataBaseName][9]
 myveda

[Dimensions][10] cube dimensions
 long_name tuple_element1 tuple_element2 ...

[DataEntries][11] data for the cube
 long_name gams_name tuple_element1 tuple_element2 ...

[DimensionText][12] for generating .vde file (only for data in [DataEntries])
 gams_set tuple_element1 tuple_element2 ...

[DimensionTextAll][13] for generating .vde file (also for data not in
[DataEntries])
 gams_set tuple_element1 tuple_element2 ...

[SubSets][14] for generating .vds file
 sub_name gams_name tuple_element1 tuple_element2 ...

[ParentDimension] defines parent-child structure
 parent_tab  child_tab1 child_tab2 ...

[ParentDimensionTextAll] .vde file definitions with parent-child structure
2d_gams_set  parent_tab child_tab
2d_gams_set  child_tab parent_tab

[ParentSubSets] .vds file definitions with parent-child structure
sub_name 2d_gams_set parent_tab child_tab
sub_name 2d_gams_set child_tab parent_tab

[Options]
TupleSeparator "string"  use a different separator symbol between tuple
elements
ShowAllSeparators        don't squeeze unnecessary separators
RelaxDimensionAll        relax strict dimensionality checks in
DimensionText(All) sections.
ValueDim n               if n=2 write PV/DV value pairs for VEDA
SetsAllowed dim1 dim2 .. write SetsAllowed specification line to VEDA .vd
file
Scenario scenarioSet     specify the scenario set; a record with expl text
goes to .vde
Format veda/csv          specify the format of the data files
Not-0 attribute ...      don't write records with zero values for these
attributes

[SpecialValues]
EPS "string"             value to be used for EPS
```

[9] Name of the application.

[10] The various tabs to appear on the VEDA-BE screen.

[11] The individual data structures (Attributes) to be managed by VEDA-BE.

[12] Optional list of individual elements of the tab_names with their descriptions. Otherwise, all instances found in the data are enumerated and their associated description passed to VEDA-BE. If one [DimensionText] is provided the auto-generated tab list is not used.

[13] Optional list of additional elements of the tab_names not found in the set/index in the model data but whose description is desired.

[14] For each tab for which set management is to be performed by VEDA-BE, the system sets and subsets need to be provided.

```
INF "string"             value to be used for +INF
MINF "string"            value to be used for -INF
NA "string"              value to be used for NA
UNDEF "string"           value to be used for UNDEF
```

```
<myveda> is usually the application name which will be displayed
         on the top of the VEDA splash screen. When a new VEDA database is
         created, a new folder with this name will appear:
         ...veda\database\mayveda_date_time.
         where date and time are the creation time stamp.
<tab_name> corresponds to the tabs of your VEDA screen
```

Lines starting with * and empty lines are ignored.
Blanks, commas and tabs are delimiters, blanks before and after delimiters are ignored. Quotes around data items are optional.
The input data is NOT case sensitive.

Example of a VEDA Data Definition file

```
* Transport model

[DataBaseName]
myveda

[Dimensions]
* tab-name  indices
Plants      i
Warehouses  j
Links       ii jj

[DataEntries]
* veda_attribute gams_name tab1 tab2 ... for gams index 1, 2, ...
"x(i,j) duals" x.m      i  Warehouses
Shipments      x.l      i  j
SupplyPrice    supply.m i
DemandPrice    demand.m j
TransportCost  c        i  j
Distance       d        ii jj
Supply         a        i
Demand         b        j
TotalCost      z.l
SupplyNodes    i        i
DeamndNodes    j        j
Rate           f

[DimensionText]
* gams_set tab
i  i

[DimensionTextAll]
j  j

[SubSets]
* sub_name gams_name tab
i1 ic  Plants
i1 id  i
```

Notes:
The long name from the [Dimensions] section can be used as a macro that expands to the tuples it defines. E.g. “Links” is identical to “ii jj”.
In the [DataEntries] section a literal tuple element can be defined as /element/.

When ValueDim=2, the [DataEntries] section can contain X.LM entries, indicating both .L and .M needs to written as a pair.

B.2 The TIMES2VEDA.VDD file for the core TIMES model

```
*
* TIMES GDX2VEDA Set Directives
*

[DataBaseName]
 TIMES

[Dimensions]
 Attribute        attr
 Commodity        c
 Process          p
 Period           t
 Region           r
 Vintage          v
 TimeSlice        s
 UserConstraint  uc_n

[ParentDimension]
 Region Commodity Process UserConstraint

[Options]
SetsAllowed Commodity Process UserConstraint
*Scenario SCENCASE
*ValueDim 2
not-0 var_fin var_fout var_act var_actm var_cap var_capm cost_flo cost_act
eq_cumflo eq_combal eq_combalm

[DataEntries]
* VEDA Attr     GAMS             - indexes -
*** Variables & Parameters
  VAR_Act       par_actl         r v t p s
  VAR_ActM      par_actm         r v t p s
  VAR_Cap       par_capl         r t p
  VAR_Cap       par_pasti        r t p v
  VAR_CapM      par_capm         r t p
  VAR_Ncap      par_ncapl        r t p
  VAR_NcapM     par_ncapm        r t p
  VAR_NcapR     par_ncapr        r t p uc_n
  VAR_FIn       f_in             r v t p c s
  VAR_FOut      f_out            r v t p c s
  VAR_FOut      agg_out          r t c s
  VAR_Comprd    par_comprdl      r t c s
  VAR_ComprdM   par_comprdm      r t c s
  VAR_Comnet    par_comnetl      r t c s
  VAR_ComnetM   par_comnetm      r t c s
  VAR_Eout      par_eout         r v t p c
  VAR_CumCst    par_cumcst       r v t uc_n c
*** Equations
  EQ_Combal     eqg_combal.l     r t c s
  EQ_CombalM    par_combalem     r t c s
  EQ_Combal     eqe_combal.l     r t c s
  EQ_CombalM    par_combalgm     r t c s
  EQ_Peak       eq_peak.l        r t c s
  EQ_PeakM      par_peakm        r t c s
  EQ_IreM       par_ipric        r t p c s uc_n
  EQ_Cumflo     par_cumflol      r p c v t
  EQ_CumfloM    par_cumflom      r p c v t
*** Parameters
  PAR_Top       par_top          r t p c uc_n
  PAR_CapLO     par_caplo        r t p
  PAR_CapUP     par_capup        r t p
  Cap_New       Cap_New          r v p t uc_n
*** Costs
  Cost_Inv      cst_invc         r v t p uc_n
  Cost_Invx     cst_invx         r v t p uc_n
  Cost_Salv     cst_salv         r v p
  Cost_Dec      cst_decc         r v t p
  Cost_Fom      cst_fixc         r v t p
  Cost_Fixx     cst_fixx         r v t p
  Cost_Act      cst_actc         r v t p uc_n
  Cost_Flo      cst_floc         r v t p c
  Cost_Flox     cst_flox         r v t p c
  Cost_Com      cst_comc         r t c
  Cost_Comx     cst_comx         r t c
  Cost_Els      cst_come         r t c
  Cost_Dam      cst_dam          r t c
  Cost_ire      cst_irec         r v t p c
  Cost_NPV      cst_pvp         uc_n r p
  Cost_NPV      cst_pvc         uc_n r c
  Time_NPV      cst_time         r t s uc_n
  Val_Flo       val_flo          r v t p c
  ObjZ          ObjZ.l
  Reg_wobj      reg_wobj         r uc_n c
  Reg_obj       reg_obj          r
  Reg_irec      reg_irec         r
  Reg_ACost     reg_acost        r t uc_n
  User_con      par_ucsl         uc_n r t s
  User_conFXM   par_ucsm         uc_n r t s
  User_conFXM   par_ucmrk        r t uc_n c s
  User_DynbM    par_ucrtp        uc_n r t p c
  User_MaxBet   par_ucmax        uc_n r p c
*** Climate and MACRO
  VAR_Climate   CM_RESULT        c t
  Dual_clic     CM_MAXC_M        c t
  VAR_Macro     TM_RESULT        c r t

[DimensionTextAll]
* Gams_set_name  Veda_Tab
adesc    attr
uc_n     uc_n
sysuc    uc_n

[ParentDimensionTextAll]
* Gams_set_name  Veda_Tab
prc_desc   r p
com_desc   r c

[ParentSubSets]
*  subset  GAMS    VEDA Tab
* processes
  DMD DMD     r p
  PRE PRE     r p
  PRW PRW     r p
  PRV PRV     r p
  REF REF     r p
  ELE ELE     r p
  CHP CHP     r p
  HPL HPL     r p
  STG RP_STG  r p
  DISTR DISTR r p
  IRE RP_IRE  r p
* commodities
  NRG  NRG    r c
  DEM  DEM    r c
```

```
ENV  ENV    r c
MAT  MAT    r c
RES  RES    r c
COMM COMM   r c
TRN  TRN    r c
AGR  AGR    r c
NE   NE     r c
IND  IND    r c
ELC+ NRGELC r c
HET+ NRGHET r c
UC_Const uc_r_each r uc_n
UC_Const uc_const  r uc_n
UC_DynBD uc_dynbd  r uc_n
```

B.3 The VEDA-BE results files

There are three files produced for VEDA-BE by the GDX2VEDA utility: the <scenarioname>.VD data dump with the attributes, <scenarioname>.VDE (set elements), and <scenarioname>.VDS (sets definition). In addition, VEDA-FE and ANSWER produce a <scenarioname>.VDT (topology) file with the RES connectivity information. These files are dumped in comma delimited format. They never require user intervention, though they may be processed by other software if desired.

Snippets of each file are shown below, after a brief description of the layout of each.

B.3.1 <scenarioname>.VD

The <scenarioname>.VD file contains the application VEDA-BE header directives (controlling the appearance of the main VEDA-BE table specification form) followed by the actual model data.

Layout, after the header: Attribute, Commodity, Process, Period, Region, Vintage, Timeslice, UserConstraint, Value;

Excerpt:

```
*  GDX2VEDAversion- 2005-10-07
*         ImportID- Scenario:DemoS_012b
*       VEDAFlavor- TIMES
*       Dimensions-
Attribute;Commodity;Process;Period;Region;Vintage;TimeSlice;UserConstraint
;PV
* ParentDimensions- Commodity: Region; Process: Region
*      SetsAllowed- Commodity;Process
*        FieldSize-
Attribute:31;Commodity:31;Process:31;Period:31;Region:31;Vintage:31;TimeSl
ice:31;UserConstraint:31;PV:20
*       NotIndexed- PV
*         ValueDim- PV
*  DefaultValueDim- PV
*   FieldSeparator- ,
*        TextDelim- "

"VAR_Act","-","AOTETOT","2005","REG1","2005","ANNUAL","-",564.8409
"VAR_Act","-","CAPEELC","2005","REG1","2005","ANNUAL","-",1148.6992095
"VAR_Act","-","COTEBIO","2005","REG1","2005","ANNUAL","-",3.939
"VAR_Act","-","COTECOA","2005","REG1","2005","ANNUAL","-",37.3712625
```

```
"VAR_Act","-","COTEELC","2005","REG1","2005","ANNUAL","-",63.8166227499999
"VAR_Act","-","COTEGAS","2005","REG1","2005","ANNUAL","-",212.309676
"VAR_Act","-","COTEOIL","2005","REG1","2005","ANNUAL","-",129.503715
"VAR_Act","-","CSHEBIO","2005","REG1","2005","ANNUAL","-",35.451
"VAR_Act","-","CSHEELC","2005","REG1","2005","ANNUAL","-",63.81662275
"VAR_Act","-","CSHEGAS","2005","REG1","2005","ANNUAL","-",495.389244
"VAR_Act","-","CSHEOIL","2005","REG1","2005","ANNUAL","-",302.175335
"VAR_Act","-","CSHESOL","2005","REG1","2005","ANNUAL","-",7.575
"VAR_Act","-","ELCNENUC00","2005","REG1","2005","S","-",746.220483540681
"VAR_Act","-","ELCNENUC00","2005","REG1","2005","W","-",723.929516459321
"VAR_Act","-","ELCREHYD00","2005","REG1","2005","SD","-",244.125
"VAR_Act","-","ELCREHYD00","2005","REG1","2005","SN","-",0.837000000000359
"VAR_Act","-","ELCREHYD00","2005","REG1","2005","WD","-",243.846
"VAR_Act","-","ELCRESOL00","2005","REG1","2005","SD","-",16.9805936073059
"VAR_Act","-","ELCRESOL00","2005","REG1","2005","SN","-",10.4147640791476
"VAR_Act","-","ELCRESOL00","2005","REG1","2005","WD","-",16.9611872146119
"VAR_Act","-","ELCRESOL00","2005","REG1","2005","WN","-",12.2907153729072
"VAR_Act","-","ELCREWIN00","2005","REG1","2005","SD","-",71.5472816780823
"VAR_Act","-","ELCREWIN00","2005","REG1","2005","SN","-",43.3049336472603
"VAR_Act","-","ELCREWIN00","2005","REG1","2005","WD","-",75.2268561643836
"VAR_Act","-","ELCREWIN00","2005","REG1","2005","WN","-",71.5472816780823
"VAR_Act","-","ELCTECOA00","2005","REG1","2005","S","-",1351.31629846897
"VAR_Act","-","ELCTECOA00","2005","REG1","2005","W","-",1044.37445353102
"VAR_Act","-","ELCTEGAS00","2005","REG1","2005","SD","-",226.711979456911
"VAR_Act","-","ELCTEGAS00","2005","REG1","2005","SN","-",300.30842173892
"VAR_Act","-","EXPCOA1","2005","REG1","2005","ANNUAL","-",745.59485
"VAR_Act","-","EXPHFO1","2005","REG1","2005","ANNUAL","-",804.770973903333
"VAR_Act","-","EXPKER1","2005","REG1","2005","ANNUAL","-",295.3885
"VAR_Act","-","EXPLPG1","2005","REG1","2005","ANNUAL","-",32.1237949472747
"VAR_Act","-","EXPNAP1","2005","REG1","2005","ANNUAL","-",400.84
"VAR_Act","-","EXPOIL1","2005","REG1","2005","ANNUAL","-",1648.4855
"VAR_Act","-","EXPOPP1","2005","REG1","2005","ANNUAL","-",453.036
"VAR_Act","-","FTE-AGRBIO","2005","REG1","2005","ANNUAL","-
",8.9265138547333
"VAR_Act","-","FTE-AGRCOA","2005","REG1","2005","ANNUAL","-
",8.46903001967851
"VAR_Act","-","FTE-AGRELC","2005","REG1","2005","SD","-",72.2276809309521
"VAR_Act","-","FTE-AGRELC","2005","REG1","2005","SN","-",66.4494664564759
"VAR_Act","-","FTE-AGRELC","2005","REG1","2005","WD","-",72.1451350098882
"VAR_Act","-","FTE-AGRELC","2005","REG1","2005","WN","-",78.418625010748
"VAR_Act","-","FTE-AGRGAS","2005","REG1","2005","ANNUAL","-
",160.377867843615
"VAR_Act","-","FTE-AGROIL","2005","REG1","2005","ANNUAL","-
",97.8265808739081
"VAR_Act","-","FTE-COMBIO","2005","REG1","2005","ANNUAL","-",48.25275
"VAR_Act","-","FTE-COMCOA","2005","REG1","2005","ANNUAL","-",37.3712625
"VAR_Act","-","FTE-COMELC","2005","REG1","2005","SD","-",309.846497299342
"VAR_Act","-","FTE-COMELC","2005","REG1","2005","SN","-",309.846497299342
"VAR_Act","-","FTE-COMELC","2005","REG1","2005","WD","-",329.999115009868
"VAR_Act","-","FTE-COMELC","2005","REG1","2005","WN","-",329.999115009868
"VAR_Act","-","FTE-COMGAS","2005","REG1","2005","ANNUAL","-
",762.742169333334
"VAR_Act","-","FTE-COMOIL","2005","REG1","2005","ANNUAL","-",507.22288375
```

B.3.2 <scenarioname>.VDE

The <scenarioname>.VDE file contains the list of individual set member elements for each index managed by VEDA-BE along with their descriptions.

Layout: Dimension Name - Region - Element name - Element Description;

Excerpt:

```
"Attribute","-","VAR_act","Process Activity"
"Attribute","-","VAR_actM","Process Activity - Marginals"
"Attribute","-","VAR_cap","Technology Capacity"
"Attribute","-","VAR_capM","Technology Capacity - Marginals"
"Attribute","-","VAR_ncap","Technology Investment - New capacity"
"Attribute","-","VAR_ncapM","Technology Investment - Marginals"
"Attribute","-","VAR_ncapR","Technology Investment - BenCost + ObjRange"
"Attribute","-","VAR_fin","Commodity Consumption by Process"
"Attribute","-","VAR_fout","Commodity Production by Process"
"Attribute","-","VAR_comprd","Commodity Total Production"
"Attribute","-","VAR_comprdM","Commodity Total Production - Marginal"
"Attribute","-","VAR_comnet","Commodity Net"
"Attribute","-","VAR_comnetM","Commodity Net - Marginal"
"Attribute","-","VAR_eout","Electricity supply by technology and energy
source"
"Attribute","-","EQ_combal","Commodity Slack/Levels"
"Attribute","-","EQ_combalM","Commodity Slack/Levels - Marginals"
"Attribute","-","EQ_peak","Peaking Constraint Slack"
"Attribute","-","EQ_peakM","Peaking Constraint Slack - Marginals"
"Attribute","-","EQ_Cumflo","Cumulative flow constraint - Levels"
"Attribute","-","EQ_CumfloM","Cumulative flow constraint - Marginals"
"Attribute","-","PAR_capLO","Capacity Lower Limit"
"Attribute","-","PAR_capUP","Capacity Upper Limit"
"Attribute","-","PAR_Top","Process topology (Opted out - SET RPT_TOP YES
to activate)"
"Attribute","-","Cap_New","Newly installed capacity and lumpsum investment
by vintage and commissioning period"
"Attribute","-","COST_inv","Annual investment costs"
"Attribute","-","COST_dec","Annual decommissioning costs"
"Attribute","-","COST_salv","Salvage values of capacities at EOH+1"
"Attribute","-","COST_late","Annual late costs"
"Attribute","-","COST_fom","Annual fixed operating and maintenance costs"
"Attribute","-","COST_act","Annual activity costs"
"Attribute","-","COST_flo","Annual flow costs (including import/export
prices)"
"Attribute","-","COST_com","Annual commodity costs"
"Attribute","-","COST_els","Annual elastic demand cost term"
"Attribute","-","COST_dam","Annual damage cost term"
"Attribute","-","COST_invx","Annual investment taxes/subsidies"
"Attribute","-","COST_fixx","Annual fixed taxes/subsidies"
"Attribute","-","COST_flox","Annual flow taxes/subsidies"
"Attribute","-","COST_comx","Annual commodity taxes/subsidies"
"Attribute","-","COST_ire","Annual implied costs of endogenous trade"
"Attribute","-","COST_NPV","Total discounted costs by process/commodity
(optional)"
"Attribute","-","Time_NPV","Discounted value of time by period"
```

```
"Attribute","-","VAL_Flo","Annual commodity flow values"
"Attribute","-","ObjZ","Total discounted system cost"
"Attribute","-","Reg_wobj","Regional total expected discounted system
cost"
"Attribute","-","Reg_obj","Regional total discounted system cost"
"Attribute","-","Reg_irec","Regional total discounted implied trade cost"
"Attribute","-","Reg_ACost","Regional total annualized costs by period"
"Attribute","-","User_Con","Level of user constraint"
"Attribute","-","User_ConFXM","Marginal cost of fixed bound user
constraint"
"Attribute","-","User_ConLOM","Marginal cost of lower bound user
constraint"
"Attribute","-","User_ConUPM","Marginal cost of upper bound user
constraint"
"Attribute","-","User_DynbM","Marginal cost of dynamic process bound
constraint"
"Attribute","-","User_Maxbet","Level of MaxBet constraint"
"Attribute","-","VAR_climate","Climate result variables"
"Attribute","-","Dual_Clic","Shadow price of climate constraint"
"Attribute","-","VAR_Macro","MACRO result variables"
"Commodity","REG2","GAS","Natural Gas"
"Commodity","REG1","GAS","Natural Gas"
"Commodity","REG2","ELC","Electricity"
"Commodity","REG1","ELC","Electricity"
"Commodity","REG2","AGRBIO","Agriculture Biomass"
"Commodity","REG1","AGRBIO","Agriculture Biomass"
"Commodity","REG2","AGRCO2","Agriculture Carbon dioxide"
"Commodity","REG1","AGRCO2","Agriculture Carbon dioxide"
"Commodity","REG2","AGRCOA","Agriculture Solid Fuels"
"Commodity","REG1","AGRCOA","Agriculture Solid Fuels"
"Commodity","REG2","AGRELC","Agriculture Electricity"
"Commodity","REG1","AGRELC","Agriculture Electricity"
"Commodity","REG2","AGRGAS","Agriculture Natural Gas"
"Commodity","REG1","AGRGAS","Agriculture Natural Gas"
"Commodity","REG2","AGROIL","Agriculture oil"
"Commodity","REG1","AGROIL","Agriculture Oil"
"Commodity","REG2","BIO","Biomass"
"Commodity","REG1","BIO","Biomass"
"Commodity","REG2","COA","Solid Fuels"
"Commodity","REG1","COA","Solid Fuels"
"Commodity","REG2","COMBIO","Commercial Biomass"
"Commodity","REG1","COMBIO","Commercial Biomass"
"Commodity","REG2","COMCO2","Commercial Carbon dioxide"
"Commodity","REG1","COMCO2","Commercial Carbon dioxide"
"Commodity","REG2","COMCOA","Commercial Solid Fuels"
"Commodity","REG1","COMCOA","Commercial Solid Fuels"
"Commodity","REG2","COMELC","Commercial Electricity"
"Commodity","REG1","COMELC","Commercial Electricity"
"Commodity","REG2","COMGAS","Commercial Natural Gas"
"Commodity","REG1","COMGAS","Commercial Natural Gas"
"Commodity","REG2","COMOIL","Commercial oil"
"Commodity","REG1","COMOIL","Commercial Oil"
"Commodity","REG2","COMSOL","Commercial Solar energy"
"Commodity","REG1","COMSOL","Commercial Solar energy"
```

B.3.3 <scenarioname>.VDS

The <scenarioname>.VDS file provides the set membership information for the dimensions where sets are allowed. Note that these are different from the user-defined sets (rule-based) that are managed in VEDA BE. But these sets can be used as a part of those rules.

Layout: Type of set (tab), region, set name, item name;

Excerpt:

```
"Commodity","REG1","ELC+","ELC"
"Commodity","REG2","ELC+","ELC"
"Commodity","REG1","ELC+","AGRELC"
"Commodity","REG2","ELC+","AGRELC"
"Commodity","REG1","ELC+","COMELC"
"Commodity","REG2","ELC+","COMELC"
"Commodity","REG1","ELC+","RSDELC"
"Commodity","REG2","ELC+","RSDELC"
"Commodity","REG1","ELC+","TRAELC"
"Commodity","REG2","ELC+","TRAELC"
"Commodity","REG1","ENV","AGRCO2"
"Commodity","REG2","ENV","AGRCO2"
"Commodity","REG1","ENV","COMCO2"
"Commodity","REG2","ENV","COMCO2"
"Commodity","REG1","ENV","ELCCO2"
"Commodity","REG2","ENV","ELCCO2"
"Commodity","REG1","ENV","INDCO2"
"Commodity","REG2","ENV","INDCO2"
"Commodity","REG1","ENV","RSDCO2"
"Commodity","REG2","ENV","RSDCO2"
"Commodity","REG1","ENV","TOTCO2"
"Commodity","REG2","ENV","TOTCO2"
"Commodity","REG1","ENV","TRACO2"
"Commodity","REG2","ENV","TRACO2"
"Commodity","REG1","DEM","DAOT"
"Commodity","REG2","DEM","DAOT"
"Commodity","REG1","DEM","DCAP"
"Commodity","REG2","DEM","DCAP"
"Commodity","REG1","DEM","DCOT"
"Commodity","REG2","DEM","DCOT"
"Commodity","REG1","DEM","DCSH"
"Commodity","REG2","DEM","DCSH"
"Commodity","REG1","DEM","DIDM1"
"Commodity","REG2","DEM","DIDM1"
"Commodity","REG1","DEM","DRAP"
"Commodity","REG2","DEM","DRAP"
"Commodity","REG1","DEM","DROT"
"Commodity","REG2","DEM","DROT"
"Commodity","REG1","DEM","DRSH"
"Commodity","REG2","DEM","DRSH"
"Commodity","REG1","DEM","DTCAR"
"Commodity","REG2","DEM","DTCAR"
"Commodity","REG1","DEM","DTPUB"
"Commodity","REG2","DEM","DTPUB"
"Commodity","REG1","NRG","GAS"
```

B.3.4 <scenarioname>.VDT

The <scenarioname>.VDT file contains all the Reference Energy System (RES) topology information.

Layout: Region, Process, Commodity, IN/OUT topology indicator. VEDA BE also enables one to look at UCs that are related to a process or commodity. <UC Name>, Process, Commodity, “UC” entries are needed for that.

Excerpt:

```
*VFEPATH=C:\Veda\VEDA_Models\DemoS_012
*ScenDesc=Demo Step 012 CO2 Tax
*ScenEDesc=Demo Step 012 CO2 Tax
"AU_NUC_MaxCAP","ELCNENUC00","-","UC"
"AU_NUC_MaxCAP","ELCNNNUC01","-","UC"
"REG1","AOTETOT","AGRBIO","IN"
"REG1","AOTETOT","AGRCO2","OUT"
"REG1","AOTETOT","AGRCOA","IN"
"REG1","AOTETOT","AGRELC","IN"
"REG1","AOTETOT","AGRGAS","IN"
"REG1","AOTETOT","AGROIL","IN"
"REG1","AOTETOT","DAOT","OUT"
"REG1","AOTETOT","DEMO","OUT"
"REG1","AOTETOT","NRGI","IN"
"REG1","CAPEELC","COMELC","IN"
"REG1","CAPEELC","DCAP","OUT"
"REG1","CAPEELC","DEMO","OUT"
"REG1","CAPEELC","NRGI","IN"
"REG1","CAPNELC1","COMELC","IN"
"REG1","CAPNELC1","DCAP","OUT"
"REG1","CAPNELC1","DEMO","OUT"
"REG1","CAPNELC1","NRGI","IN"
"REG1","COTEBIO","COMBIO","IN"
"REG1","COTEBIO","DCOT","OUT"
"REG1","COTEBIO","DEMO","OUT"
"REG1","COTEBIO","NRGI","IN"
"REG1","COTECOA","COMCO2","OUT"
"REG1","COTECOA","COMCOA","IN"
"REG1","COTECOA","DCOT","OUT"
"REG1","COTECOA","DEMO","OUT"
"REG1","COTECOA","NRGI","IN"
"REG1","COTEELC","COMELC","IN"
"REG1","COTEELC","DCOT","OUT"
"REG1","COTEELC","DEMO","OUT"
"REG1","COTEELC","NRGI","IN"
"REG1","COTEGAS","COMCO2","OUT"
"REG1","COTEGAS","COMGAS","IN"
"REG1","COTEGAS","DCOT","OUT"
"REG1","COTEGAS","DEMO","OUT"
"REG1","COTEGAS","NRGI","IN"
"REG1","COTEOIL","COMCO2","OUT"
"REG1","COTEOIL","COMOIL","IN"
"REG1","COTEOIL","DCOT","OUT"
"REG1","COTEOIL","DEMO","OUT"
```