



# Greenhouse Gas Mitigation Screening Exercise

For LEAP and Excel

Updated April 2007



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# 1 Introduction

These computer exercises are designed to introduce you to some of the basic techniques used in a GHG Mitigation Assessment.

You will undertake two very simple exercises that will help you to learn some of the skills needed to conduct a GHG Mitigation assessment.

1. **In Exercise One**, you will conduct a simplified static screening of mitigation options. This will consist of two basic parts.
  - In part one, you will complete a simple spreadsheet that calculates some of the main quantitative indicators used in a mitigation screening, including the GHG emissions reductions potential from each mitigation option (in Tons of CO<sub>2</sub> equivalent) and the costs (in annualized \$ per ton of CO<sub>2</sub> equivalent).
  - In part two you will combine these numbers with a qualitative assessment of various different screening criteria in order to develop an overall screening matrix.
2. **In Exercise Two**, you will use LEAP to create a simple GHG mitigation scenario. The scenario will be created by taking some of the data developed in the first simple static screening exercise and using it as input to LEAP's dynamic integrated energy and GHG mitigation analysis. You will use LEAP to create some of the charts and tables that would typically be included in a national communication on mitigation.
3. **In Exercise Three** you will enter additional data to quantify the costs and benefits of the scenario within LEAP.

## 2 Logistics

Organize yourselves to work in groups of 2 or 3 for the quantitative aspects of these exercises. For the qualitative exercises, form teams of about 5-10 people each, appoint a chair, who will moderate the discussion, and a reporter, who will take notes and prepare a brief (5 minute) presentation to plenary.

The workshop presenters will provide further information about how you will be divided into groups and which rooms will be used by each group.

### 3 Country Context

While the information presented in these exercises is fictional, it may be useful to imagine a hypothetical country so that you can better assess some of the qualitative criteria.

The country is a rapidly growing developing country. Its urban population is fully electrified and has average income levels close to those in the OECD, while its poorer rural population has very limited access to modern energy services, and is heavily reliant on biomass fuels to meet basic needs. In peri-urban areas, electrification has reached 50%.

The country has a warm climate and is only sparsely populated. It has a large potential for forestation, and solar energy and also has good wind resources. It also has good but limited potential for expanding its hydropower system. However, all potential areas for hydropower development are already densely populated and hence any hydropower development will require large numbers of people to be resettled.

### 4 Exercise One: Mitigation Screening Exercise

#### 4.1 Part One: Quantitative Screening

The goal of this exercise is to conduct a simplified quantitative screening of GHG mitigation options. To complete this exercise you will need to work with Microsoft Excel. We assume basic familiarity with Excel.

Start by opening the Excel spreadsheet “**screening.xls**”.

This spreadsheet is a partly completed GHG mitigation screening calculation developed for a fictitious set of data<sup>1</sup>. The spreadsheet is made up of various worksheets: with one worksheet devoted to each potential mitigation option. You can access the different worksheets by clicking the tabs at the foot of the screen in Excel.

The options included in the spreadsheet are only meant to illustrate the use of the screening techniques: they are NOT intended as recommendations of mitigation options for any particular country and they are specified using entirely fictitious data. Moreover, the options are not intended as a comprehensive list of mitigation options that might be available in a country.

The potential mitigation options included in the spreadsheet are:

- LPG cooking stoves used to substitute for charcoal stoves in urban households.
- Efficient motor drives in the industrial sector.
- Efficient refrigerators in the domestic sector.

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<sup>1</sup> The spreadsheet is based on a screening tool named “GACMO” developed by UNEP and SEI.

- Improved vehicle fuel economy standards in the transport sector.
- Combined heat and power (CHP) in the industrial sector.
- Hydro power for electric generation.
- Solar photovoltaics for electric generation.
- Reforestation as a way of enhancing GHG sinks.

The workbook includes two additional tabs (worksheets) labeled “Assumptions” and “Cost Curve”.

- **The Assumptions sheet** includes the basic characteristics of the fuels used in the spreadsheets including their emissions factors and prices. It also includes other defaults such as the discount rate used to annualize costs and the Global Warming Potential (GWP) of the three GHGs included in this simplified analysis: CO<sub>2</sub>, NO<sub>x</sub> and CH<sub>4</sub>.
- **The Cost Curve sheet** is used to plot a cost curve for all of the options analyzed in the worksheet. The cost curve plots cumulative GHG reduction from successive mitigation options (Tons of CO<sub>2</sub> avoided) against cost per unit of GHG reduction (e.g. \$/Ton). A property of the curve is that the area under the curve yields the total cost of avoided emissions. As you complete the data for the options in each tabbed worksheet the Cost Curve will be plotted. You may need to reorder the rows in the cost curve sheet in order to get the Cost Curve to plot correctly.

This exercise illustrates a simple approach to developing a cost curve, the so-called “**partial approach**”. In this approach:

- Each technology is evaluated separately and compared to a reference technology.
- Overall emission reductions and costs are created by combining options while assuming no interaction between options.

This approach is simple to conduct but does not consider the possible interactions between options. For example, the costs and mitigation potential of demand-side efficiency options will depend on what kind of supply technologies are used to generate electricity. In these simple exercises we ignore these problems and simply assume that electricity is provided by the average baseline electricity mix. In reality, supply-side mitigation options (e.g. more hydro) might affect the carbon intensity of the supply mix, and hence the actual level of emissions that can be avoided by a demand-side efficiency measure.

A second issue is that our spreadsheet analysis will be static: we will only consider the savings that might be achieved in a single year: 2030. Later on, in the second exercise we will use a dynamic modeling tool, LEAP, to create integrated scenarios that examine how both the baseline and the mitigation options might evolve over time from the base year in 2000 to 2030. In this latter approach we will be able to consider interactions between measures.

In spite of its limitations, the **partial approach** can still be a useful approach for getting a rough first estimate of GHG mitigation costs and potentials and therefore it is the approach we will use here in this first exercise.

### **Spreadsheet Exercise**

Use the following descriptive information for each option to complete the worksheet and prepare a cost curve and accompanying data table that describes the GHG emissions reductions potential from each mitigation option (in Tons of CO<sub>2</sub> equivalent) and their costs (in annualized \$ per ton of CO<sub>2</sub> equivalent). Bear in mind that the descriptions and data provided here are simplified for the purpose of this analysis and use fictitious data.

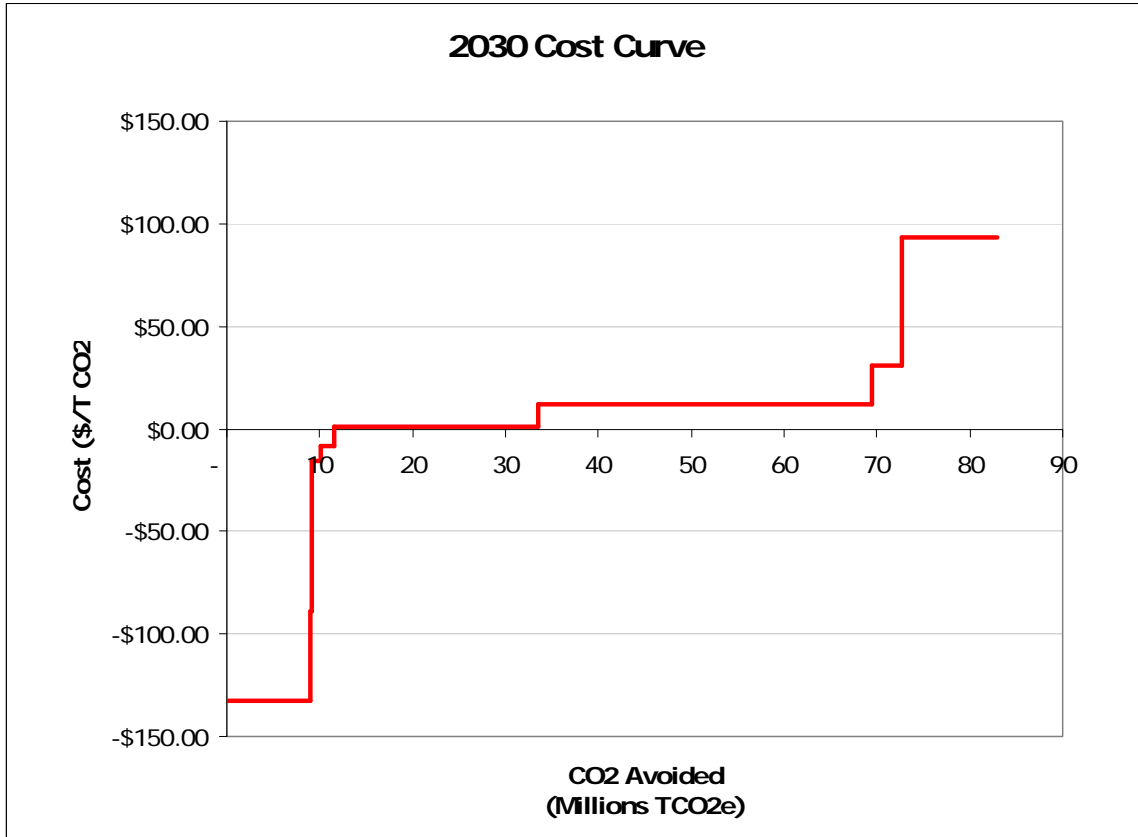
The options are as follows...

- **LPG Stoves:** By 2030, efficient LPG stoves could replace kerosene stoves in 3 million households. Kerosene stoves annually consume 8 GJ of energy per household and work at an efficiency of 30%. While the LPG stoves work at an efficiency of 60%. LPG stoves cost \$40 and have an expected lifetime of 8 years. Kerosene stoves cost \$15 and last 5 years.
- **Efficient Motor Drives in Industry:** By 2030, the introduction of efficient electric motors throughout the industrial sector is expected to be able to save 10,000 GWhr of electricity at a cost of 10 cents (\$0.10) per kWh.
- **Efficient Refrigerators in Households:** By 2030, efficient refrigerators could replace standard refrigerators in 1 million households. Efficient fridges will use 400 kWh/year, while standard fridges consume 700/kwh/year. Efficient fridges cost \$500 and have a lifetime of 10 years. Standard fridges cost \$300 and last 8 years. Assume one fridge per household.
- **Improved Vehicle Fuel Economy Standards in the Transport Sector:** New regulations for vehicle fuel economy will lead to the average fuel economy for cars decreasing from 8.0 liters/100 km to 6 liters/100 km by 2030. This will affect approximately 100,000 vehicles. Each vehicle drives 18,000 km/year. The regulations are expected to be met by manufacturers moving to smaller and more efficient vehicles which will add approximately \$500 to the cost of a vehicle. Assume that vehicles have a lifetime if 15 years.
- **Combined Heat and Power (CHP) in Industry:** By 2030, 20 million GJ of industrial process heat produced from oil fired boilers could instead be produced from more efficient natural gas fired CHP plants. The oil fired boilers operate at 55% efficiency, while the CHP plants would produce heat at 50% efficiency together with electricity at 25% efficiency (for a combined efficiency of 75%). The electricity can be sold back to the grid and is assumed to displace the average baseline mix. To produce this amount of heat, 800 MW of CHP plant will be required at a cost of \$1400/KW. CHP plants have a lifetime of 35 years.

- **Hydro power for electric generation:** Approximately 6000 MW of hydropower could be built by 2030 displacing coal which is expected to be built in future as the main base load power plant in a baseline scenario. The hydro plants will have an efficiency of 100%, an expected availability of 70% and a plant lifetime of 35 years. Hydropower capital costs are expected to be \$4000 per KW. Variable O&M costs are expected to be \$1 per MWhr. The hydropower plant would be built and run to replace coal fired plant that would have an expected availability of 70%, a thermal efficiency of 35%, a lifetime of 35 years, a capital cost of \$1000 per KW, and variable O&M costs of \$3 per MWhr.
- **Solar Photovoltaics for Electric Generation:** 4000 MW of solar power could be built by 2030, again displacing coal-fired base load plant. The solar plants would have an efficiency of 100%, an expected availability of 30% and a lifetime of 30 years. Total capital costs are expected to be \$4000 per KW. Variable O&M costs are expected to be \$20 per MWhr. Because of solar's low availability, the 4000MW of solar would only display about 1500 MW of coal plant. The coal fired plant would have a thermal efficiency of 35%, a lifetime of 35 years, a capital cost of \$1000 per KW, and variable O&M costs of \$3 per MWhr.
- **Reforestation (Enhancing GHG sinks):** Reforestation projects are expected to cover 4 million ha by 2030. Each hectare is expected to sequester about 1.5 tonnes of carbon per year at a cost of \$5 per tonne of carbon.

Use the above information to complete the “screening.xls” spreadsheet. You should end up with a cost curve looking like the one shown below:

Option Name	Million Tons CO2 Option Potential	Million Tons CO2 Cumulative Mitigation	\$/Ton CO2 Cost of Saved CO2	X bar	Y bar
Baseline	-	-			
Vehicle Fuel Economy	8.98	9	-\$132.38	(8.98)	\$ 43.3
Efficient Refrigerators	0.10	9	-\$89.13	(0.10)	\$ 73.5
LPG Stoves	1.01	10	-\$15.60	(1.01)	\$ 7.5
Industrial CHP	1.41	12	-\$8.06	(1.41)	\$ 9.4
Forestry	22.00	34	\$1.36	(22.00)	\$ 10.9
Hydro Power	35.92	69	\$12.31	(35.92)	\$ 18.5
Industrial Motors	3.24	73	\$30.86	(3.24)	\$ 62.8
Solar Power	10.26	83	\$93.65	(10.26)	



Notice that the curve shows costs increasing from left to right. The options on the far left actually have negative costs, indicating that for these options GHG mitigation can be achieved with net benefits to the economy.

The area under the curve yields the total cost of avoided emissions.

## **4.2 Part Two: Qualitative Screening**

In part two of this exercise you will work together as groups to decide on an overall ranking for the mitigation options you began to examine in part one.

To do this, complete the empty screening matrix provided here in the appendix to these exercises.

The first two rows of the matrix are simply placeholders for the numbers you developed for the cost curve in exercise one.

The remaining rows can be used to rate the options based on more qualitative criteria, for which numbers are either not available or are uncertain.

As a group, decide on how you want to rate each of the options. Various approaches are possible and equally valid. For example, you may wish to use:

- A score (e.g. 0-5 or 0-10),
- A ranking (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, etc.)
- A rating (low/medium/high),
- A comment for each criterion.

You may wish to let each person in the group “vote” on a score or ranking or you may decide to agree a rating more informally.

Once you have ranked each of the individual options, try to agree on an overall score or ranking for each option. You may wish to use a weighting system or you may use a more informal process. Please document in a few words the method you choose.

Once you have completed the screening matrix, you will be asked to present your findings in plenary in a short (3-5 minute max) presentation. You will be asked to present the cost curve you developed, along with the screening matrix. Please also present answers to the questions:

- As a group: what process did you use to develop the screening matrix?
- How did you combine each of the criteria into an overall score or ranking?
- In what ways is this analysis too simplified to reflect real-world conditions?
- How might you improve upon it in a real mitigation assessment?
- Do you believe that developing a screening matrix will be useful as a step in your own national mitigation assessments?

## 5 Exercise Two: Creating a Mitigation Scenario in LEAP

In this second exercise you will work with LEAP, the Long range Energy Alternatives Planning System to create a very simple example of a mitigation scenario.

The exercise is not intended to fully train you in the use of LEAP. It is intended only to give you a brief introduction to some parts of the system; to give you a chance to create a simple mitigation scenario and to produce various reports of the type that might be included when reporting on a mitigation assessment in a National Communication.

Exercise 2 builds upon the data and results developed for static screening you undertook in Exercise one. In this second exercise you will take the basic information for your five “top ranked” mitigation options, and enter this into LEAP to create a dynamic mitigation scenario that examines how energy and emissions savings might occur over the period 2001-2030.

You will then use LEAP to create a few charts and tables that report the overall emissions savings in the mitigation scenario compared to the baseline scenario.

To keep things simple, you will work with a partially completed LEAP data set that already has a fully defined Baseline scenario.

### 5.1 A Very Brief Introduction to LEAP

Start **LEAP** from the **Start/Programs/LEAP** menu. Once started, LEAP will display a title screen and then the main screen will appear (shown below).

As much as possible LEAP works like other standard Windows software, so if you are familiar with other Windows tools like Microsoft Excel or Windows Explorer, then you should be able to start using it straight away.

LEAP is structured as a set of different *views* of an energy system. The **View Bar** located on the left of the screen, displays an icon for each view. For this exercise we will only use two views:



The **Analysis View** in which you will enter data and construct your mitigation scenario.



The **Results View** where you will examine the calculated scenarios as graphs and tables.

The **Analysis View** (shown below) contains a number of controls apart from the view bar. On the left is a tree which is the main organizational tool for the data in LEAP. On the right are two linked panes. At the top is a table in which you view or edit data the data describing your scenarios. Below it is an area containing charts and tables that summarize the data you entered above. Above the data table are toolbars that gives that access to commonly used commands and a standard menu.

The main menu and toolbar give access to major options.

Data is organized in a tree.

Scenario selection box

Edit data by typing here.

Switch between views of the Area here.

Name	Current Accounts Expression	Scale	Units	Per
Household	8	Million	Household	
Urban	30	Percent	Share	of Household
Rural	Remainder(100)	Percent	Share	of Household

The status bar notes the current Area and View.

Data can be reviewed in chart or table format.

The main parts of the **Analysis View** are described in more detail below:

- **The tree** is the place where you organize your data for both demand and supply (Transformation) analyses. The tree contains different types of branches:
  - 📁 **Category branches** are used mainly for the hierarchical organization of data in the tree.
  - ⚙️ **Technology branches** contain data on the actual technologies that consume, produce and convert energy.

- **Fuel branches** are used to indicate resources as well as the feedstock fuels and outputs of Transformation processes.
  - **Environmental loading branches** represent the various pollutants emitted by energy demand and transformation technologies.
- **Data Table:** The top-right part of the screen shows a data table where you can view or edit the data associated with the variables at each branch in the tree. As you click on different branches in the tree, the data table shows a series of “tabs”. Each tab corresponds to one variable. The variables you see depend on which part of the tree you click on. For each tab, a table presents the data associated with that variable. Each row in the table represents data for a branch in the tree.
  - **Chart/Table/Notes:** The lower-right part of the screen summarizes the data entered above as a chart or a table.
  - **Scenario Selection Box:** Above the data table is the scenario selection box, which you can use to select between **Current Accounts** and any of the scenarios in an area. Current Accounts is the data for the base year of your study. Different scenarios in LEAP all begin from the base year. In this exercise you will be given a completed **baseline** scenario, and you will then enter the data for a **Mitigation** scenario. Use the scenario selection box to select among the Current Accounts and the scenarios.

## 5.2 Reviewing the Baseline Scenario

In this exercise we will work on a partially completed data set or **Area** named “Exercise”. An Area in LEAP is a complete description of a particular energy system, typically a country. Start by opening the area named “Exercise”. To do this select menu option **Area: Open** and then select the area named “Exercise”.

Let’s begin by reviewing the Current Accounts and Baseline scenario which has already been completed for you (to keep this exercise short!)

First, in the **Scenario Selection Box**, choose **Current Accounts**. Now use the tree to navigate the structure of this data set. First open up the tree branches under the Demand branch. You will see that this data set is very simple and aggregate. Demands are broken down by major sector (Households, Services, Industry, Transport, and Agriculture). Under each sector, are a simple set of branches listing the final fuels consumed in each sector. Each fuel is shown in the tree as a technology branch (🔧). Finally under each fuel, are a set of branches that specify the emissions for each fuel (🔧). In this exercise there are emissions specified for CO<sub>2</sub>, CO, CH<sub>4</sub>, VOCs, NO<sub>x</sub>, N<sub>2</sub>O and SO<sub>2</sub>.

Now let’s look at the data associated with these branches. Click on one of the sector branches in the tree and then look at the tabs and data pane on the right. You will see that energy consumption data is also specified in a very simple way. Normally in LEAP you would specify separate data describing **activity levels** (e.g. number of households, or

pass-km of transport) and **energy intensities** (GJ/households per year or GJ/pass-km). LEAP then multiplies these together to calculate total final energy demand. That is, it uses this relationship:

$$\text{Total Final Energy Consumption} = \text{Activity Level} \times \text{Final Energy Intensity}$$

But in this exercise the data are specified in an even more simple fashion. The Activity Level variable has simply been set to “No data” and total energy consumption data is specified on the tab marked **Final Energy Intensity**. In other words we have used this relationship:

$$\text{Total Final Energy Consumption} = \text{Final Energy Intensity}$$

Select the **Final Energy Intensity** tab now. You will see the values of the total final energy consumption for each branch specified as data in Millions of Gigajoules. In the lower part of the screen the data is echoed back as a chart.

Now open up the branches below one of the fuels and look at the **Environmental Loading** Tab. You will see a series of expressions that specify the emissions factors for each pollutant per unit of fuel consumption for that fuel. Typically emissions factors are specified in Tonnes/Terajoule or kg/Terajoule. To calculate total emissions of each pollutant, LEAP simply multiplies total energy consumption by each emission factor using this relationship:

$$\text{Total Emission} = \text{Total Final Energy Consumption} \times \text{Emission Factor}$$

Now in the **Scenario Selection Box** select the **Baseline** scenario. Click on one of the sector branches in the tree and look again at the **Final Energy Intensity** tab. Now, instead of seeing a set of simple value you will see a set of *time-series expressions* that specify how total final energy consumption changes from the base year to the end year of the analysis.

In this exercise, all the time-series values are specified using LEAP’s built-in **Interp** function. The Interp function works by letting you specify values for any future years. It then assumes a straight line change between the years calculated by simple linear interpolation. For example, this function...

**Interp(2000,18, 2010,28, 2020,60, 2030,80)**

...specifies a value of 18 in the year 2000 and a value of 28 in 2010. Thus the interpolated value that LEAP calculates in 2005 is 23.

Now let’s have a look at how the data is specified for the Energy Supply system. This data all lives under the **Transformation** branches in the LEAP tree. In LEAP, energy supply data is specified by first making a list of *modules* immediately below the Transformation branch. These modules correspond to major energy supply sectors like

electricity generation, transmission and distribution, oil refining, charcoal making, ethanol production, coal and oil extraction, etc. Each module can be further divided into different *processes*, each of which can have one or more *feedstock fuels*. A process might be a particular type of power plant or a type of oil refining facility for example. Each module is dispatched to produce one or more *output fuels*.

In our simple example, there are only two modules: one dealing with the **Transmission and Distribution (T&D)** of electricity and a second one below it dealing with **Electricity Generation**. The T&D module is very simple: it simply specifies expected losses during transmission and distribution. The Electricity Generation module has four processes describing the capacity, availability, efficiency and merit order dispatch characteristics of four types of power plants: coal, hydro, oil and solar. The first three exist in the base year, while solar is listed as a potential future type of power plant. As on the demand side all of the data required to specify a baseline scenario has already been entered to keep the exercise simple.

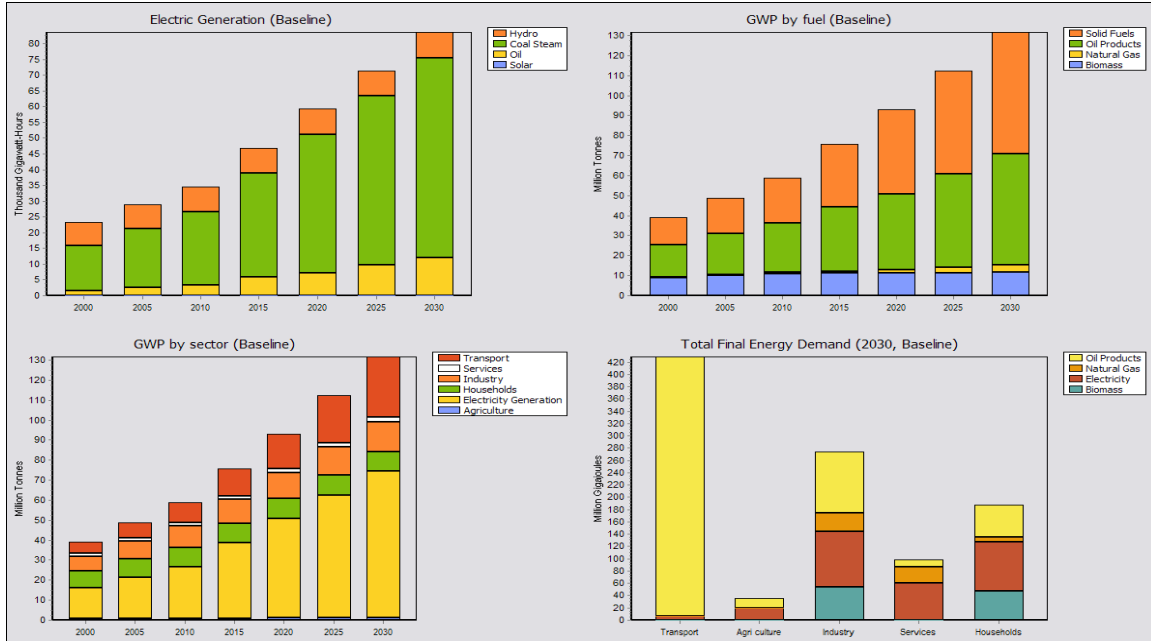
Now, let's switch to the **Results View** to see some results associated with the already complete Baseline scenario. Click on the results view, and if prompted allow LEAP to calculate results. This should only take a few seconds.

Now let's look at some results in Chart form. The Results view has numerous options for selecting results.

- First use the **tree** to pick the branches for which you wish to see results. For example, you might choose to see demands in the household sector, or GHG emissions for the whole area.
- The **Result** selection box at the top of the screen is used to pick the category of results you are interested in. Different types of results are available at different tree branches. For example, final energy demand results are only available at demand branches while emissions and GHG results are available at both demand and supply branches.
- Two tabs at the top of the view let you switch between **Charts** and **Tables**: both formats contain the same basic information.

Reports can be viewed for one or more scenarios and can be customized in a wide variety of ways. You can also use the "**Favorites**" option to bookmark the most useful charts for your analysis.

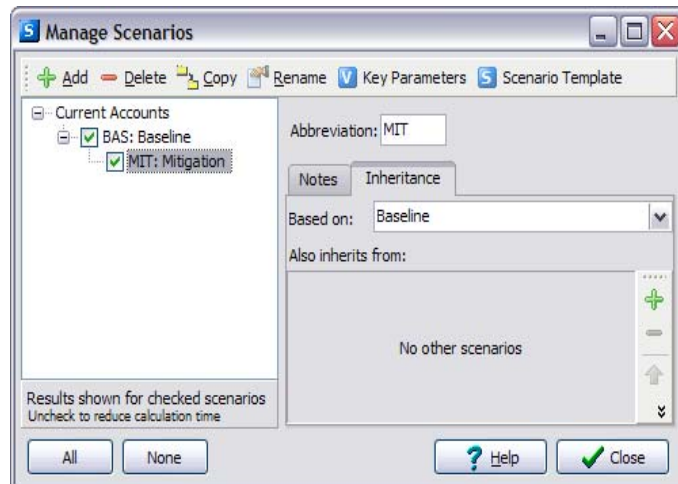
To make things easy, we have preconfigured a set of **Favorite** charts you can use to examine results. Take a look now at the Favorite results for **Total Final Energy Demand in 2030, Electric Generation** and **Global Warming Potential** (by sector and by greenhouse gas). These are shown below.



*Tip you can see these four charts together in the Overviews screen.*

### 5.3 Entering Mitigation Data in LEAP

Now you are ready to start specifying the Mitigation scenario. We will start by creating a mitigation scenario. Switch back to the **Analysis View** and click on the **Manage Scenarios** button (S). In the Manage Scenarios screen (shown right), use the Add button (+) to add a new scenario named Mitigation. Make sure this scenario *inherits* from the Baseline scenario.



In this way, all of the data and expressions for the Mitigation scenario will initially be exactly the same as those in the Baseline scenario.

Thus, to specify the data for the new scenario you will only need to specify the places where the mitigation scenario is different from the Baseline. Much of the data specified for the Baseline (such as emissions factors) will remain unchanged.

Now close this screen and return to the Analysis View. If necessary, select Mitigation as the active scenario in the **Scenario Selection Box**.

We will now enter data to represent some of the options we studied in Exercise One in our mitigation scenario.

In a real mitigation study it might be desirable to do a thorough end-use oriented analysis in which both the baseline and the mitigation scenario are described in terms of the likely penetration of different technologies. That kind of exercise is data intensive and time consuming and goes beyond what can be done in this simple exercise. Instead, in this exercise we will specify most of our options by simply entering the amount of fuel consumption that is avoided (or increased) relative to the Baseline scenario as a result of implementing the mitigation option.

Let's enter the data for the Household LPG stoves option. If you look at the spreadsheet "screening.xls" you will see that this option is expected to reduce consumption of kerosene by 24 million GJ in 2030 while increasing consumption of LPG in 2030 by 12 million GJ. The changes can be assumed to start from nothing in the base year (2000) and increase linearly to reach these values by 2030.

We can specify this information in LEAP as follows. First, select the Households branch in the tree then select the **Final Energy Intensity** tab and then enter the following two expressions for the Wood and LPG branches. The expressions should override the expressions that were inherited from the Baseline scenario.

For Kerosene:

**BaselineValue-Interp(2000,0, 2030, 24)**

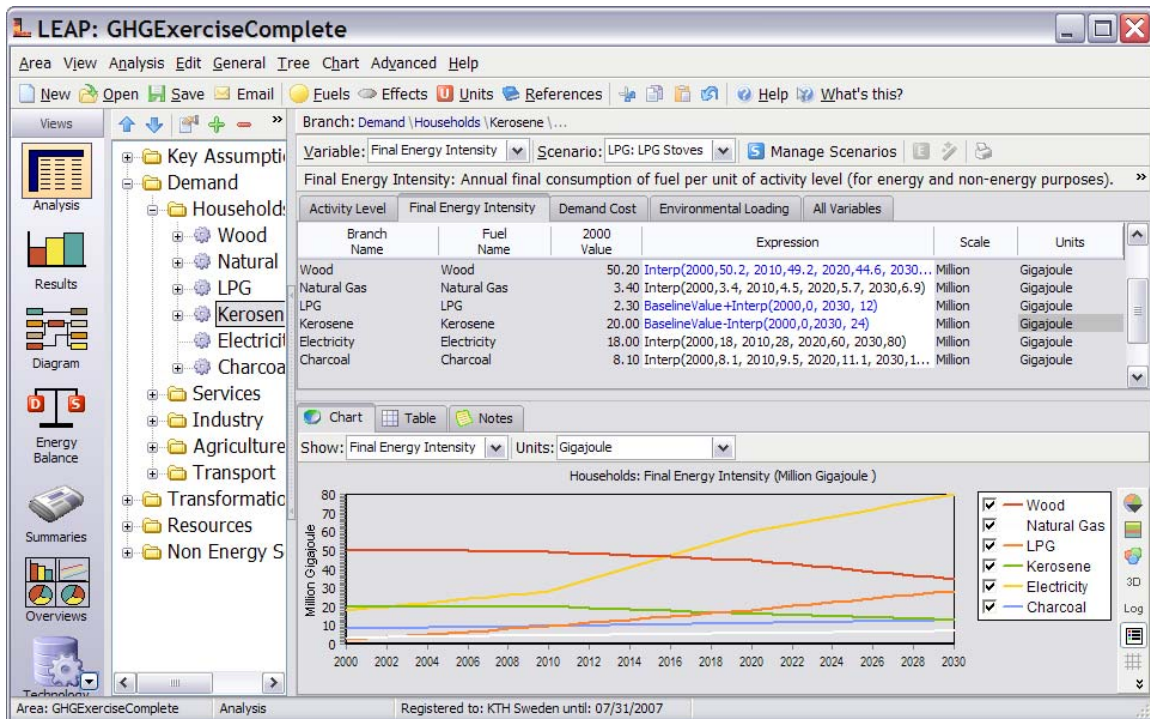
This expression specifies that the energy consumption of kerosene in the mitigation scenario gradually decreases versus the baseline scenario, so that by 2030 it is 24 million GJ less.

For LPG:

**BaselineValue+Interp(2000,0, 2030, 12)**

This expression specifies that the energy consumption of LPG in the mitigation scenario gradually increases versus the baseline scenario, so that by 2030 it is 12 million GJ more.

When entering the data in LEAP's Analysis View, the screen should look something like this:



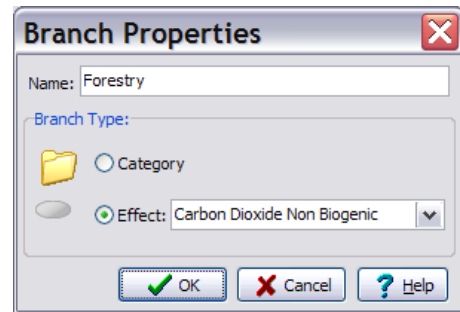
Use this same approach to continue specifying the data for the other mitigation options that you wish to include in your mitigation scenario. For now only include the following measures:

- LPG Stoves
- Efficient Refrigerators
- Vehicle Fuel Economy
- Industrial CHP
- Forestry

Most of the other options can be entered into LEAP in a way similar to how you specified the LPG stoves option. However specifying either of the two supply-side options (solar and hydro) or the forestry option requires a bit more explanation:

- **Entering data for the Hydro Measure:** For this option you will need to enter data in the Transformation\Electricity Generation module. Click on the Processes branch and then select the **Endogenous Capacity** tab. This screen lets you specify a set of plants that will be added automatically and as needed as demands grow in order to meet a specified planning reserve margin. In this exercise the planning reserve margin is set to 40%. You can see that in the baseline LEAP will add Coal and Oil plants in amounts of 500 MW and 300 MW respectively as needed to keep the reserve margin on or above 40%. You will need to change this by first adding the Hydro process to the list. Click the Add button (+) at the right of the table to add a new process to the ones listed in the **Endogenous Capacity** screen. Now change the **Addition size** values to read (Coal: 300, Oil: 300, Hydro: 200).

- Entering data for the Forestry Option:** Unlike all the other options, the Forestry mitigation option is a non-energy sector option. Its implementation has no direct effect on the energy sector with which LEAP is primarily concerned. However, you can still characterize this option in LEAP in very simple terms. Select the **Non-Energy Sector Effects** branch in the tree and then click the Add button (+) above the tree to add a branch. Label it “Forestry” and select an associated pollutant for it: Carbon Dioxide (Biogenic). The screen should look like the one on the right.



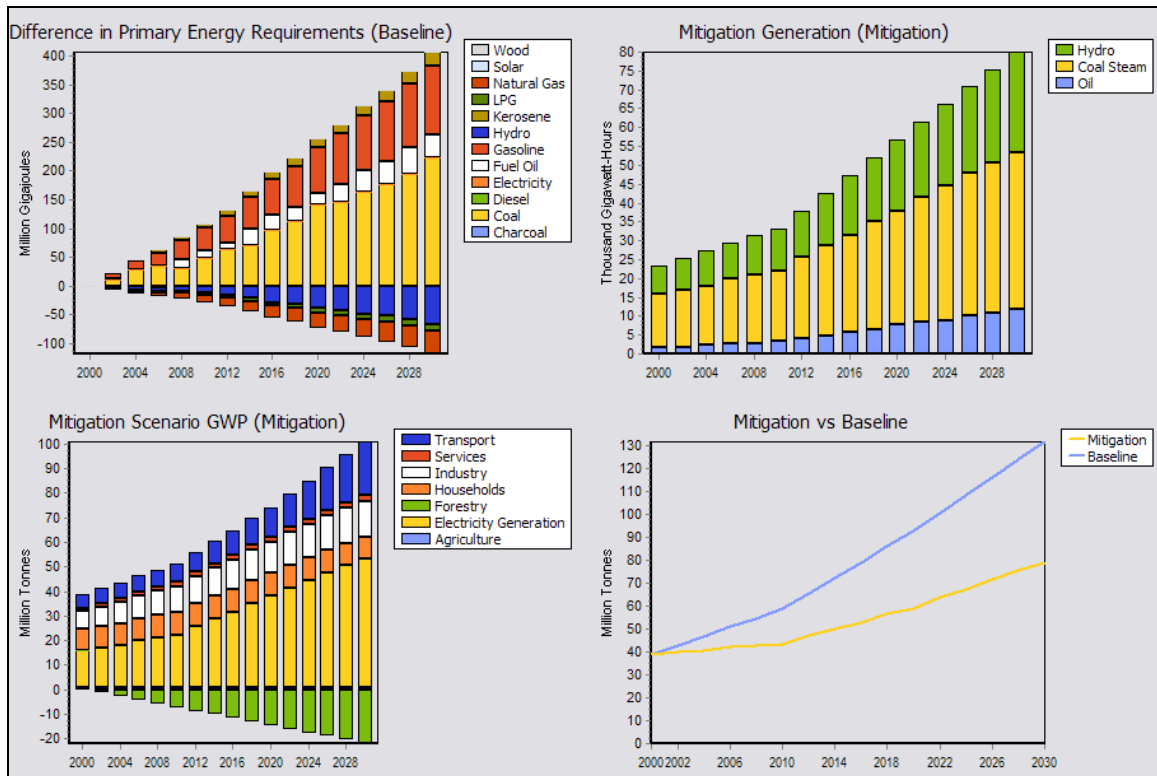
- Click **OK** to return to the Analysis View and in the data table use an expression to specify the emissions sequestered in the Mitigation scenario in 2020 (22 million tonnes of CO<sub>2</sub>). Don’t forget to set the scaling factor and units to Millions and Tonnes respectively. Enter the emissions sequestered as a negative value because they are a net sink compared to the Baseline scenario. One way to enter this would be to use the following expression:

**BaselineValue-Interp(2000,0,2030, 22)**

## 5.4 Viewing Results in LEAP

Once you have completed specifying the data for the mitigation scenario, switch to the Results view and again use the Favorites menu option to the key results for the scenario (and for how it compares to the Baseline scenario).

Compare your results to the ones produced here. These results are based on a scenario that includes all of the mitigation options except for Solar. Bear in mind that your results will be different if you have included a different set of options in your mitigation scenario.

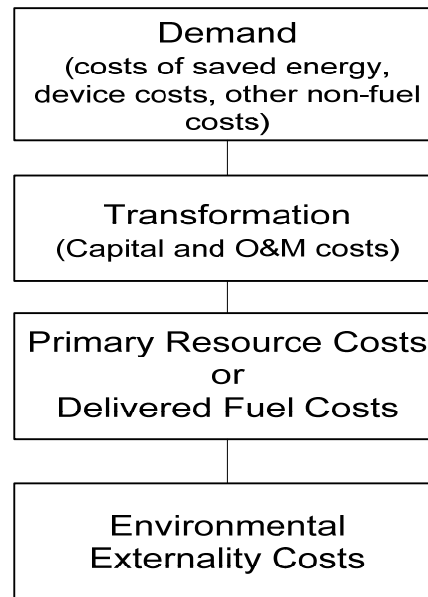


## 6 Exercise Three: The Costs and Benefits of the Mitigation Scenario.

In this third exercise we will enter data about the costs of the various policies and measures employed in the Mitigation scenario and then use LEAP to look at the overall costs of the scenario versus the “do nothing” baseline scenario.

LEAP performs cost-benefit calculations from a societal perspective by comparing the costs of any two policy scenarios. LEAP can include all of the following cost elements:

- Demand costs capital and operating and maintenance costs expressed as total costs, costs per activity, or costs of saving energy relative to some scenario.
- Transformation capital costs
- Transformation fixed and variable operating and maintenance costs.
- Costs of indigenous resources
- Costs of imported fuels
- Benefits of exported fuels
- Externality costs from emissions of pollutants
- Other miscellaneous user-defined costs such as the costs of administering an efficiency program.



To set-up a costing analysis in LEAP it is first necessary to draw a consistent boundary around your system, so that LEAP will not double-count costs and benefits. For example, if you count the costs of fuels used to generate electricity you should not also count the cost of the electricity in an overall cost-benefit calculation.

Contrast this integrated perspective with the rough project-by-project approach that we used in developing the original screening spreadsheets. Taking this integrated perspective has a number of distinct advantages:

1. It is able to capture interactivity: the effect that one measure has on another. For example: our efficient refrigerators measure was originally judged in terms of the CO<sub>2</sub> saved based on a simple assumption about the baseline electric fuel mix. But in an integrated scenario we may be combining demand-side efficiency measures with supply-side fuel switching measures. Using LEAP we can see the interactive effects.

2. LEAP's analysis is dynamic: thus we can see what happens over time as demand-side measures penetrate the market and the electric supply sector grows accordingly to meet demands.

If you have not already done so, switch-on costing in LEAP by returning to the Analysis View, and going to **General: Basic Parameters; Scope** screen. Now go to the **Costing** tab and select the boundary that will be drawn around the system for the purposes of costing. For this exercise we will select "Complete Energy System" as the boundary, meaning that fuel costs are accounted for only when they are imported or exported or when indigenously produced fuels are extracted as primary resources.

Now go back to the Analysis View and select the **Current Accounts** scenario. We will first enter data into LEAP that describes the costs (or benefits) of each.

You will need to refer to the spreadsheets you used for evaluating each mitigation measure. Enter the following information:

## 6.1 Demand-Side Measures

- **LPG Stoves:** From the spreadsheet, calculate the total annualized non-fuel costs per GJ of kerosene saved for this measure (\$/GJ). Enter this data in LEAP for the Household/Kerosene branch on the Demand Cost tab using the "Cost of Saved Energy" costing methodology. Notice that costs of saved energy are always defined relative to some counterfactual. In this case the cost is defined relative to the baseline scenario. Notice also that in LEAP we will assess fuel costs separately from non-fuel costs, so you will need to calculate all of the costs except for the fuel costs.
- **Efficient Refrigerators in Households:** Here you will need to use the spreadsheet to calculate the annual electricity savings and the total non-fuel costs of the measure.
- **Improved Vehicle Fuel Economy Standards in the Transport Sector:** Here you will need to use the spreadsheet to calculate the annual gasoline savings and the total non-fuel costs of the measure (\$/GJ).

*Tip: Note that in our screening cost curve some of the measures (vehicles, refrigerators, LPG stoves, CHP) had negative overall costs (since fuel savings for these measures outweighed the investment costs). These are NOT the costs we enter into LEAP's demand analysis. Instead in LEAP we need to specify only the non-fuel costs of each measure. We will deal with the fuel savings later on using LEAP's integrated cost-benefit analysis perspective.*

- **Combined Heat and Power (CHP) in Industry:** Here you can specify cost data in terms of the cost per GJ of fuel oil replaced with CHP. Again, you will need to

## 6.2 Transformation Measures

Entering data on the supply-side is more straightforward. Take the data on page describing the capital, O&M, and lifetime of the three effected power plant types: coal, hydro, oil and solar PV and enter it on the various costing tabs under the Transformation: Electric Generation module. That data is repeated here for convenience:

Plant	Capital cost (\$/kW)	Variable O&M Cost (\$/MWh)	Lifetime (Years)
Coal	\$1000	\$3	35
Oil	\$2000	\$5	30
Hydro	\$4000	\$1	35
Solar PV	\$4000	\$20	30

Remember to use the default discount rate of 5% as the value for the interest rate for each plant. This is the value used to annualize the capital costs for each plant.

## 6.3 Non-energy Measures

LEAP is primarily an energy model. Currently it does not have the capability to include non-energy sector costs. Thus you cannot include the costs of the reforestation measure.

## 6.4 Resource Costs

Finally, we need to specify the costs of all of the various resources used in both scenarios. This data is entered under the Resource branches in LEAP for both indigenously produced primary fuels and for imported fuels. Enter into LEAP the fuel prices specified on the **Assumptions** spreadsheet to complete the specification of the costs in your LEAP analysis.

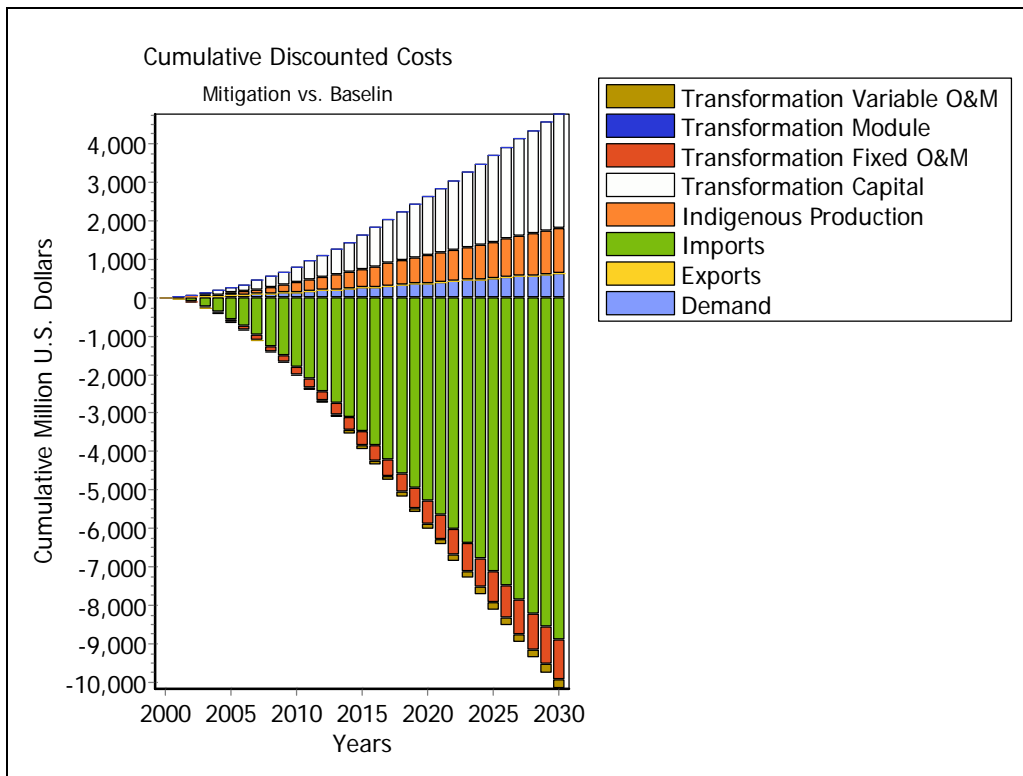
Finally, you should check that there are sufficient base year reserves of coal and natural gas available so that LEAP does not resort to importing these fuels. You can simply enter a very large number (e.g. 1 trillion GJ for each fuel).

## 6.5 Viewing Results

You should now be ready to view some results. Click the results view and after LEAP has calculated review the overall cost results for the mitigation scenario minus the baseline scenario. Select a chart configured to show the following:

- Cost results for the whole area.
- Differences between the mitigation and baseline scenarios.
- Cumulative discounted costs
- X axis showing years, Legend showing cost categories.

You should see a chart like this:



You can also review a cost-benefit summary in the summaries view. It should look like the one shown on the right. Notice that the Net Present Value of the Mitigation scenario vs. the Baseline scenario is a benefit of about 5.4 Billion US\$.

Why are there positive costs for the demand and Transformation sectors but negative costs for Resources? \_\_\_\_\_

Cumulative Costs and Benefits. Compared to: Scenario: Baseline. Years: 2000-2030	
(Billion 1990 U.S. Dollar, discounted at 5.0%)	
	Mitigation
<b>Demand</b>	
Households	0.2
Services	0.0
Industry	0.4
Agriculture	0.0
Transport	0.0
<b>Transformation</b>	
Transmission and Distribution	0.0
Electricity Generation	1.7
<b>Resources</b>	
Production	1.2
Imports	-8.9
Exports	0.0
<b>Environmental Externalities</b>	0.0
<b>Net Costs</b>	-5.4
<b>GHG Savings (Mill. Tonnes C Eq.)</b>	210.4