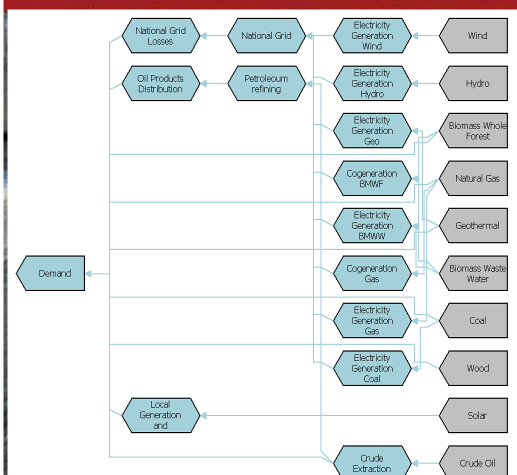
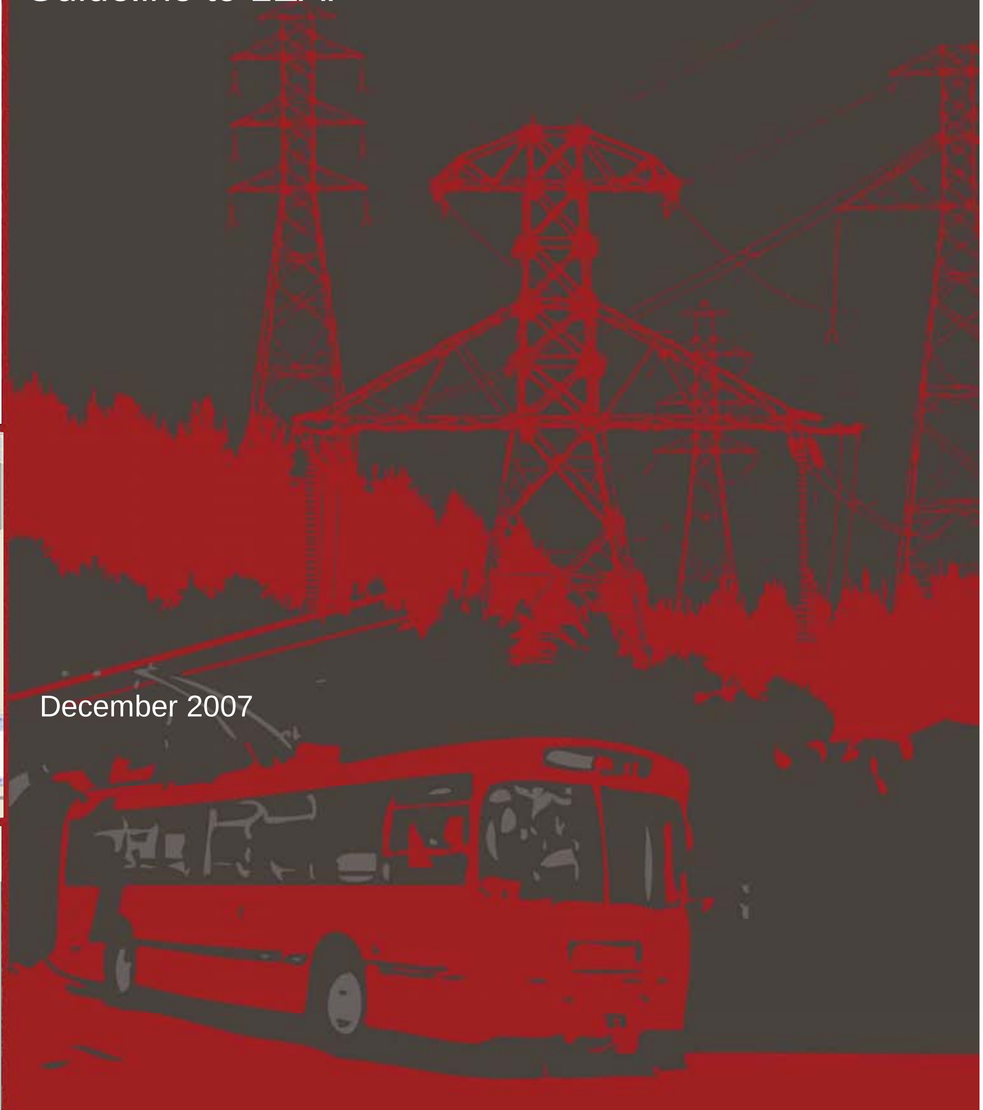
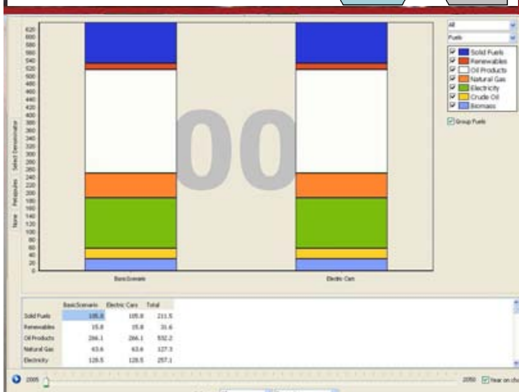
New Zealand's EnergyScape

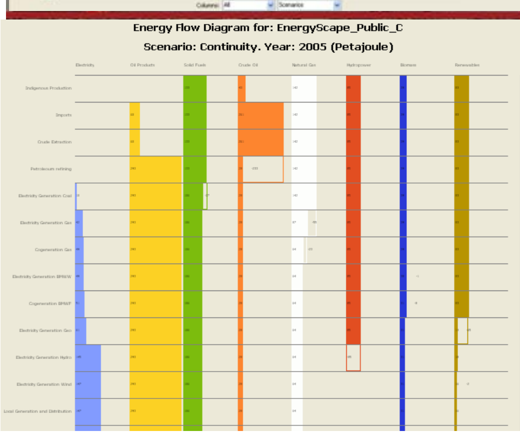
2000 2005 2030 2050



Guideline to LEAP







December 2007

Guideline to LEAP with EnergyScape

Introduction

EnergyScape is a project which established a framework that enables interpretation of New Zealands' energy future subject to international market pricing and domestic policy. In order to encourage a broad range of stakeholders to contribute and draw on the framework, a relatively self-explanatory energy network data presentation tool was required. After a review of the available energy system modelling and display tools, the EnergyScape team identified that the product LEAP (Long-range Energy Alternatives Planning System) was most the most suitable platform for EnergyScape.

LEAP, the Long-range Energy Alternatives Planning system, is an advanced Windows-based software tool for integrated energy-environment mitigation analysis . LEAP has been developed by the Stockholm Environment Institute-Boston (www.seib.org) with support from international organizations to meet the needs of researchers, NGOs and government agencies worldwide.

LEAP is the most widely-used tool of its kind in the World today with over two thousand users in more than 140 countries. LEAP has been adopted as the tool of choice by numerous countries wishing to plan their energy systems to meet sustainable development goals. Its policy-relevant focus on basic-needs energy use, energy efficiency, and the environmental dimensions of energy planning make it a powerful tool to promote rational, environmentally-sound approaches in the energy sector.

This document intends to be a brief description of LEAP capabilities regarding EnergyScape products. A full user guide is available at the COMMEND website (http://www.energycommunity.org/webhelp/index.html).

Installation

The **minimum** system requirements for running LEAP are:

Processor	400 MHz Intel® Pentium® class PC or compatible
Memory	64 MB RAM
Disk	100 MB free
Operative System	Microsoft® Windows® 98 or later (Windows® NT/2000 or XP recommended)
Web browser	Microsoft ® Internet Explorer 4.0 or later
Access rights to PC	Full install rights required. Note: When running in Windows® Vista® LEAP requires administrator rights.
Multi-user system	LEAP is designed as a single-user system. The developers do not recommend running LEAP from a shared network drive.

LEAP does not require an internet connection to operate except for automatic updates and specific communication tasks (datasets download, emailing datasets). LEAP can communicate directly with Microsoft® Excel®, Microsoft® Word® and Microsoft® PowerPoint® but they are not required.

A free demo version of the software LEAP can be downloaded from the COMMEND website (http://www.energycommunity.org/) after first undertaking the free registration.

The demo installer operates in a READ-ONLY mode that allows opening and working with the full functionalities of the system, but all saving options are disabled.

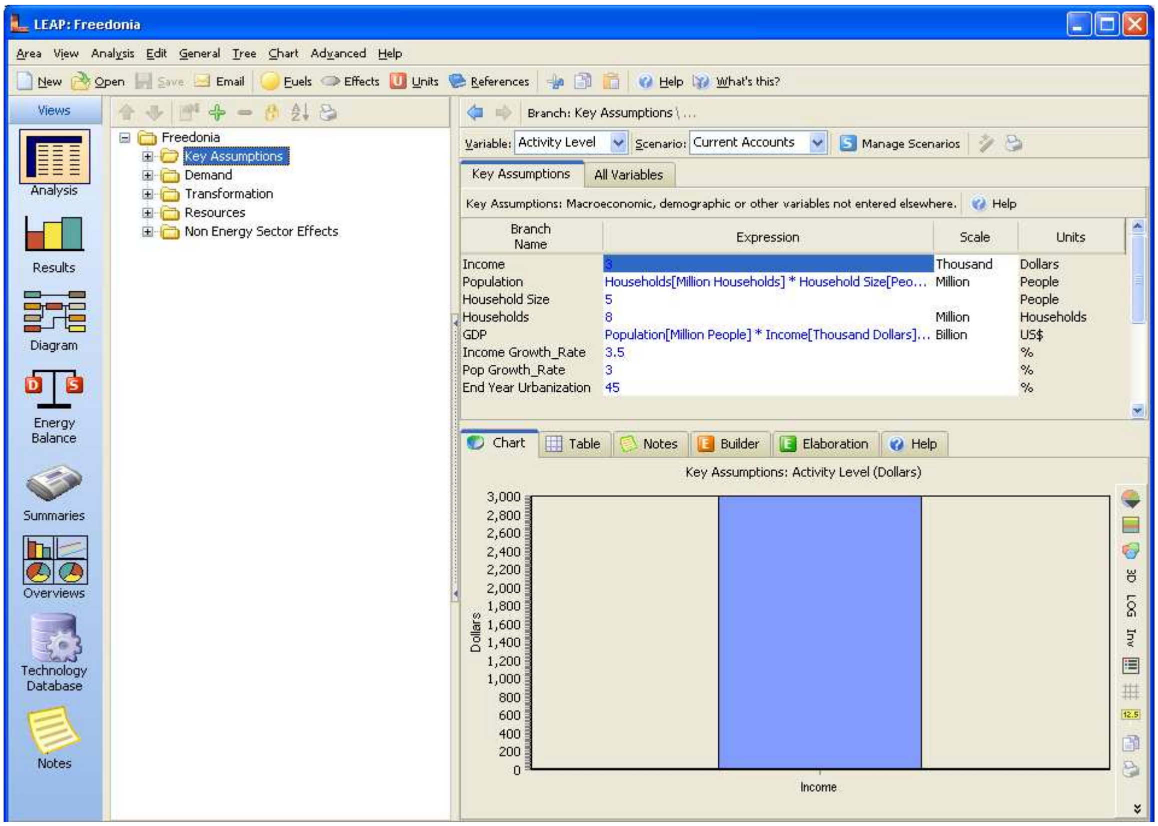
Once the installer (SETUP.EXE) has been downloaded, double click on it to begin the installation and follow the instructions.

Once the installer (SETUP.EXE) has been downloaded and installed, it is possible to view the EnergyScape public sample (http://www.niwascience.co.nz/ncces/projects/energyscape/accessing_leap/).

Freedonia

LEAP comes with an example dataset called FREEDONIA, a fictitious area with all the necessary information to test the capabilities of LEAP.

Figure 1 – FREEDONIA environment when opening for the first time.



EnergyScape sample

A sample EnergyScape product (EnergyScape_Public_C) has been provided on the NIWA website (http://www.niwascience.co.nz/ncces/projects/energyscape/accessing_leap/). This sample product provides a demonstration of how LEAP can communicate information about New Zealands' energy network.

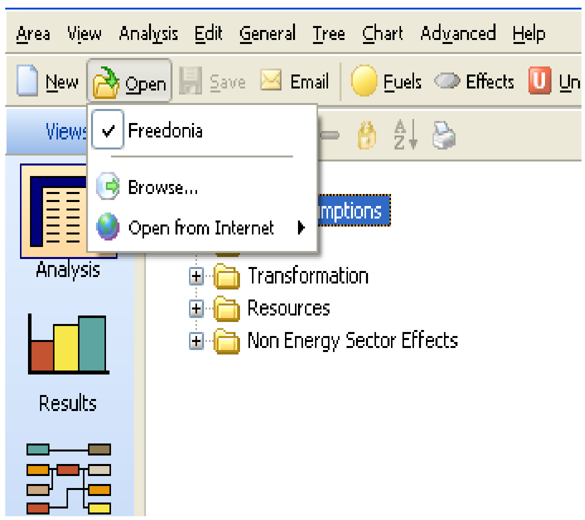
Each year the Ministry of Economic Development issues a verified annual snapshot of New Zealands' energy system. This sample represents the production, transmission, demand and cost data that is contained within 'New Zealand Energy Data File 2005'.

Opening the sample

To open the sample, click on OPENà BROWSE, and then select 'EnergyScape_Public_C.ZIP'

We recommend that you save this ZIP file to a relevant directory on the local hard disc.

Figure 2 – Browsing for a new area



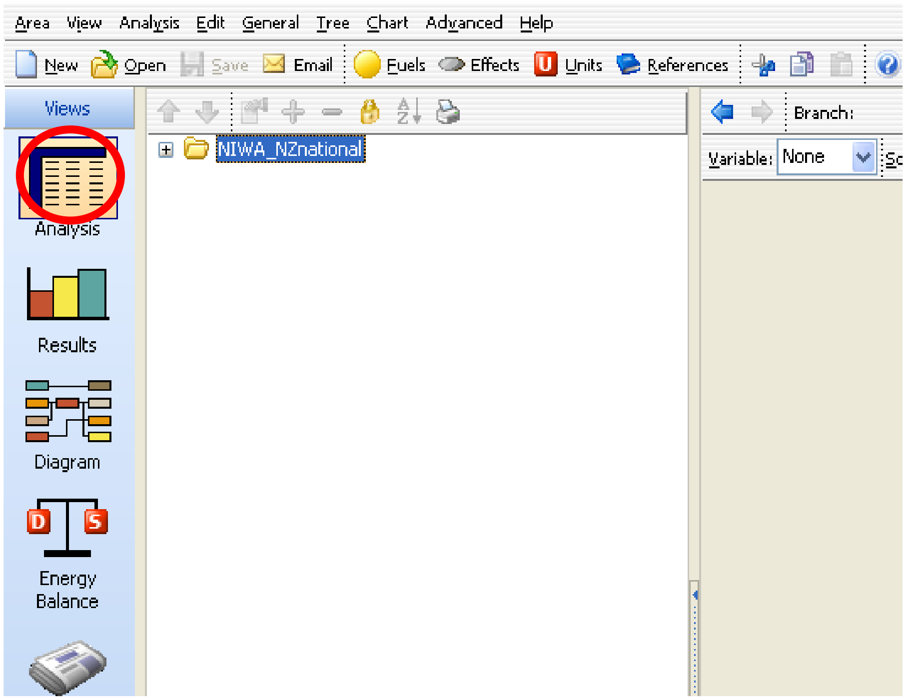
Once the file has been selected, LEAP will copy the data into a working directory (My Documents\LEAP Areas) and display the information. Now that you have successfully installed LEAP and the sample, you can browse through it as you wish.

The continued instructions below, step the user through a few LEAP functions so that the user has improved familiarity with LEAP.

Visualisation of energy network structure

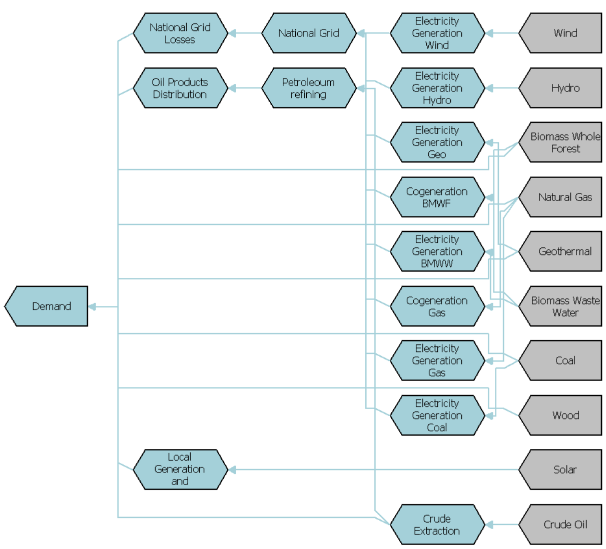
LEAP provides a simple overview diagram of the modelled network structure. To find this image, just select the diagram icon in the left hand panel (see Figure 3).

Figure 3 – Locating a visualisation of the structure



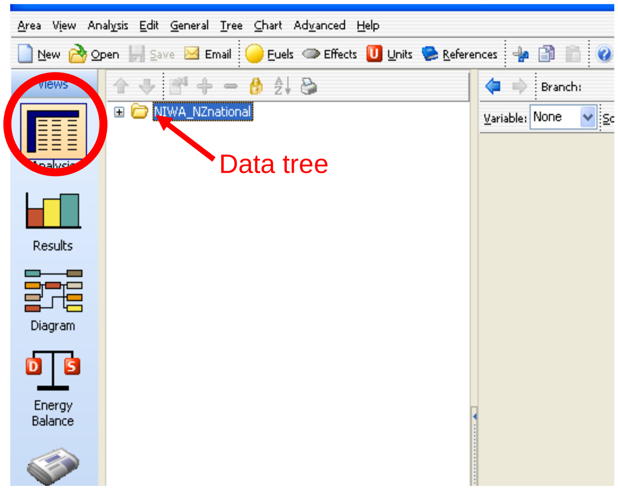
This will then bring up an image of the energy network structure (see Figure 4). It is note worthy that LEAP is demand side driven, hence demand is depicted on the left hand side. Sources of primary energy (on the right hand side of the diagram) feed into the transformation and distribution modules before being utilised in the demand area.

Figure 4 – Structure of energy network



The details of the links and specifications of the modules can be viewed in the Analysis section (see Figure 5).

Figure 5 – Accessing the analysis section

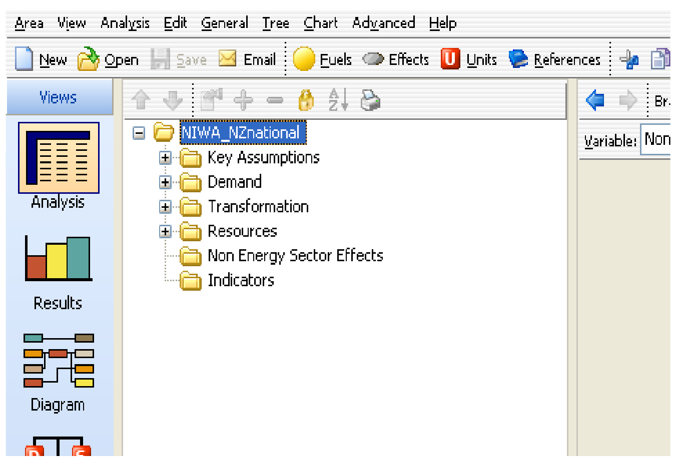


Each module in the structure is listed under the data (in the middle panel). The data in the *tree* is organized by categories that can have a number of levels depending on the complexity of the system being modelled.

To see the complete tree, click on the top menu Tree à Expand All. That command opens all the branches in the area and that is the maximum amount of detail available on this sample.

Alternatively, a more manageable level of detail can be obtained by clicking Tree à Outline Level à 2. The result is illustrated in Figure 6.

Figure 6 – Tree expanded to level 2



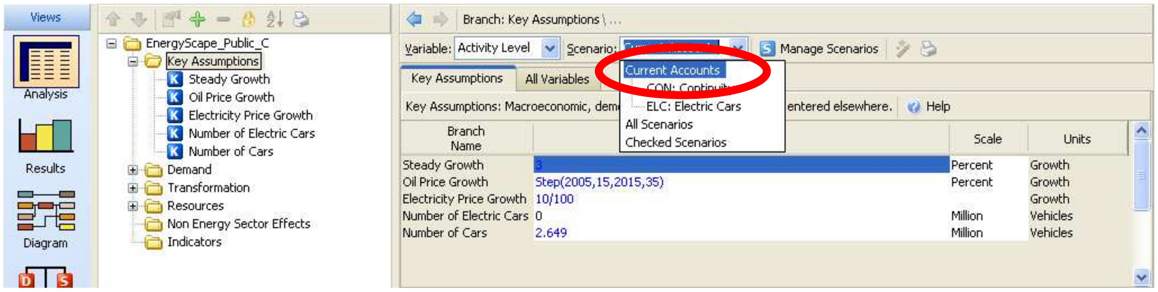
If you click on the different branches you will see that the information begins to be accessible. We will step through each of the *branches*.

It is noted, that for now we will restrict the display to what is called Current Accounts (see Figure 7). The Current Accounts correspond to the constant values that all the variables have for the first year of the simulations (in this case, 2005). Later in this guide we will go into the different scenarios available for this area and how the data is entered as a time series.

Key Assumptions branch

The first *branch* (Key Assumptions) is used to store values relevant for the calculation of the energy consumption or generation in the area.

Figure 7 – Key Assumptions branch



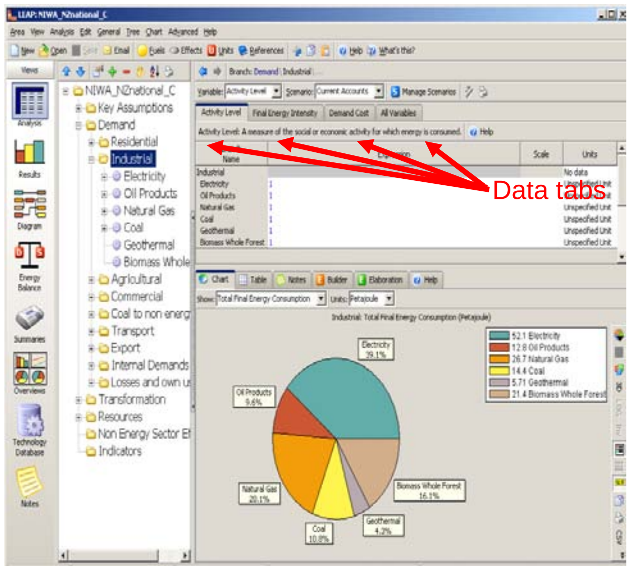
In the provided sample, there are 5 assumptions: “Steady Growth”, “Oil Price Growth” and “Electricity Price Growth”. These assumptions are related to the growth of the demand and its costs in the future.

- Steady Growth. The sample nominates a 3% growth in the demand for energy between 2005 and 2050. This is not an official estimate of forecast growth, merely a reasonable number to drive the model.
- Oil Price Growth. The sample nominates a 15% escalation in the price of crude oil and oil products between 2005 and 2015, followed by a 35% escalation in the price towards 2050. This is not an official estimate, and is higher than historical trends, but has been set to demonstrate the potential effects of peak oil.
- Electricity Price Growth. The sample nominates a 10% escalation in the price of electricity to consumers between 2005 and 2050. The ratio of price between commercial, industrial and residential will be held constant. This is not an official estimate, but is higher than historical trends based on the expectation of grid and network upgrades required as energy intensity increases.
- Number of domestic transport vehicles. A parameter used to characterise the transportation demand.
- Number of electric vehicles. A parameter used to characterise the transportation demand.

Demand branch

The second *branch* (Demand) is used to store values relevant to energy consumption. The first click on the demand branch does not yield much detail. We need to go deeper into the tree by expanding sub-branches (try clicking on the (+) next to demand). In this sample, there are nine sub-branches (see **Figure 8**).

Figure 8 – Accessing demand sub-branches



Each of these sub-branches corresponds to a different demand sector. If you click on *Industrial* sub-branch you will see that four (4) tabs appear in the right panel, namely: Activity Level, Final Energy Intensity, Demand Costs and All Variables.

- Activity Level. Is a measure of the activity associated with the respective demand. For example, it could mean the number of hours that a process is active during a year or it could be the kilometres travelled by a vehicle type. In this sample the activity level is normalized to 1 for 2005, therefore, a value of 1.5 would mean a 50% higher activity than in 2005.

- Final Energy Intensity. Is the energy required by the corresponding Activity Level. If the activity level is expressed in hours/yr, then the energy intensity would be in <energy>/hours. In our case, the energy intensity is the energy consumption during 2005 in Petajoules.

- Demand Costs. This corresponds to the costs of the energy consumed within this branch. It can be expressed as total cost, energy savings or as it is in this sample, as Activity Cost. The activity cost is related to the activity level. Therefore, as we are using the activity level being the activity relative to 2005, the activity costs must be the total costs for 2005.

Environmental impact and cost data detail

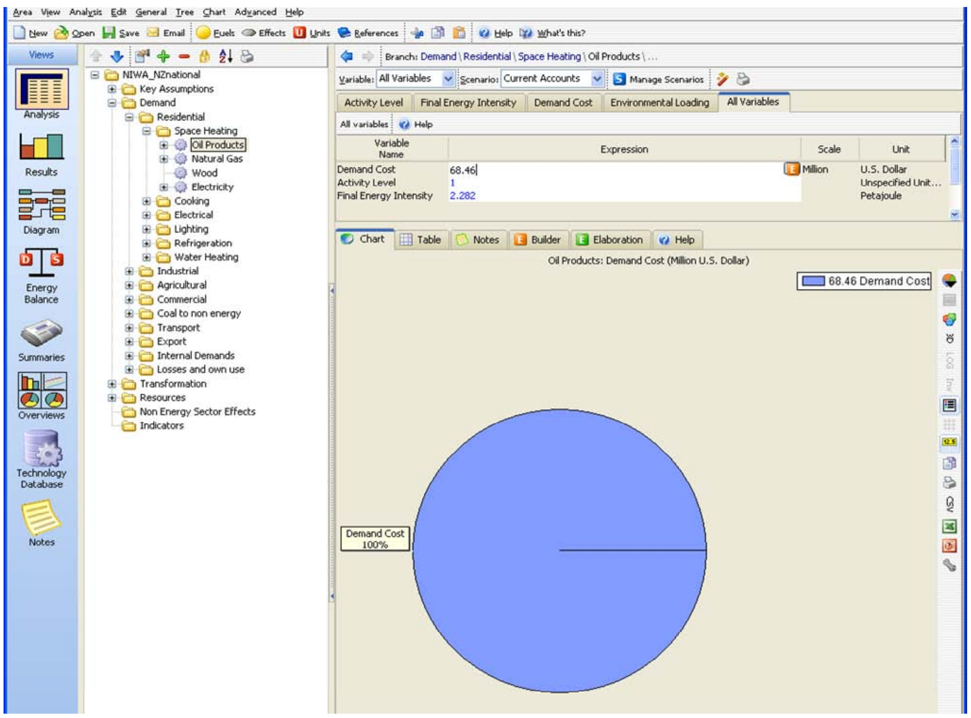
In the sample, we have added more detail into the residential branch, in order to demonstrate how environmental data is handled.

The residential sub-branch has been broken into further sub-sectors, namely: Space Heating, Cooking, Electrical, Lighting, Refrigeration and Water Heating. The user must expand this sub-sectors before getting data detail.

Each sub-sector has the capacity to use several different fuels (e.g. oil products, natural gas, wood and electricity). If the user click on these click on any of these technologies (e.g oil products) there will be five tabs in the right panel – the four that you saw in the industrial branch and an 'Environmental Loadings' tab. It is here that any environmental impact (emissions or other impacts) are characterized. Opening the Environmental Loadings tab we will reveal that the emission factor associated with the oil products used for residential space heating is 60.4 tCO_2/TJ.

Another very useful tab is the 'All Variables' tab. This tab displays all the relevant variables for the selected branch (see Figure 9).

Figure 9 – 'All variables' tab



The information available for this branch consists of Demand Cost, Activity Level and Final Energy Intensity. The relationship between these parameters is:

Energy Consumption = Final Energy Intensity × Activity Level

Total Cost = Demand Cost (Activity cost) × Activity Level

All the branches under Demand have the same structure and contain the same kind of information available (Final Energy Intensity, Activity Level, Demand Cost and Environmental Loadings).

Before going into the Transformation branch, we will first become familiar with scenarios and time series data.

Scenarios and time series data

In the sample we have provided two very simplified scenarios:

1. **Basic scenario**. This corresponds to steady growth of all the energy demands. The growth is defined by the Steady Growth variable under Key Assumptions and it is used in the scenario through the Activity Level for each branch. There are some simple product price changes governed by the Oil Price Growth and Electricity Price Growth variables under Key Assumptions. The price growth is input in the model through the Demand Cost for each branch.
2. **Electric cars.** This scenario is identical to the Basic scenario except that Demand\Transport\Domestic Transport is split in two fuels (Oil Products and Electricity) so that part of the Domestic Transport demand is served by electric cars and the rest by conventional vehicles.

Above the tabs in the right hand panel is a pull down menu which enables the user to obtain data from difference demand scenarios. For this exercise, open the ‘Demand\Residential\Space Heating’ branch and change the scenario to “All Scenarios” (see Figure 10). You should notice that there is now more data on every tab.

Figure 10 – Scenario selector pull down menu

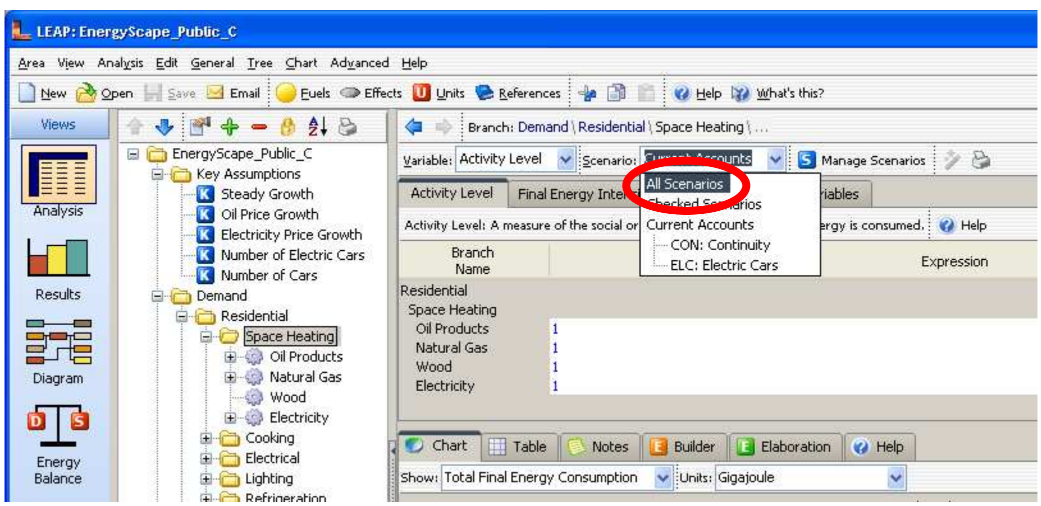
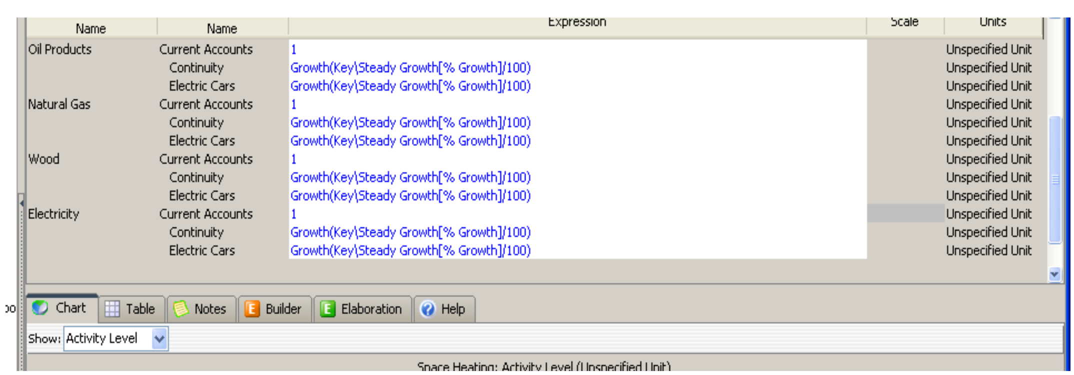


Figure 11 – Activity level data for ‘Demand\Residential\Space Heating’ branch

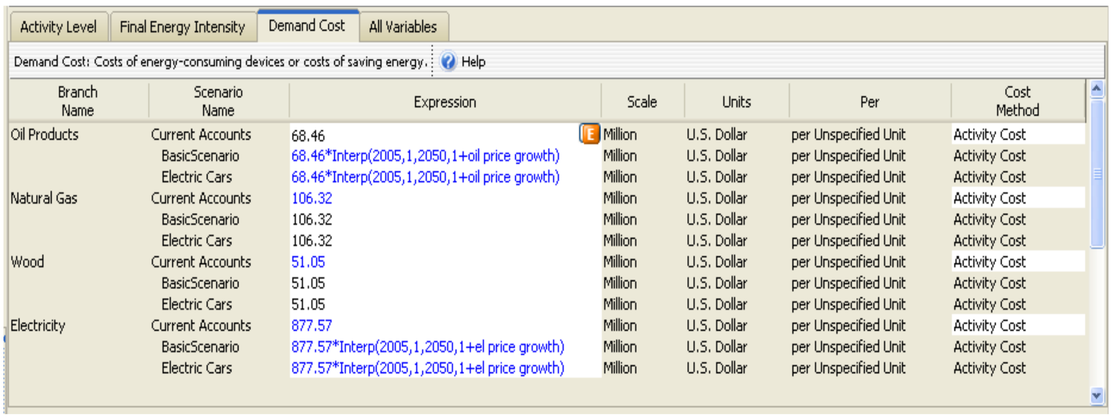


The Activity Level identified for Current Accounts is the value of the parameter in the first year of the simulation (2005). The expression next to Basic Scenario and Electric Cars identifies a formula used to a assign a value for each of the year of the simulation for the given scenario. The function used in these scenario is an interpolation function (Growth) used by LEAP to enable compound growth of demand. The syntax used here applies the growth defined in the Steady Growth variable in the Key Assumptions section every year from 2005 to 2050.

For more details about this and other functions please use LEAPs help or user guide.

In the Demand Cost tab (see **Figure 12**) the expressions defining the costs for the different scenarios relate to the cost oil and electricity price growth rates defined in the Key Assumptions.

Figure 12 – Demand cost tab for Demand\Residential\Space Heating\Oil Products branch



Branch Name	Scenario Name	Expression	Scale	Units	Per	Cost Method
Oil Products	Current Accounts	68.46	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	BasicScenario	68.46*Interp(2005,1,2050,1+oil price growth)	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	Electric Cars	68.46*Interp(2005,1,2050,1+oil price growth)	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
Natural Gas	Current Accounts	106.32	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	BasicScenario	106.32	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	Electric Cars	106.32	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
Wood	Current Accounts	51.05	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	BasicScenario	51.05	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	Electric Cars	51.05	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
Electricity	Current Accounts	877.57	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	BasicScenario	877.57*Interp(2005,1,2050,1+el price growth)	Million	U.S. Dollar	per Unspecified Unit	Activity Cost
	Electric Cars	877.57*Interp(2005,1,2050,1+el price growth)	Million	U.S. Dollar	per Unspecified Unit	Activity Cost

It is noted that some of the prices do not change over time (e.g wood, natural gas) while others are zero (e.g solar). If you want to change the growth rate of the prices you just need to change the corresponding value under Key Assumptions.

Developing an electric car scenario

In the sample we have only partially completed developing the electric car scenario. We did this by:

1. Copying the basic scenario and saving it as electric car scenario (Manage Scenario, Add (Electric Cars), Inherit from Current Accounts)
2. Adding ‘number of cars’ as a key assumption (Key Assumption, Add, Units (Million vehicles)).
3. Adding ‘number of electric cars’ as a key assumptions (Key Assumption, Add, Units (Million vehicles))

What is needed to complete the process is:

4. Change the activity level for domestic transport to be:

   66.49 billion passenger kilometres with Growth(Key\Steady Growth[% Growth]/100)

5. Change the activity share for domestic transport\Oil products to be:

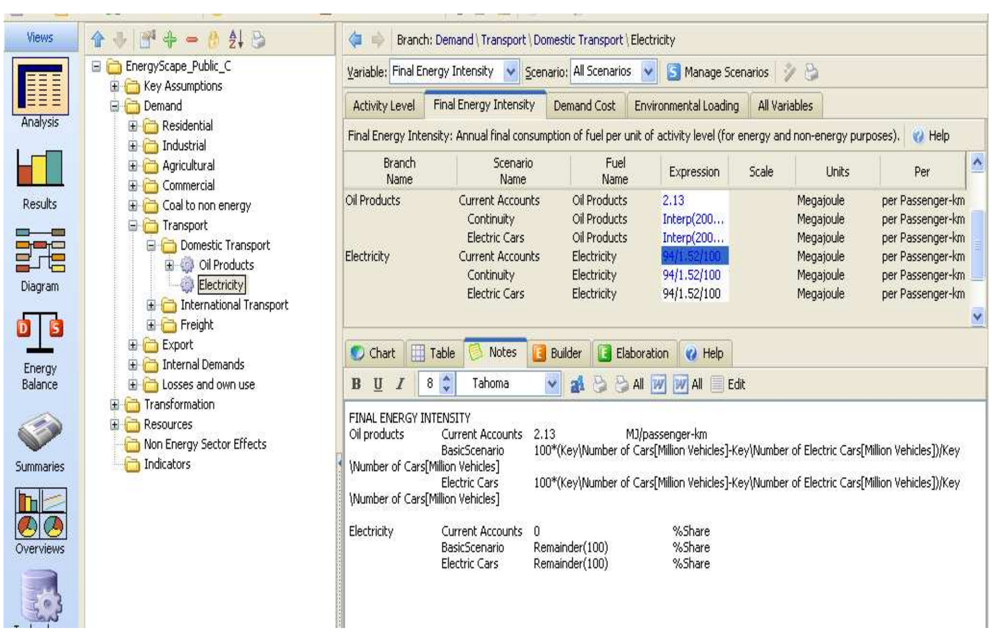
   100*(Key\Number of Cars[Million Vehicles]-Key\Number of Electric Cars[Million Vehicles])/Key\Number of Cars[Million Vehicles]

6. Change the activity share for domestic transport\Electricity to be: Remainder(100)
7. Change the final energy intensity for domestic transport\Oil products to decline from 2.13 in 2005, to 1.94 in 2030, and 1.14 in 2050 MJ/ Pkt.
8. Change the final energy intensity for domestic transport\Electricity to constantly be: 94/1.52/100 MJ/ Pkt

It should be noted that the share of the domestic transport market that is electric vehicles does not have be defined directly as a time series in the electric vehicle share, rather it can relate to the number of electric vehicles defined in (Key Assumptions\Number of electric vehicles). This is a very important point for the consistency of the scenarios, since these parameters are available to all scenarios.

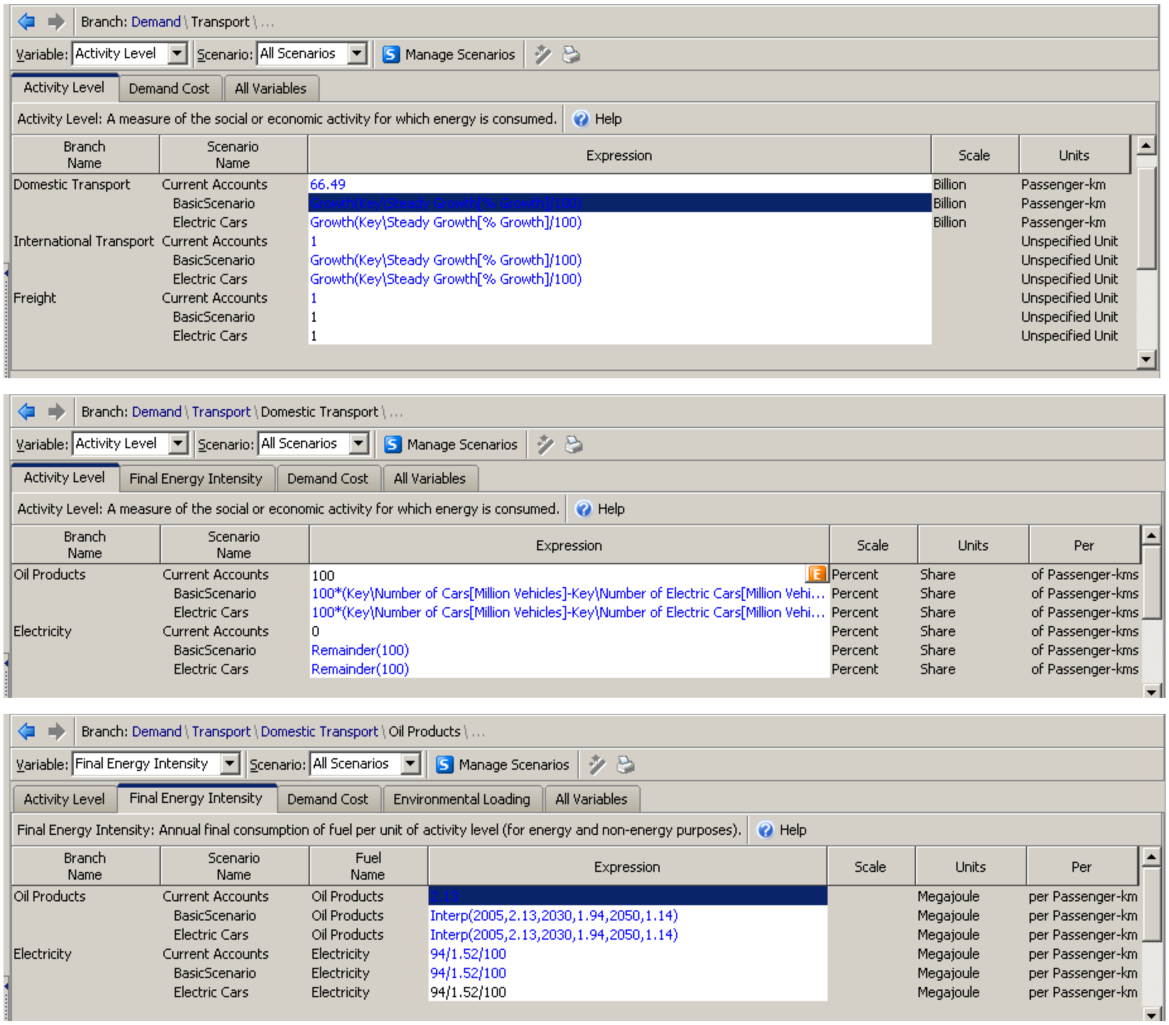
To aid you, we have copied the required lines into the notes areas of the processes (see Figure 13 below).

Figure 13 – Notes area provides text for the scenario development example



What the respective tabs should look like is depicted in **Error! Reference source not found.** below.

Figure 14 – Transport tabs at completion of scenario development



Transformation branch

The third *branch* (Transfomation) is used to detail the processes that take the primary resources and make them available to the demand. This part of the tree is particularly sensitive to the order in which the modules are placed in the tree. The first module from the top should be the module that delivers the energy directly to the demand and the chain of transformations should follow on subsequent sub-branches.

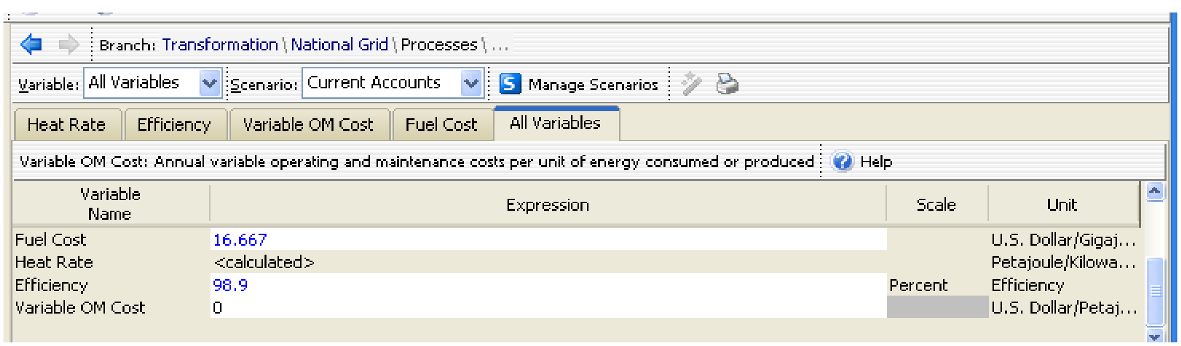
There are two types of modules in this sample area.

i. "Simple" modules, which are generally used for transmission, where the relevant information includes:
   - Efficiency
   - Costs
   - Environmental impact.

ii. "Detailed" modules, which can have more than one input and/or output fuel, where the relevant information includes:
   - Capacity
   - Availability
   - Efficiency
   - Historical production
   - Costs (capital, decommissioning and fixed and variable operational costs)
   - Lifetime
   - Environmental impact
   - Export / import requirements.

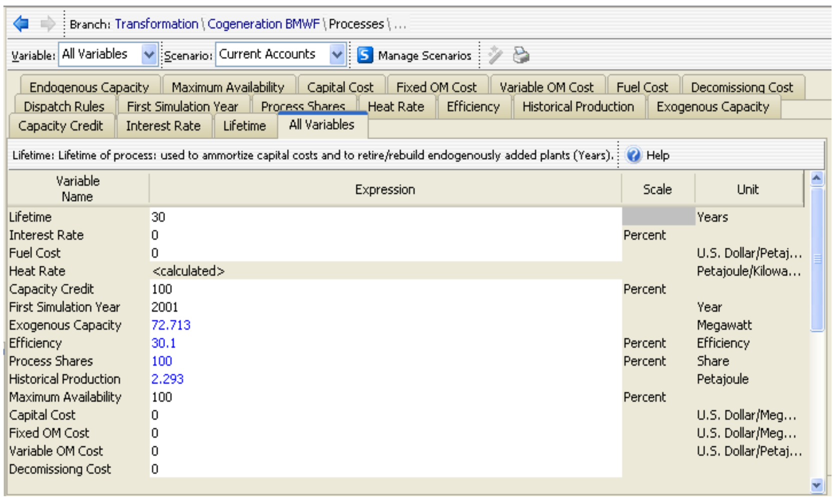
The ***National Grid*** module is an example of a "simple" module with costs for the fuel delivered. The All Variables tab of this module is illustrated in Figure 15. Here cost of fuel, the heat rate, and the efficiency of the process as well as the variable operating costs, are documented. In this sample, only the Fuel Cost and the Efficiency are input. The Heat Rate is calculated internally by LEAP to match the Efficiency. The Variable OM Cost is set to zero for simplicity. By changing the view from Current Accounts to All Scenarios shows the change in the Fuel Cost just as it was expressed in the Demand branches.

Figure 15 – All variables tab of *National Grid*



The ***Cogeneration BMWF*** module is an example of a "detailed" module with two feedstock fuels (Biomass Whole Forest and Biomass Waste Water) and one output fuel (Electricity). The All Variables tab of this module is illustrated in **Figure 16**. Most of the items are self explanatory but care must be taken with Process Shares if more than one process is involved in the module. For simplicity all modules in the sample have only one process under them. Note that the values for the Exogenous Capacity correspond to the minimum capacity required to satisfy the reported generation / production for 2005. Also, the Efficiency corresponds to the reported values for 2005 as the ratio between the output and the input in energy units. This module does not have Fuel Costs associated with it feedstock fuels but others like Petroleum Refining\Crude Oil do have costs and those costs are, in the same way as the Demand costs, changing in time for the different scenarios in this sample.

Figure 16 – All variables tab of Cogeneration BMWF



Resources branch

The last branch (Resources) details the reserves and yield parameters of primary (e.g. Crude oil, Wood, Wind, Solar) and secondary fuels (e.g. Electricity, oil products) resources are specified and their parameters in terms of reserves and yield defined.

For simplicity, in this sample essentially unlimited reserves of the fossil fuels and unlimited yield for the renewable sources have been specified, and only a selection of fuel costs are provided.

In order to provide for import information about oil products (crude and refined), a few options need to be set for the Oil Refinery module that are related to the Crude Oil Resource.

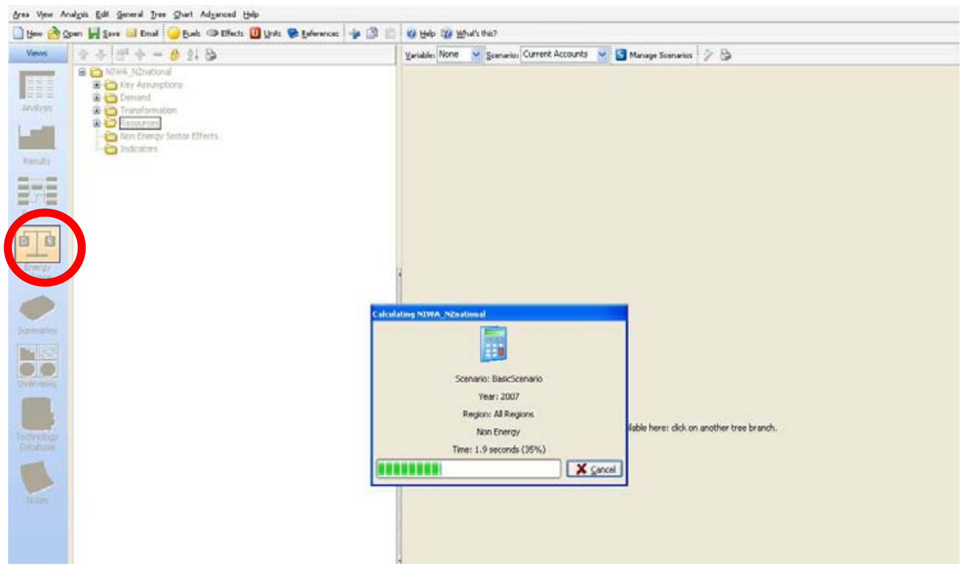
First, for all the resources it is specified that "Any remaining requirements stay unmet. This means that if there is not enough resources to satisfy the demand for them, then when looking at the results that demand will show as unmet indicating that further capacity/reserves are required to satisfy the demand. This is done by right-clicking on the individual resource and selecting the appropriate alternative.

Then, for all the Transformation modules **except** the Petroleum Refinery, the processes are set so that "Any remaining demand stays unmet". This is done by right-clicking on the **output fuel** under the transformation brands, selecting Properties and the appropriate alternative from the menu. For the Petroleum Refinery process, it is necessary to select "Import fuel to meet shortfall" in the Oil Products properties. In this way, if there is not enough capacity to satisfy the demand for all fuels except crude oil and oil products, the demand will remain unmet while there will be an import of crude oil and oil products if the capacity is not enough.

Reviewing the energy balance

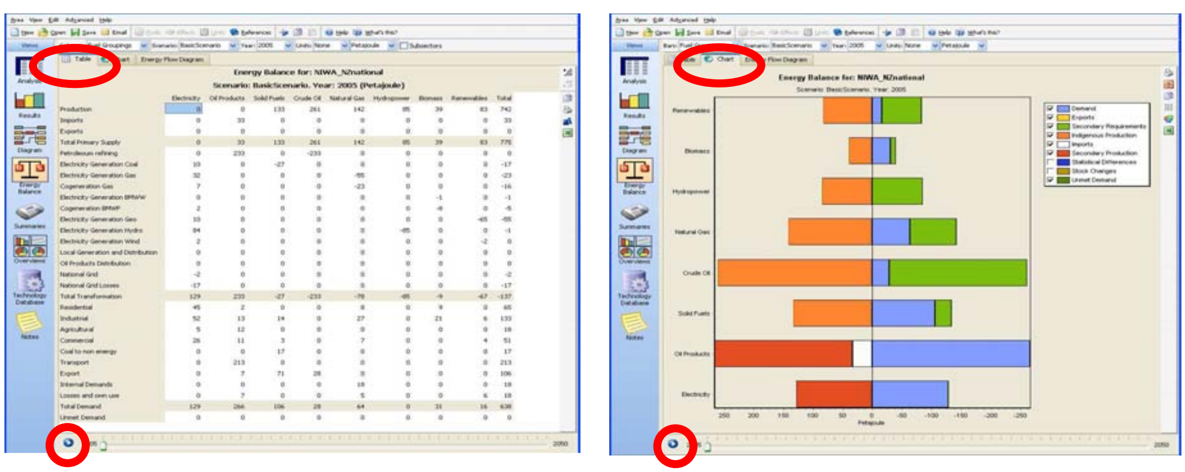
The energy balance can be obtained by clicking on the Energy Balance in the left pane. This will trigger the re-calculation of all scenarios (see **Figure 17**).

Figure 17 – Energy balance re-calculation in progress



Once the calculations have finished you will see a table or graph with the results of the balance (see **Figure 18**). It is possible to see how the energy balance changes over time by clicking the play button at the bottom left corner. The energy balance can be displayed by fuels or fuel groups, or it can be viewed as an Energy Flow Diagram.

Figure 18 – Results presentation options



To review the result in m more detail, click on the results icon on the left pane and wait until the calculations have finished (see Figure 19).

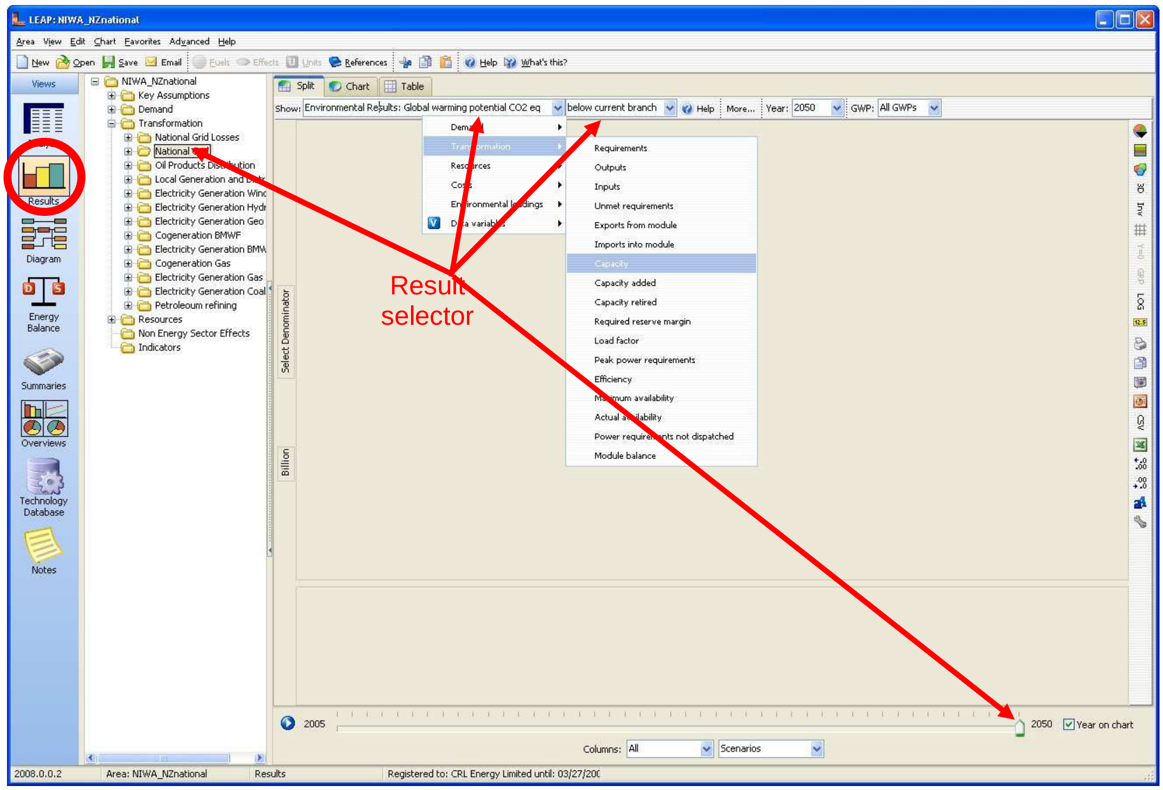
Specific data is obtained by:

1. Selecting the tree branch that you're interested in from left hand pane.
2. Selecting detail from pull down menus
3. Selecting the year of data using the time travel at base of right hand pane.

Not all the results are available for every branch because some are demand specific and others are production specific.

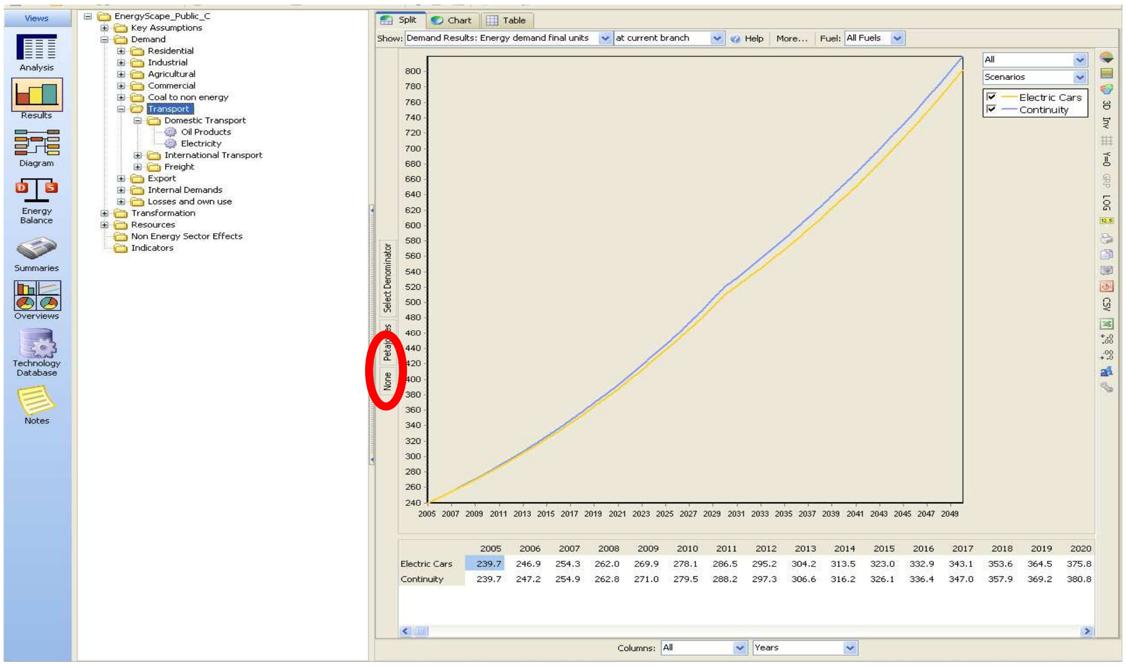
It is possible to select the way the results are presented, either just for one scenario or a comparison between the scenarios. Furthermore, the results can be grouped according to their type (i.e. by fuel, by environmental impact, by fuel type, by branch).

Figure 19 – Access to detailed results



It is possible to change the units of results output by selecting an option from the side menu (see Figure 20).

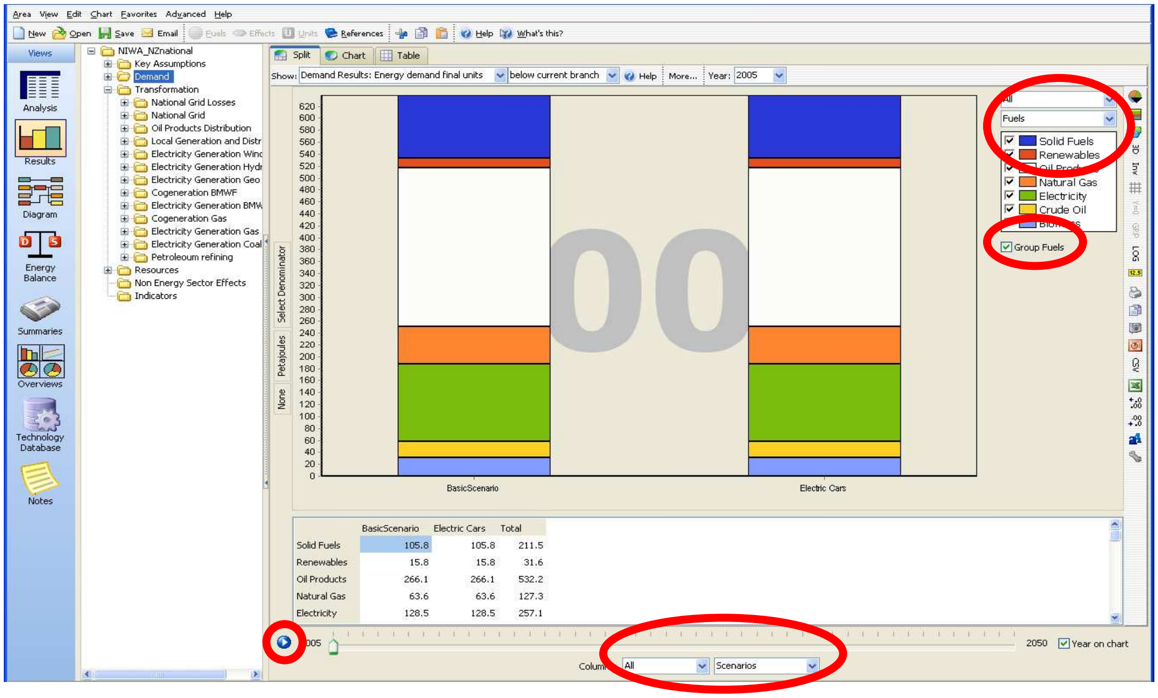
Figure 20 – Changing the units of outputs



To compare the results of two scenarios, select Show à Demand à Energy Demand Final Units (according to Figure 19) and then select All Fuels, Group Fuels for the colours and All Scenarios for the columns. The result should be something like what is shown in Figure 21). First you will see the situation for 2005 and if you click on the "play" button you will see the two bars dynamically reflect changes resulting from the defined scenarios.

For more alternatives for presenting results, please consult the LEAP documentation.

Figure 21 – Comparison of two scenarios



We hope the above examples have given you the skills to build, and obtain results from simple LEAP models. Remember, if you have troubles consult the LEAP guide or contact us. Good LEAPing.