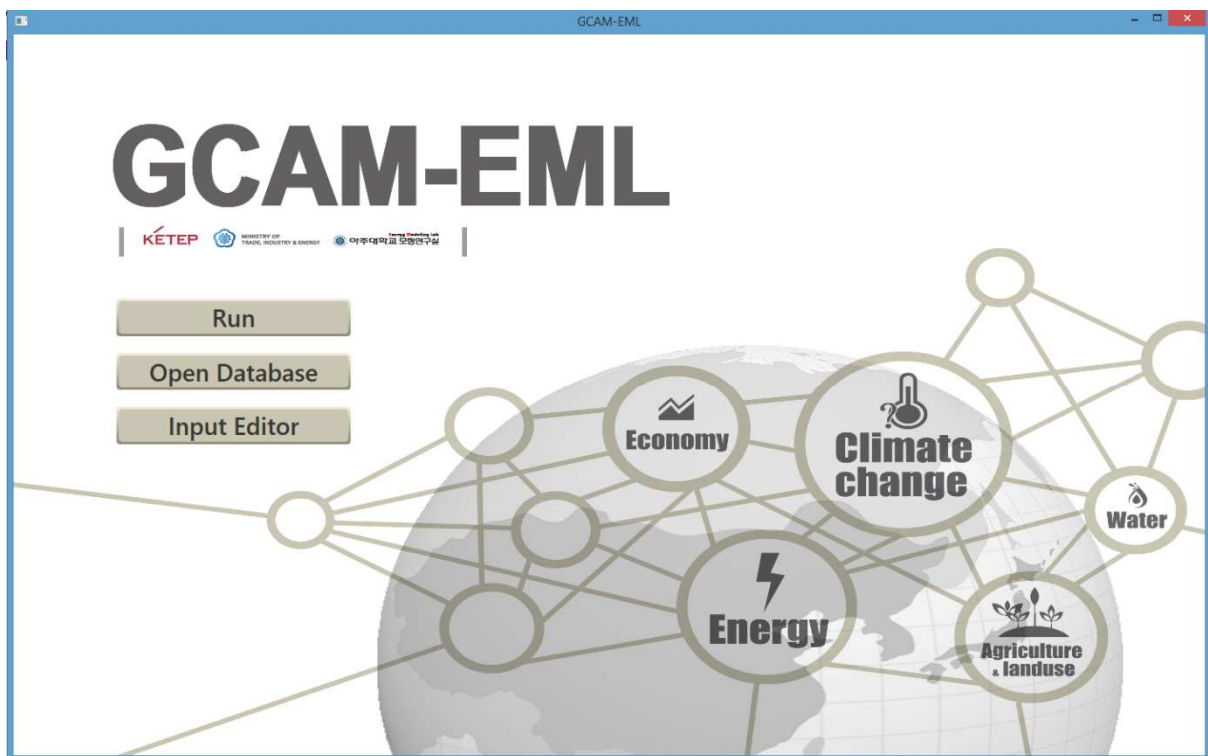# GCAM-EML ver. 1.0.15.1229

Energy Modeling Laboratory

Ajou University

January 2016

Release Note

GCAM-EML ver. 1.0.15.1229

This Program is developed by the collaborative work of Energy Modeling Laboratory at Ajou University and Joint Global Change Research Institute (JGCRI) / Pacific Northwest National Laboratory (PNNL).

January 8th, 2016

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http://eml.ajou.ac.kr/

How to Use

Global Change Assessment Model – Energy Modeling Laboratory (GCAM-EML) is currently available for download in EML website[1]. By clicking the link provided in the webpage, automatic download of installation file *setup.exe* will be initiated. The user can simply double-click the *setup.exe* to start the installation process of GCAM-EML. The Install Shield Wizard would attempt to install the GCAM-EML in Program Files folder.

After finishing the installation process, the user may find the main execution file of GCAM-EML, the *GCAM-EML.exe* in the desktop. The shortcut icon is as shown in figure below:


Otherwise, the user can check in the installation folder, which is (usually) C:₩Program Files (x86)₩GCAM-EML folder. There are two main folders under the installation folder, which are ₩exe folder and ₩input folder. The ₩exe folder contains the main execution file (here it is named *Xcam.exe*), some main input files (configuration files and updated Korean end-use sector input files), and other supporting files and program (several .dll files, Graphviz 2.30, and others).

Meanwhile, the ₩input folder contains most of the input files for the program, which is inherited from the original Global Change Assessment Model (GCAM), developed by Joint Global Change Research Institute (JGCRI)[2].

To start using GCAM-EML, double-click the main execution file, *GCAM-EML.exe*. The front-screen of the GCAM-EML would look like the figure below:

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[1] http://eml.ajou.ac.kr/eml/?page_id=692

[2] As stated in http://www.globalchange.umd.edu/models/gcam/download/ (last accessed January 8th, 2016): *Researchers are welcome to make any changes they like for their own research interests. However,* **any revised version, with altered input data or model code, must be identified not as GCAM** *but as GCAM-xxxx.* Hence, the upgraded version of GCAM developed by Energy Modeling Laboratory is rebranded as GCAM-EML.
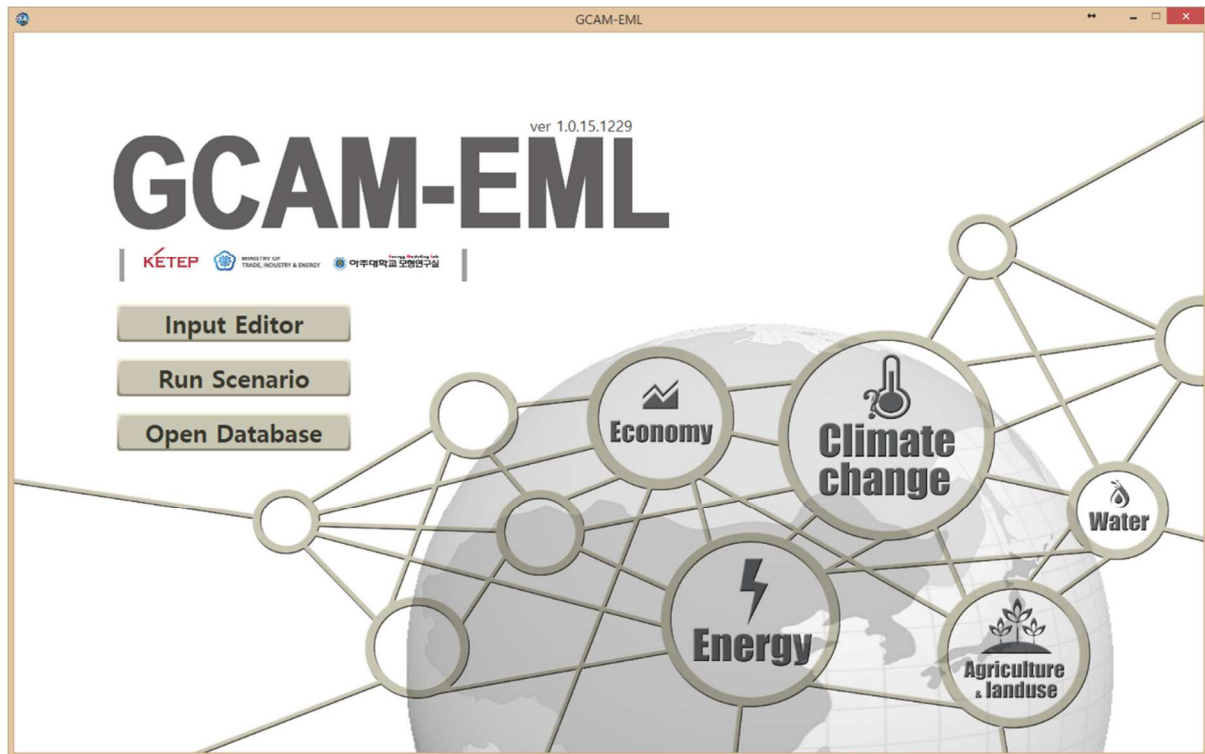
As seen in the figure above, there are three function options in the program: Input Editor, Run Scenario, and Open Database.

1. Input Editor

The Input Editor simplifies the reading and redefinition of model structure in GCAM-EML, especially the end-use sectors. There are three main end-use sectors in GCAM-EML, which are: building, industry, and transportation. The Input Editor function transforms input csv file, which sets the structure of the end-use sector, into xml file, which is later feed into GCAM. In the GCAM-EML installation folder, the example of input files is already available. These files are developed to update the structure of Korean end use sectors. The user may check the ₩exe₩input data folder. The files included there are:

1. building_kor.csv
2. industry_kor.csv
3. transportation_kor.csv

To use the Input Editor function, start by clicking the *Input Editor* Button to enter the screen below:
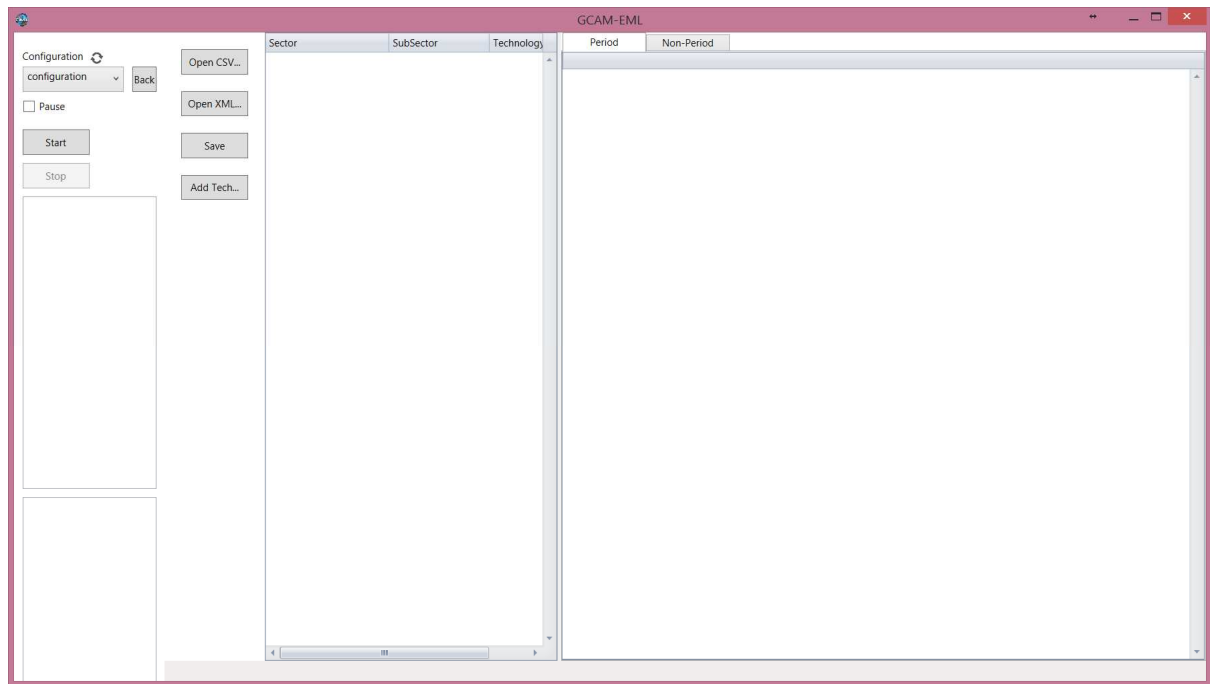
To read in the csv file, the user can simply click the *Open CSV...* button and choose the target csv as shown in figure below. Again, the folder for csv file examples is (usually) C:\Program Files (x86)\GCAM-EML\exe\input data.
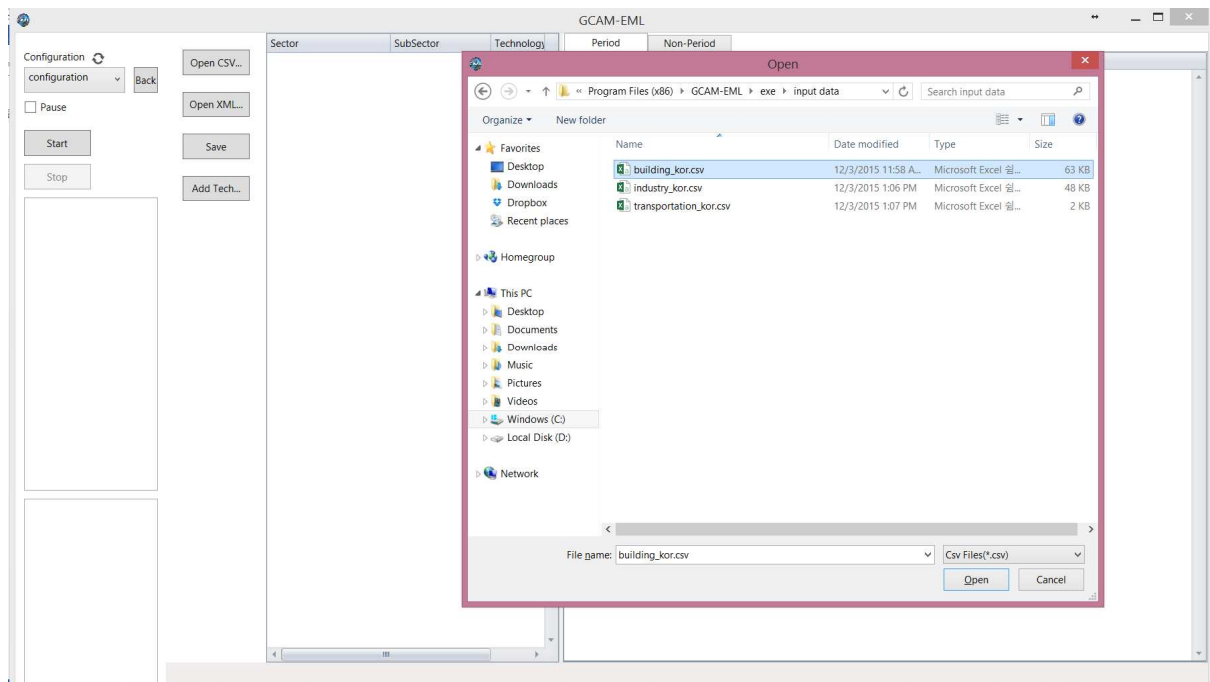

For example, the user can select the building_kor.csv as input file. This file basically disaggregates the building sector of Korea in GCAM-EML from the original simplified version of two building types (residential and commercial) and three energy services (heating, cooling, and others). The new disaggregated version has five types of residential building, fourteen types of large commercial building, and twenty types of small-medium commercial and public building. In total, there are 39

types of building. Each building category has different set of energy services: nineteen for residential building, nine for large building, and twelve for small-medium commercial and public building.

The csv input file mainly defines the building types and the energy services that are demanded by the building. The energy consumption data is inputted for each building type, energy service, and fuel. The Input Editor then redefines the consumer, sector, and technologies in the original GCAM structure. The base-year energy consumption (which is used for calibration) is read from the csv input file. Other parameters such as the satiation level and base building size are also read in by the program from the same csv file.

After selecting the appropriate csv file, the program would read in the data and translate it into the xml file for building sector. Here, the user can choose to see the data within a consumer, sector, subsector, and technology. The user then can check if the input data for the building sector is correct or appropriately set or not. The user also able to change the data right on the UI, simply by clicking and inputting the desired value. The displayed data on the screen is shown in figure below:
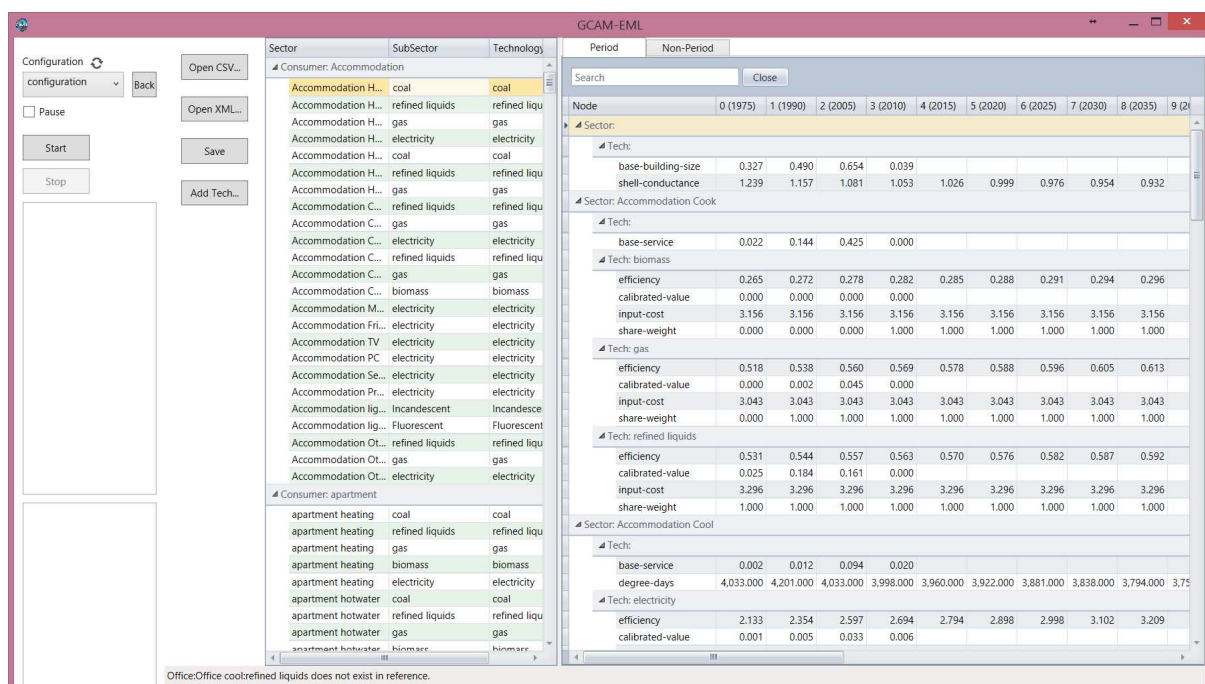
Please note that the program also compares the total size of calibrated values between the new definition/structure and the original (reference). This checking process is important to make sure that there is no error in the model. The general rule is that the values before and after the change should be the same[3]. If the value is close enough, then we can simply proceed to the next step. If not, then a modification must be made to the input file so that the total calibrated values before

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[3] If the new total calibrated values is not the same with the original, then there is a high possibility that the running of GCAM-EML would resulting in some calibrated errors.

and after the structure modification is the same[4].

Afterwards, the user can click *Save* button to save the resulting file into the xml file. The resulting file would be saved as kor_building.xml, which is located in ₩GCAM-EML₩exe folder. Similar to this, the Input Editor function can also edit the industry_kor.csv and transportation_kor.csv into kor_industry.xml and kor_transport.xml, respectively.

2. Run Scenario

The second function, *Run Scenario*, is the main function which manages the run process of GCAM-EML. It is intended to be a more advanced and user friendly version of the original GCAM run. Other the traditional function of running the program, it is also equipped with many information gathering features. To utilize this function, press the *Run Scenario* button to enter the screen as shown below:
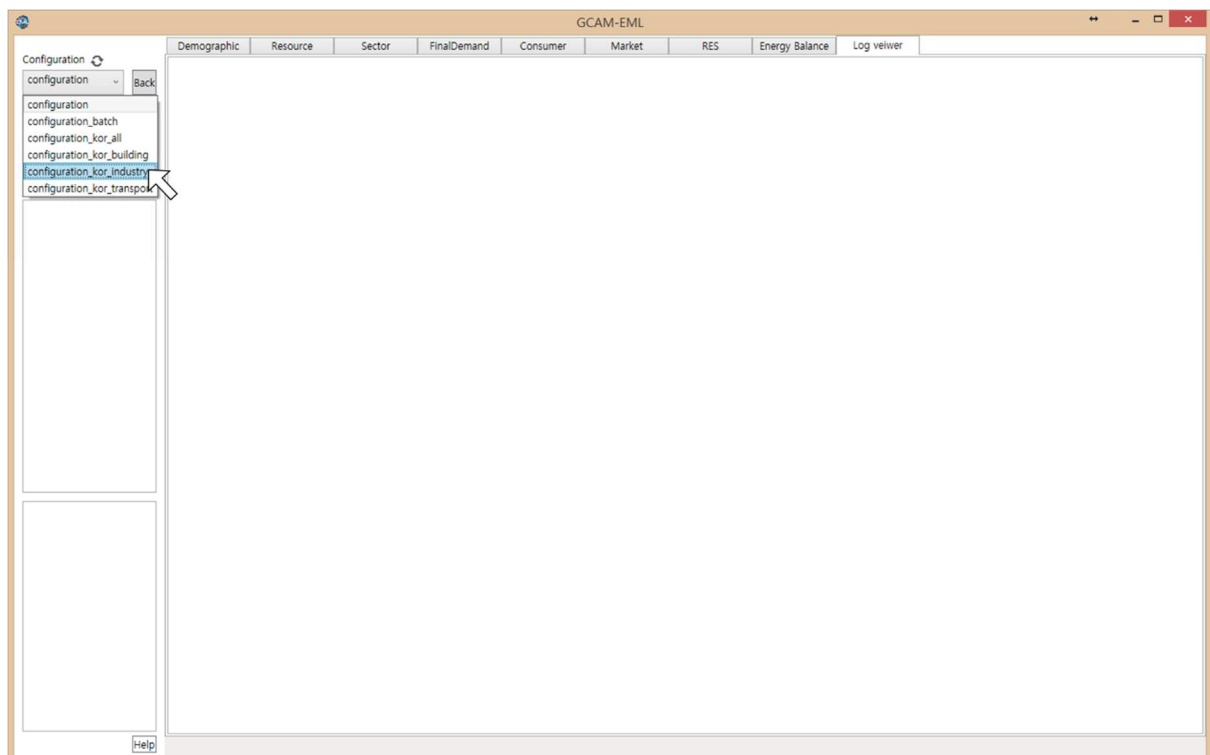

To run GCAM-EML, the user needs to select the configuration file first. The configuration file is an xml file that lists the input files that are feed into the program as well as governs the GCAM-EML running options/settings. The input xml files that are listed in the configuration file would form the structure of GCAM-EML system. To select the configuration file, click the small down arrow under *Configuration*. As shown in figure above, it will open up the list of configuration files available. This

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[4] It must be noted that there is still an issue in the transportation end use sector (transportation_kor.csv), which resulting in the two compared values are not the same.

list comes from the xml file list under the ₩exe₩config folder. The default file that can be chosen is the *configuration.xml*[5]. After selecting the desired configuration file, press *Start* to start running the GCAM-EML.

At this point, the model will run as can be seen in the bottom part of the GCAM-EML screen. There, the user can determine at which point (period) the program is currently running. The improved GCAM-EML also provides several tabs to assist the user understand the progress and the process inside the GCAM running. The *Log Viewer*, for instance, lets the user to see the log, similar to what is shown when running the original GCAM. Figure below shows the example of *Log Viewer* which shows the parsing process of the input files. In the bottom part, it can be seen that the program is still running in Period 0.
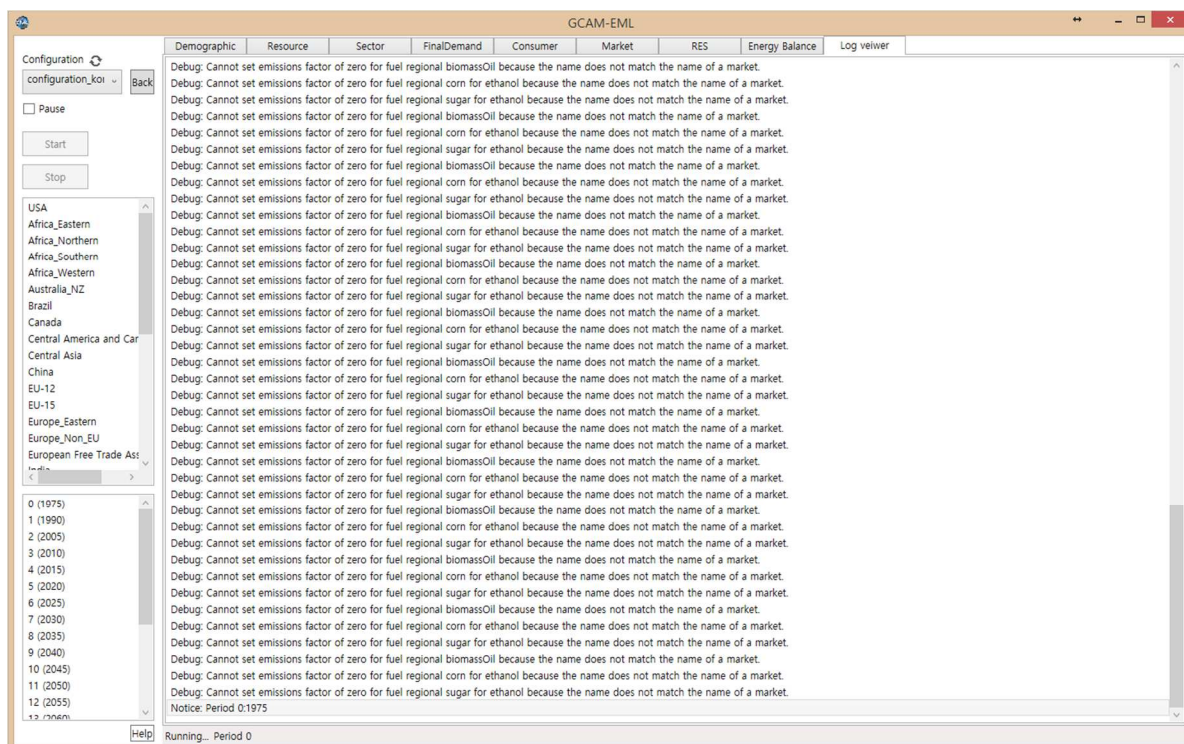
The other tabs display the data and information that are being processed by the program. Usually this progressing data process is not available, unless the user runs a debugging process of the GCAM code. Some of tabs represent the many class of parameters in GCAM, which interact between

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[5] The default configuration.xml file would run the original structure of GCAM. Other files that are provided and can be selected include configuration_kor_building.xml which runs the Korean disaggregated building instead of the original one, configuration_kor_industry.xml which runs the Korean disaggregated industry, configuration_kor_transportation.xml which runs the Korean disaggregated transportation instead of the original one, and configuration_kor_all.xml which runs all three Korean updated end-use sectors at the same time.

each other, such as *Demographic, Resource, Sector, Final Demand,* and *Consumer.* The *Demographic* tab is a specific class for population and GDP related parameters, such as labor productivity and productivity growth. The *Resource* tab shows the data related with resource in GCAM (coal, crude oil, natural gas, uranium, etc.), such as the grade-wise available resource and its extraction cost. The *Sector* tab deals with the many sectors in GCAM which build the energy and Agricultural and Land Use (AgLU) system. The sectors are the connectors between resources and final demands, including the transformation system and end use services. Information such as efficiency, non-fuel input cost, and base year calibrated-value can be observed in this tab. The *Final Demand* consists of information related with transportation and industry sectors, while the *Consumer* currently holds the information about building sector (residential and commercial). In these tabs, the user can check the parameters that control the demand calculation, such as base-service, income-elasticity and price-elasticity. At figure below, an example of checking the parameters in gas processing sector is shown.
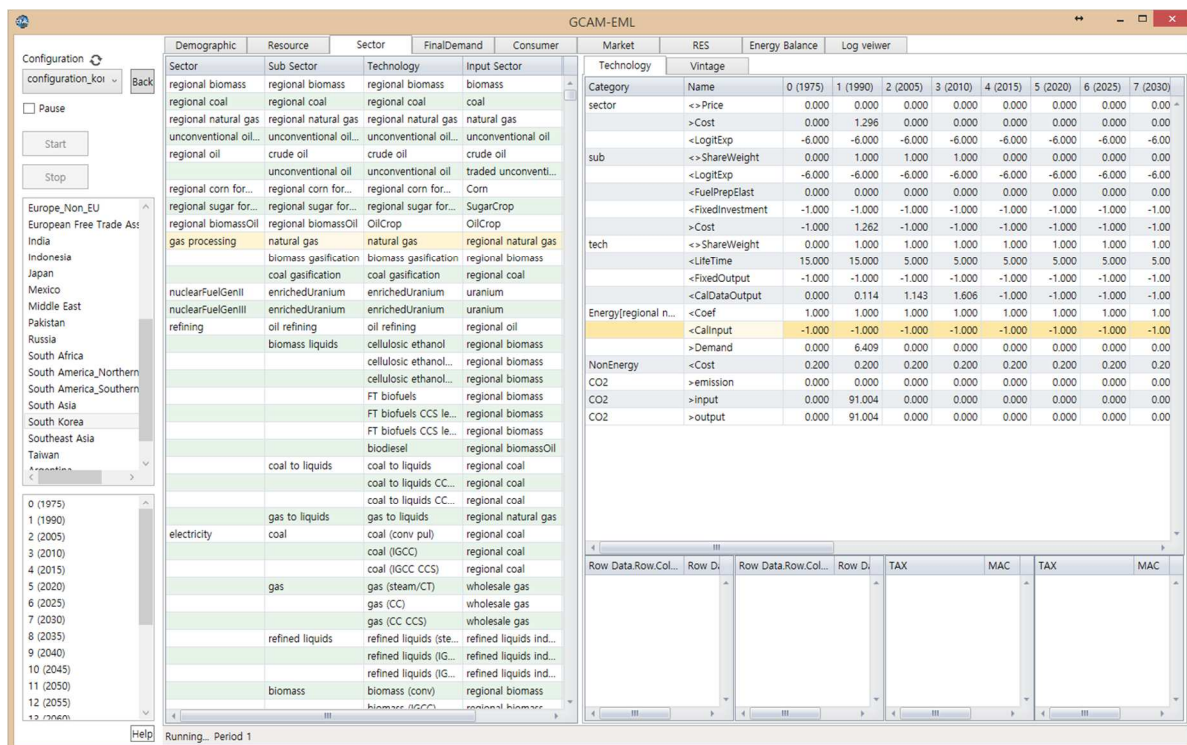
Since GCAM is a partial equilibrium, market mechanism is used to find the solution of the model. The tabs *Market* and *Solver* are important to check this process. Figure below shows the *Market* tab in GCAM-EML. As can be seen, under the *Market* tab, there are four sub-tabs, which are *Region, Global, Supply, and Demand.* The sub-tab *Region*, which is shown in the figure below, displays the regional markets data in GCAM-EML, based on the region and period selected in the left. The sub-tab *Global* displays the data for global market. Meanwhile, the *Supply* and *Demand* sub-tabs display the region-wise *Supply* and *Demand* that compose the global market. It can be shown that the total value of *Supply, Demand,* and *Market* for a commodity (energy or agriculture) is the same, which shows the partial equilibrium process in GCAM-EML.

The *RES* tab stands for the Reference Energy System. This feature is developed to untangle the complexity of energy system in GCAM. By selecting the region and period, and clicking *Layout*, the Reference Energy System graph is displayed[6]. From here, the user can choose a specific sector and see its relationships with other sectors within GCAM. Some important information of the selected sector is also displayed in the bottom of the graph.

Figure below shows the example of utilization of *RES* tab. As can be seen, there is color coding in the graph. The green color denotes a Resource, grey/blue means sectors in energy system, cyan implies final demands, while yellow shows the AgLU system related sectors. When a sector is selected, it'll be shown to have pink border in RES. Meanwhile, the inputs and outputs of this selected sectors would have brown and orange border, respectively.

All nodes in this RES are grouped into several categorizes: resource, primary energy, secondary energy, final energy, energy service, and final sector. These categories can be seen in the bottom part of the node graph. All nodes are lined up based on its category, except the AgLU related ones. The RES provides option to simplify the graph by ticking the *Details* option just in the right of *Layout* button. The simplified version would only displays the energy related nodes and removing the AgLU system ones. The additional feature of this RES tab is saving the image by right-clicking the graph and selecting *Save as image…*

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[6] The display process of the Reference Energy System makes use of the open software Graphviz version 2.30, especially the dot.exe.
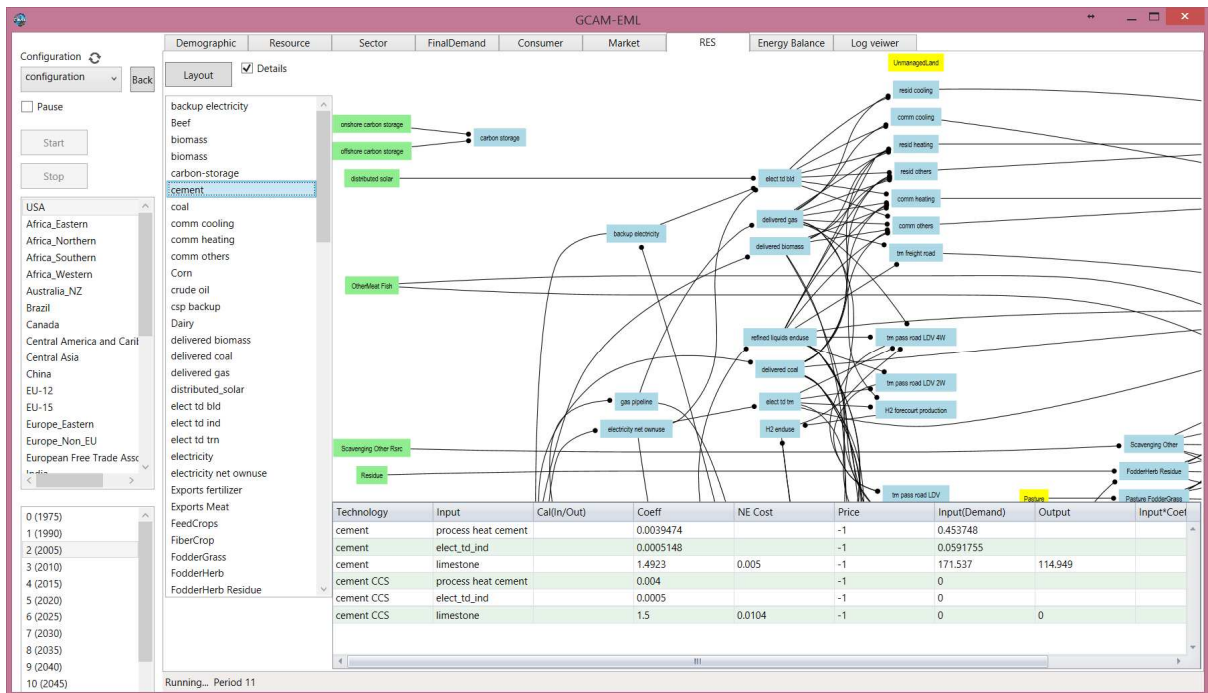
Last, the *Energy Balance* tab shows the flow of energy and agriculture related products in the Energy and Agriculture and Land Use systems. Figure below shows the example of *Energy Balance* tab utilization.
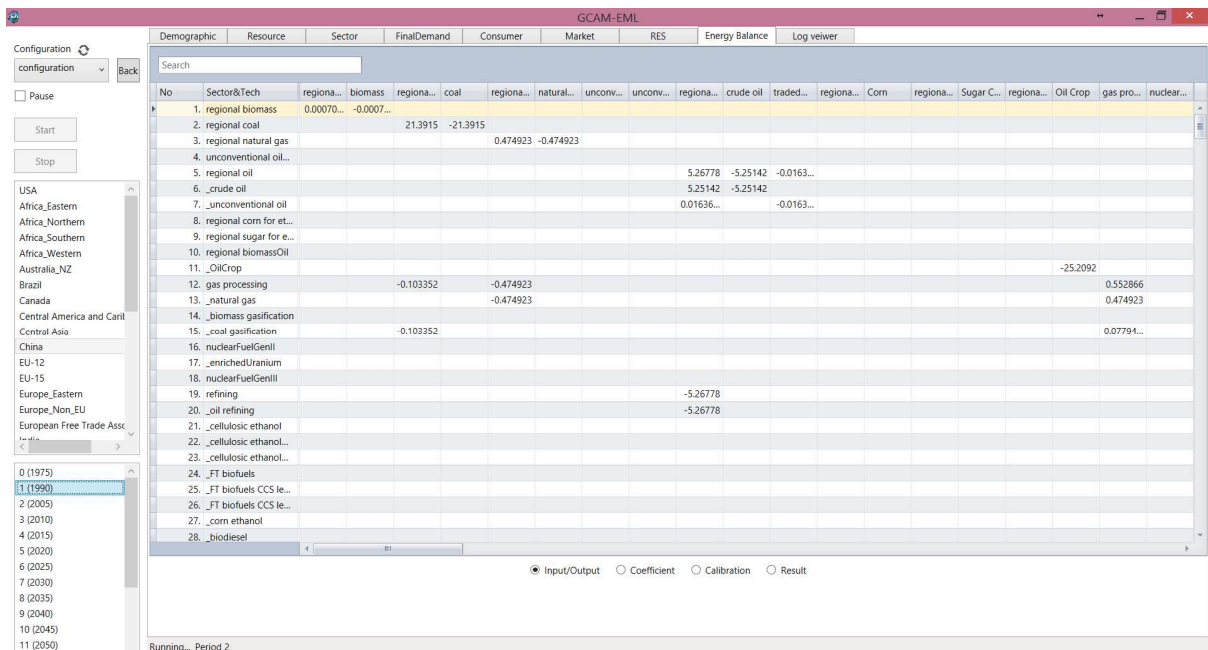
Please also note that the user should choose the specific region and period before selecting the tabs to check the information there. As seen in the bottom part, there are four options in *Energy Balance* tab: *Input/Output, Coefficient, Calibration*, and *Result*. Each of these option provides different information. This tab not only shows the base year, but also for all of every 5 year EBs are presented.

The *Input/Output* is the default option. The table shown is what is usually referred as GCAM-EML

Energy Balance. This Energy Balance is a bit different in format than the traditional Energy Balance like the one produced by the International Energy Agency (IEA). Here, the Energy Balance is developed to be a bit similar to the way Input-Output table is prepared in the economics study. It must be noted that the row names show the sector in GCAM, while the column names show the energy input[7]. The negative values here mean the consumption of energy input, while the positive values mean the production of the output.

The *Coefficient* option shows the coefficient (Input over Output) value in a technology. This parameter determines the conversion between an input and output of a sector in GCAM. The *Calibrated-Value* option displays the calibrated-value that is used to calibrate GCAM parameters in the base year. Meanwhile, the *Result* option displays the result of Input (from *Input/Output*) multiplies with Coefficient, while keeping the Output value intact. With this, the total value of Inputs and Outputs of a sector would be balanced (zero).

Additional features are added in this *Energy Balance* tab. These features can be selected by right-clicking the Energy Balance display. The first two of those features are the *Hide Empty Columns & Rows* and *Hide Aglu Sectors*, which are useful to simplify the look of the Energy Balance. With these two options selected, the user can have a compact Energy Balance. The last feature is *Save to CSV...* which exports the table into csv file.

| | Demographic | Resource | Sector | FinalDemand | Consumer | Market | RES | Energy Balance | Log veiwer |

Search

No	Sector&Tech	regiona...	biomass	regiona...	coal	regiona...	natural...	unconv...	unconv...	regiona...	crude oil	traded...	regiona...	Corn
1.	regional biomass	0.00070...	-0.0007...											
2.	regional coal			21.3915	-21.3915									
3.	regional natural gas					0.474923	-0.474923							
4.	unconventional oil...													
5.	regional oil									5.26778	-5.25142	-0.0163...		
6.	_crude oil									5.25142	-5.25142			
7.	_unconventional oil									0.01636...		-0.0163...		
8.	regional corn for et...													
9.	regional sugar for e...													
10.	regional biomassOil													
11.	_OilCrop													
12.	gas processing			-0.103352			-0.474923							
13.	_natural gas						-0.474923							
14.	_biomass gasification													
15.	_coal gasification			-0.103352										
16.	nuclearFuelGenII													
17.	_enrichedUranium													
18.	nuclearFuelGenIII													
19.	refining									-5.26778				
20.	_oil refining									-5.26778				
21.	_cellulosic ethanol													
22.	_cellulosic ethanol...													
23.	_cellulosic ethanol...													
24.	_FT biofuels													
25.	_FT biofuels CCS le...													

(Context menu shown over rows 8–11: Hide Empty Columns & Rows / Hide Aglu Sectors / Save to CSV...)

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[7] Due to the nature of GCAM-EML structure that is made of sectors that demand other sectors as energy inputs, the naming of sector and energy input is mostly the same.

Another feature is to *Pause* momentarily the running of GCAM-EML at the current period. Please note that the model will halt after the whole process within a period is done. Then, the user may continue the run by pressing the *Start* again. The user can also press the button *Stop* to completely abort the running of GCAM-EML

When the GCAM-EML completely runs, as shown in figure below, the output file will be produced. In GCAM-EML, the output is in form of xml file, which is automatically named as output_db_DDMMYYYYHHMM.xml. The DDMMYYYYHHMM format is for the date, month, year, hour, and minute at which the output file is produced. Additionally, GCAM-EML also produces the second output file, which is named as output_kor_db_DDMMYYYYHHMM.xml. The keyword "kor" means that this file will only record the output for South Korea region only. This additional output file is designed to simplify and reduce the size of the output file.
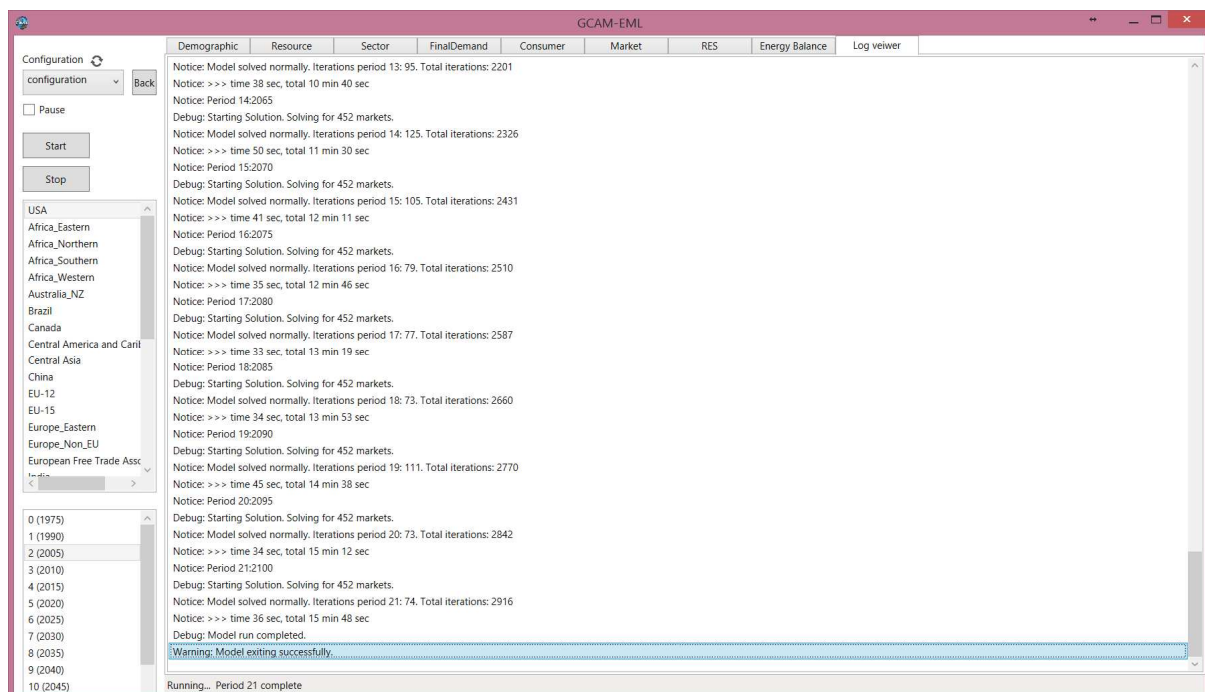
It must be noted that all output files are automatically saved in ₩exe₩log folder of installation folder.

3. Open Database

This function enables the user to easily check the output file of GCAM-EML which is in xml form. This feature is loosely based on the Model Interface of GCAM. It basically extracts information from output file and display it to the user in form of tables and graphics. The Open Database function of GCAM-EML can also compare two cases at the same time. This is particularly useful to compare reference and scenario case. Click the *Open Database* button to enter the screen as shown below:
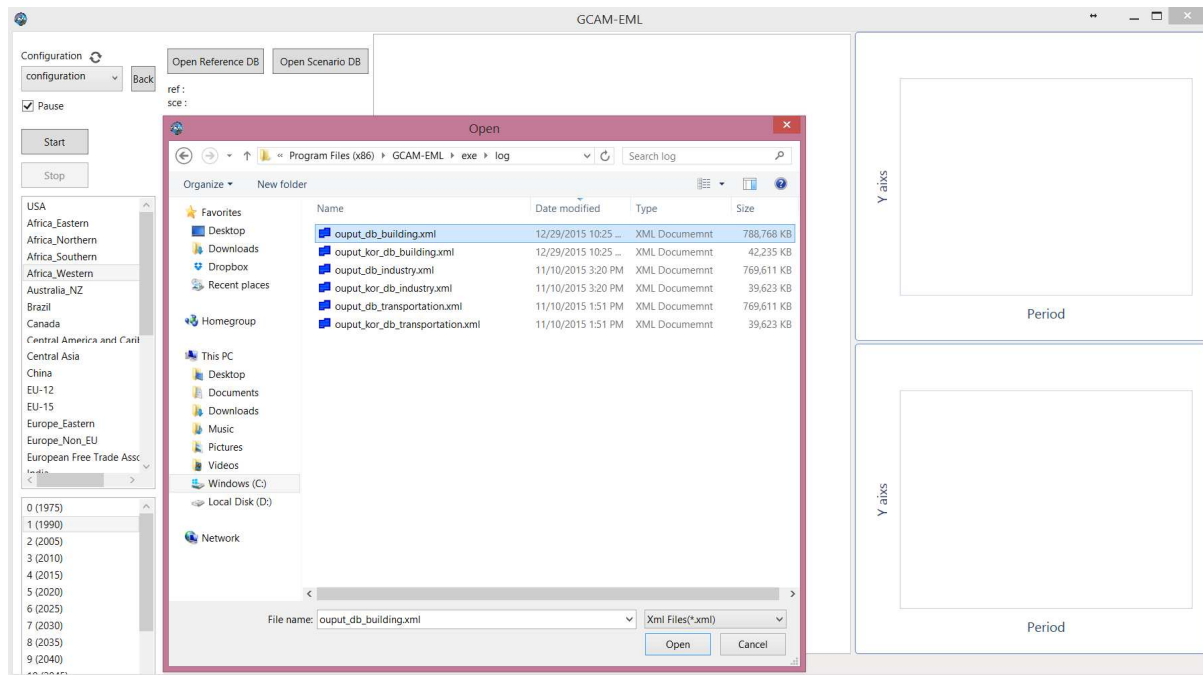
To open the target output file, please click the *Open Reference DB* button. Please be reminded that the output files of GCAM-EML is located in ₩exe₩log folder within the installation folder. Some examples are already provided so that the user can check the Open Database feature even if he/she has not tried to run GCAM-EML before. As shown in figure above, the user can select the target xml file, for example output_kor_db_building.xml[8]. As mentioned, GCAM-EML also gives ability to the user to compare two scenarios at the same time. This feature can be used by selecting the second output file through clicking *Open Scenario DB* and choosing another DB file. For example, let us select output_kor_db_transportation.xml.

Then, the user can choose one of the many queries available. The queries are classified into several categories, such as electricity, buildings, industry, and transportation. Before that, the user must also select the region. Since in the current example, only South Korean region is available, that specific region is selected. Then, let us try to choose query *Electricity generation by aggregate technology,* which is located under the *Electricity.* To produce the result, click *Run Query.* Then, the GCAM-EML would produce the information as requested by the user in form of table and graphics. The figure below shows the screen:

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[8] This output file contains GCAM-EML results for South Korea region only when running the configuration file configuration_kor_bld.xml. The output file name is renamed from the original output file for convenience. Other files that are included in the folder are output_db_industry.xml, output_db_industry.xml, output_db_kor_industry.xml, output_db_transportation.xml, and output_kor_db_transportation.xml. If the file name does not contain "kor" keyword, then it contains the output information for the whole regions.
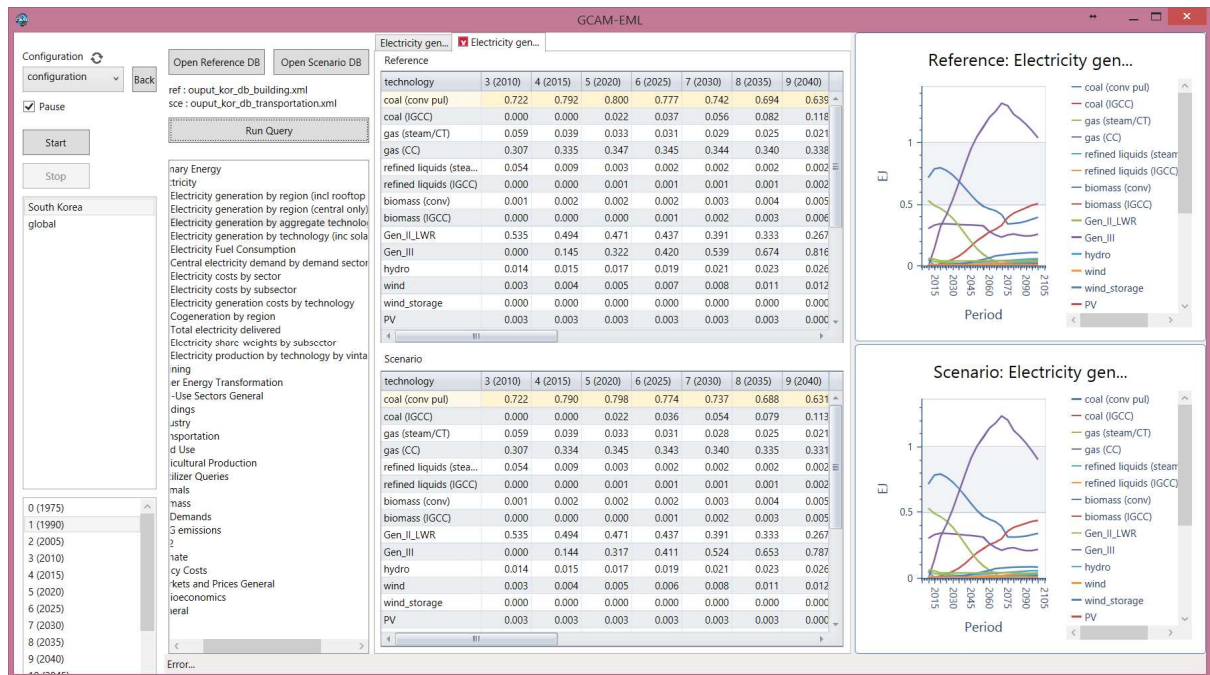
As shown in figure above, the user can easily compare the results between the two scenario using this feature. The information that is extracted by the query is displayed in form of table and graph for both Reference case (top) and Scenario case (bottom). The user can continue to extract other information using the query. The new results will be displayed in new tabs.