Welcome to the NEEDS Sustainability Assessment Survey

The purpose of this survey is ask a wide range of stakeholders about their preferences regarding the performance of future generating technologies over a broad range of sustainability criteria. It will provide you with immediate feedback on the technology results for your own preferences, and then tell us your final preferences for our own analysis.

This User Guide describes the most important features of the application, including general information, the criteria hierarchy, how to enter your preferences, how to see the performance of the best technology (and others), how to see the ranking implied by your preferences, and how to save, modify and iterate your preferences until you are satisfied. It contains the following sections;

- General Information
- The Main Screen
- The User Preferences
- Preference Selection
- The Criteria Chart
- Using the Multi-Criteria Analysis (MCA) Application
- Advanced Analysis

General Information

The NEEDS multi-criteria analysis allows you to enter your preferences for different measures of generation technology performance, and then solve to find a ranking of technologies. Each solution is called an iteration. The first iteration presented to you in automatically generated with equal preferences for all criteria. Each time you enter your own preferences and hit the "Solve" button you generate a new iteration. You can name or add comments to each new iteration. At any time you can recall an old iteration and make further changes. Each solution generates a full ranking of technologies, but the best way to confirm your opinion of the ranking is to check whether you are happy with the performance tradeoffs for the best (top ranked) technology.

All iterations except the last remain private to the user. So if at the end of your analysis your favorite iteration is not the last one, please select your favorite iteration from the pull-down iteration menu and hit the "Solve" button one last time.

Note that you can pause and logout at any time during the NEEDS survey. (In fact, it is even recommended that you may take a break, and come back with a fresh perspective). The survey will log you out automatically after 45 minutes of inactivity, but all your previous analysis iterations are automatically saved and available when you log back in.

If you forget your PIN number for subsequent logins, you may recheck the email originally sent to you. Otherwise, please click on the "Forgot PIN?" link of the login webpage, and a new screen will ask you again for your User Name (email address). Enter the white characters in the black box, click "Replace PIN" and a new PIN code will be emailed to you.

Please note that if you initially signed up with the wrong language, you should use the "Contact" link to tell the survey administrator. Your account will be reinitialized and you can start again with a First-time login.

This User Guide will now introduce you to the main elements of the MCA interface, and how to use the survey. We thank you again for your participation, and hope that you will learn a lot about your own multi-criteria decision making process!

The Main Screen
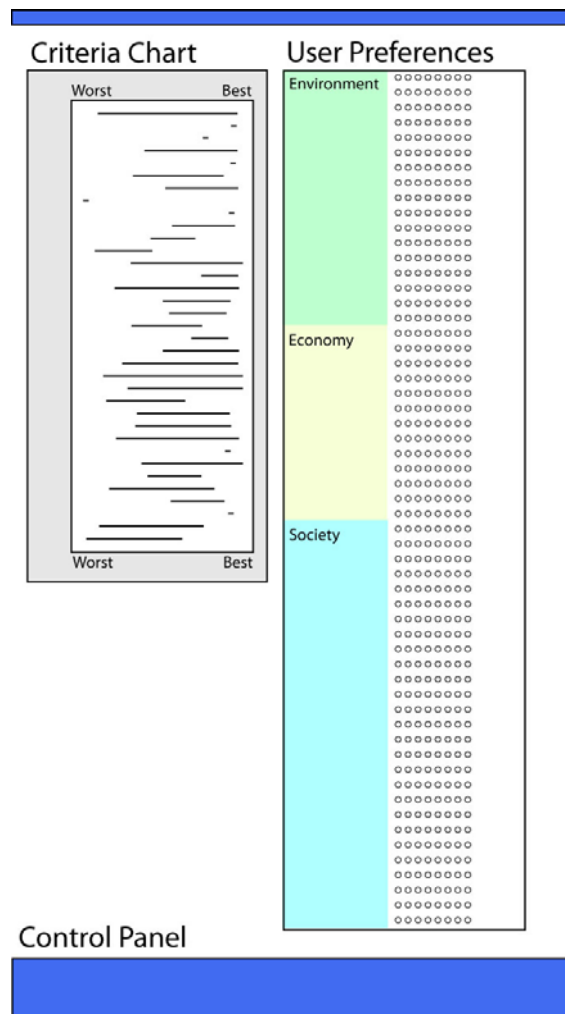
The main screen is made up of three elements.

The top left-hand side shows a chart of horizontal bar graphs called the "Criteria Chart." This displays the performances of the technologies for various sustainability indicators. Here it is possible to select and highlight different technologies.

The right-hand side of the main screen displays the preference selection and is called "User Preferences". There is a column of criteria and horizontal lines of buttons. Selecting a button indicates the level of relative importance given to a criterion within the hierarchy.

Across the bottom of the main screen is a blue tool bar (labeled "Control Panel") that contains the various options and commands for the preference analysis. It also contains links for help and further information.

Figure 1. Schematic diagram of the main screen elements.

User Preferences

A short section of the chart containing the criteria and preference buttons is shown as an example in Figure 2 below.

Figure 2. Example of the criteria and preference buttons in the Preference Chart

The three main indicators of sustainability - **Environment**, **Economy** and **Society** - are the highest level in the criteria hierarchy and are displayed in bold lettering. In Figure 2 it can be seen that the different levels of the hierarchy are also shown by indentation and the intensity of the background color. In this example, "Resources" and "Climate" are the next level in the hierarchy, followed by "Energy" and "Minerals". At the fourth and lowest level are the specific indicators for which actual values have been determined, either by analysis or by expert judgment. However, the full four-level hierarchy system is not always followed. For example the second level criterion "Climate" in Figure 2 leads directly to the fourth level indicator of "CO_2 emissions." And in some places the hierarchical tree does not divide at each level (the criterion "Minerals" leads to only one indicator "Metal Ore"). Because both "Climate" and "Minerals" each have only one indicator they do not require their own preference buttons.

Moving your screen cursor over each criterion will reveal a longer and more descriptive name and the indicator units, as shown below in Figure 3.

Figure 3. "Pop-up" showing longer criterion name.

Preference Selection

To enter your preference for a criterion, you must click on one of the eight buttons on a line. Selecting the leftmost button means that the criterion is entirely ignored (its importance is zero). The remaining seven buttons span the preference range from "vastly less important than average" to "vastly more important than average." Moving your screen cursor over each button will show these levels, as illustrated below in Figure 4. The default setting of the User Preferences block has all of the criteria set to "average importance".

Figure 4. Example of a preference button description for 'Fossil Fuels.'

Please note that it is important to understand the multiplicative nature of the preference scale. The seven buttons ranging from "vastly less" to "vastly more" important than average have relative weights of 1/16, 1/4, 1/2, 1, 2, 4, and 16. This means that for the first two steps above or below average, the preference increases or decreases by a factor of two, and for the last step in each direction by a factor of four. At each level below a branching in the hierarchy these preferences are normalized. The overall weight for each indicator is then calculated by multiplying the preferences down the hierarchy.

For example, assume that Environment, Economy and Society are equally weighted at the highest level as "average." These preferences (1 each) normalize to values of 1/3 each. Suppose that within Environment that Resources and Climate are "more than average"(2) and Ecosystems and Waste are "less than average"(1/2). Then the preferences on this level normalize to values of 0.4, 0.4, 0.1 and 0.1, respectively. If within Resources, Energy is "more than average" and Minerals are "less than average", then the preference values of 2 and ½ normalize to 0.8 and 0.2, and similarly for Fossil Fuels and Uranium (0.8 and 0.2). For this example then the weight for the "Fossil Fuels" indicator is the product of the normalized values calculated for Environment, Resources, Energy and Fossil Fuels, or 0.33 x 0.4 x 0.8 x 0.8 = .0853

We can therefore conclude that it is important to have a sense of balance in selecting preferences. Making all criteria very important will have the same effect as leaving

them all average. It is best to give your preferences in a balanced way, increasing the importance of some criteria and decreasing others.

The process of multiplying preferences down the hierarchy means that the effect of any one indicator is diluted. This is why the preference scale is multiplicative, not linear, and also why the choice is available to ignore a criterion at any level by setting its weight to zero (using the leftmost button). For example, if the leftmost button for the criterion "Economy" is clicked, then the problem will be solved considering only the remaining environmental and social criteria (obviously you cannot ignore all criteria and get a meaningful answer).

The Criteria Chart

The Criteria Chart block on the left side of the main page shows the performance of each electricity generation technology according to the individual, lowest level indicators. Only this level of the hierarchy is shown in the Criteria Chart because, as mentioned above, it is only for these indicators that actual values have been determined, either by scientific analysis or by expert judgment. Figure 5 below shows the top and bottom parts of the Criteria Chart. The indicators in this chart are in the same vertical order as they are displayed in the Preference Chart.
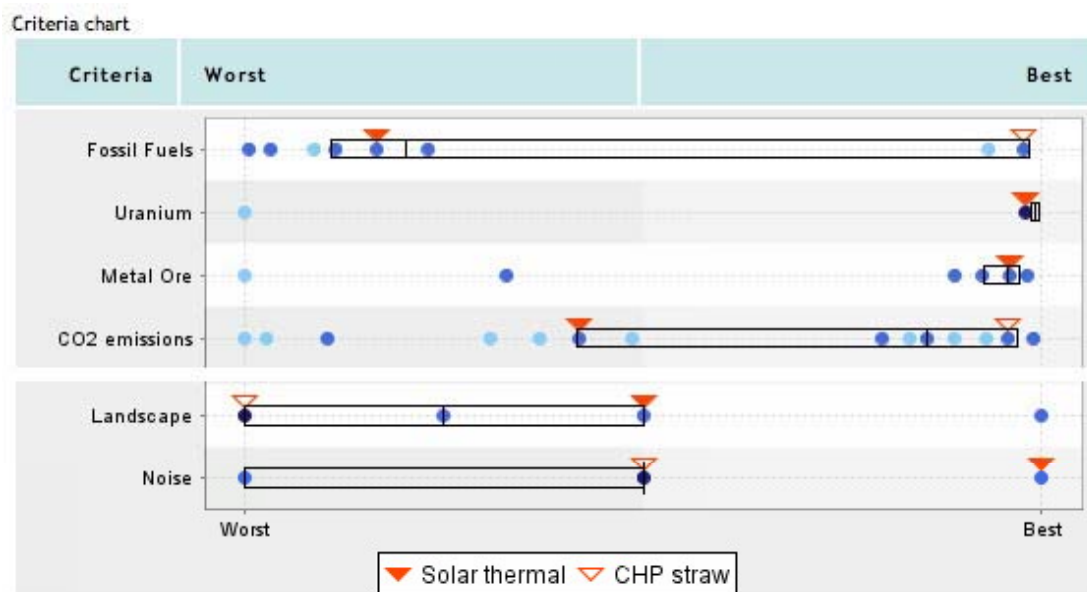
Figure 5. A section of the Criteria Chart showing how the criteria values are presented.

It is important to understand that the individual performance graphs are normalized across the range of results. For example, if an indicator has a range of between 5 (worst) and 10 (best) for all technologies, then the chart is adjusted to a range of 0 to 1. If a higher indicator value means worse performance (e.g. cost or emissions), then the normalized scale is reversed. You will notice that the chart has been arranged so that the worst values are always on the left and the best values are always on the right.

Dots represent technologies. The dots are two different intensities of blue as well as black. This refers to the number of technologies exhibiting very similar performances and therefore occupying the same position: light blue = 1 technology, dark blue = 2 to 8 technologies and black = more than 8 technologies.

The boxes (optional) highlight the technology distribution by quartiles, with the small vertical line inside each box representing the middle (or median) point. This means that 25% of the technologies lie on the outside of the box to the left, 25% are inside the box to the left of its center line, 25% are inside the box to the right of its center line, and 25% are outside the box to the right.

Individual technologies can be flagged by colored triangles, as indicated by the legend at the bottom of Figure 5 above. The default is to show the one or two best technologies for the last two preference sets solved, but you may also optionally flag selected individual technologies.

Again, by moving your cursor over each dot a pop-up window will provide additional information, including the normalized value, short technology name and absolute value. The units are shown at the end of the first line, and are of course the same for all technologies. This is shown below in Figure 6.
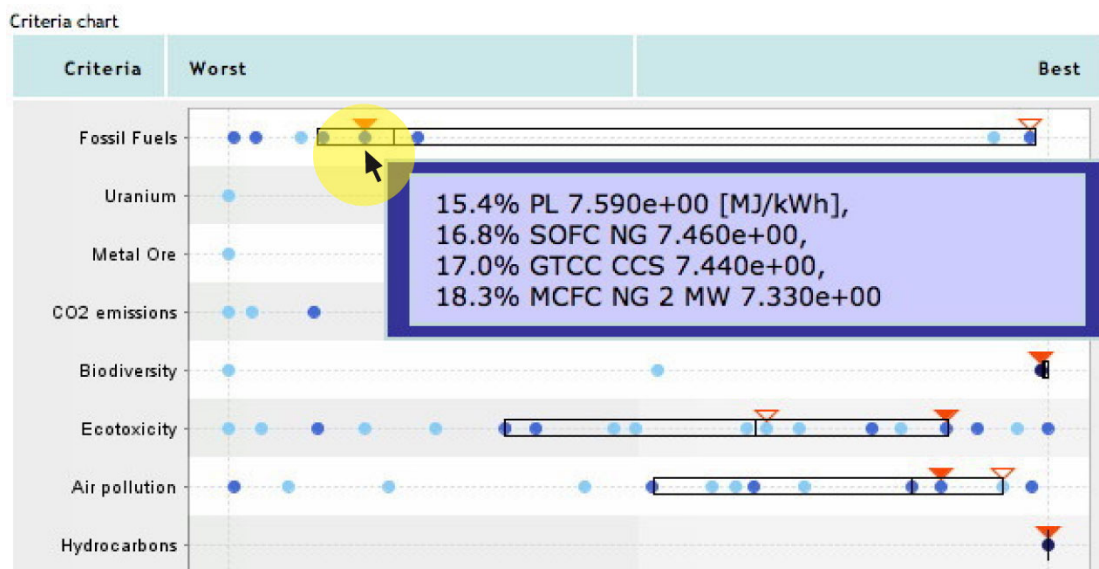
Figure 6. Example of a pop-up window describing technologies located under one dot.

In this example, the cursor is positioned over the solid red triangle showing the "best" technology (MCFC NG = molten carbonate fuel cell, using natural gas). The pop-up window shows that this dot represents four technologies in the 25% to 50% quartile (below the median line). The normalized values for these technologies range from 0.154 to 0.183, and since less fossil fuel use is better, the normalized scale has been reversed and the absolute indicator values range from 7.59 to 7.33 MJ/kWh (units of fossil fuel use). In this example MCFC NG 2MW therefore performs marginally better than the other three. The abbreviated technology names can appear rather confusing (which may also help to anonymize them, thus preserving neutrality during the multi-criteria exercise!), but their full names can easily be displayed. Simply select the "Ranking table" button in the Control Panel at the bottom of the main

screen (see Figure 8 in the following section), which displays both the short and long form of all technology names.

Using the MCA Application

As previously mentioned, the original default setting on the main screen has all preferences set to "average importance". From this basis you can go on to make your own preference selection and observe changes to the ranking. The following guide will help you to arrive at a final ranking result;

1. Select a previous set of preferences (iteration), *if this is not your first session*.

2. Select your preferences, or alter your previous set.

3. Click the pink "Solve" button in the Control Panel (see Figure 8 below).

   - **Note:** Please be sure to click "Solve", which will save your preferences, before selecting any other options.

4. Give a name or add a comment the current preference profile using "Edit the note."

5. Examine the indicator tradeoffs for the currently best technology (as shown by the orange triangle). Which criteria would you like to improve or be willing to compromise? Then click any of the following buttons to see further results:

   - "Ranking chart" – Shows the technologies in ranked order in the form of a bar graph.

   - "Ranking table" – Shows the technology ranking by number and includes the short and long technology names.

   - "Compare by Criteria" - Select a subset of technologies by dragging them from the left column to the right column. Their performances are then shown as a bar chart for the 18 best and 18 worst criteria.

6. In "chart options" (above the Control Panel) technologies can be selected for highlighting by a colored triangle in the Criteria Chart.

7. Repeat. You can enter any number of new preference profiles, or recall a previous profile and modify it. Simply scroll through the iteration list, and then click "Select" to load the saved profile. You can also take a break by hitting the "Logout" button to exit the website, and then return later to continue your analysis.

The final preference profile that you save using "Solve" should be your favorite, as it is the only one we will collect for the survey. Therefore you may have to recall an earlier profile and re-solve it so that it becomes your last one.

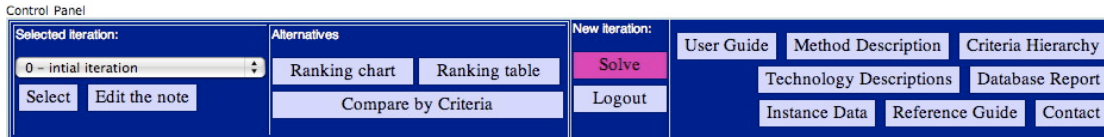Figure 7. MCA application stepwise user guide.

Figure 8. The Control Panel tool bar.

The "Ranking chart" or "Ranking table" buttons in the Control Panel at the bottom of the main screen (see Figure 8 above) display the bar chart and table screens that are shown below in Figure 9. At the right of the Control Panel there are links to various documents for help and reference, including this User Guide. There is also a "Contact" button that you may use to report problems or ask questions.
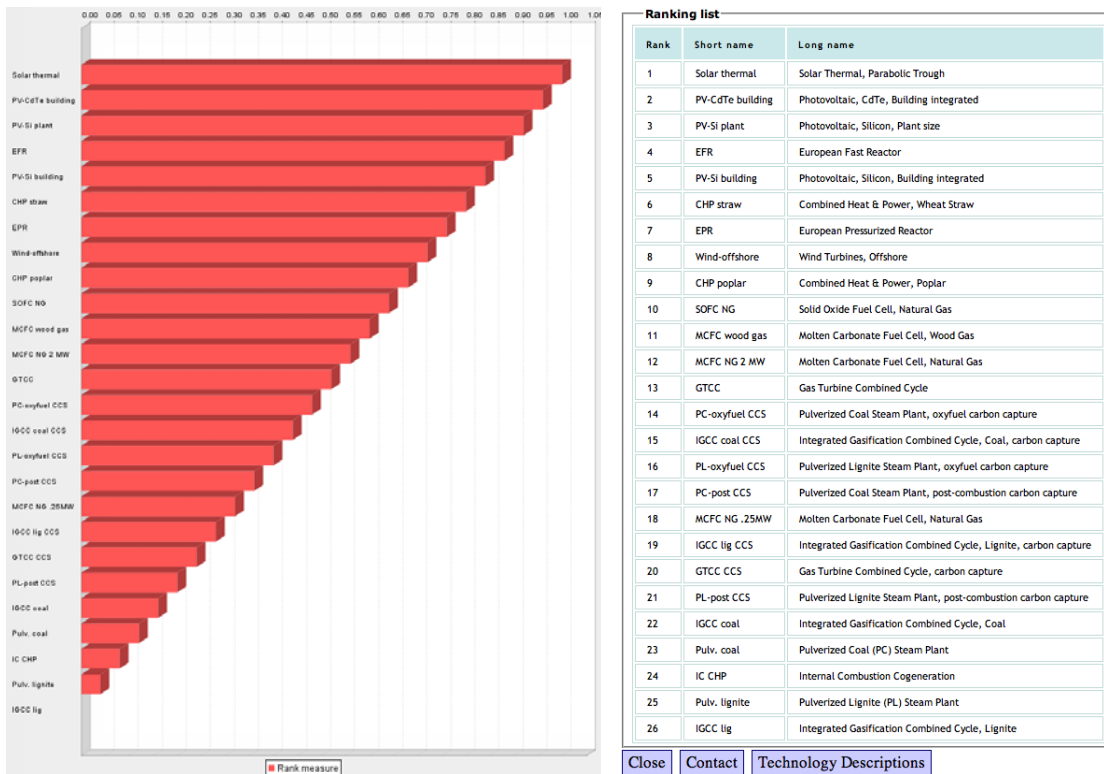

Ranking list

Rank	Short name	Long name
1	Solar thermal	Solar Thermal, Parabolic Trough
2	PV-CdTe building	Photovoltaic, CdTe, Building integrated
3	PV-Si plant	Photovoltaic, Silicon, Plant size
4	EFR	European Fast Reactor
5	PV-Si building	Photovoltaic, Silicon, Building integrated
6	CHP straw	Combined Heat & Power, Wheat Straw
7	EPR	European Pressurized Reactor
8	Wind-offshore	Wind Turbines, Offshore
9	CHP poplar	Combined Heat & Power, Poplar
10	SOFC NG	Solid Oxide Fuel Cell, Natural Gas
11	MCFC wood gas	Molten Carbonate Fuel Cell, Wood Gas
12	MCFC NG 2 MW	Molten Carbonate Fuel Cell, Natural Gas
13	GTCC	Gas Turbine Combined Cycle
14	PC-oxyfuel CCS	Pulverized Coal Steam Plant, oxyfuel carbon capture
15	IGCC coal CCS	Integrated Gasification Combined Cycle, Coal, carbon capture
16	PL-oxyfuel CCS	Pulverized Lignite Steam Plant, oxyfuel carbon capture
17	PC-post CCS	Pulverized Coal Steam Plant, post-combustion carbon capture
18	MCFC NG .25MW	Molten Carbonate Fuel Cell, Natural Gas
19	IGCC lig CCS	Integrated Gasification Combined Cycle, Lignite, carbon capture
20	GTCC CCS	Gas Turbine Combined Cycle, carbon capture
21	PL-post CCS	Pulverized Lignite Steam Plant, post-combustion carbon capture
22	IGCC coal	Integrated Gasification Combined Cycle, Coal
23	Pulv. coal	Pulverized Coal (PC) Steam Plant
24	IC CHP	Internal Combustion Cogeneration
25	Pulv. lignite	Pulverized Lignite (PL) Steam Plant
26	IGCC lig	Integrated Gasification Combined Cycle, Lignite

Close   Contact   Technology Descriptions

Figure 9. The Ranking Graph and Ranking Table screens.

Advanced Analysis

There are many different ways of using the MCA application and it has been designed to enable you to experiment and to expand your understanding of the interactions and tradeoffs between the 36 sustainability indicators.

Creating a set of preferences (or preference profile) can be done in several ways;

- Bottom-up Strategy: Some people prefer to select their preferences starting with the lowest level indicators first. What is learned from balancing the indicators against each other may then help you to choose your preferences at higher criteria levels.

- Top-down Strategy: Other people prefer to begin with the highest level criteria (environment, economy and society) and work their way down the criteria hierarchy, based on their overall perspective of the various aspects of sustainability. Lower level preferences must still be balanced relative to others on the same level of the hierarchy branch.

- Technology Profile: Experiment with different preference profiles to learn which preferences promote different groups of technologies, e.g. renewables, nuclear or fossil. Technology choices should be based on indicator preferences, and not vice versa, so this is best viewed as a learning tool on how preferences and technologies are linked together.

- Indicator Tradeoffs: Survey the indicator performance for the current "best" technology to see where you think it performs the worst (and best). Then increase your preference weight on the worst indicators, or decrease the weight on indicators where the performance is better than you think necessary.

Please remember, you are free to access and run the application as often as you like BUT you should leave your best/preferred preference profile as the last one. This will then be used by us in the analysis after we collect the survey data.

If your preferred preference profile is one of your previous ones then simply select it, "solve" it again and then rename it as the final choice.

PLEASE NOTE:

For a more complete and technical explanation of all aspects of the MCA application, please refer to the "Reference Guide" via the link in the blue Control Panel. The "Contact" link will also provide you with the contact information of those overseeing the survey stage of the NEEDS project.