

**User Guide**

**Abatement Cost Chart**

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**Energy Modelling Laboratory**

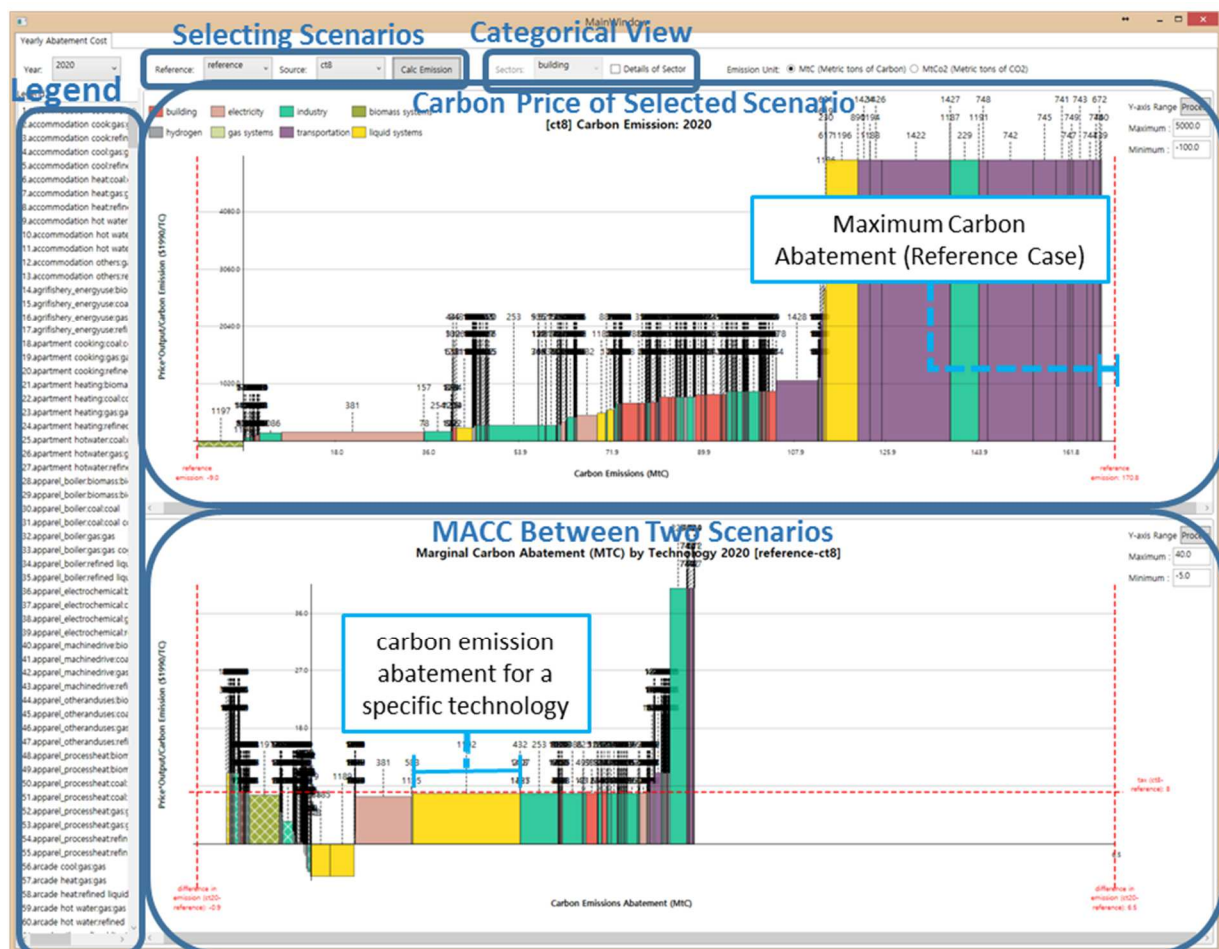
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## How to Use

The Abatement Cost Curve program is designed to simplify the drawing of Marginal Abatement Curve (MAC) graph. The MAC graph mainly displays the relationship between carbon emission reduction (horizontal x-axis) and the price for that reduction (vertical y-axis). The MAC is divided into technology 'blocks'. Each block shows the amount of carbon emission reduction that technology can contribute and the cost of that reduction.

The main source of the data for the MACC is the GCAM-EML output file. The unit of carbon emission reduction is in MTC (metric ton of carbon) and the unit of reduction cost is in 1975\$ per ton of carbon).

To use the program, simply double-click the main execution file AbatementCostChart.exe. The program reads an input file, which is named MACC.csv. The input file contains the information of carbon emissions and prices for all technologies and scenarios. To open another MACC data set, rename the new csv file into MACC.csv and re-run the program. Figure below shows the general display of the Abatement Cost Curve program.



The features of this program include:

➤ Display

In general, there are two graphs shown in the program. The top graph displays the single scenario Carbon Price (1990\$/TC vs CO<sub>2</sub> Emission (MTC). Here, the single scenario selected is the Source scenario. Meanwhile, the bottom graph displays the MACC between two scenarios, either between two levels of carbon taxes or between carbon tax and reference scenario.

In the bottom graph, a horizontal red dotted line is provided. It shows the incremental incentive of carbon tax between two scenarios. For example, between Carbon Tax 12 and Carbon Tax 8 scenarios, the red dotted line would be on the level of 4 1975\$/ton C. There is also a vertical red dotted line, which shows the maximum CO<sub>2</sub> emission/abatement.

The technologies displayed can be categorized into sectors. These sectors are color coded based on so that the user can easily identify them. Finally, the legend that is located in the left part of the screen explains the sectors' name. They are also noted in the graph with number)

➤ Select Year

In the leftmost top of the screen, user can select the year (period) of the MACC. The periods are based on the GCAM-EML scenario run, which is usually from 2020 to 2100 with 5-years interval. Usually the default year is 2020.

➤ Select Scenarios to be compared in the MACC

The user can select the scenarios to be compared by selecting the Reference and Source as shown in figure above. For example, the user can compare the scenario of Carbon Tax 12 (CT12) as Source and Carbon Tax 8 (CT8) as Reference.

➤ Select Categorical View, such as electricity, building, industry, etc.

The main screen displays the MACC for the whole technologies available in GCAM-EML. Since the number of technologies is huge, the categorical view is important so that the user can have a better focus. For example, the electricity category would display the technologies that are used to generate electricity such as various coal power plants.

Figure below displays the example of categorical view in the Abatement Cost Chart program.



### ➤ Change Units

In the rightmost top of the screen, the user can change the unit of the carbon from the original MTC to metric ton of CO2 (MTCO2).

### ➤ Zoom

There are various methods to work with the zoom in the graph. By using the combination of key Ctrl and Scroll, the user can zoom in and out the graph. Using the combination of key Shift and Scroll, the user can alter the maximum point of the y-axis. This feature is important to provide different perspective of the graph. Since the number of the technologies are huge and some of them have a striking difference in term of reduction cost magnitude, it is not easy to observe all values at the same time. Using this y-axis altering feature, the user can observe technologies that have very low reduction cost, which is not observable otherwise, by reducing the range of the y-axis.

### ➤ Y-axis

Another way to change the y-axis range is by inputting the value in the *Maximum* and *Minimum* box for each graph. Please press the button *Process* to run the change made.

## Introduction to the MACC Data

The Marginal Abatement Curve (MACC) is created by running several carbon tax scenarios in GCAM.

The current procedure includes these carbon tax scenarios:

Year	CT4	CT8	CT12	CT16	CT20
2020	4.00	8.00	12.00	16.00	20.00
2035	5.79	11.59	17.38	23.17	28.97
2050	8.39	16.78	25.17	33.56	41.95
2065	12.15	24.30	36.45	48.61	60.76
2080	17.60	35.20	52.80	70.40	88.00
2095	25.49	50.98	76.47	101.96	127.44
2100	28.84	57.68	86.51	115.35	144.19

The carbon tax is in 1990 \$/ton C. Each scenario has a base carbon tax of 4, 8, 12, 16, and 20 1990 \$/ton C starting from 2020, respectively. Then, an increase of 2.5% is applied annually for each carbon tax scenario.

To create MACC, we need to have the data set for both carbon emission reduction (x-axis) and carbon abatement price (y-axis). The carbon emission data is quite straightforward, since it is directly generated by GCAM. The carbon abatement price, though, requires a further investigation.

Currently, the formula used to calculate carbon price for each technology is:

$$P_C = \frac{Q_{Out} * P_{Out}}{CO_2}$$

where:

$P_C$  is price of carbon for each technology (1990 \$/ton C)

$Q_{Out}$  is the output of each technology, which can be energy or service (EJ, Mt, million passenger-km, million ton-km, etc.)

$P_{Out}$  is the price of each technology, which is a combination of energy price, efficiency, and non-energy cost (1975 \$/GJ, \$ 1975/kg, 1990 \$/pass-km, 1990 \$/ton-km, etc.)

$CO_2$  is the carbon emission for each technology (MTC)

The difference in units is solved by using the appropriate conversion factors.

The carbon abatement (or reduction) cost between the two scenarios is then calculated as follow:

$$P_{C,Red} = P_{C,2} - P_{C,1}$$

where:

$P_{C,Red}$  is the carbon abatement cost

$P_{C,2}$  and  $P_{C,1}$  are the price of carbon between two scenarios. In general, the carbon tax level of  $P_{C,2}$  is higher than that of  $P_{C,1}$ .

Accordingly, the carbon emission reduction is calculated as follow:

$$CO_{2,Red} = CO_{2,1} - CO_{2,2}$$

$CO_{2,Red}$  is the carbon emission reduction

$CO_{2,1}$  and  $CO_{2,2}$  are the carbon emission between two scenarios. In general, the carbon tax level of  $CO_{2,1}$  is higher than that of  $CO_{2,2}$ , thus the carbon emission of  $CO_{2,1}$  is lower than that of  $CO_{2,2}$ .