REDEO
RURAL ELECTRIFICATION
DECENTRALIZED ENERGY OPTIONS

EC-ASEAN Energy Facility
Project Number 24

REPORT FOR ACTIVITY 4

REDEO PROTOTYPE TOOL
USER GUIDE

OCTOBER 2005

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1. INTRODUCTION

1.1 PURPOSE OF REDEO

The primary objective of the REDEO tool is to provide planners of rural electrification with a set of flexible and computerized planning tools for integrating sustainable, off-grid distributed generation options in the planning process, at a provincial scale. The REDEO methodology takes various socio-economic development factors such as education, health, accessibility etc. into account when identifying areas with a high potential for development. Once these areas are identified, they are clustered with the remaining areas with a lower potential for development.

Power demand and peak is then forecasted per cluster and the cost of various production options worked out. Power resources are then deployed per cluster instead of small, isolated villages. The user can then compare the life cycle kWh cost of the various production options based on which he can decide which would be the best scenario for electricity service provision in the Province.

1.2 THE REDEO TOOL

The REDEO tool is an add-on to the Geographical Information System (GIS) Manifold 6.0® system and provides the user with a number of buttons to enhance the basic functions already performed by Manifold® and provide the facility to generate electrification scenarios in a particular area based on the data input into the tool.

This is done with several indicators such as accessibility, population, development potential etc. provided as input data to the tool. Its novelty is to produce results not only in table form, but also in the form of easy to visualize maps.

1.3 TECHNICAL CHOICES AND SYSTEM REQUIREMENTS

1.3.1 TECHNICAL CHOICES

The first choice to be made was the one of the GIS platform to be used. Specially, it was possible to select the ArcView GIS, which is the most used GIS in the academic world, but that is also a very expensive software, or to choose another GIS tool. This second option was finally chosen, and the Manifold GIS was chosen for the following reasons :

- Manifold is available at a very low price for a non academic use, and this is a necessary condition for the dissemination of the Redeo tool
- Manifold includes all of the required geographical functionalities required by the technical and economical calculation routines used by the Redeo methodology
- Manifold uses no specific data structure or data format, and is fully compatible with the standard geographical input data. Specially, ArcView data structure can be easily imported inside Redeo.

Then, there were two different possible design for the tool. On one hand the tool's modules could have been developed in an external environment using Manifold libraries. This approach allows the use of advanced programming tools, dedicated to development like debugger and tracer. But it leads to a tool split in several parts and some problem may occur for computer low skilled end users due to the management of the interactions between Manifold and the modules and because of necessary modifications in the windows registry base.

On the other hand, the REDEO tool modules can be developed inside the Manifold environment and operating as an add-on. This allows an integrated solution, a better ease of implementation and flexibility for possible future developments. Although this second method implies a low code writing support and minimal development tool and environment, it has been selected in order to facilitate the tool dissemination, by minimizing the interactions between the tool and the operating system.

The inside tool organisation is described on the figure below :

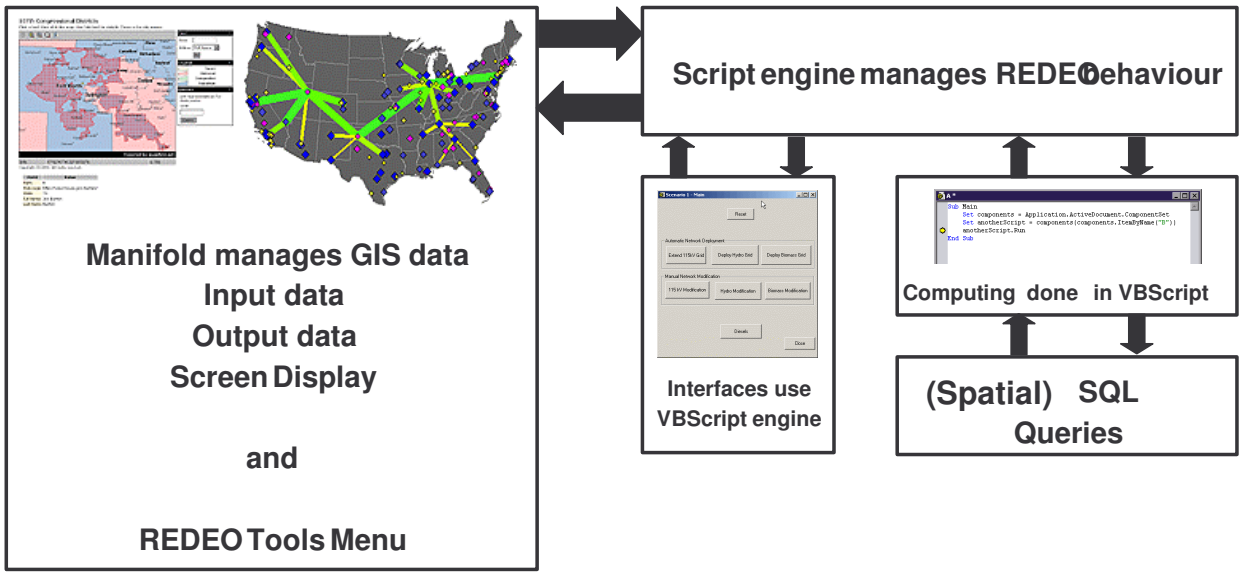


figure 4:Technical Structure

1.3.2 SOFTWARE REQUIREMENTS

As REDEO tool is based on a geographical information systems - Manifold, the REDEO software requirements are linked to the ones of Manifold, namely :

- REDEO better runs on Win XP, and does not support NT, 9x or Me.
- REDEO requires Microsoft .NET Framework 1.1. (that is a free extension of Windows XP)
- REDEO requires Microsoft Internet Explorer 5.01 (but you may use whatever browser you like)

1.3.3 HARDWARE REQUIREMENTS

The hardware requirements are also the ones of the GIS tool too but they can vary considerably depending on the size and on the level of detail of the study case area. The minimal configuration should be :

- CPU : 500Mhz PIII or Athlon
- RAM : 512 MB
- Disk : 50 GB
- GPU : Any NVidia

But this minimal configuration may lead to a slow computation and very low size limits concerning the studied areas. An optimal configuration is :

- CPU : 2.4 Ghz Athlon
- RAM : 1 GB
- Disk : 100 GB
- GPU : Any Nvidia

1.4 CONTENT OF THIS USER GUIDE

The purpose of this user guide is to explain the functions of all the capabilities of the REDEO tool in a systematic manner. The REDEO tool is modular in nature and for each module in the planning process; there is a button in the REDEO toolbar.

THE REDEO TOOLBAR

This user guide explains the operation of each button.

1.4.1 INPUT DATA[1]

The data input by the user is in the form of maps and tables. The following information is needed:

[1] Details regarding each and map and table to be imported into the tool follow in section 2.

- Data about existing and potential power resources such as hydro, biomass, main grid lines and substations. This includes location, production specifications and costs.
- Data about each locality including the development infrastructure
- Load forecasting parameters- peak, specific consumption, location of load point (if relevant), penetration rate.
- Population growth rates
- Diesel fuel costs
- Electricity transmission and distribution costs

1.4.2 OUTPUT DATA

The data output by the tool is in the form of maps and tables. The outputs produced are as follows:

- A map showing the initial infrastructure present in the region
- Maps of the clusters, CHPD[2] and OL.
- A map, graph and table showing a summary of the load forecast table
- Summary map and tables of the production options
- Map of the electrification scenarios created showing the connected clusters and the activated/deactivated resources in the region
- Analysis table of the impact on environment and development of a selected production option.

1.5 THE REDEO TOOLBAR


New Redeo Project


Data input


Production potions


Clustering


Scenario creation


Load forecast


Results

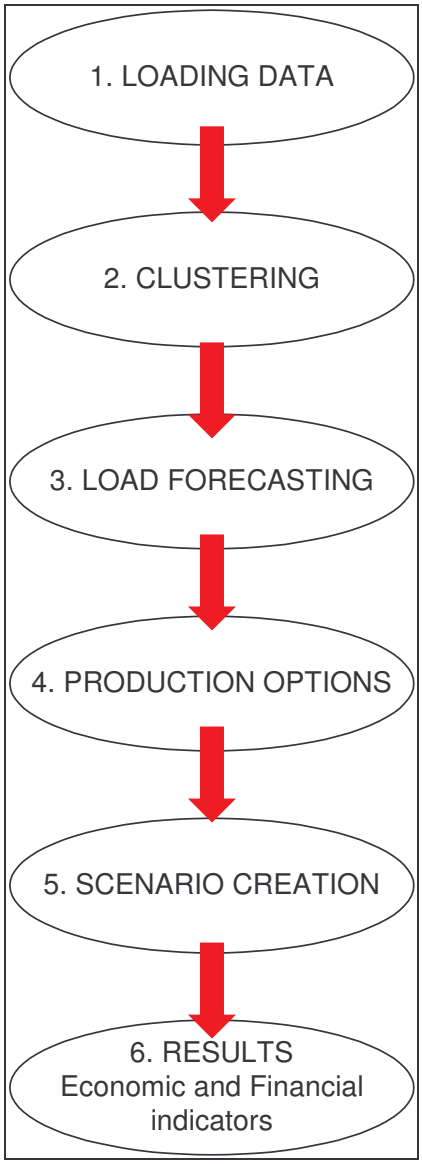
[2] A CHPD is a Center with a high potential for development and an OL is an Other Locality. (I.e.- a locality that is not a CHPD).

The order of execution needs to be as shown in this flowchart.

Each subsequent step relies on data in the phases prior to it and cannot be completed successfully if the order is not followed.

It is possible to review earlier stages of the process at any time though.

For example, the load forecast could be revised after production options have been selected.



- Clustering consists in aggregating the localities of a given province into clusters, which are actually synergetic development areas. This then has the advantage of reducing the number of points for which one has to undertake the load forecast and analyze options for providing an energy service. A cluster is composed of Center with High Potential for Development (CHPD) and its “satellites” or Ordinary Localities (OL). Those localities which are not included in the clusters are excluded from the analysis: these are isolated centers which will be supplied either through stand alone diesel, Pico / micro hydro or PV;
- Load is then forecasted over a 25-year period by 5-year steps, for each cluster and by consumer category. Both peak load and energy are forecasted.
- The user inputs available information on hydro potential sites, biomass availability, HV lines and substations as potential source points (candidate production options)
- In the scenarios module, the REDEO software then deploys MV lines to connect these sources to load centers (the clusters), computing the average life cycle cost of the delivered kWh. For those remaining clusters, the energy production mode will be diesel. The software then works out whether the least cost would be stand

alone diesel for a single cluster or whether it would be cheaper to connect more than one cluster to a larger generating unit.

- The results module then produces for each one of the selected projects ([3]) a set of economic, financial and socio economic indicators.

1.6 REDEO VERSION

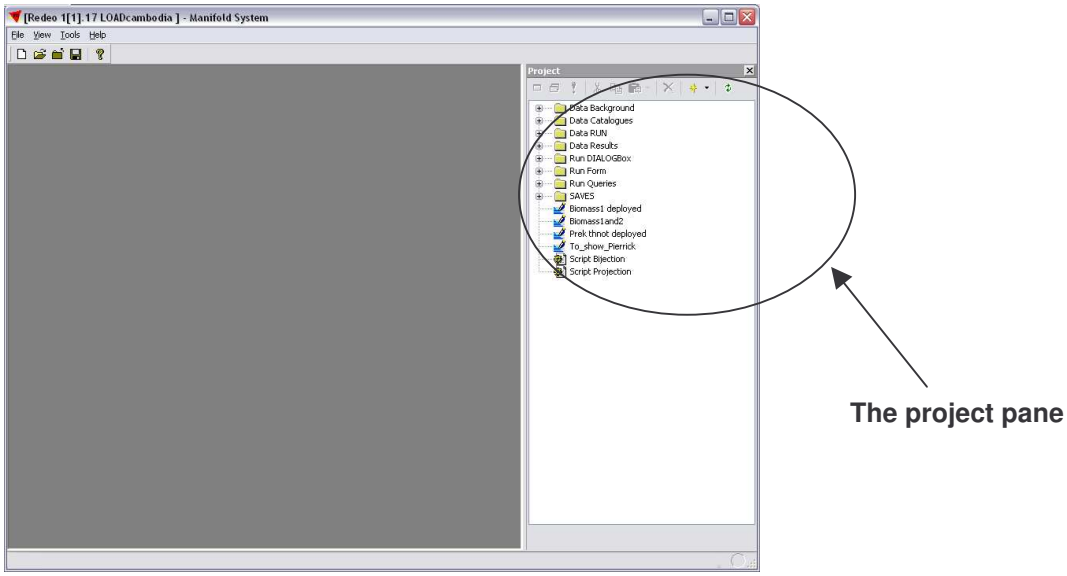
- The version of the tool related in this user guide is REDEO 2.9 .

[3] - A project is defined as a combination between a generation unit and load points.

2. THE PROJECT PANE

Before the tool can be used, a manifold file with the necessary data preloaded into it needs to be opened. As the REDEO tool is just a plug-in, it shall be visible in the main manifold window. If it is not visible, it can be selected by clicking on Tools-> Add-ins and then selecting the six REDEO toolbar buttons. If they are not available, then click on Tools-> Add-Ins -> Add-In Manager and select ***Custom***. The REDEO toolbar should now be displayed.

The project folders can be viewed in the ***Project*** pane. If this pane is not visible, it can be viewed by pressing Alt+Shift+P.



There are two folders in which the data needs to be preloaded by the user:

- The GIS Data Background folder
- Data Catalogs folder

2.1 GIS DATA BACKGROUND FOLDER

All the information on the studied area available for analysis has to be loaded in this folder. In addition, maps with information about political boundaries, railroads, rivers etc. that would be convenient to have when visualizing scenarios can also be stored in this folder.

The following points need to be kept in mind when adding data to this section:

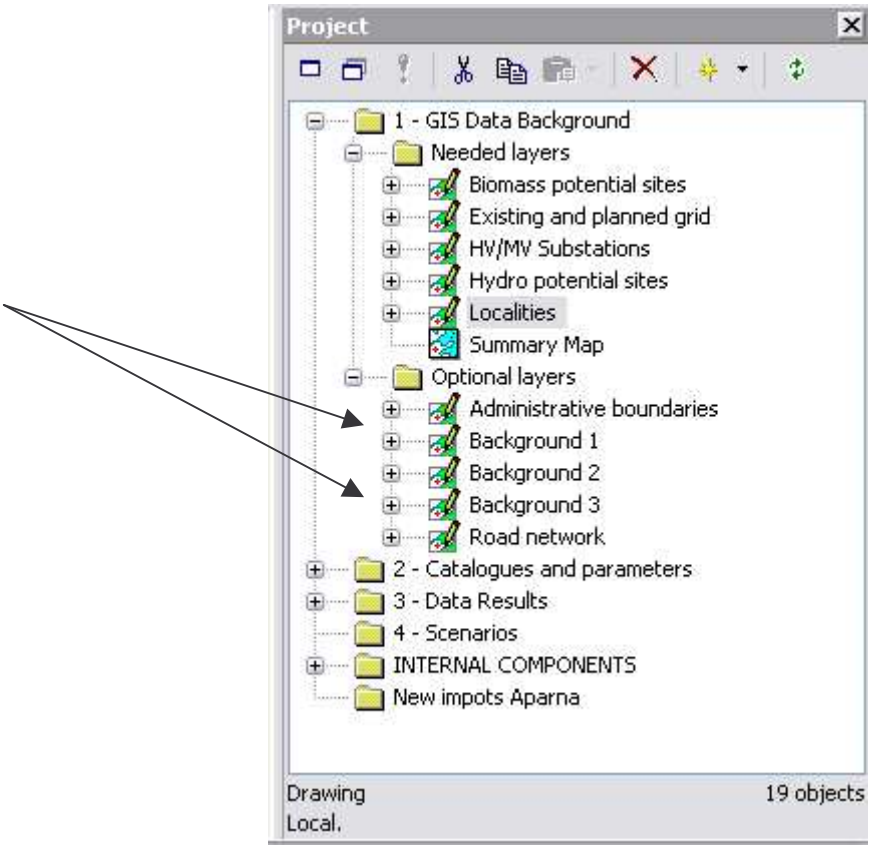
- Manifold® drawing layers with associated tables for each layer are needed by the tool.
- The type (i.e.- Boolean, integer….) is important and must be kept in mind when adding data to the tables. If data about a required field is not available, the column should still be added, and then the values can be input as zeros /blank spaces.
- The names of the folders should be the same as those specified below. Changing the name of the layers or folders in which they are shall cause errors in the calculation process.
- It is possible to add extra components such as maps of rivers, political boundaries etc. that are not needed by the REDEO tool. In order to keep things neat and manageable, it is suggested that these files be stored in the optional layers subfolder

of the GIS Data Background folder. They can be viewed either by double clicking on them or by dragging and dropping the icon for the drawing in the project pane onto the current map on display by the tool.

- The possibility of adding extra data in the tables associated with each map also exists and this could be helpful if the REDEO tool is also being used as a database.

What follows in this section is a detailed explanation of each component that has to be added to the ***GIS Data Background*** folder. All components consist of drawings. Each manifold drawing has a table associated with it. The tables need to have certain fields required by the REDEO tool. These fields are explained in the sections about each table.

Additional background layers than can be imported by the user.



2.1.1 LOCALITIES

This is one of the most important tables in the REDEO tool. The data about each locality in the area being analyzed by the tool is input in this section. The following data is required as a minimum, but other information can also be subsequently inputted by hand, if they are not available in the statistical database but available only as a result of a survey.

FIELD	MANIFOLD NAME	TYPE	UNIT
Name of the Locality	LOCALITY_NAME	ANSI, variable length	Text
Number of households in the locality	HHold	Integer, 32 bit	Number of households
Total population	Pop	Integer, 32 bit	Number of people
Health facilities	HF	Floating point, double	Refer to Appendix A, *weighting system*
Education facilities	EF	Floating point, double	Refer to Appendix A, *weighting system*
Presence of an Administrative center	AC	Floating point, double	Refer to Appendix A, *weighting system*
Number of people having a job	Emp	Floating point, double	Refer to Appendix A, *weighting system*
Presence of a road	Road	Floating point, double	Refer to Appendix A, *weighting system*
Presence or not of health facilities in the next five years	FHF	Floating point, double	Refer to Appendix A, *weighting system*
Presence or not of education facilities in the next five years	FEF	Floating point, double	Refer to Appendix A, *weighting system*
Presence of an administrative center in the 5 coming years	FAS	Floating point, double	Refer to Appendix A, *weighting system*
Number of people having a job in the next five years	FEmp	Floating point, double	Refer to Appendix A, *weighting system*
Presence of a road in the next five years	FRoad	Floating point, double	Refer to Appendix A, *weighting system*

It is suggested that the values entered in this table use a weighting system. For example, the roads data could be entered as 0.1 or a small path and 1 for a highway. In order to ensure equal weights of all the resources when calculating the potential for development in an area, it should be ensured that the weighting systems for all the fields in the table are similar. If roads range from 0 to 1, then the values for education facilities should also range from 0 to 1.

2.1.2 POWER SOURCE FROM THE EXISTING NETWORK

A map with the existing network with the substations in the region that can be used to supply power from the main grid line; of course, if there is a network just outside the boundaries of the Province with a possible substation, it should also be represented.

The table associated with this map should have the following fields:

FIELD	MANIFOLD NAME	TYPE	UNIT
Name and rating	Name	ASCI, variable length	Text
Capacity	Available_Power	Floating point, double	kW ([4])
Energy cost	Cost of available power	Floating point, double	$/kWh
Indicator whether the site is considered in the scenario creation function	Marker	Boolean	N/A

There are no HV or transmission costs associated to the rural electrification projects. However, the line cost from the Substation (exiting and hence also not added on to the project costs) to the cluster are included. In most cases, this would be 33 or 22kV lines.

Transformer costs are not taken into account as we assume that the cost of a step down transformer from an incoming grid would be approximately the same as that of a step up transformer from a local production source. MV and LV cost of lines will be the same for all production options within a cluster.

2.1.3 BIOMASS POTENTIAL

A map of potential biomass sites in the region. The assumption here is that the knowledge of planners regarding potential of biomass (be it crop residues or dedicated energy crops) for bio-electricity production is very low. Hence, the GIS background folder just requires for the user to fill in the biomass available. This could either be the plantation in terms of tonnes of crop per annum or tonns of residue per annum as well as the type of crop / residue.

Should the user want to add a residue / crop, this will have to be added on to the catalogue .

[4] - to be changed subsequently to kVA

The table associated with this map should have the following fields:

FIELD	MANIFOLD NAME	TYPE	UNIT
Name – type of crop / residue	Name – from the drop down menu of the catalogue table	ASCI	Text
Total annual crop production	Total_Annual_Crop	Floating point, single	Tons/year
Total annual residue available	Total_Annual_residue	Floating point, single	Tons / year
Indicator whether the site is considered in the scenario creation function	Marker	Boolean	N/A

A simplification for this prototype version is that the energy is produced constantly over the year – which is not necessarily the case – as there is a seasonality of residues at least. Considering only what biomass can guarantee in terms of capacity over the year leads probably to under sizing, as it may be worth it for some months in the year to have diesel backing up the low biomass availability.

2.1.4 HYDRO POTENTIAL

A map of potential hydro sites in the region. The table associated with this map should have the following fields:

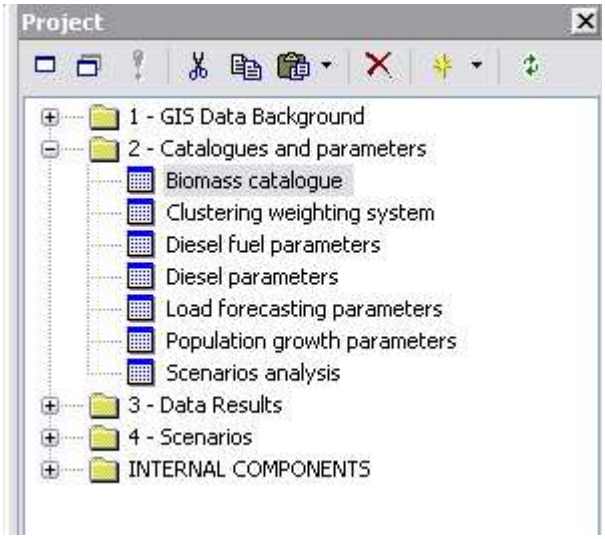
FIELD	MANIFOLD NAME	TYPE	UNIT
Name	Name	ASCI	Text
Available energy	Energy	Integer, 32 bit	KWh/y
Available power guaranteed capacity over the year	Power	Integer, 32 bit	kW
Investment cost	Investment	Integer, 32 bit	USD
Operation and Maintenance cost	OM	Floating point, single	% Investment cost / yr
Indicator whether the site is considered in the scenario creation function	Marker	Boolean	N/A

In the case of hydro, the investment cost has to be inputted by the user for each site, as it is extremely site specific. If feasibility or identification studies are unavailable, assumptions should be made. The same remark applies to hydro as for biomass, as regards the seasonality effect.

2.2 DATA CATALOGUES

The data catalogs are tables that contain information about the various power generation options, load forecast etc. They could be reused for other Provinces and in any case contain default values. The user can change and adapt them to the specific country / regional context he is working on.

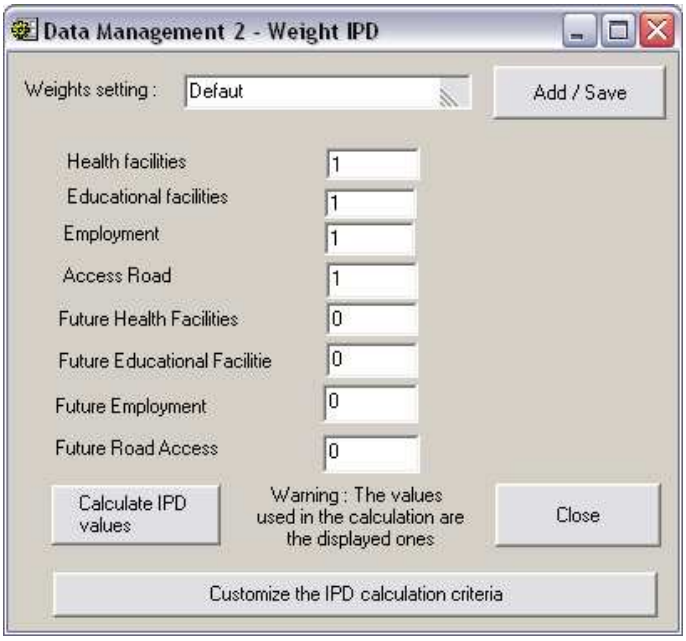
The data in this folder can be modified using the Data Input button in the REDEO tool and therefore, it is not necessary to preload data into this folder. If the REDEO tool is also being used as a Database, then it might be necessary to input data directly into this folder. An explanation of the data contained in each component follows.



2.2.1 CLUSTERING WEIGHTING SYSTEM: DETERMINING THE INDICE FOR POTENTIAL DEVELOPMENT (IPD)

The data in this table is used to calculate the Indice of Potential for Development (IPD). There are two levels of indices needed to calculate this:

- The weights given to each factor in the IPD calculation are stored in a table. The data in this table can be edited by the user in the data entry section of the tool.



- Within some categories, such as hospitals, there are different levels of services: hospital with operating facilities, rural clinic, … : a weight of 0 to 1 is given at this point ([5]).
- The option of customizing the IPD calculation is there and additional criteria can be added into this menu

2.2.2 LOAD FORECASTING PARAMETERS

- This table holds the load forecast information and can be edited from the data input menu if the tool. Refer to section 3.4.For each consumer category (in the localities table), it contains energy consumption per year, peak, growth rate per 5 year steps, and the penetration rate (% of total numbers of a consumer category connected) per 5 year step;

[5] - Please note that this rating is used both for IPD calculation and load forecasting.

FIELD	DATA TYPE	UNIT
CHPD/OL consumption by household or shop	Floating point, double	kWh/year/household or shop
CHPD/OL Contribution to peak by household or shop	Floating point, double	kW / household or shop
CHPD/OL/shop Penetration rate	Floating point, double	Percentage (between 0 and 1)
Average number of small shops by 100 HH	Floating point, double	Number of shops
Hospital	Floating point, double	kWh/year/hospital
Hospital	Floating point, double	kW/year/hospital
Hospital	Floating point, double	Percentage (between 0 and 1)

As can be seen from the above table, numbers of consumer type can be either as a function of the number of households or an absolute number.

Consumer categories can be added – see section 3.4.

2.2.3 DIESEL GENSET GENERATION PARAMETERS

Regarding diesel generation, the REDEO tool automatically sizes the required generator (both in terms of energy and capacity required, based on the energy demand and peak load of the clusters) and then calculates the investment cost and fuel consumption based on:

- Investment cost ($) = A + B*(capacity needed)
- Efficiency of power production (number of kWh per liter of diesel)
- The tool needs the following parameters about diesel.

The user then inputs the current price of diesel and his estimates for evolution over the next 25 years ($/liter).

PARAMETER	TYPE	UNIT
Operation and Maintenance cost	Floating point, single	USD/year
Lifetime	Floating point, single	Years
Diesel fixed cost (A)	Floating point, single	USD
Diesel variable cost (B)	Floating point, single	USD/kW
Efficiency ([6])	Floating point, single	kWh/liter of diesel

2.2.4 LINE AND SUBSTIONS / TRANSFORMERS

As explained in the above section, the only data that needs to be inputted at this point is:

- The cost of 1 m of MV lines
- The discount rate which is required to calculate the average life cycle cost of kWh for the different generation options

All other economic parameters will be inputted at the stage of results generation by the tool (see section 3).

2.2.5 BIOMASS CATALOGUE

Similarly to the diesel catalogue, the biomass catalogue stores information about the attributes of possible biomass generators. Refer to section 3.2 and 3.3 for details about entering data into these fields. Any additional data that needs to be stored about the generator should be input by the user directly into the tables.

[6] - Should vary depending on the size of the genset – in the second version

The data fields required is as follows:

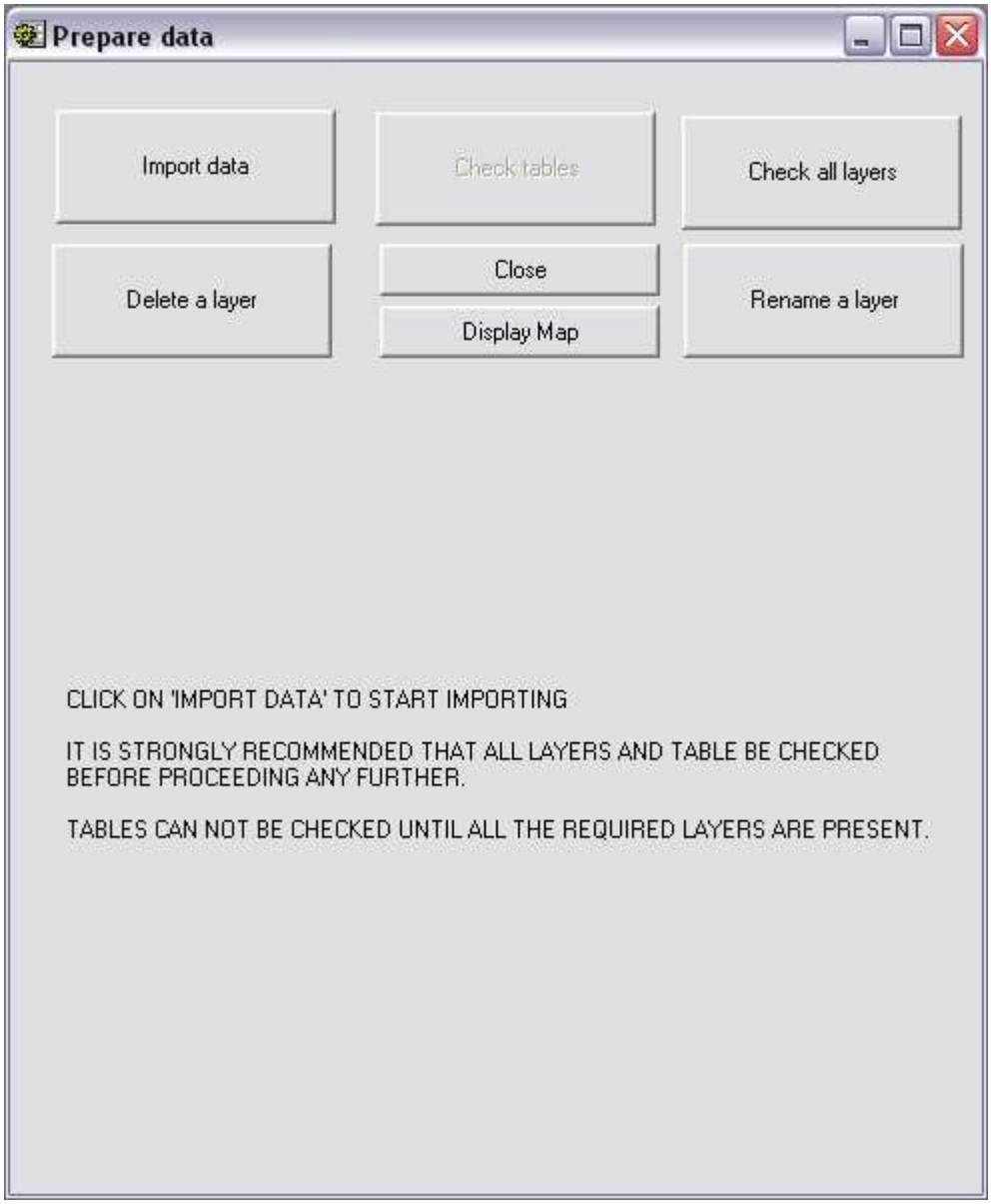
Biomass Catalog

FIELD	MANIFOLD NAME	TYPE	UNIT
Generator Name: type of crop / residue	NomID	ASCI, Variable Length	Number of people
Minimum crop production	MinTotalCrop	Floating point, single	Tons
Maximum crop production	MaxTotalCrop	Floating point, single	Tons
Ratio of residue available per ton of crop production			%
Investment cost	Cout_Ini	Floating point, single	USD / kW
Operation and Maintenance cost	Cout_OM	Floating point, single	USD/year/kW
Biomass fuel cost	Fuel_Cost	Integer, 16 bit	USD / tonne
Electricity produced per ton of residue	Electricity_Crop	Floating point, single	KWh/Ton
Ratio of energy generated to capacity (load factor) in number of hours utilization per year ([7]).			Hours / year

2.3 IMPORTING AND CHECKING DATA

Data can be imported into the project using the New Redeo Project button on the REDEO toolbar.  On clicking this button a menu is displayed for importing new layers into the project. This function imports, checks, renames, deletes and displays the layers that are present.

[7] Seasonality effect for the next version



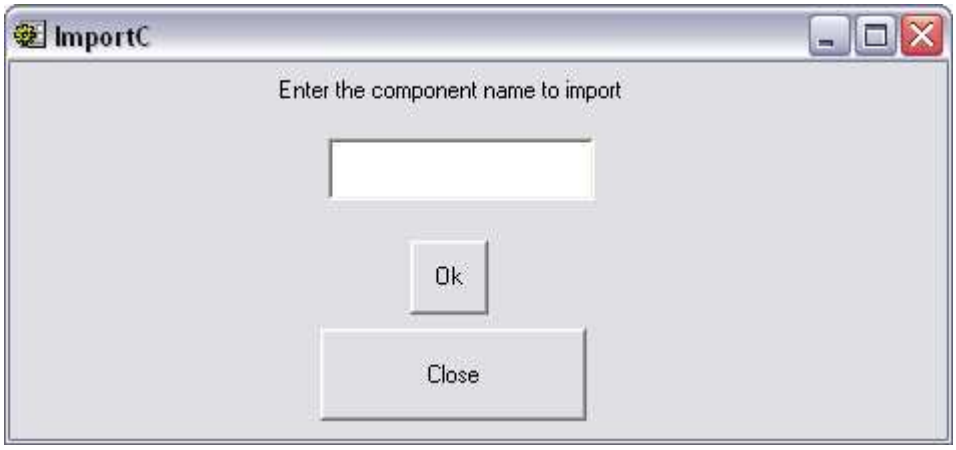
Note: The check all layer and check all tables buttons only check the ***required layers***. Required layers consist of the minimum data set that is required for the analysis to be carried out by the tool.

2.4 IMPORT DATA

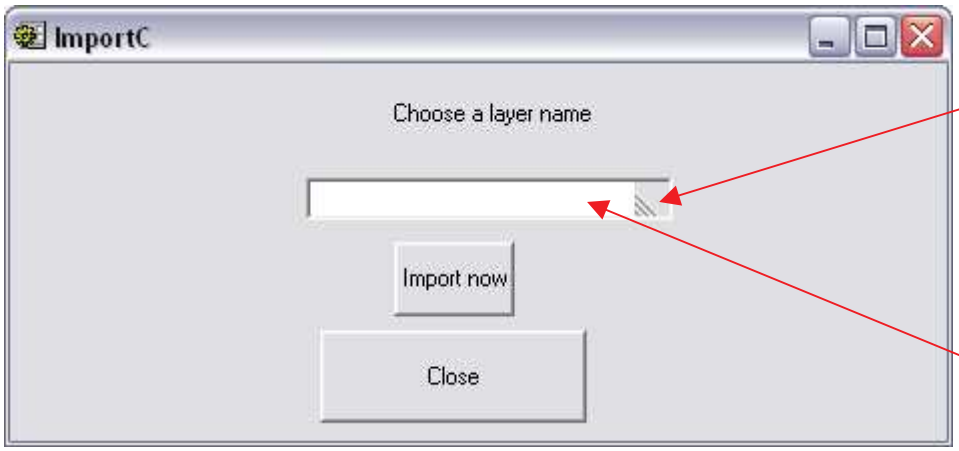
Clicking on the Import data button shows a menu that gives the user two options:

- Importing a component from a saved manifold .MAP file
- Importing a GIS file.

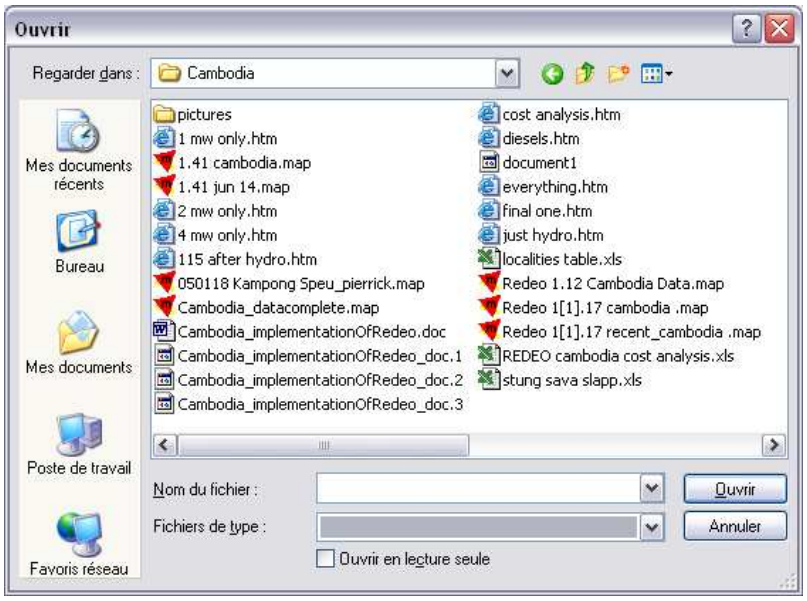
2.4.1 IMPORTING A COMPONENT FROM A MANIFOLD FILE



Enter the component name and click ok. If an invalid component name is entered and error message shall be displayed and nothing will be imported.



- Select a name for the component to be imported.

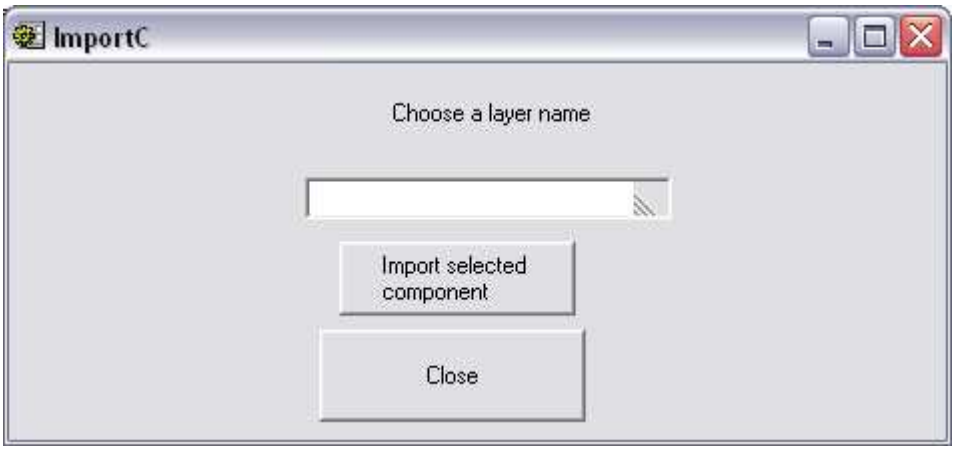


- Select a file form your computer to import

Caution: Only .map files can be selected; otherwise an error message shall be displayed.

2.4.2 IMPORTING OTHER GIS DATA

GIS data can be imported by clicking on the 'Import GIS Data' button. A window asking the user to select a name for the layer to be imported is displayed.

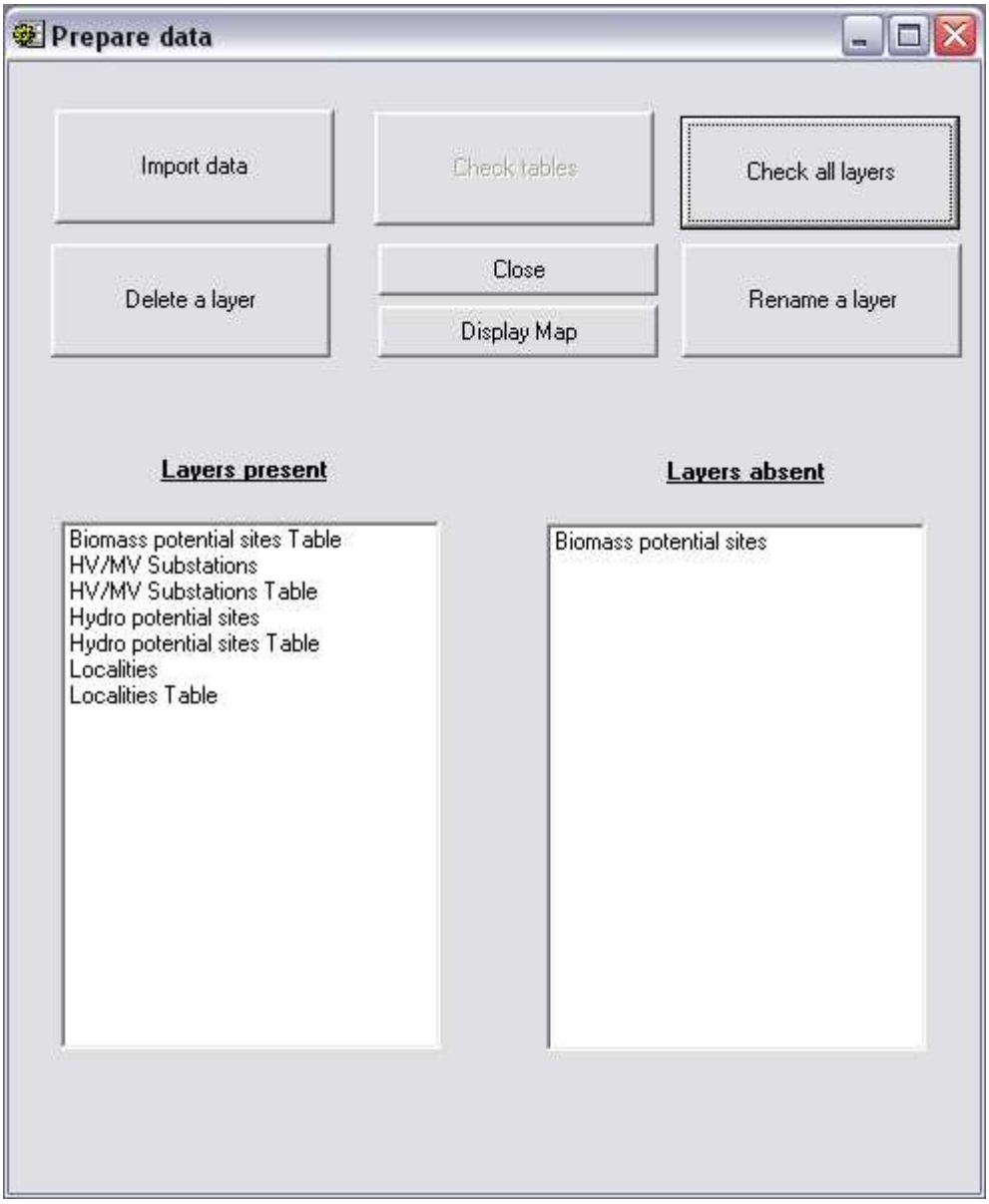


After selecting a name, select a component to import from your computer. All imported components are stored in the 'needed layers' folder of the GIS Data Background folder

2.5 CHEKING COMPONENTS

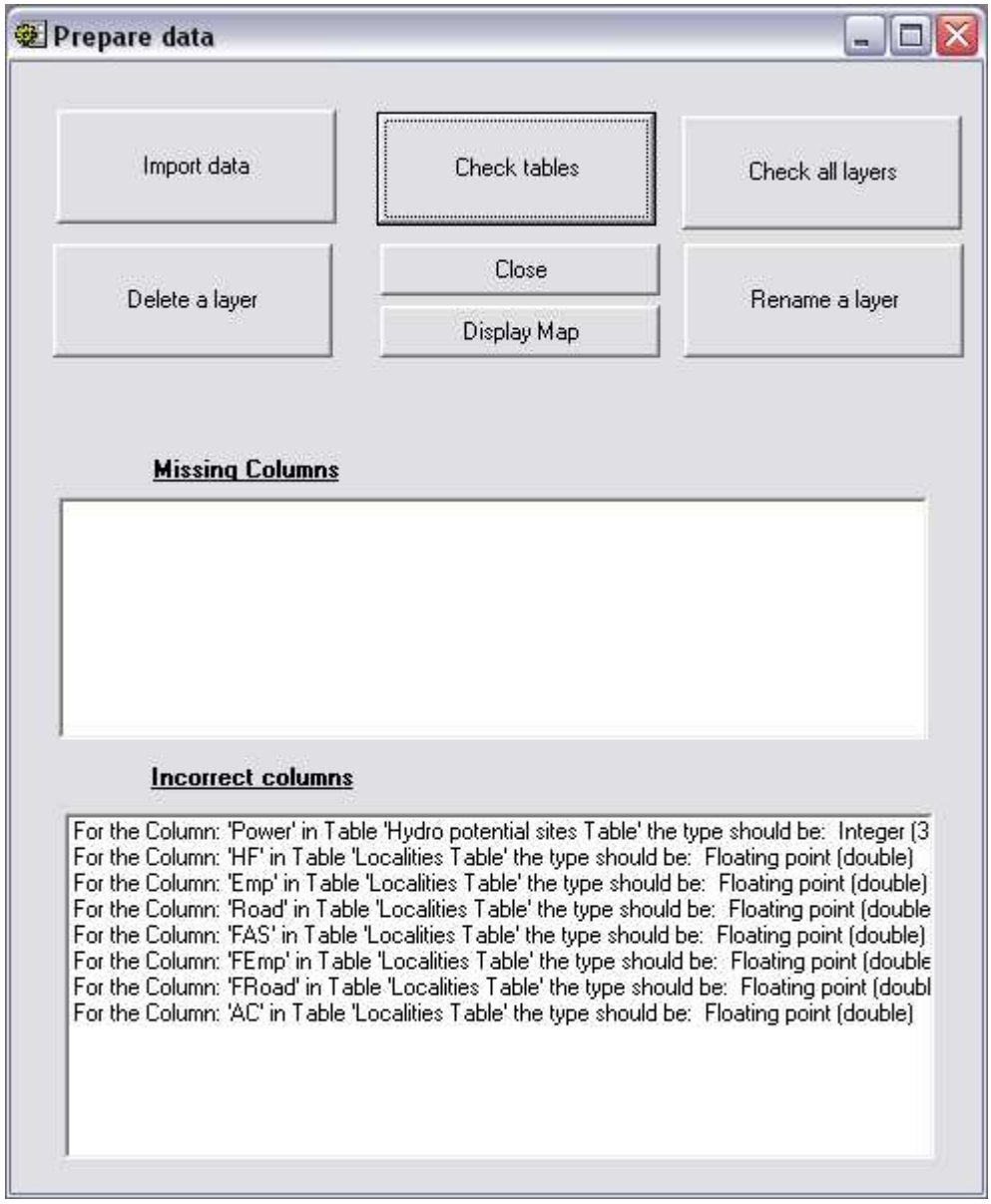
2.5.1 CHECKING LAYERS

It is important to check that all the necessary layers have been imported by clicking on the 'Check Layers' button after you have imported all the layers. Absent and present layers are displayed in the window.



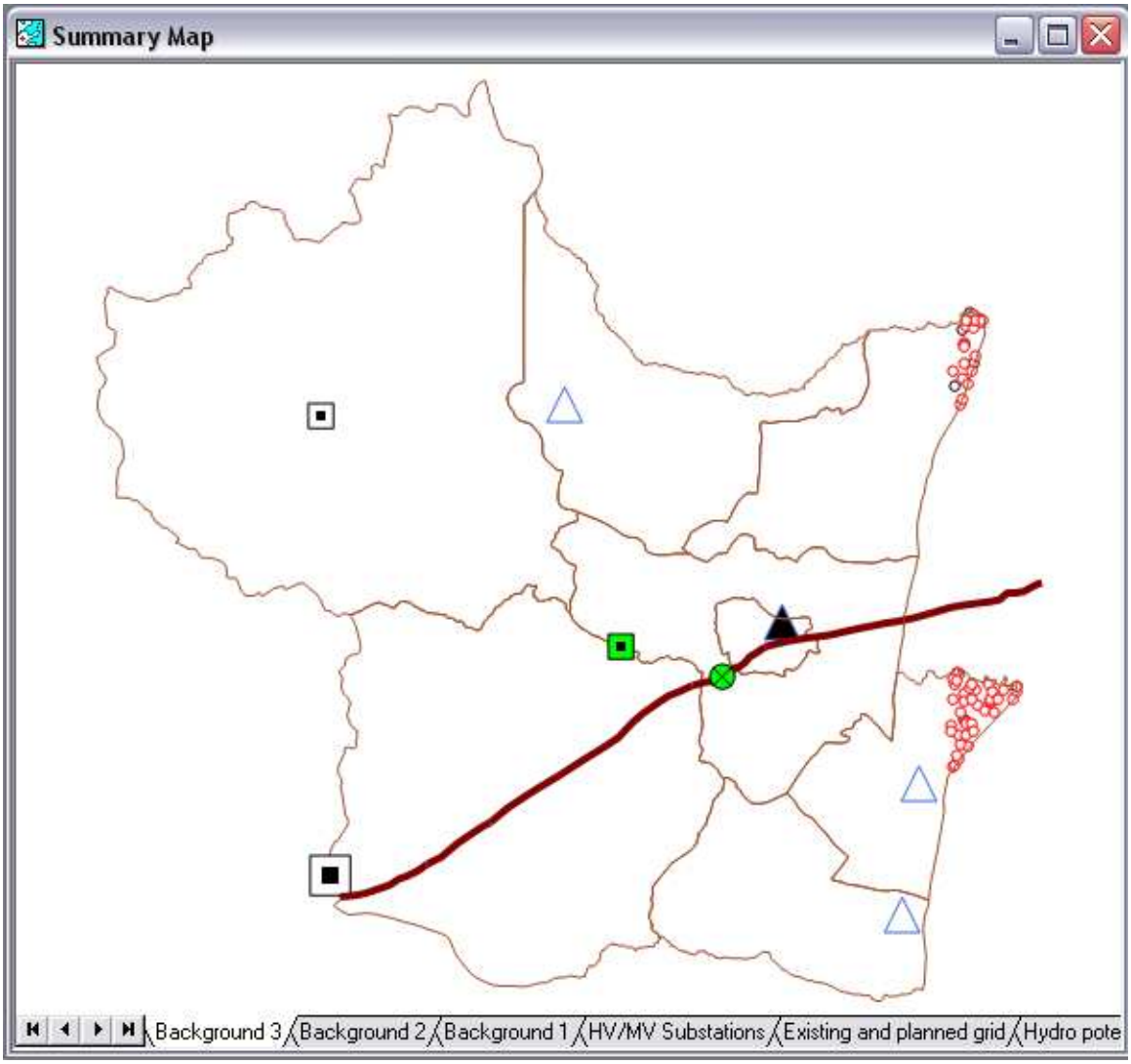
2.5.2 CHECKING TABLES

Tables can only be checked once the layers have been checked and all the layers are present.



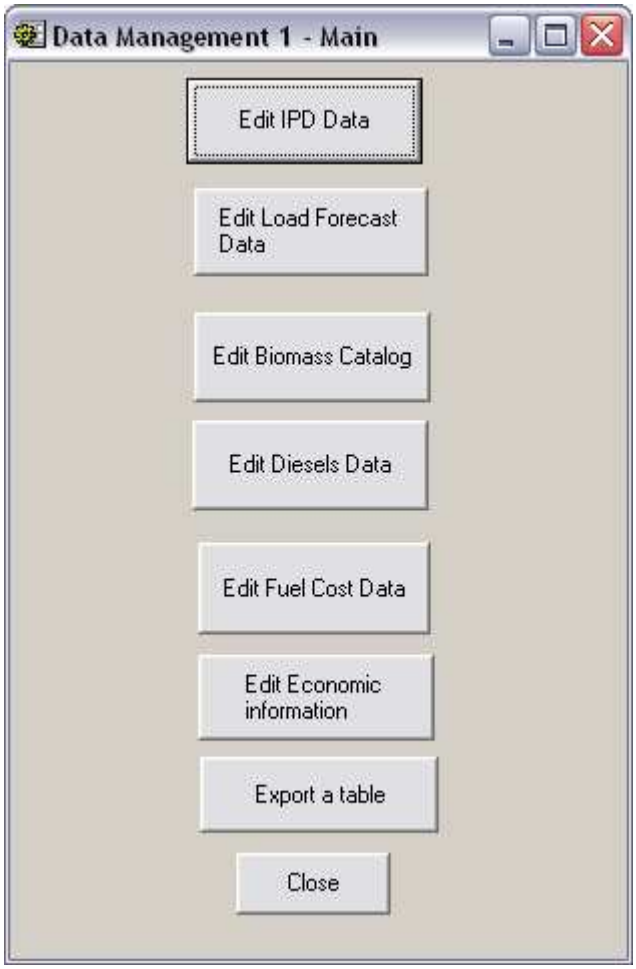
2.5.3 DISPLAY MAP

This function displays a basic map with all the layers in the GIS Data Background folder.


Summary Map
Background 3
Background 2
Background 1
HV/MV Substations
Existing and planned grid
Hydro pote

3. DATA INPUT

The data input feature allows the user to change all the numerical data input values. The possibility of changing geographical data does not exist.



3.1 EDIT IPD DATA

By taking several indicators such as population, education and health facilities, employment and road access as inputs, the tool computes the “Index of Potential for Development” (IPD) for each locality.

IPD Definition

The Index for Potential for Development (IPD), is based on the Human Development Index (HDI).

The human Development index is composed by three indicators:

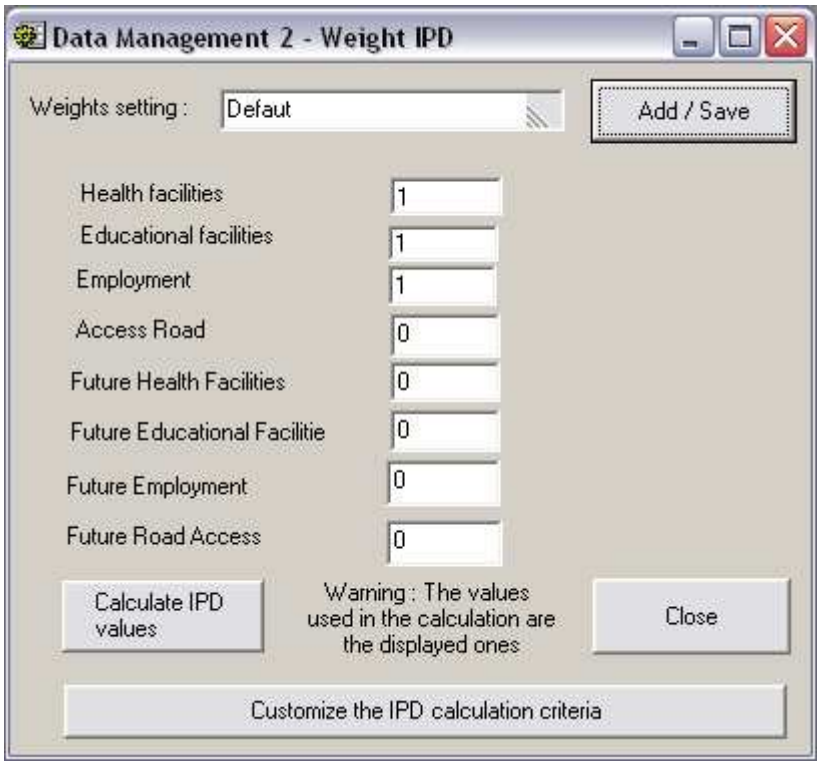
- A health indicator: life expectancy
- An education indicator: composed of literacy rate and rate of children going to school
- An economical indicator: GDP per inhabitant.

For each of these three indicators, a number between 0 and 1 is given; such the repartition of the values taken by each country is correct and occupies the whole interval. For example, for the life expectancy a country gets 1 if its life expectancy is 85 years, it gets 0 if it is 25 years. The HDI of a country is the arithmetical average of these three indices. The IPD used in REDEO is adapted from this classical definition and the user has the ability to change the predefined criteria used in the IPD calculation and add or remove factors depending on their relevance/importance in the area being studied.

3.1.1 IPD FUNCTION

The IPD is calculated based on the weights entered for each data value in the localities table. The user can edit the weights of the data entered for the calculation of the IPD for each locality. These weights should be in proportion to the importance that the factor has in the development of the area. It is known that for some cases, there is no data present for certain fields. For example, if no data is present for road access in a particular area, then the weight for road access should be entered as 0. This shall ensure that road access shall not be taken into consideration when the IPD is calculated.

It should be noted that the values used in the localities table should be relative to the importance that particular factor has in the development of the locality, as it will be used to calculate its IPD[8].



3.1.2 FORMULA FOR IPD CALCULATION

The tool calculates the IPD by multiplying the data for each field entered in the dialog shown above, with the value loaded into he database for that particular factor.

Then a Potential for Development will be computed for each locality based on the following formula: PD(i)=SUM(W(i,j)*IPD(i,j)), where:

[8] Refer to Appendix A for details on the weighting system that should be used in the Localities Table

- "i" represents the locality
- "j" represents the IPD
- W(i,j) is the weight of the IPD j in the weighting system
- IPD (i,j) is the value of the IPD j for the locality I

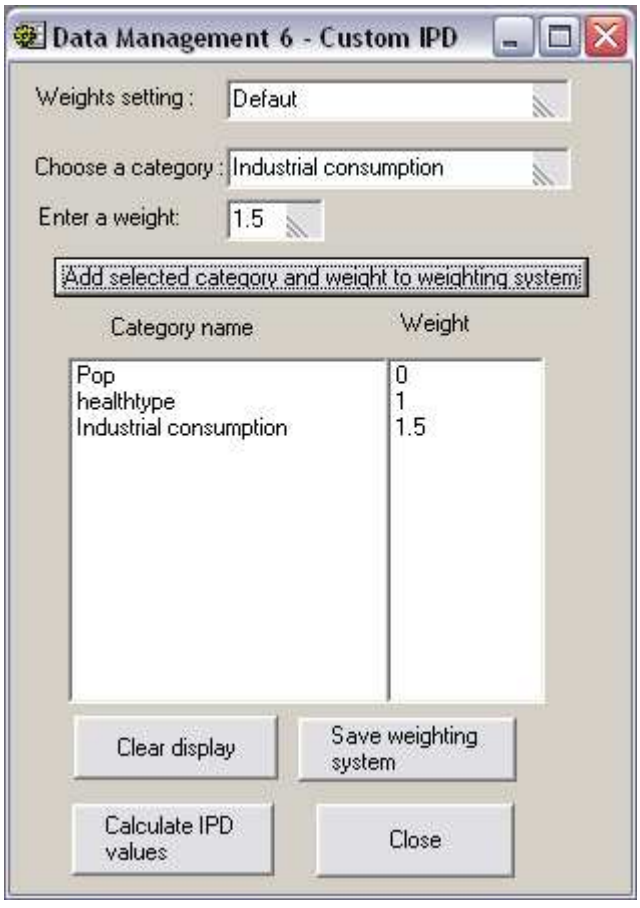
The results will be saved in a column "PDev" of the Localities Table.

3.1.3 HAVING MULTIPLE WEIGHTING SYSTEMS FOR IPD CALCULATION

Multiple models of weight settings can be set by clicking on the Add/Save button after changing the name and attributes of the weight setting. The IPD calculated by the tool shall be that of the weight setting that is displayed when the 'Process IPD' button is clicked. Upon completion of the calculation, a message stating that the calculation had been done shall be displayed.

3.1.4 CUSTOMIZING THE IPD CALCULATION

Clicking on "Customize the IPD calculation criteria" opens a new menu.



The sequence of steps to follow is:

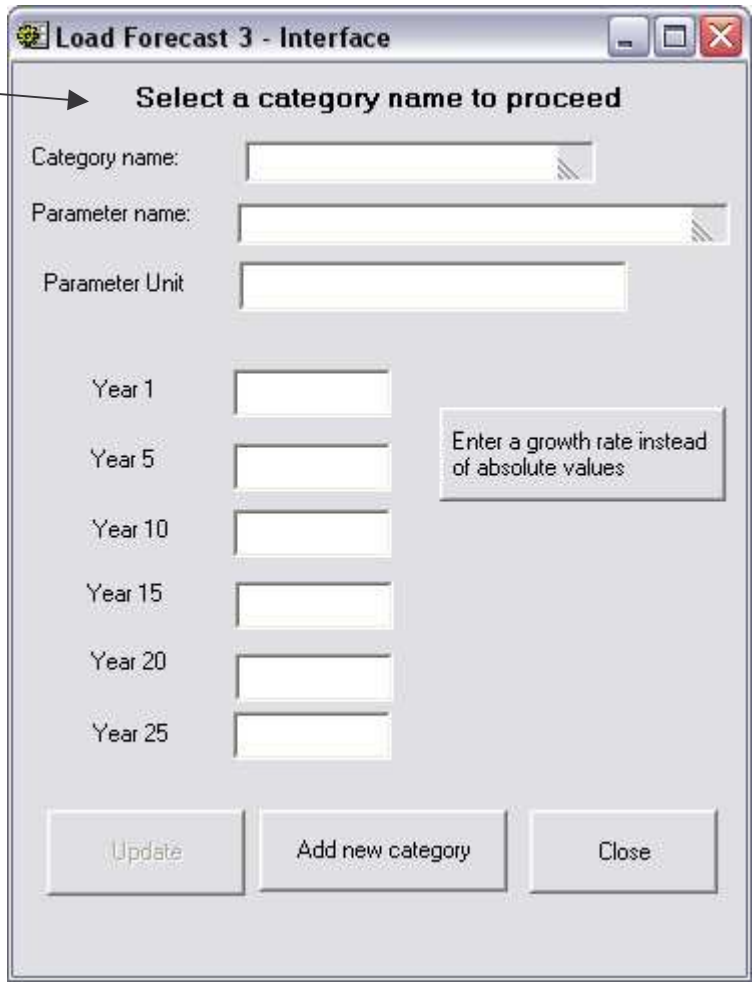
- Input a weight setting that you would like to use
- Choose a category from the menu. The categories available for selection in the menu are all the columns present in the localities table.
- Enter a weight for the selected category

- Click on the “Add selected category and weight to weighting system” so that it is displayed in the interface
- Clicking on “Save Weighting system” saved the weighting system in the tool
- The IPD can be calculated with or without saving the data
- Clicking on clear only clears the display and no changes are made to the previously stored data.
- To change the weight of a category, select the category from the “Choose a category” menu and then input the desired weight. Clicking on “Add selected category and weight to weighting system” shall update the display.

3.2 EDIT LOAD FORECAST DATA

The data used to calculate the load forecast can be changed by the user.

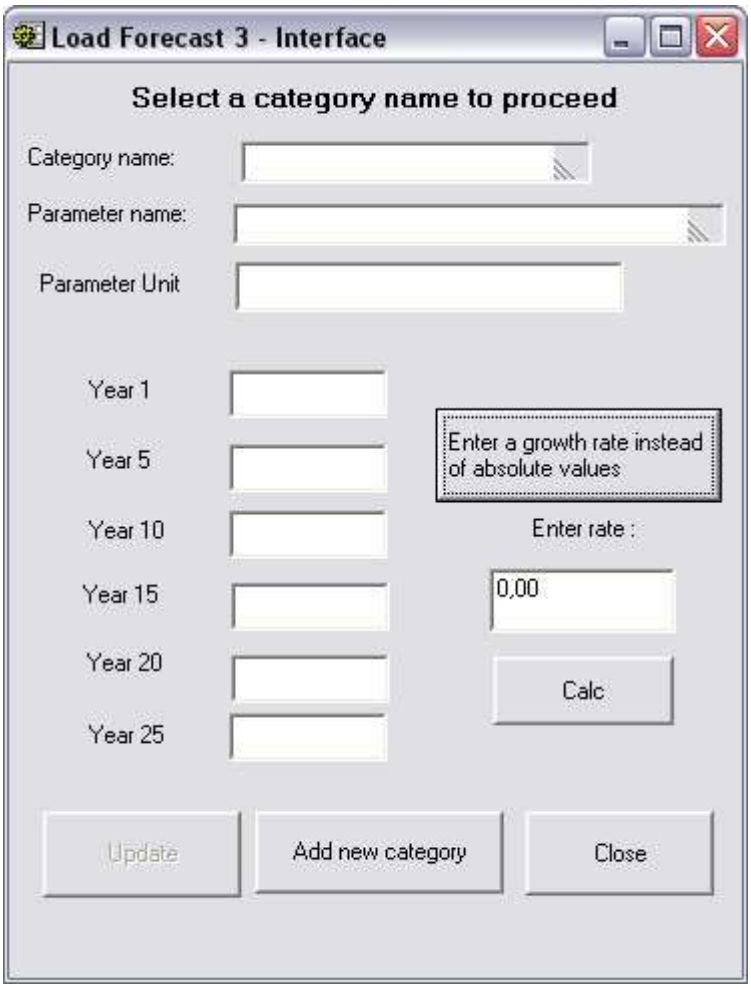
Follow the instructions to view and edit the data in this table.



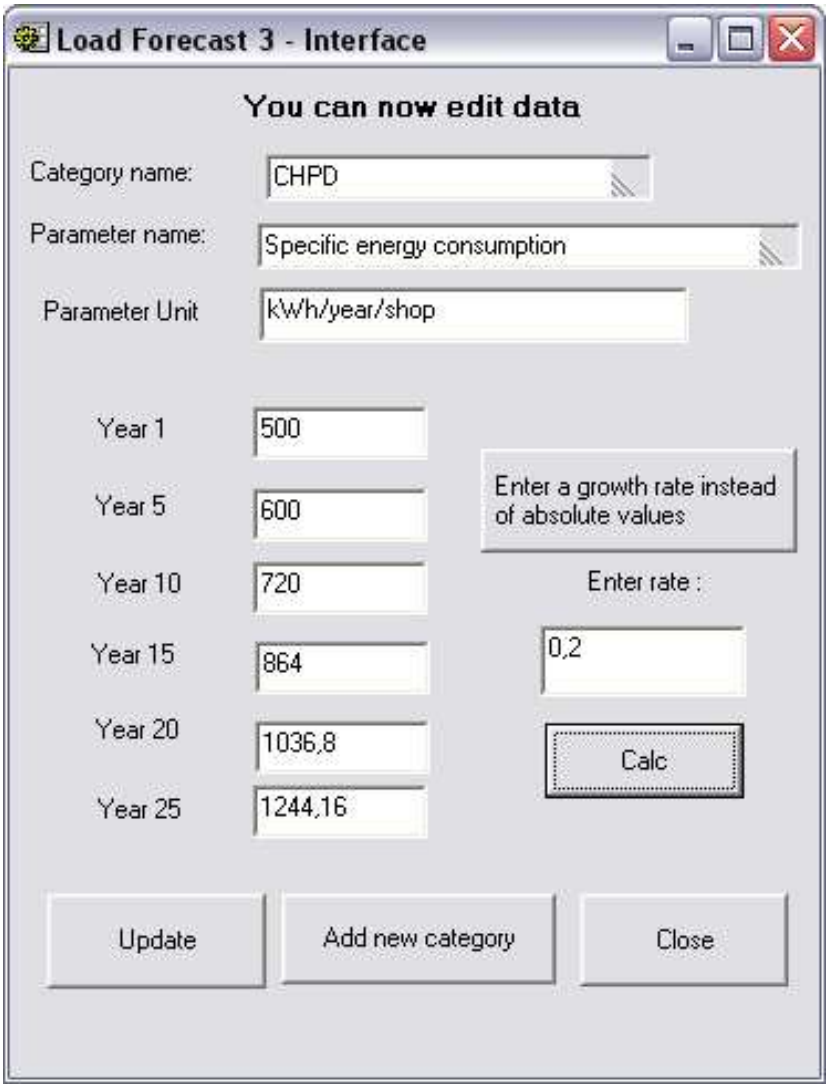
The user can edit the data in this table. Once a category name has been selected, select a parameter name. Edit the information about the parameter and click ‘update’. The values are not saved unless and until the update button is clicked.

3.2.1 USING A CONSTANT GROWTH RATE

Instead of manually entering the values for a particular parameter, the growth rate can be entered for a particular parameter by selecting 'enter a growth rate instead of specific values'. On clicking this button, an additional text box is displayed to input the growth rate along with a 'calc' button to calculate the result based on the inputted growth rate.



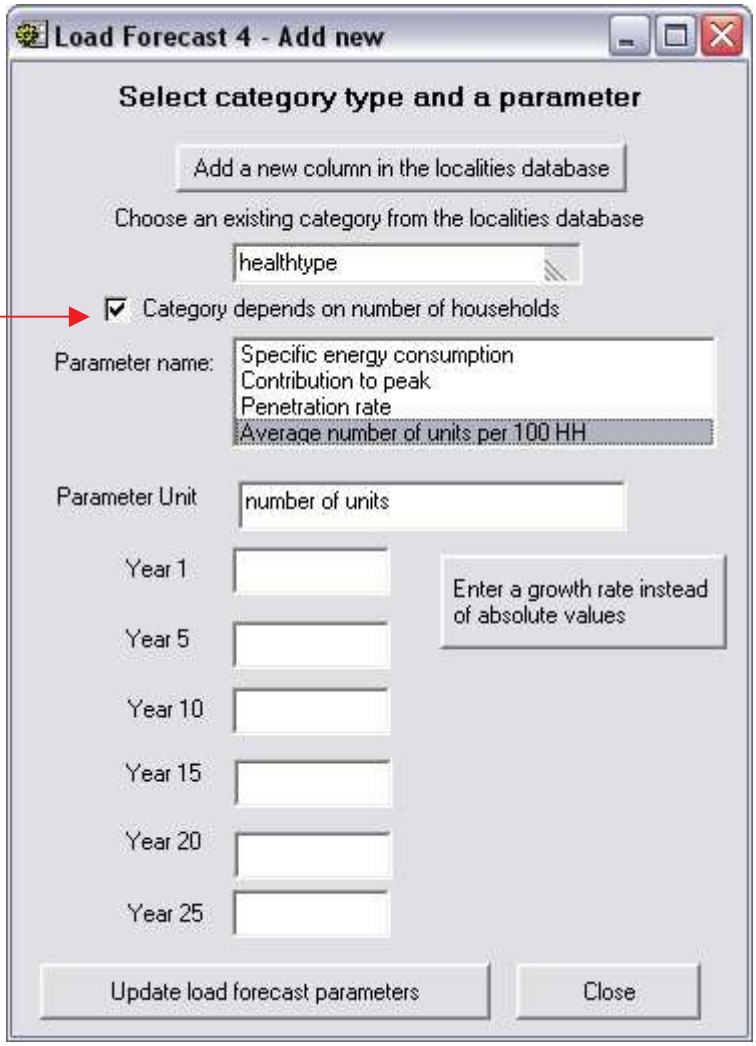
First, enter the year 1 value and the growth rate. **Click '*Calculate*'.** The display is now updated. The rate is a percentage between 0 and 1. An updated sample dialog is shown below.



3.2.2 ADDING A NEW CATEGORY

New categories can be added in the load forecast calculations by clicking on ***Add new Category***. A new dialog (shown below) is then displayed.

Every category that is added can either be dependent or independent of the number of households in the area. If it depends on the number of households, then the number of households per unit is a parameter.



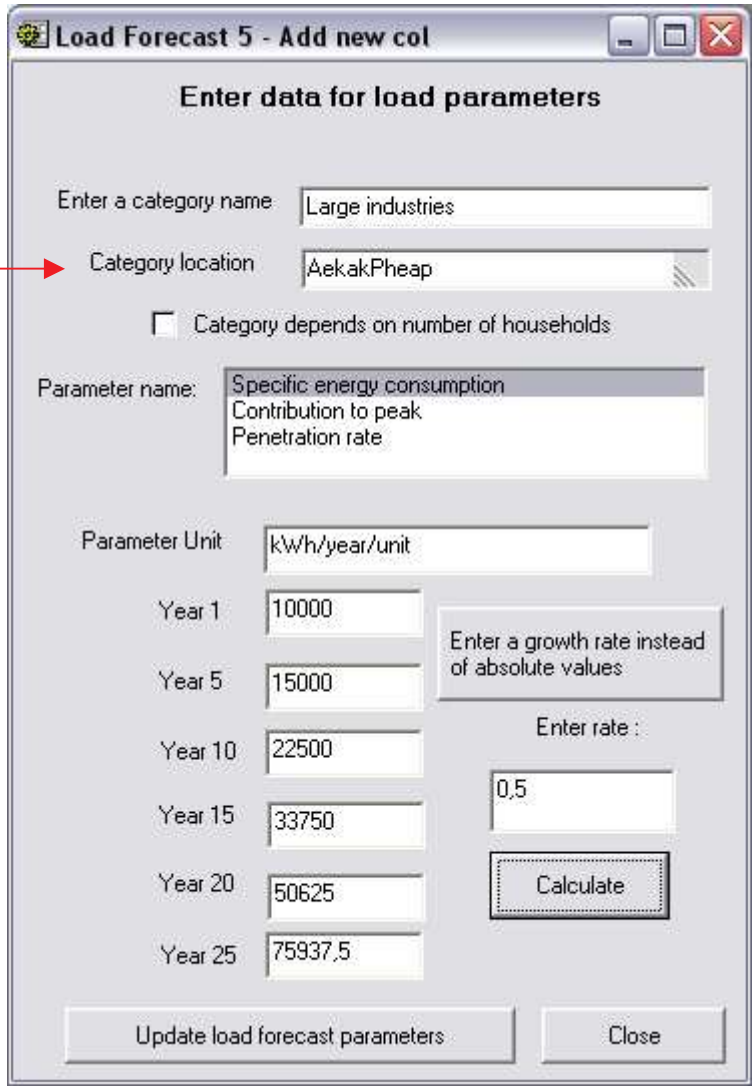
The sequence of steps that need to be followed are similar to that in the initial load forecast dialog.

- Choose an existing category from the localities table. If a new category (such as a large industry) has to be added then click on the “Add a new column in the localities database” button.
- Select whether the category depends on the number of households in the area or not.
- Click on a parameter name and enter the load forecast values wither by inputting a rate and the value for year 1 or by putting in specific values for all years.
- Click on ‘update’ after inputting the values for a parameter.
- Note: the update button has to be clicked for *EACH* parameter in a given category.

3.2.3 ADDING A NEW COLUMN IN THE LOCALITIES DATABASE

If a category does not depend upon a particular column in the localities database, then a new column can be added to the localities table. For example, this could be necessary if a particular load point such as an industry has to be added. On clicking on this button, the following interface is displayed:

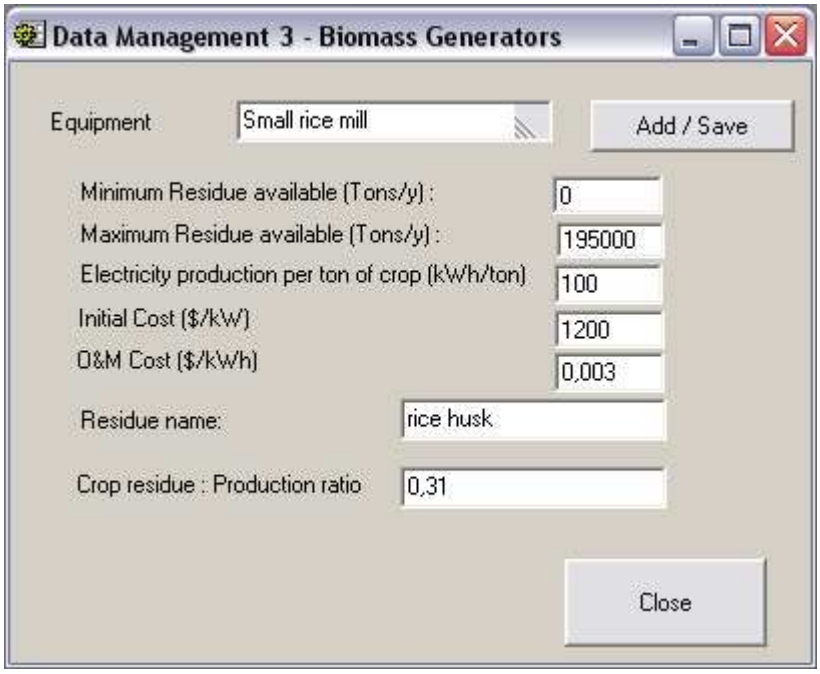
If a location is not pertinent, then please select <none> from the menu.



The rest of the functions in this dialog are the same as those in the other load forecast interfaces shown above.

3.3 EDIT BIOMASS CATALOG

This function allows the user to edit the data catalog for the biomass.



The capacity of the biomass plants is calculated by the tool based on number of hours availability per year of the biomass. ([9]) The operation and maintenance costs need to be input by the user as well as the cost of the biomass fed into the systems (cost of production or of purchase).

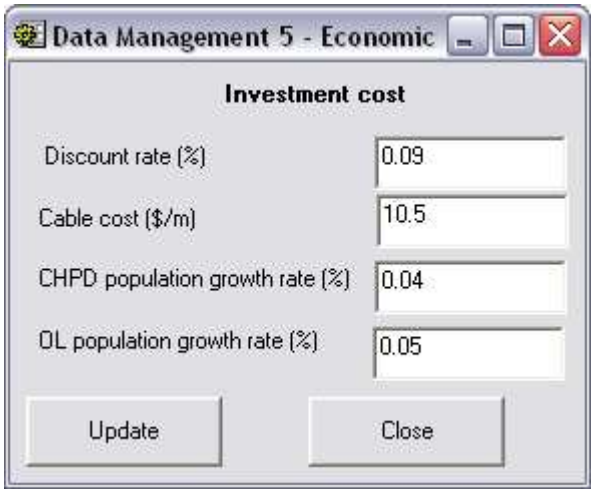
A default catalogue based on existing technologies and generators is available is provided in the tool. The user can add a new type of generator based on new / local information available. The type of generator can to be changed. After changing the attributes of the generator model, clicking add/save shall save the specifications in the data catalog folder under 'biomass catalog'.

The facility to have multiple models if provided to the user as it might be possible to have more than one type of raw material or processing technology in a region. For samples of biomass generator specifications, refer to appendix B 'Biomass specifications'.

3.4 EDIT ECONOMIC INFORMATION

This function is used to input the discount rate, cable costs and population growth parameters in the region. The data that is initially displayed is the data that is currently stored in the tool. In order to save the edited data it is necessary to click on the update button.

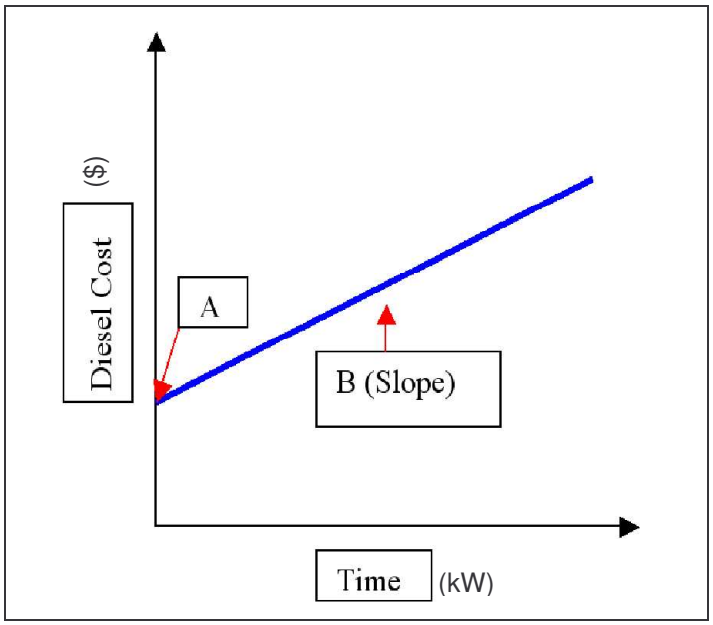
[9] - The seasonality effect will be worked into the next version of the tool.

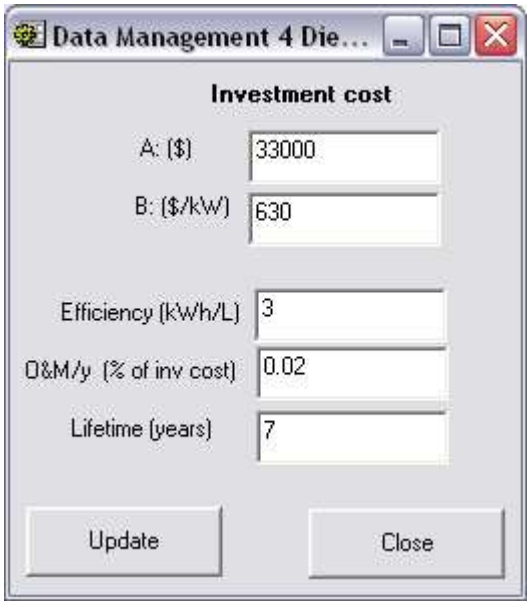


3.5 EDIT DIESELS DATA

This function allows the user to edit the data catalog for diesel. Efficiency, Operation and Maintenance cost, Lifetime and diesel fixed and variable costs can be edited at this point. The diesel fuel cost is edited in the next module.

The values for A and B in the graph are the slope and y intercept of the diesel graph shown below. It is necessary to click on the update button to save the results in the data catalog.



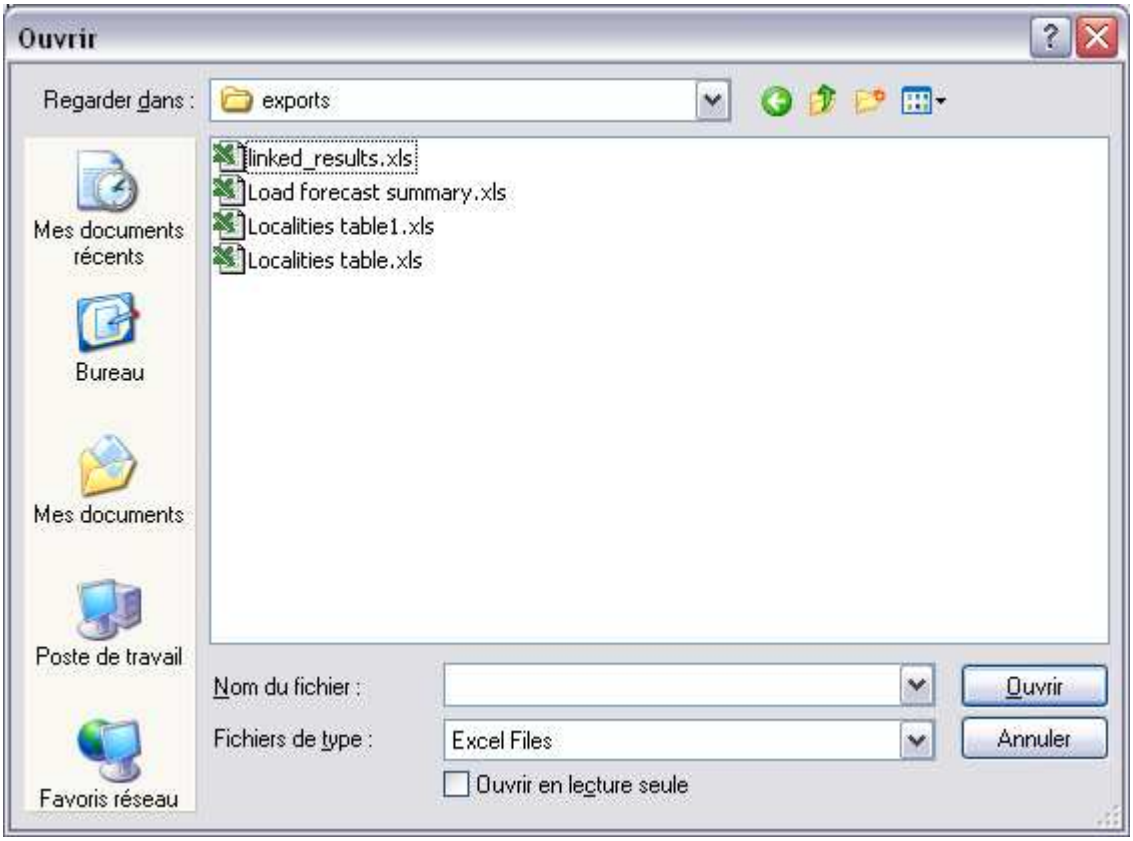


As mentioned above, there is a table that displays the fuel cost for 25 years. The cost of diesel in $/liter has to be input buy the user.

3.6 SAVING A TABLE

Selecting this option exports a selected table into excel.

Choose a table to export and click *Export*. A dialog to select or enter the name of the file being exported is displayed. Select a file name or enter a new file name for the export. The table will be exported into selected location as an excel file.


Ouvrir
Regarder dans :
exports
linked_results.xls
Load forecast summary.xls
Localities table1.xls
Localities table.xls
Mes documents récents
Bureau
Mes documents
Poste de travail
Favoris réseau
Nom du fichier :
Fichiers de type :
Excel Files
Ouvrir
Annuler
Ouvrir en lecture seule

4. CLUSTERING

For a given Province, the already electrified clusters are excluded from the analysis. Those where more than 30% of localities are electrified come under this definition.

4.1 THE PURPOSE OF CLUSTERING

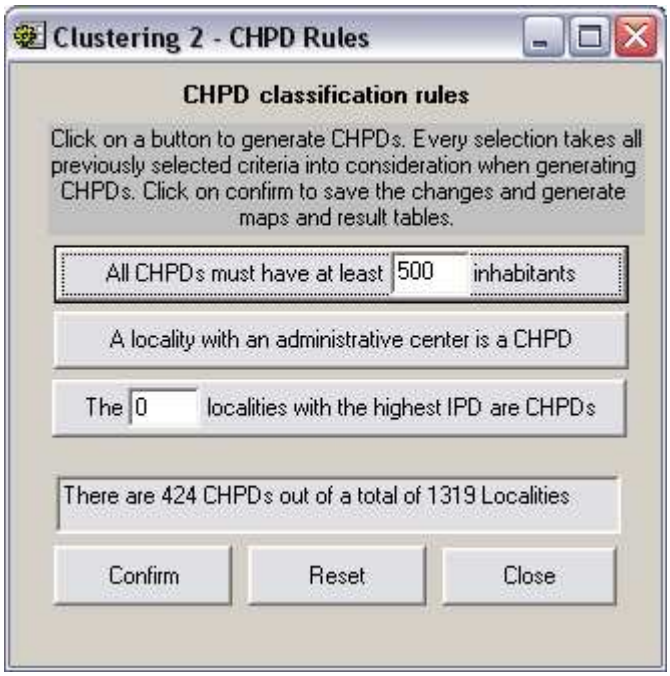
After calculating the IPD for each locality, the next step in the REDEO approach is to define Centers with a High Potential for Development. The user selects the number of IPDs that should be classified as CHPDs. Areas that are not classified as CHPDs and called OLs (Other Localities). In the clustering approach, the OLs surrounding a CHPD are clustered with it. I this way, when resources are deployed, they are deployed per cluster and not pr village or locality. This simplifies that planning approach and reduces the total number of points that have to be connected to the power resource being deployed. For example, if a given area under analysis has 2000 localities, and the top – say 10% - 200 IPDs are selected as CHPDs, then after clustering the resources have to be deployed to just 200 villages instead of 2000.

4.2 EDIT IPD DATA AND CALCULATE IPD

This step is the same as that explained in the section on data input and need not be repeated if the IPD has already been calculated.

4.3 CHPD RULES AND COMPUTING

This option allows the user to define areas as CHPDs. The user can select various criterion based on which areas are classified as CHPDs.



- Number of inhabitants: The user can select the number of inhabitants a given locality needs to have in order to be classified as a CHPD.
- Administrative centers: Areas with administrative centers are automatically classified as CHPDs
- Number of IPDs having the highest CHPD: The input number of localities having the highest IPD are classified as CHPDs.

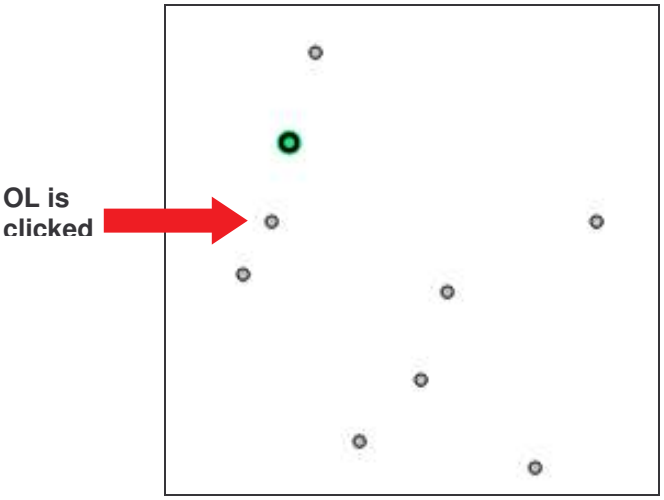
Enter the parameter name and then click on the button to classify CHPDs. After selecting one criterion, a message is displayed stating how many localities have been classified as CHPDs. The next criterion selected takes only those localities that are already CHPDs into consideration. Hence, the total number of CHPDs progressively decreases, as the criterion get more and more specific. To start afresh, click on the Reset button.

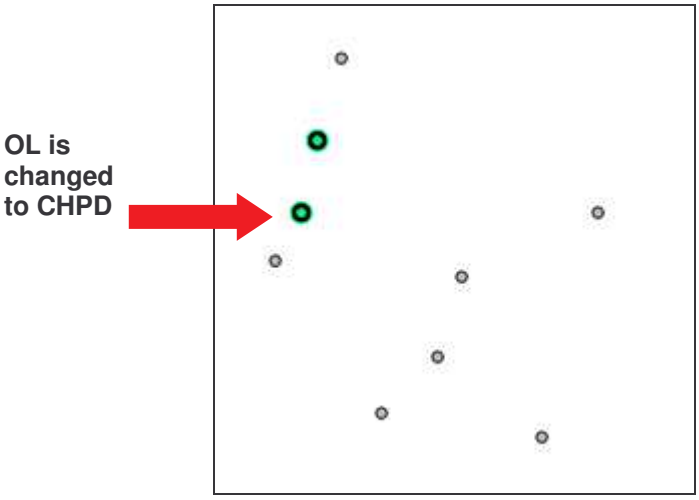
Before closing the menu, it is important to confirm the CHPD selection so that maps and table that are required for further analysis on the selected CHPDs are selected.

4.4 MODIFY CHPD AND OL

The generated CHPDs and OLs can be modified by clicking on an OL to change it to a CHPD and by clicking on a CHPD to change it to an OL.

The sequence of steps is shown below.



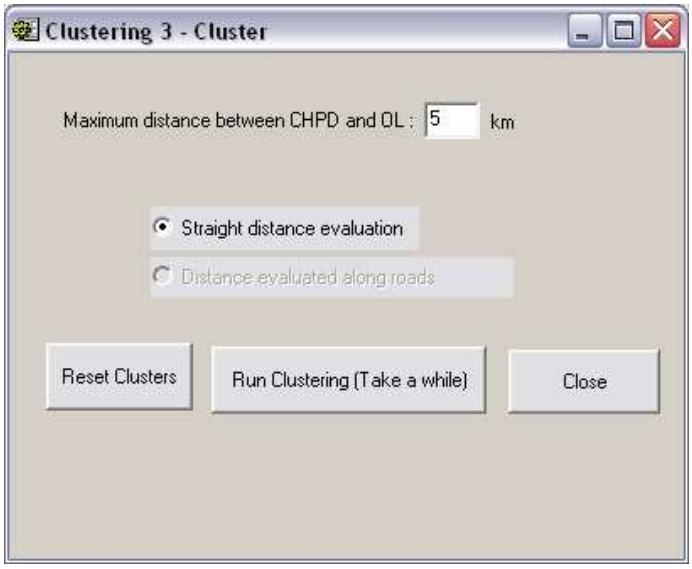


This function is important as later on, when clusters are generated. An OL is connected to a CHPD. To generate a cluster the OL connected to it has to be within a given range from the CHPD. If there are no CHPDs within the given range, then a cluster shall not be made. If there are OLs that are not connected to a cluster, then they are not considered in the electrification scenarios module.

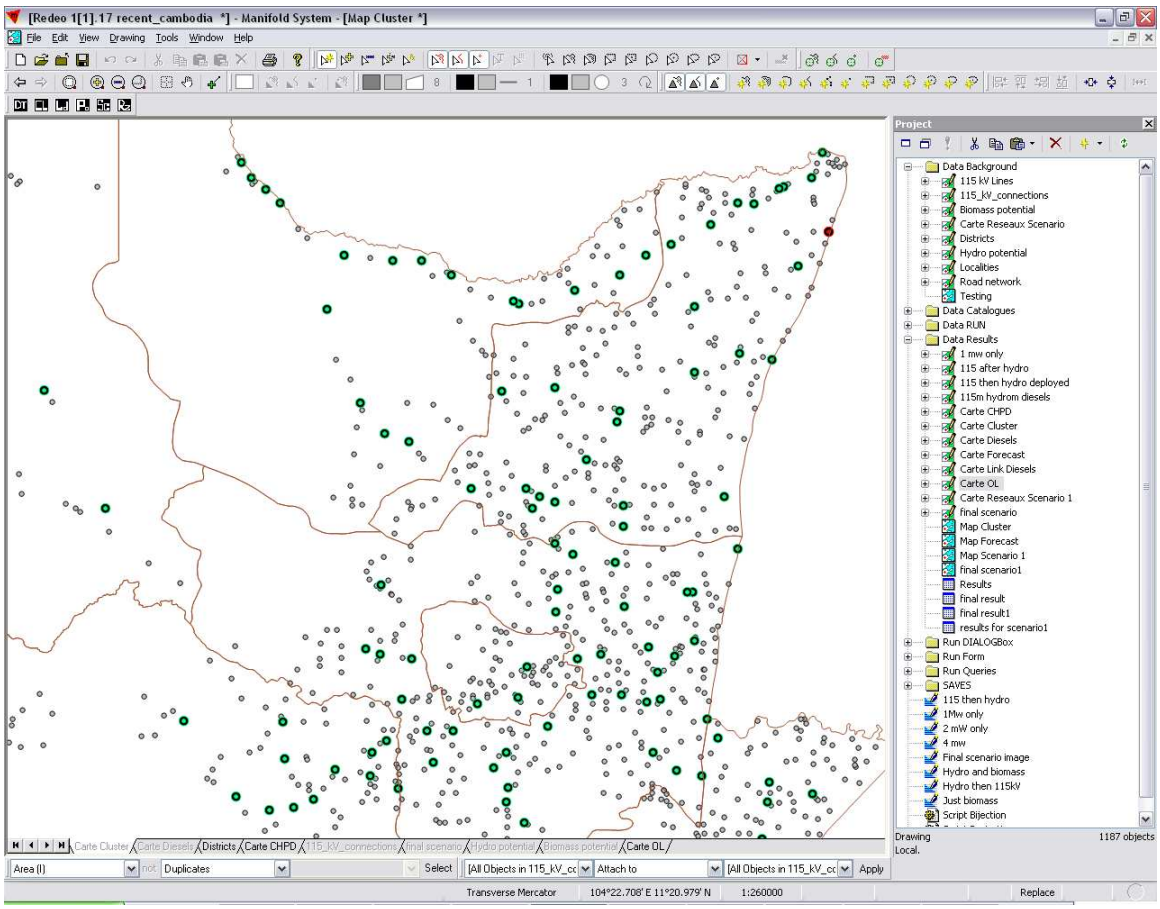
4.5 Generate cluster

- The clustering function connects as many OLs as it can to a CHPD, given the constraint of a maximum distance between the CHPD and the OL.

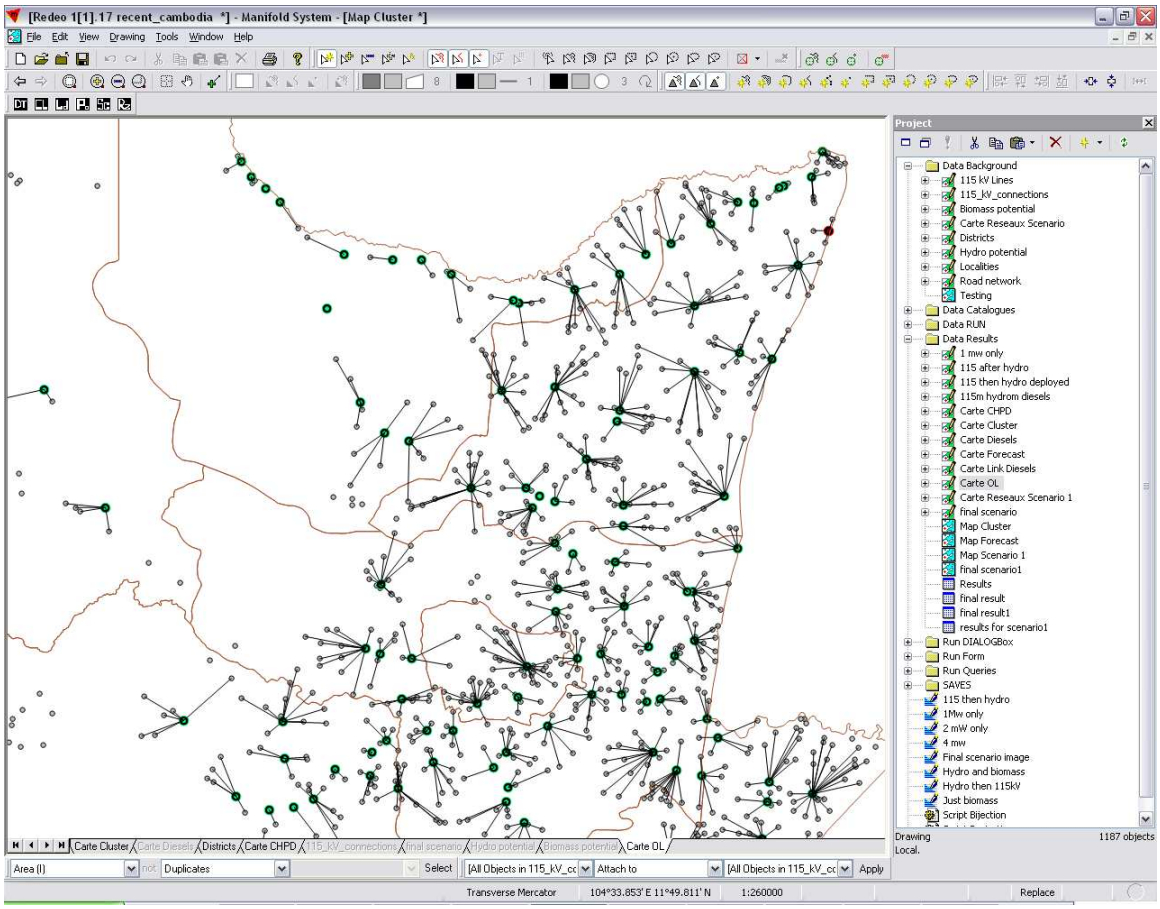
- Clusters can be reset using this function.
- A list of localities that could not be connected to the clusters is displayed at the end of the cluster generation function.



Map before clustering:



Map after clustering with a distance constraint of 5km



4.6 Modify cluster

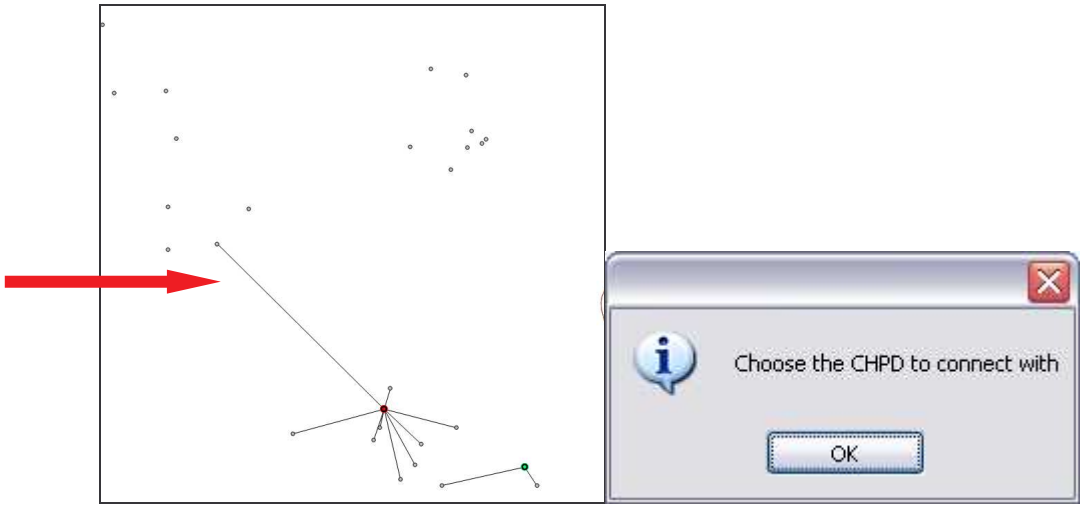
The user can modify a cluster either by connecting an OL to a cluster or disconnecting an OL from a cluster.

Connecting an OL to a Cluster

- An OL can be connected to a cluster manually by clicking on the OL first.
- The following message is then displayed:

- Clicking on a CHPD then connects the OL to the CHPD.

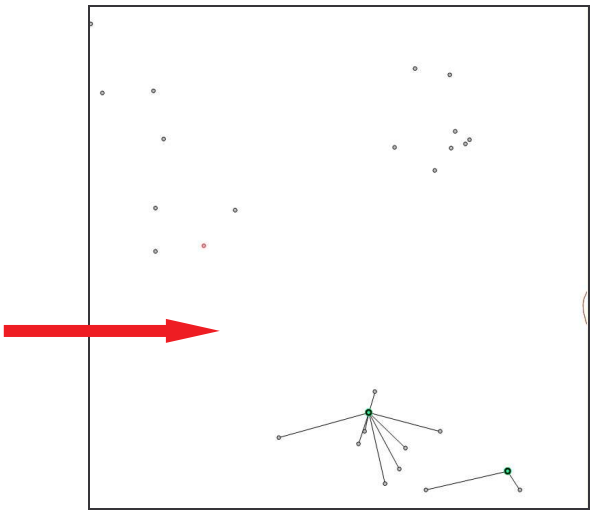
Figure 1: Connecting an OL to a cluster



Disconnecting an OL from a cluster

- An OL can be disconnected from a cluster simply by clicking on the OL.

Figure 2: Disconnecting an OL from a cluster

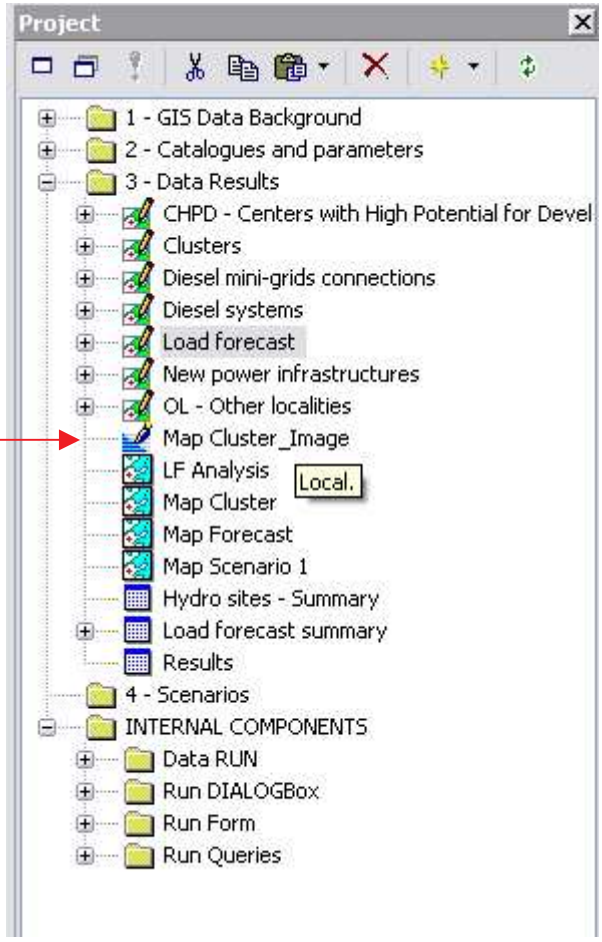


4.7 Validate cluster

Clicking this button allows the user to validate the current cluster settings that have been generated and/or modified. The un-clustered localities are excluded from the next steps of the analysis, as they will be considered for isolated electrification.

4.8 SAVE AN IMAGE

An image can be saved within the manifold project in the “Data results” folder or as a .gif file outside manifold.



"Map cluster" is saved as "Map cluster_image".

"Save as a manifold layer"

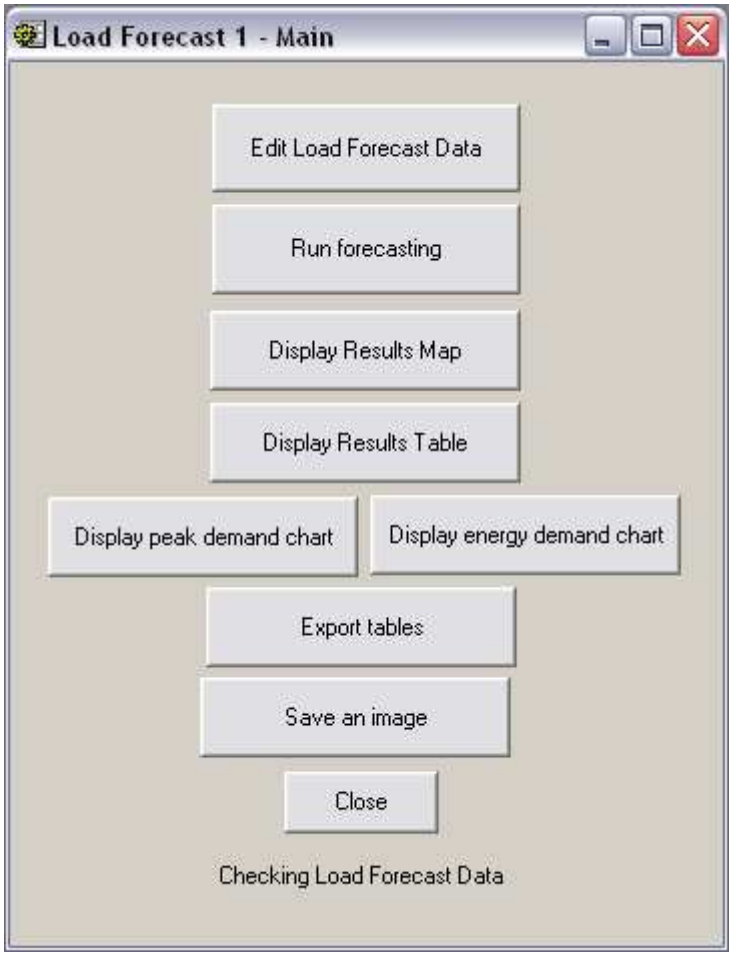
Select a map to save, and then select where it should be saved. The map shall be saved as an image in the "Data results" folder. The saved image name is the same as the map name followed by "_Image".

Save as jpeg/gif file

Saves the map as an image in the selected directory. Warning: entering an invalid extension shall cause an export error. Please input only "JPEG" or "GIF" as extensions.

5. LOAD FORECAST

This module is used to predict the energy demand in an area for the next 25 years in 5-year steps



5.1 EDIT LOAD FORECAST DATA

This is the same as the edit load forecast function in the data input section. Refer to section 4; load forecast in part III Data Input.

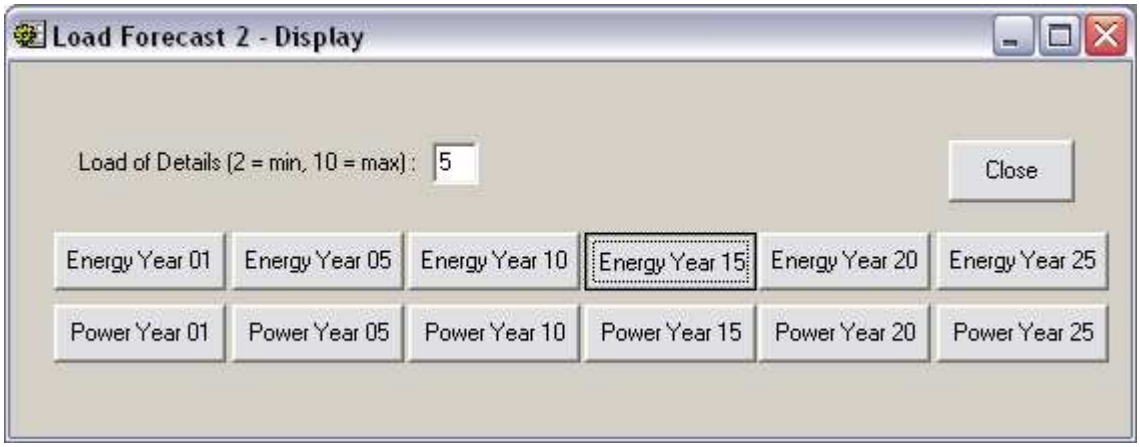
5.2 RUN FORECASTING

Clicking on this button starts the forecasting process. This may take a while.

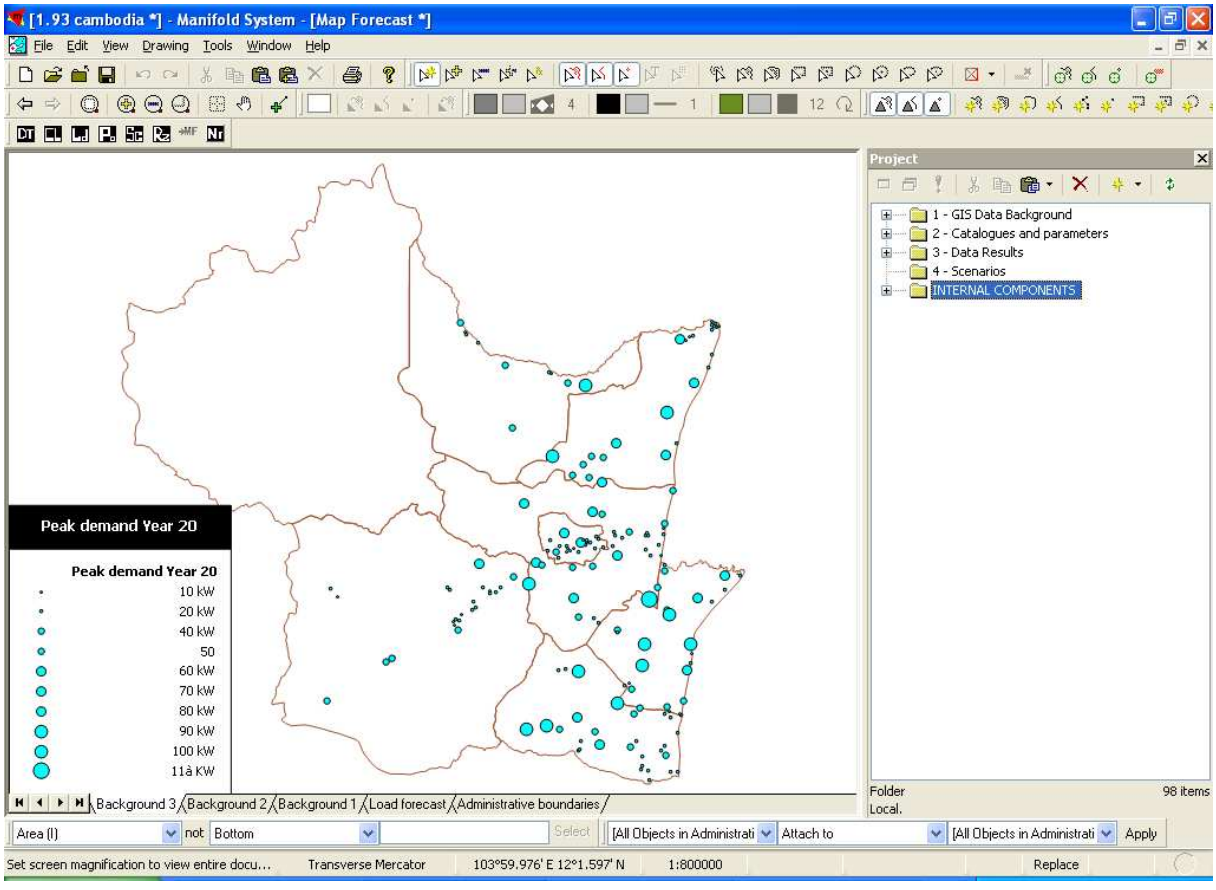
5.3 DISPLAY RESULTS MAP

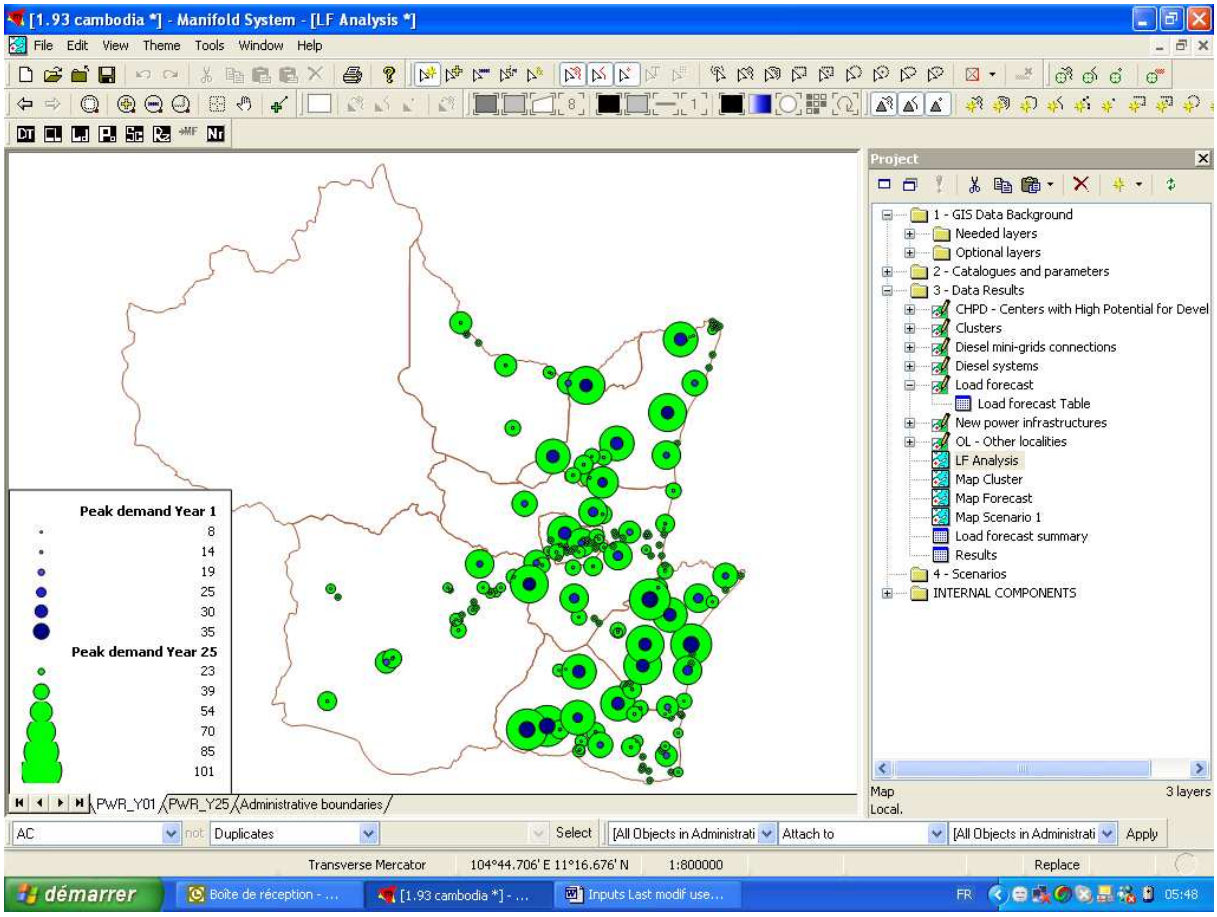
Displaying the results of the load forecast can be done by choosing which year the display is wanted for.

Load of details is the detail that the user wants in the results display. That is, points ranging in size from 2 to 10.



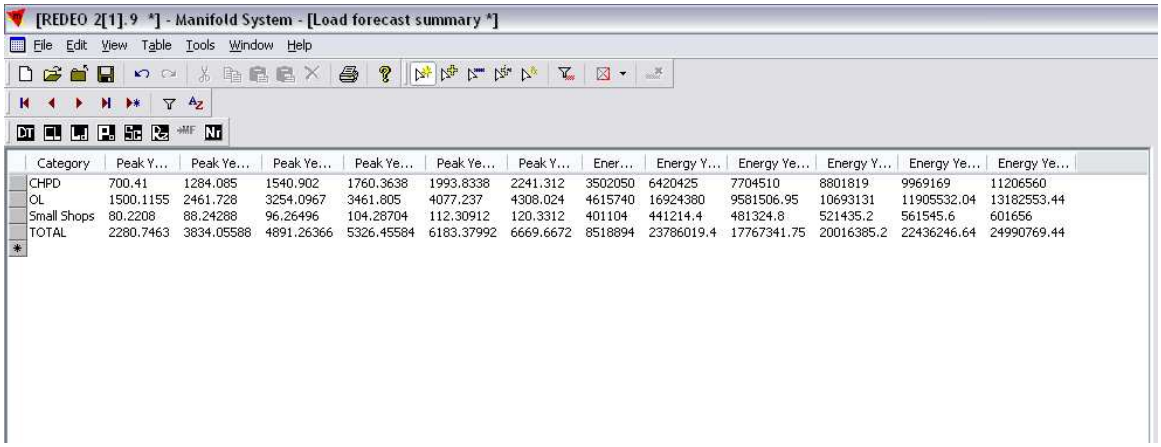
The map labeled 'Map Forecast' then displays the results where the size of the points in the display refers to the estimated peak load (kW) or demand in kWh.





5.4 DISPLAY RESULTS TABLE

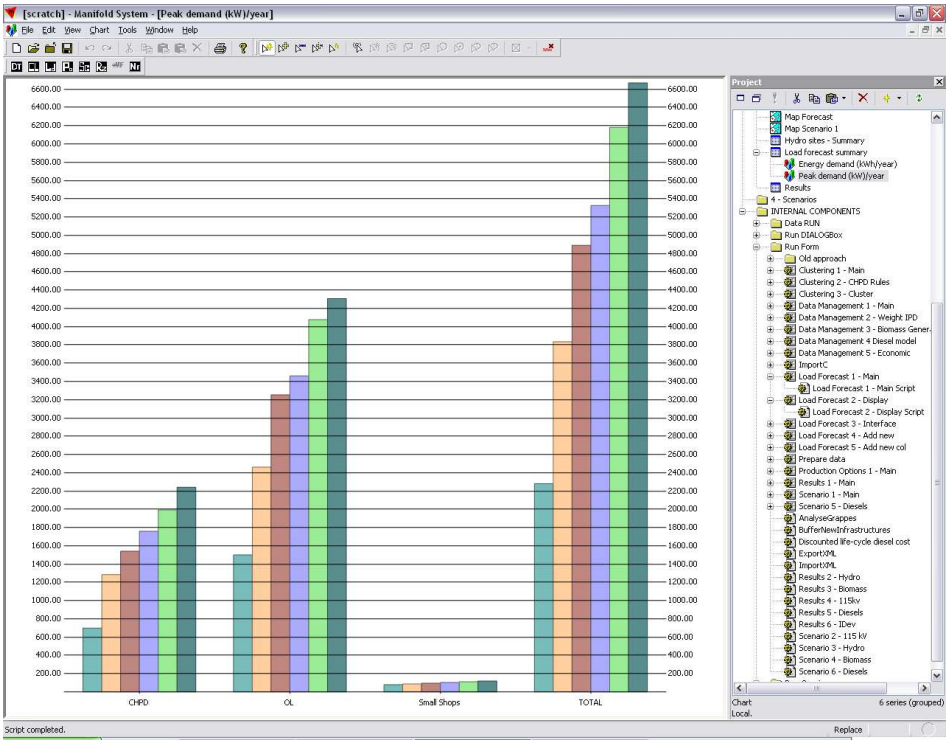
Clicking on this button displays a table with a summary of the load forecast for each category. That is, the peak and energy demand is displayed for each load category. The total demand is displayed in the last line of the table.

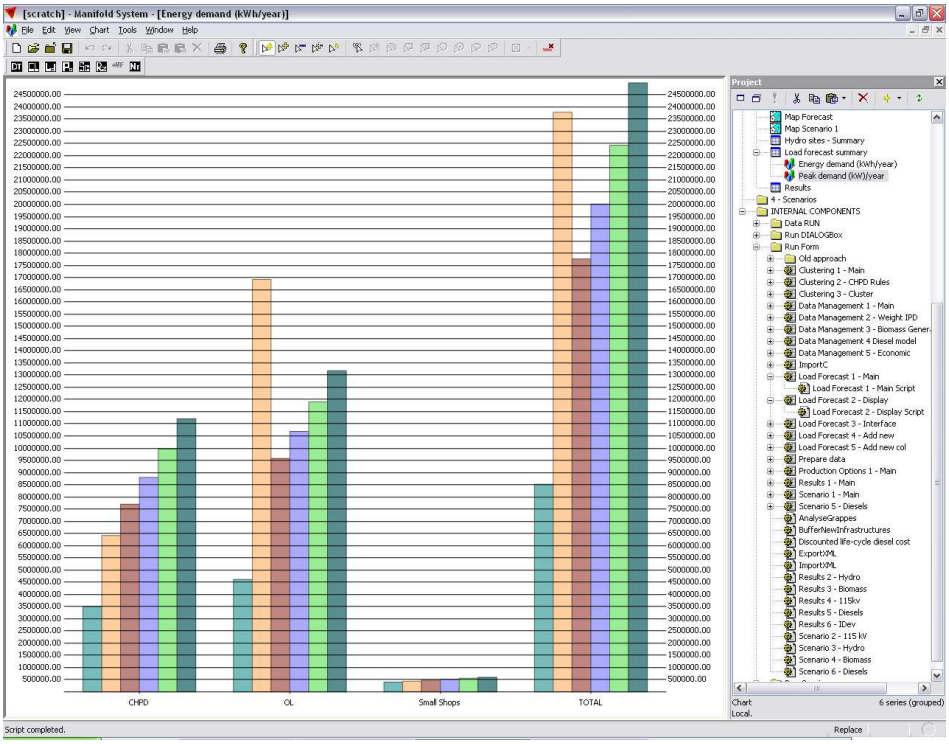


Category	Peak Y...	Peak Ye...	Peak Ye...	Peak Ye...	Peak Ye...	Peak Y...	Ener...	Energy Y...	Energy Ye...	Energy Y...	Energy Ye...	Energy Ye...
CHPD	700.41	1284.085	1540.902	1760.3638	1993.8338	2241.312	3502050	6420425	7704510	8801819	9969169	11206560
OL	1500.1155	2461.728	3254.0967	3461.805	4077.237	4308.024	4615740	16924380	9581506.95	10693131	11905532.04	13182553.44
Small Shops	80.2208	88.24288	96.26496	104.28704	112.30912	120.3312	401104	441214.4	481324.8	521435.2	561545.6	601656
TOTAL	2280.7463	3834.05588	4891.26366	5326.45584	6183.37992	6669.6672	8518894	23786019.4	17767341.75	20016385.2	22436246.64	24990769.44

5.5 DISPLAY PLAK DEMAND AND ENERGY DEMAND CHART

A graphical display of the load forecast is shown. The x-axis has the category name and the y-axis has the forecasted peak or energy demand.





5.6 SAVING RESULTS

The tables generated by this module can be saved by clicking on the 'export tables' menu. This option exports tables as excel files to the specified folder on your computer. Maps can either be saved as images within the manifold project or as picture files (.gif) on the computer.

The tables related in this module that could be exported are:

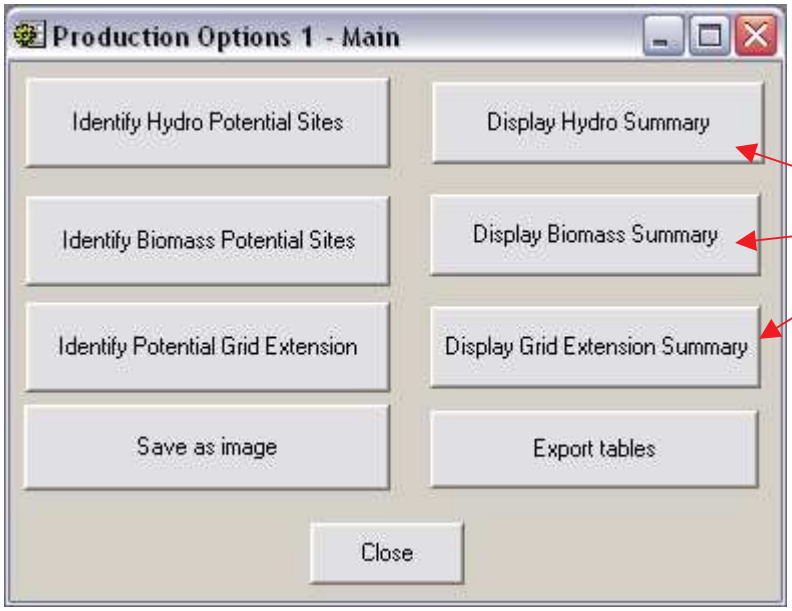
- Load forecast summary
- Load forecasting parameters

The maps relevant to this module are:

- LF Analysis
- Map Forecast

6. PRODUCTION OPTIONS

The production options module lets the user choose which production options should be considered when generating the electrification scenarios. The user can change the options for Hydro, Biomass and connections to the main grid line. The options that can be changed include activation and deactivation of the candidate production sites. This means that the user can choose if a particular site should be taken into consideration when deploying the resources for the fictive electrification scenarios is the next module.



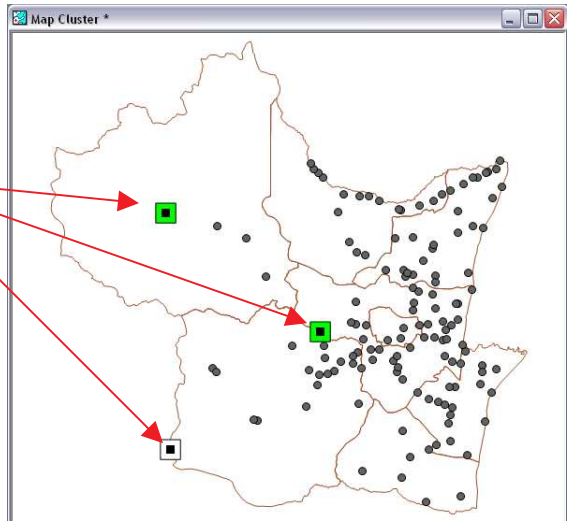
Clicking on these buttons simply displays a summary of the production option.

Although the values in these tables can be edited, this does not affect the data catalogues. The data can only be changed by clicking on the 'Identify' buttons.

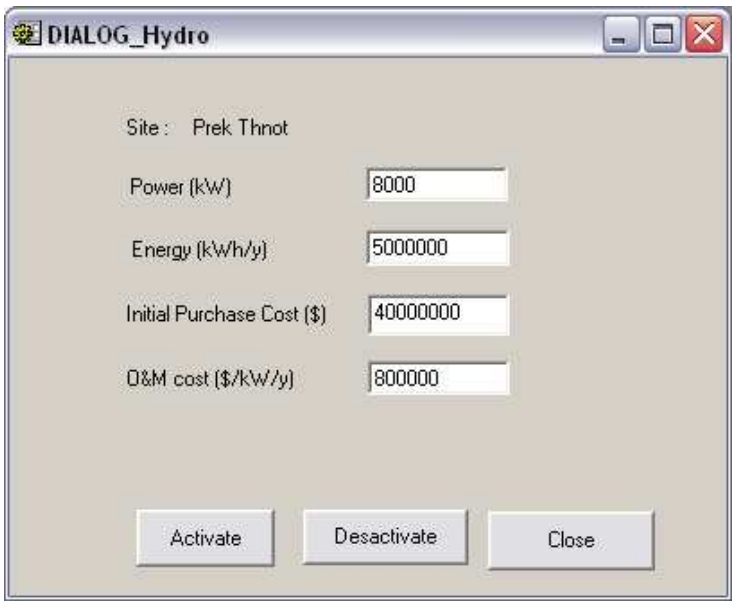
6.1 HYDRO POTENTIAL

On clicking the Identify Hydro Potential sites button, a map displaying potential sites is displayed.

Hydro potential sites



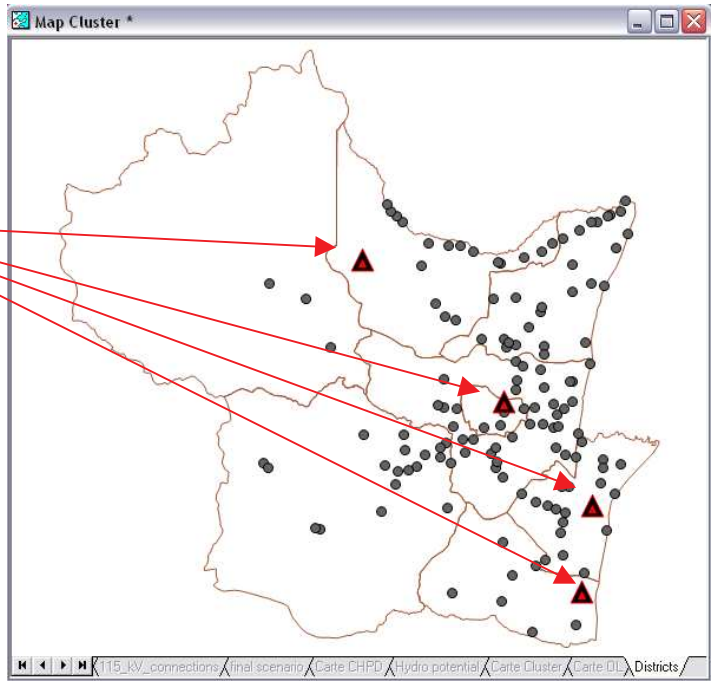
By clicking on a site, the properties of that particular site can be changed. The option to consider a site in the scenario creation function '***activate/deactivate***' is there in this menu.



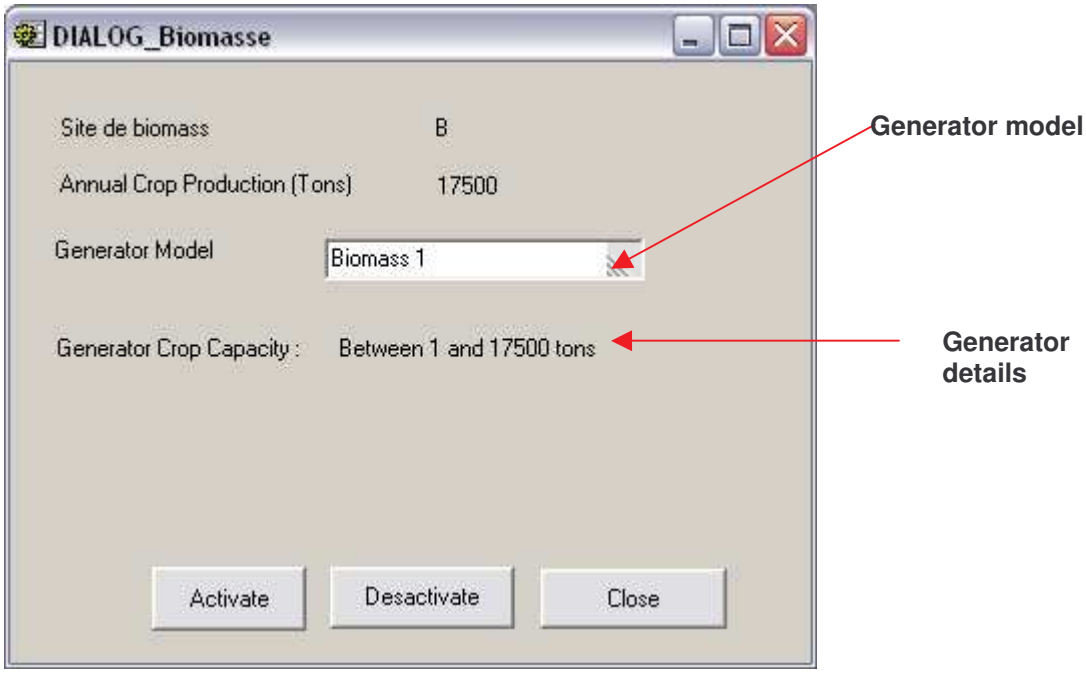
6.2 BIOMASS POTENTIAL

Clicking on this option makes a map with biomass potential sites pop up.

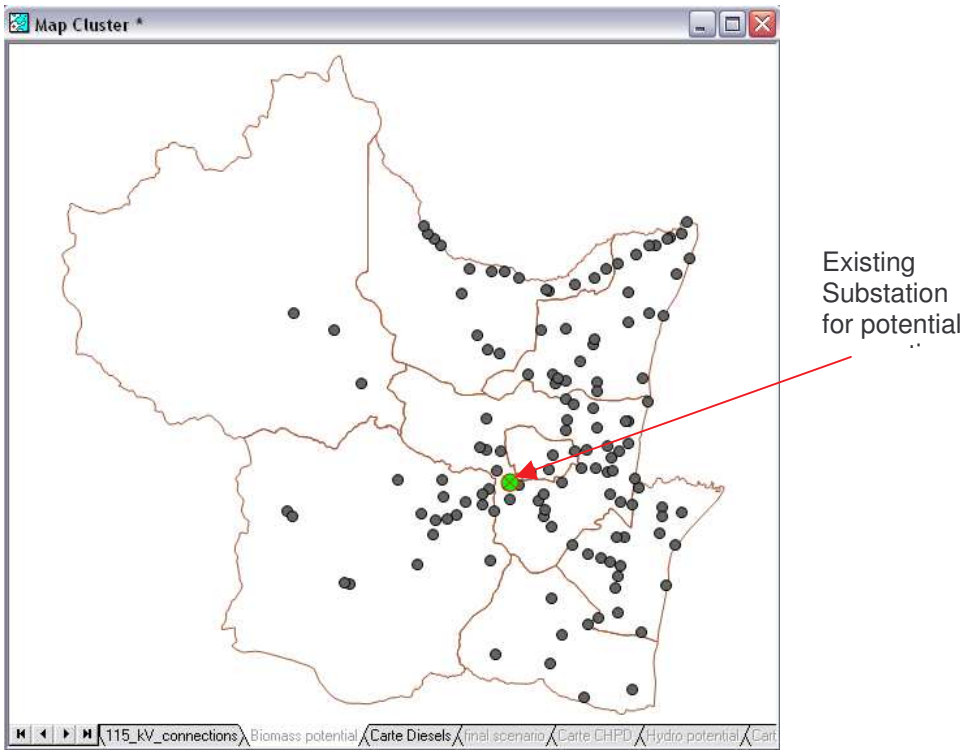
Biomass potential sites



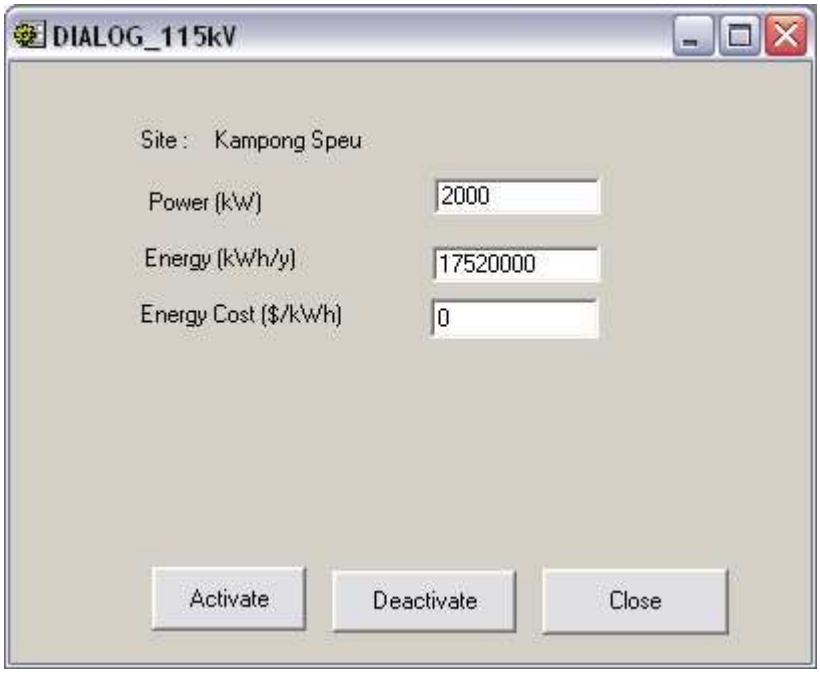
Clicking on a biomass site shows the attributes of that site. In the menu, the generator model for biomass can be changed and the site can be activated or deactivated.



6.3 GRID CONNECTION



Data required for each potential connection can be changed by clicking on the site.



This information box appears when clicking on a substation point on the map.

6.4 PRODUCTION OPTION SUMMARIES

All the data for scenario creation is now ready. A summary of the production options can be displayed at this point. It should be noted that changing the production options in the summary tables should not change the data about the productions options in the GIS Data Background folder.

6.5 EXPORTING/SAVING DATA

Tables can be saved outside manifold as excel files by selecting this option.

The table names that contain the results of the Production option summaries are:

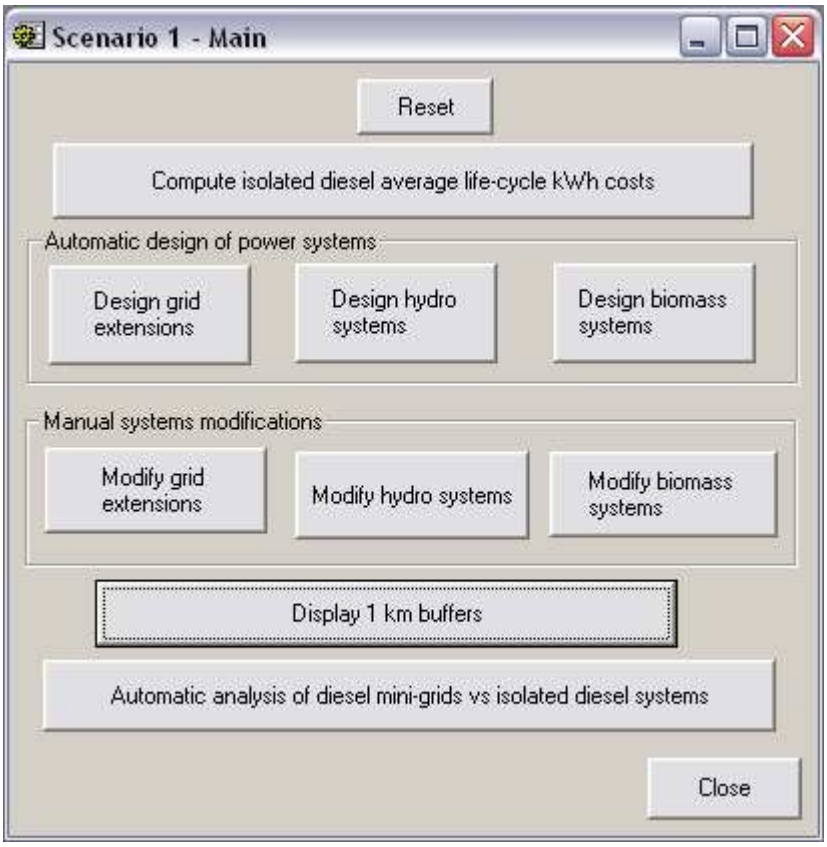
- SumBiomass
- SumHydro
- Sum115

Data can also be saved as an image by clicking on ‘Save as Image’. The map with production options data is:

- Map cluster

7. SCENARIO CREATION

This module allows the user to define and analyze electrification scenarios. The option to deploy and validate electrification scenarios is possible.

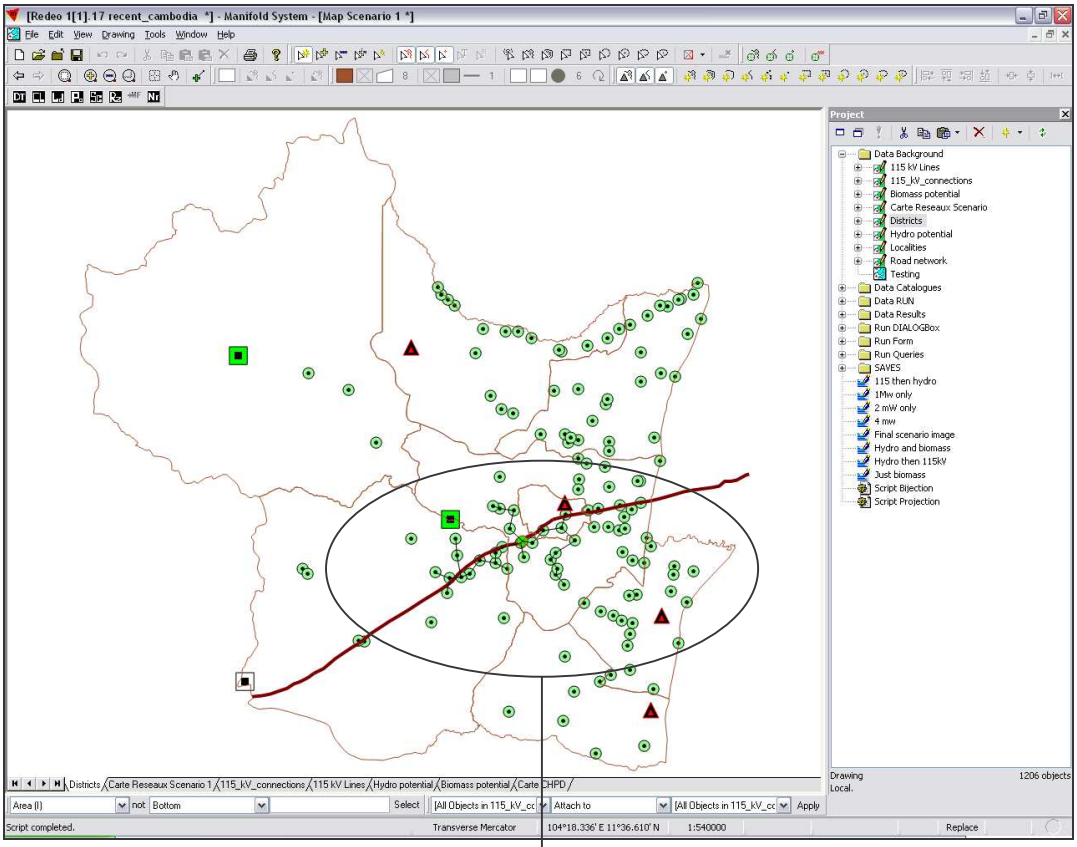
- 

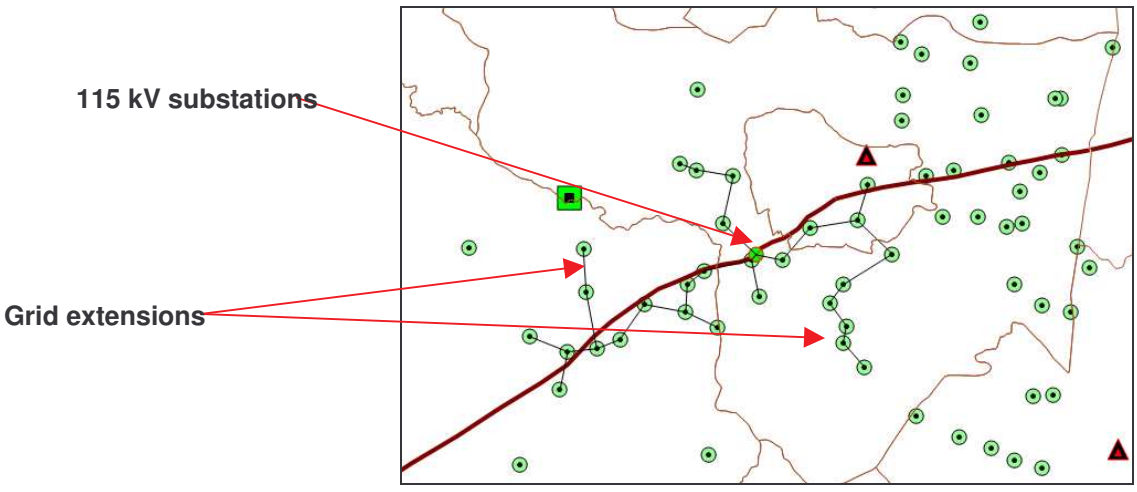
7.1 METHODOLOGY

The first resource that should be deployed is the grid extension. The grid can be extended:

- As long as there is enough capacity and energy available on the line to connect an additional cluster
- And if the average life cycle kWh cost of energy service through grid extension is lower than the average life cycle kWh cost of energy service through a local diesel generator.

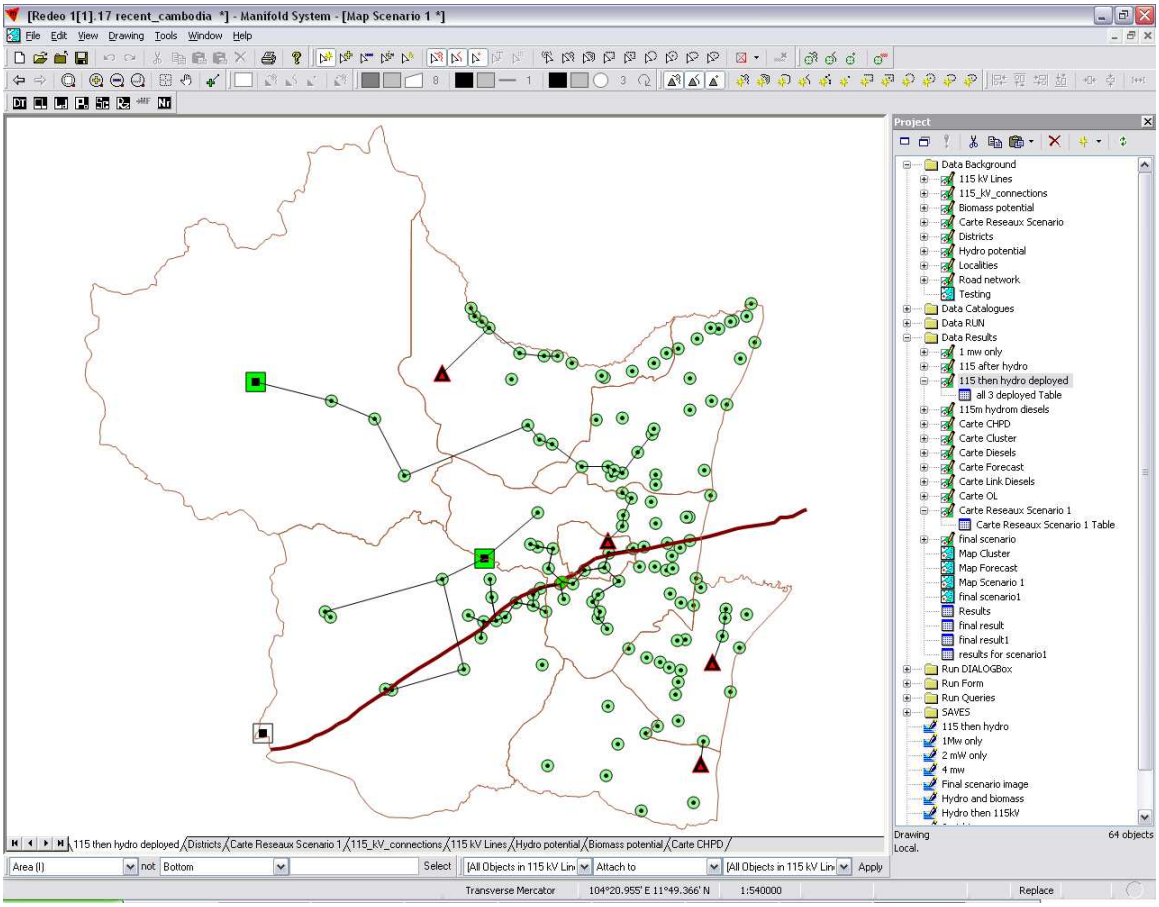
The average life cycle cost of kWh is taken as the NPV of all costs over the 25 years divided by the total number of kWh needed over the period.





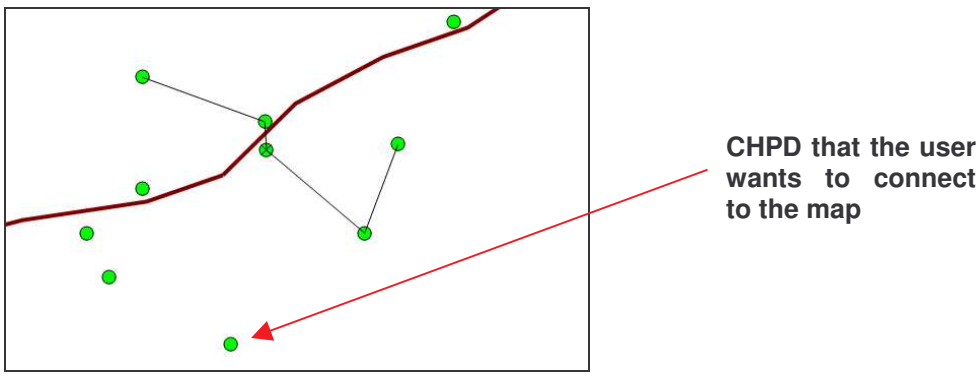
After grid extensions, hydro and biomass resources can be deployed. The hydro and biomass are compared to the cost of diesel in the same area. If the option of connecting hydro/biomass to the cluster in question is cheaper, then the cluster is connected to the resource. A map in which all three resources have been deployed is shown below. Hydro and biomass energy continues to be deployed until:

- The average lifecycle kWh cost of hydro or biomass is lower than that of isolated diesel for a given cluster AND there is sufficient energy and capacity available to meet demand.



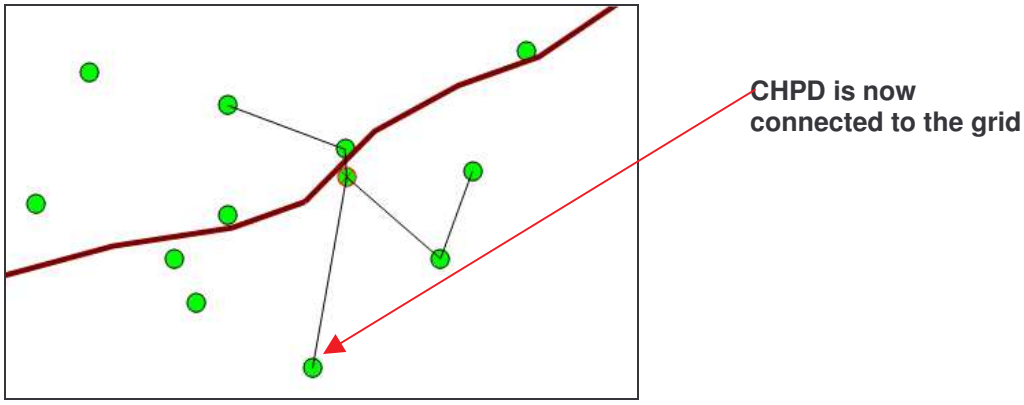
7.2 MODIFYING CONNECTIONS

The connections made by the tool can be altered manually. This is done by clicking on the CHPD at the center of the cluster, and then clicking on the resource that has to be connected it to. If the power demand by the cluster in question exceeds the maximum capacity of the plant, an error message shall be displayed. If the supply can be provided, then a confirmation message is displayed.



On clicking on a CHPD that is *not connected* the following messages are displayed:

On clicking on a point on the grid, the CHPD is connected to the grid and a confirmation message is displayed.



7.3 DIESEL GENERATORS

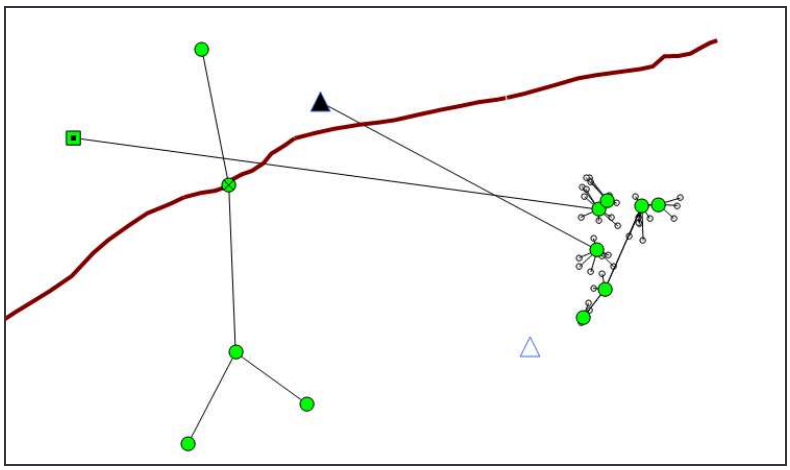
The diesel resources should be deployed after grid extensions, hydro and biomass has been deployed. The option of taking all, some or none of the previously deployed resources is there in this module. Click on an option to select/deselect it.

There are here 2 options: either an isolated diesel genset for a given cluster or a genset for group of clusters it is not economical.

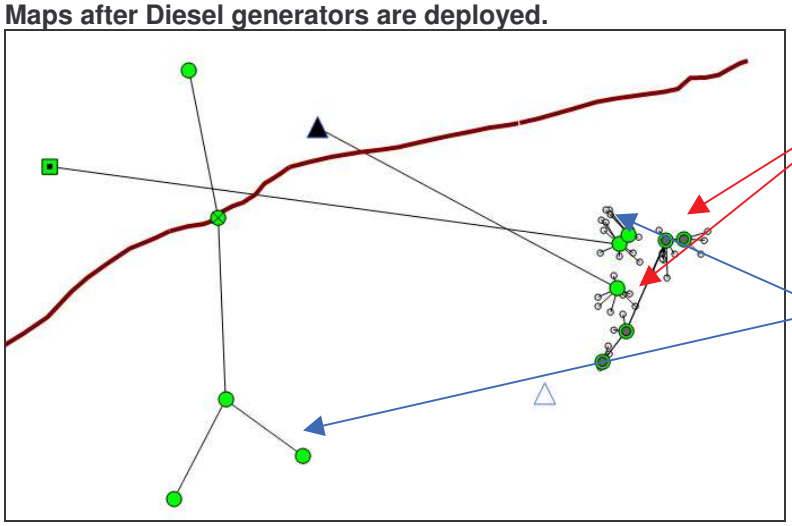
Hence the life cycle average kWh cost is calculated for cluster i, for cluster j and for cluster (I+j) including the cost of the line to connect the 2 clusters. The cheapest of the options is retained.

The order retained is starting from the largest cluster.

Map before Diesel generators are deployed



Maps after Diesel generators are deployed.



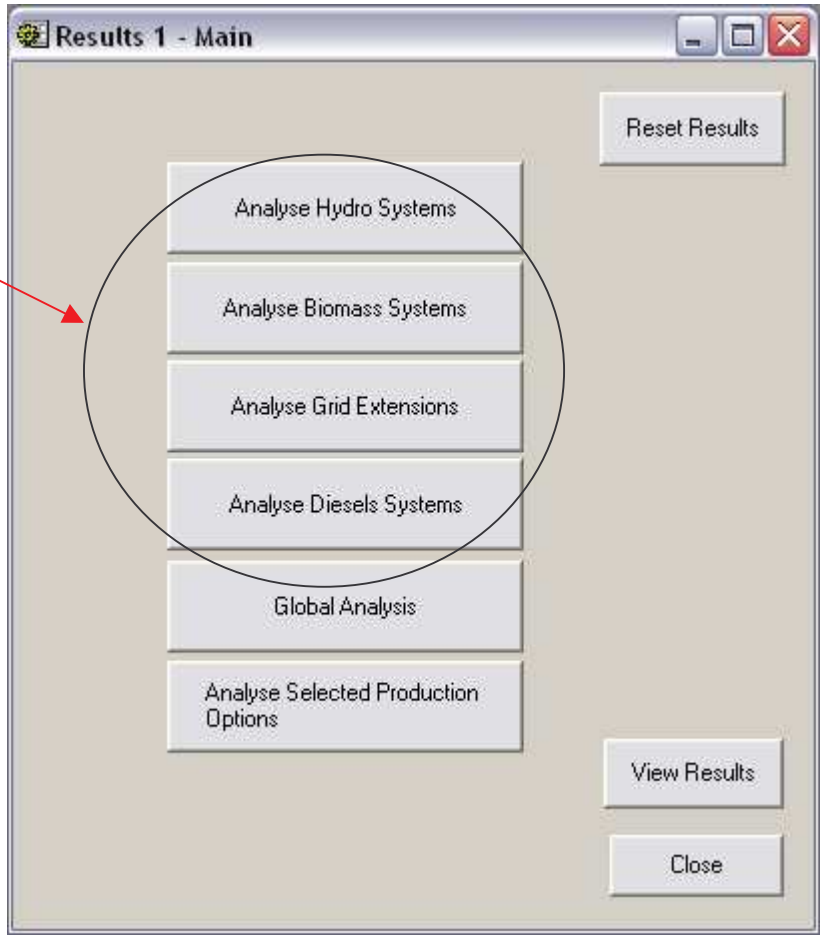
Clusters with Diesel generators

Clusters without diesel generators. This is because electrifying them with other options is a more economical option.

8. RESULTS

The results of the deployed resources are now ready to be displayed.

Clicking on these buttons makes the tool perform a basic cost analysis of the resource.



Clicking on the ***Global Analysis*** button analyses all the deployed resources.

View results opens a table with the analysis results. For each one of the "projects", the results table provides:

- the total number of households in the connected clusters
- the percentage of households effectively connected for a given project
- the present value of the investment cost
- total energy consumed in year 25
- average life cycle kWh cost

Analyze selected production projects ([10]) displays a table with the impact the potential electrification scenario has on the particular clusters under analysis.

[10] NB: also called scenarios in the software and to be cleaned out.

For the group of projects selected, the following indicators are provided:

Technology	Household Covered	Investment cost	Annual O&M cost	Name	Energy	kWh Cost	Activate
Network extention	1313	523527,885020303	800000	Kampong Speu	8000000	0,102617639425102	0
Hydro	782	460336,336777794	88000	Prek Thnot	100000000	2,74833633677779E-02	0
Standalone	880	7370657,21454024	200000,002980232	Krang Ponley05051109	50000000	0,147413144290805	0
**********	0	0	0		0	0	0
Household Electrification(%)	49,0979120210825	0	0		0	0	0
Localities Electrification(%)	47,7611940298507	0	0		0	0	0
**********	0	0	0		0	0	0
Health Centers Electrification(%)	0	0	0		0	0	0
Pop. acces to Electrified H.C.(%)	0	0	0		0	0	0
Mean distance to H.C.(km)	4,92532185208657	0	0		0	0	0
Mean distance to Electrified H.C.(km)	0	0	0		0	0	0
**********	0	0	0		0	0	0
Educational Centers Electrification(%)	15,3846153846154	0	0		0	0	0
Pop. acces to Electrified E.C.(%)	23,276479862405	0	0		0	0	0
Mean distance to E.C.(km)	5,83501514862108	0	0		0	0	0
Mean distance to Electrified E.C.(km)	19,3383127048403	0	0		0	0	0
**********	0	0	0		0	0	0
GHG emissions (diesels & RES) (Ton)	999999,977648258	0	0		0	0	0
GHG emissions (only Diesels)(Ton)	2999999,93294477	0	0		0	0	0

For the selected projects, the user can also input an average kWh tariff and the IRR – Internal Rate of Return – for the combination of projects is calculated.

The second version of the tool will also allow for calculating the financial kWh cost and return on equity possible (by paying out dividends only when profit levels allow so) which will require to input:

- Percentage of equity
- Two credit facilities (duration, grace period, interest rate)
- Fiscal information

APPENDIX A: WEIGHTING SYSTEM

WEIGHTING SYSTEM FOR IPD CALCULATION

It is important that the weights are entered in proportion to their importance in the area under analysis. For example, if roads are of prime importance in the development of a certain area, the weight entered for 'Access Road' may be 1 and the weight of all the other fields might be set to 0.8. This would ensure that the localities with roads have a higher IPD.

In the localities table[11], the values for education, employment, road access and administrative status must also follow a weighting system. As a result of applying a uniform weighting system, the weights for all the columns should range from 0 to 1.

A sample weighting system that could be used is shown below. The weights have been assigned in proportion to the number of localities that have a particular facility. Therefore, this weighting system might not work for another area taken into consideration.

Education infrastructure	Index	nb of localities
Secondary school	1	15
Primary school	0,6	360
nothing	0	271
Accessibility index	Index	nb of localities
Main Road	1	112
Secondary Road	0,6	106
Other	0	428
Economical index	Index	nb of localities
Big industry (>100emp)	+0,4	
Medium industry (>10emp)	+0,3	
Small industry (>1emp)	+0,2	
Other	0	
Health infrastructure	Index	nb of localities
Health Center	1	9
Nothing	0	637

[11] Refer to section 2.1.3, Localities table for a complete description of all the required data and columns present in the localities table.

APPENDIX B: BIOMASS GENERATOR MODELS

	Biomass Characteristics								
Sector	**Total crop production**	**crop residue : production ratio (%)**	**Residue Name**	**Conversion Process**	**Life (yrs)**	**Electricity production**	**Installed capacity**	**Investment cost ($/kW)**	**O&M**
Sugarmill	<1,284,000 tonnes of sugar cane per year	29% - 32%	bagasse	combustion <5MW	20-25	100 kWh/ton of sugarcane	<5MW	1200	0,003 USD/KWh
Sugarmill	>1,284,000 tonnes of sugar cane per year	29% - 32%	bagasse	combustion >5MW	20-25	100 kWh/ton of sugarcane	>5 MW	800 - 1100	0,003 USD/KWh
Rice	<195,000 tonnes of rice per year	22%	rice husk	<2 MW	20	90-125 kWh/tonne of Paddy	<2 MW	1500 - 2000	3,24 USD/MWh
Rice	>195,000 tonnes of rice per year	22%	rice husk	>2 MW	20	90-125 kWh/tonne of Paddy	>2 MW	1400 - 1500	3,24 USD/MWh
Palm Oil	tonnes of fresh fruit bunches processed	43-45%	Palm Empty Fruit Bunches, Shell and Fibre	combustion	20-25	120 kWhe/t of fresh fruit bunches		800-1300	c. 5% of investment costs per year
Palm Oil	tonnes of fresh fruit bunches processed	20m3 of biogas for every tonne of fresh fruit bunch processed	Wastewater from palm oil (POME)	Biogas	20	1m3 of gas produces = 1 kWh	<1MW	600 - 800	1,3 USD/MWh
Saw Mills	m3 of debarked wood log	50%	Shavings, off-cuts etc	combustion	20-25	80 kWh/tonne of debarked wood log		1000	c. 5% of investment costs per year
Ply Mills	m3 of debarked wood log	50%	Shavings, off-cuts etc	combustion	20-25	120 kWh/tonne of debarked wood log		1000	c. 5% of investment costs per year
Municipal Waste	tonnes of waste		Municipal Waste	Biogas	20	600 kWh/tonne of waste		1300	n/a
Livestock Breeding	No° of bovine and sheep and goat heads	4,5 kg of dung/bovine/day and 0,4 kg/day/sheep or goat	Dung - bovine and / or sheep goat	Biogas	20	0,05 to 0,08 m3 gas/kg fresh weight and 1M3 of biogas produces about 1 -2 kWh	<1MW	600 - 1000	0,028/kWh