BIRDS Tutorial

BIRDS is a web-application designed for sustainability performance (energy, cost, and environmental impacts) comparisons for eleven different U.S. commercial building types. BIRDS provides the framework to take an initial building design and make comparisons across different locations, energy standard editions, and/or study periods.

The comparison process has four steps:

1. Select the building prototype to evaluate.
2. Select baseline values and alternatives for comparison (location, standard edition, and study period).
3. Select baseline and alternative weighting preferences for environmental performance.
4. View results graph and data.

BIRDS begins on the "BIRDS-Overview" tab shown in Figure 1-1, which describes the basic information about the purpose of the tool. Once a user is familiar with the purpose of the tool, the user can begin the evaluation process.

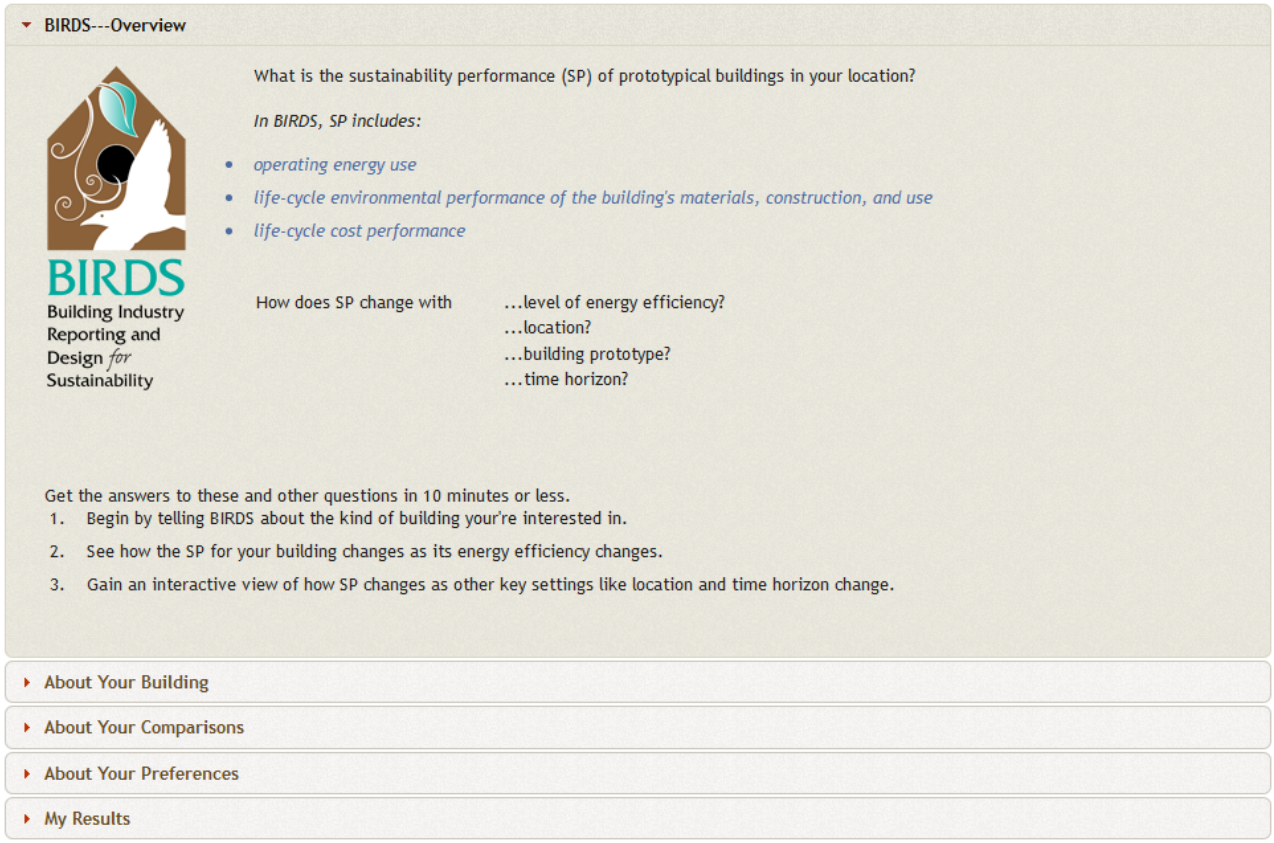


Figure 1-1 BIRDS Overview

1.1 Selecting Building Prototype

From the "BIRDS – Overview" tab the user clicks on the "About Your Building" tab. The section expands, as shown in Figure 1-2. The user selects the My Building Prototype information by selecting Building Type and Number of Floors from the dropdown menus. Note that only apartments, dormitories, and office buildings have more than one option for the number of floors. The remaining building types have a default number of floors.

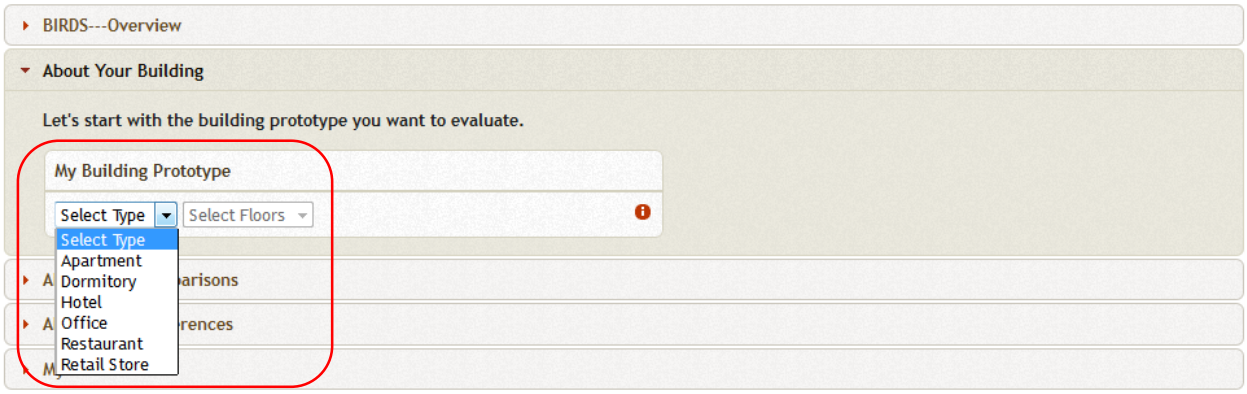


Figure 1-2 Selecting Building Prototype

By clicking on the red information icon, the building details are expanded as shown in Figure 1-3. After selecting the building type the user wants to analyze, it is time to select what the user wants to compare.

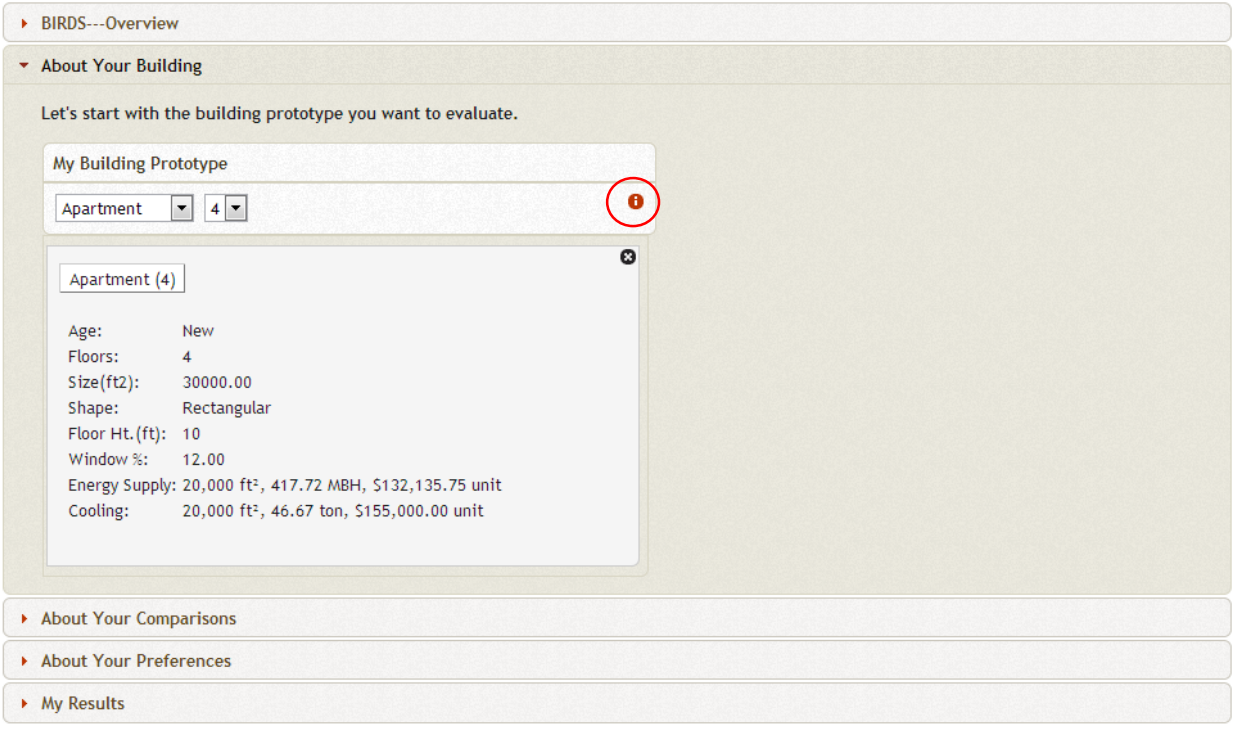


Figure 1-3 Building Prototype Details

1.2 Selecting Comparisons

Clicking on the "About Your Comparisons" tab displays dropdown menus for the preferred Baseline Values for the building's State, City, Standard Edition, and Study Period as shown in Figure 1-4. These are the baseline values that will be used for all comparisons. Note that all baseline values must be defined or an error will occur in the results. For illustration purposes, the Baseline Values are Anchorage, Alaska, using *ASHRAE 90.1-1999* and a 10-year study period.

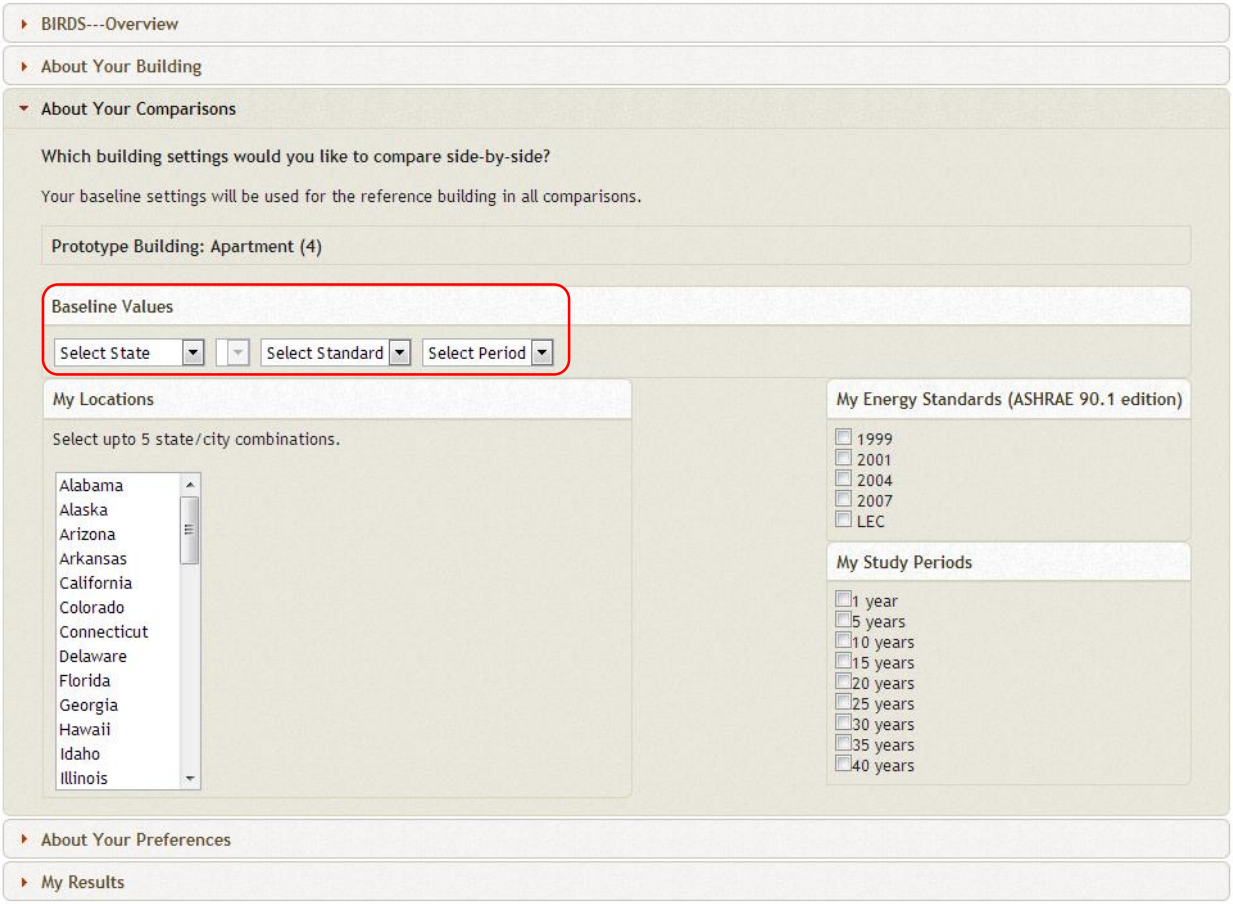


Figure 1-4 Selecting Comparisons

Next, the user can select alternative locations for comparison. After selecting a state from the scroll box, a checkbox list of available cities in that state will appear. The city/state combination will be added to the list to the right, which can contain up to 5 locations for comparison, as shown in Figure 1-5. The user can select up to 5 alternative Energy Standard editions from the checkbox list at the top right, which include *ASHRAE Standards 90.1-1999, 90.1-20*01, *90.1-2004*, *90.1-2007*, and a Low Energy Case (LEC) based on *ASHRAE 189.1-2009*. Finally, the user can select up to 9 alternative Study Periods in the checkbox list at the bottom right, which range from 1 year to 40 years. Once the user has defined the baseline values and the alternative values for comparison, the user needs to define environmental weighting preferences.

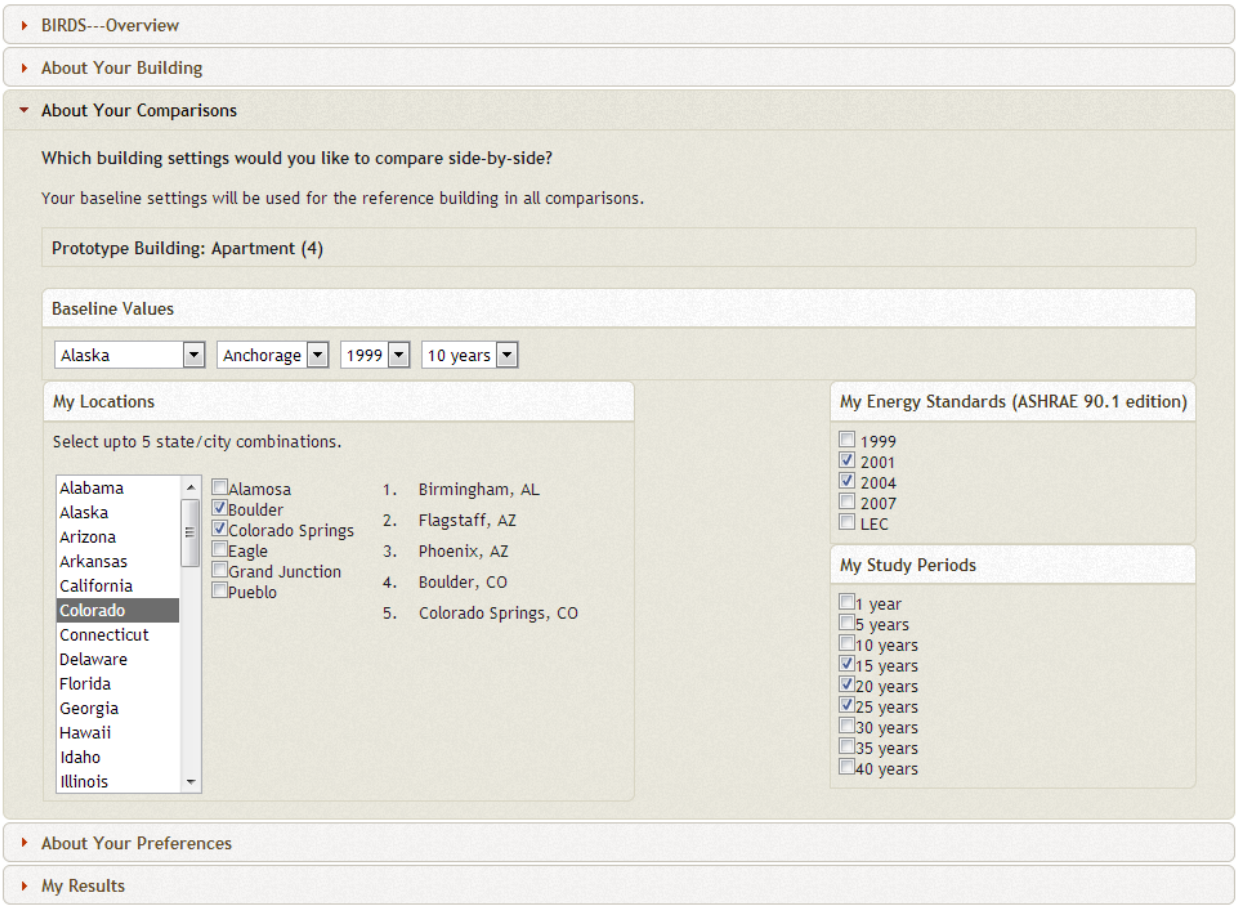


Figure 1-5 Selecting Alternative Locations, Energy Standard Editions, and Study Periods

1.3 Selecting Environmental Weighting Preferences

Clicking on the "About Your Preferences" section displays the Baseline Environmental Impact Weightset dropdown menu, which includes 5 options as shown in Figure 1-6. Below the Baseline Weightset are the alternative weight-sets that will be available for comparison. By selecting the red information icon in the Pre-defined weights, the user can view the environmental impact values for pre-defined weight-sets.

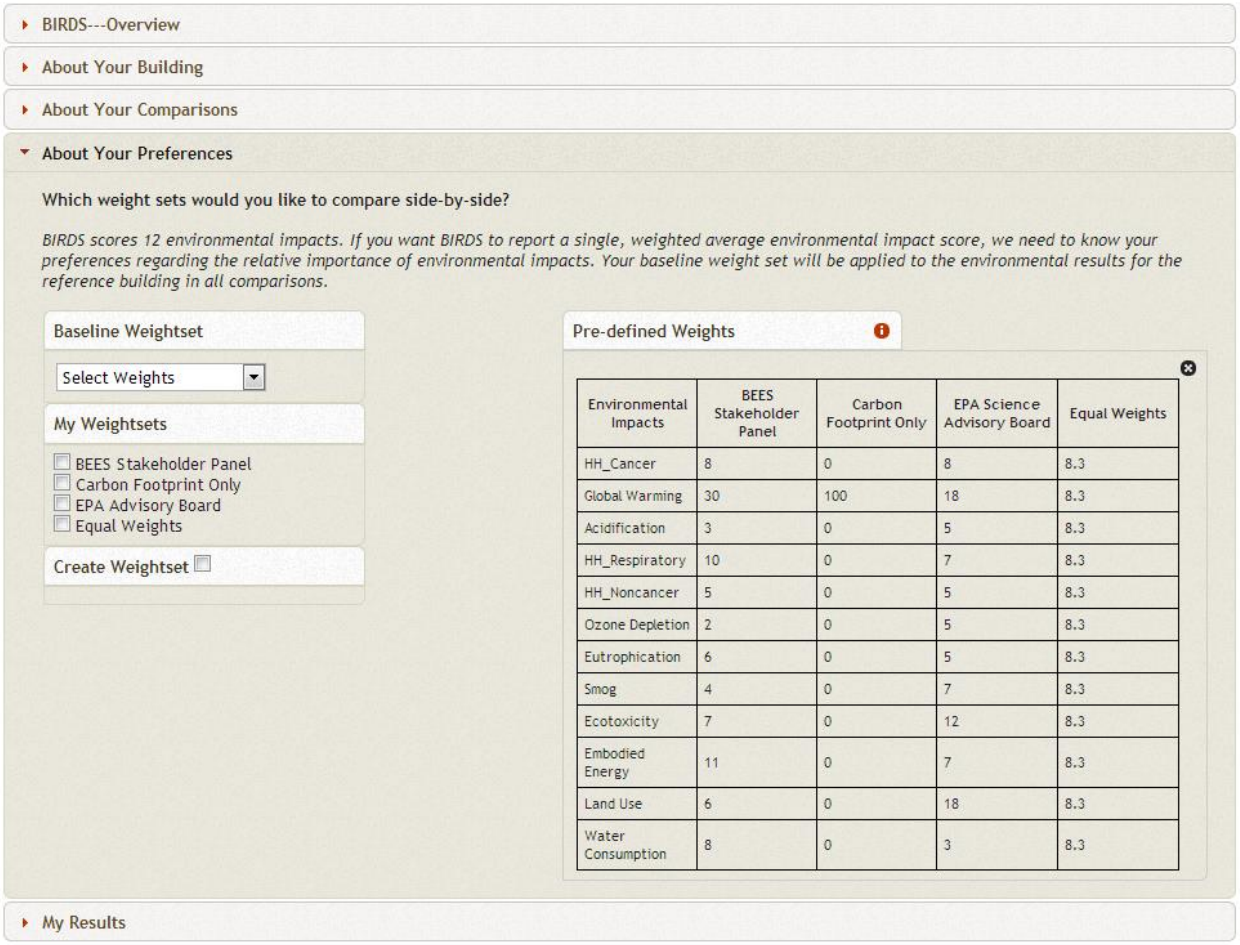
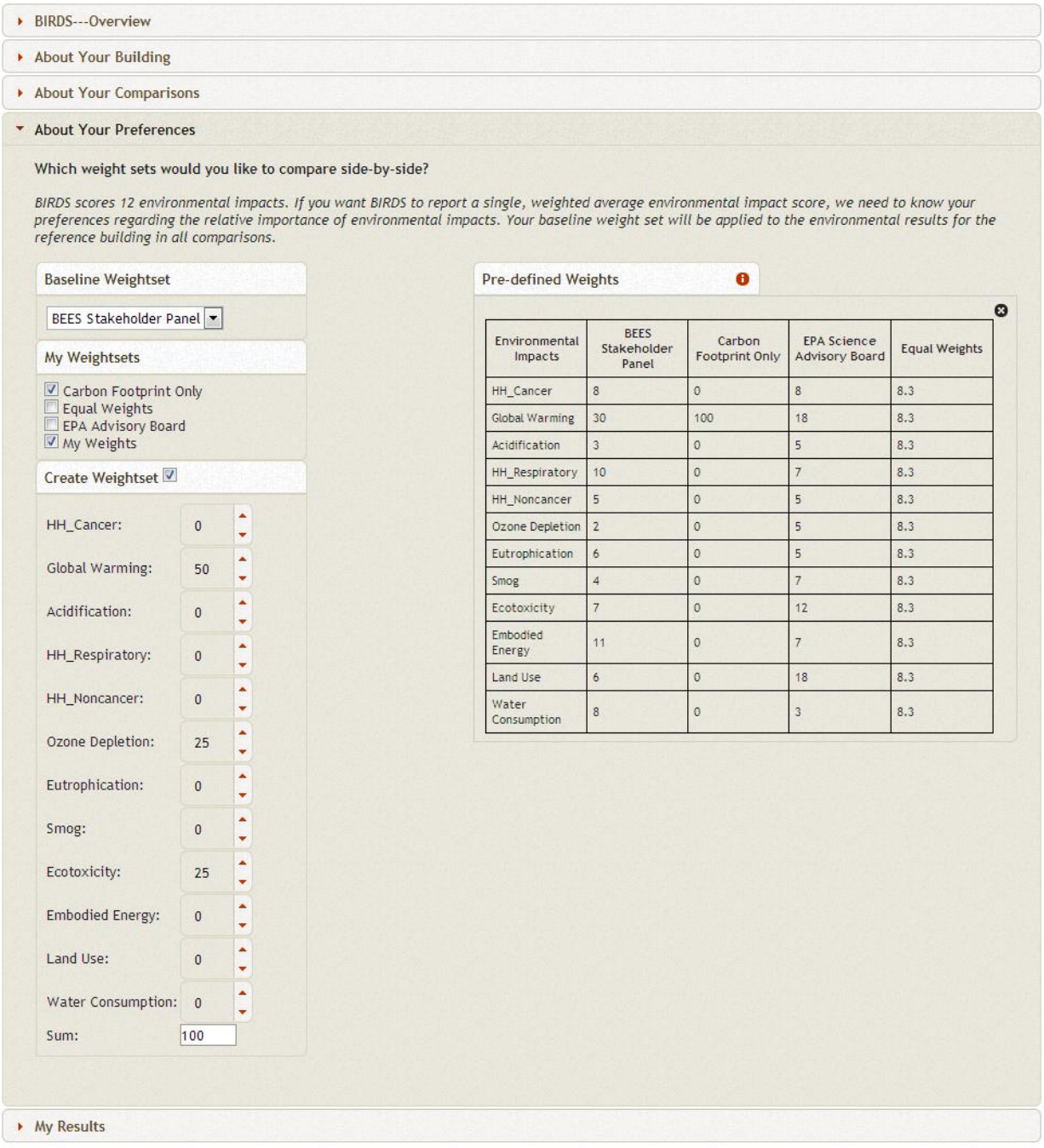


Figure 1-6 Selecting Environmental Weighting Preferences

The user is given flexibility to create a custom weight-set by checking the Create Weightset checkbox, which can be used as the baseline or as an alternative. As shown in Figure 1-7, checking the box brings up a list of the 12 environmental impact categories. Each category must be given a weight between 0 and 100, with the sum of all 12 weights adding up to 100. Once a custom weight-set is defined it will become a selection available in the Baseline Weightset dropdown and as a checkbox in the My Weightsets alternative options. At this point, all the necessary user inputs have been defined and the user can now look at the results.



Environmental Impacts	BEES Stakeholder Panel	Carbon Footprint Only	EPA Science Advisory Board	Equal Weights
HH_Cancer	8	0	8	8.3
Global Warming	30	100	18	8.3
Acidification	3	0	5	8.3
HH_Respiratory	10	0	7	8.3
HH_Noncancer	5	0	5	8.3
Ozone Depletion	2	0	5	8.3
Eutrophication	6	0	5	8.3
Smog	4	0	7	8.3
Ecotoxicity	7	0	12	8.3
Embodied Energy	11	0	7	8.3
Land Use	6	0	18	8.3
Water Consumption	8	0	3	8.3

Figure 1-7 Defining a Custom Weightset

1.4 Viewing Results

Clicking on the "My Results" tab will display the "Select Chart Options" section. Three different chart types are available in the application: Life-Cycle Cost, Operating Energy, or Environmental Impact Score (EIS). As shown in Figure 1-8, the user must select the Chart Type from the dropdown menu, the Baseline for the comparison to be made, and the Units in which the user prefers the results. Note that the units include a per unit of floor area impact, which is only

reported in square feet and not square meters because the tool is designed for use domestically, which predominantly uses I-P unit instead of metric units.

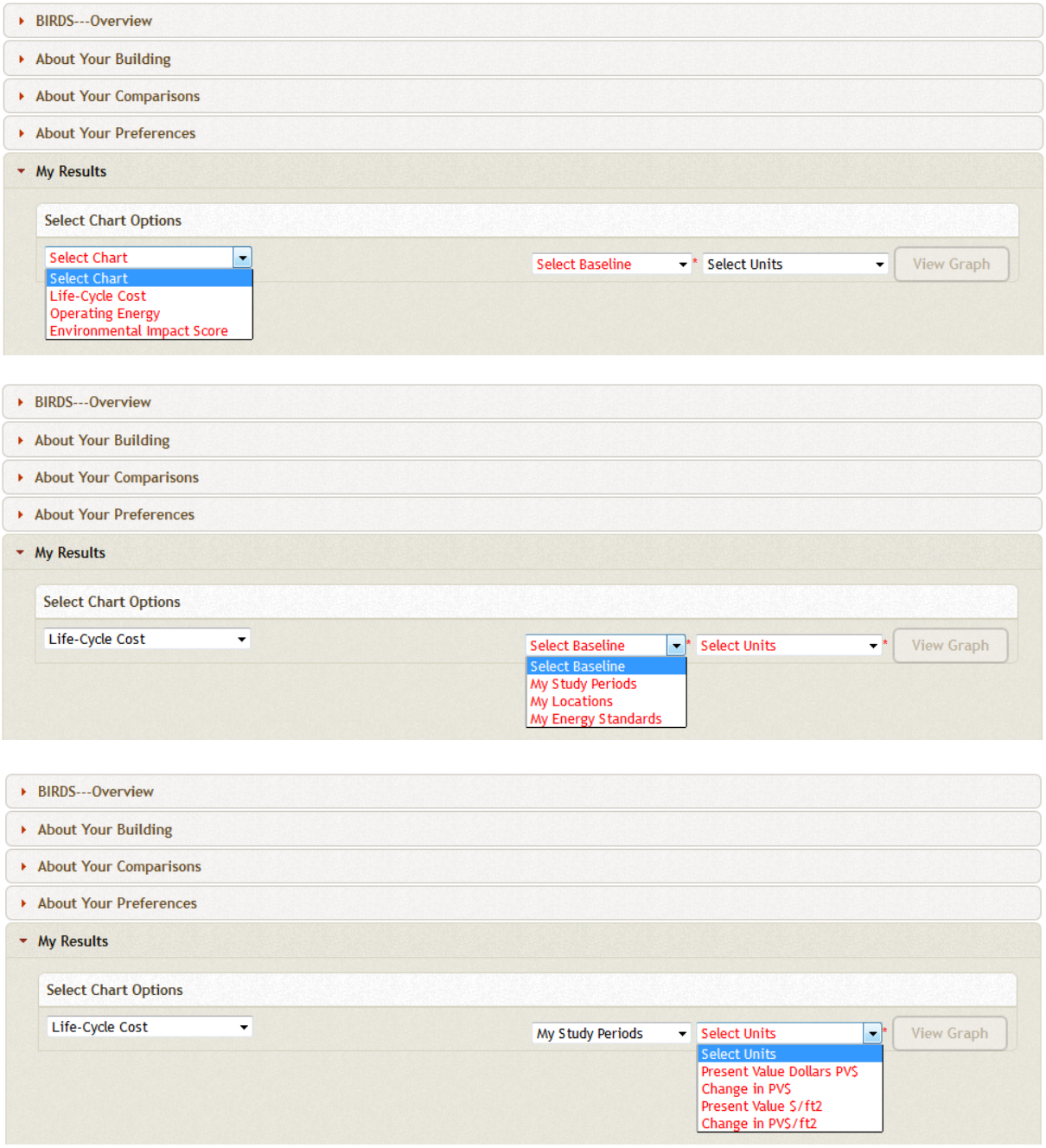
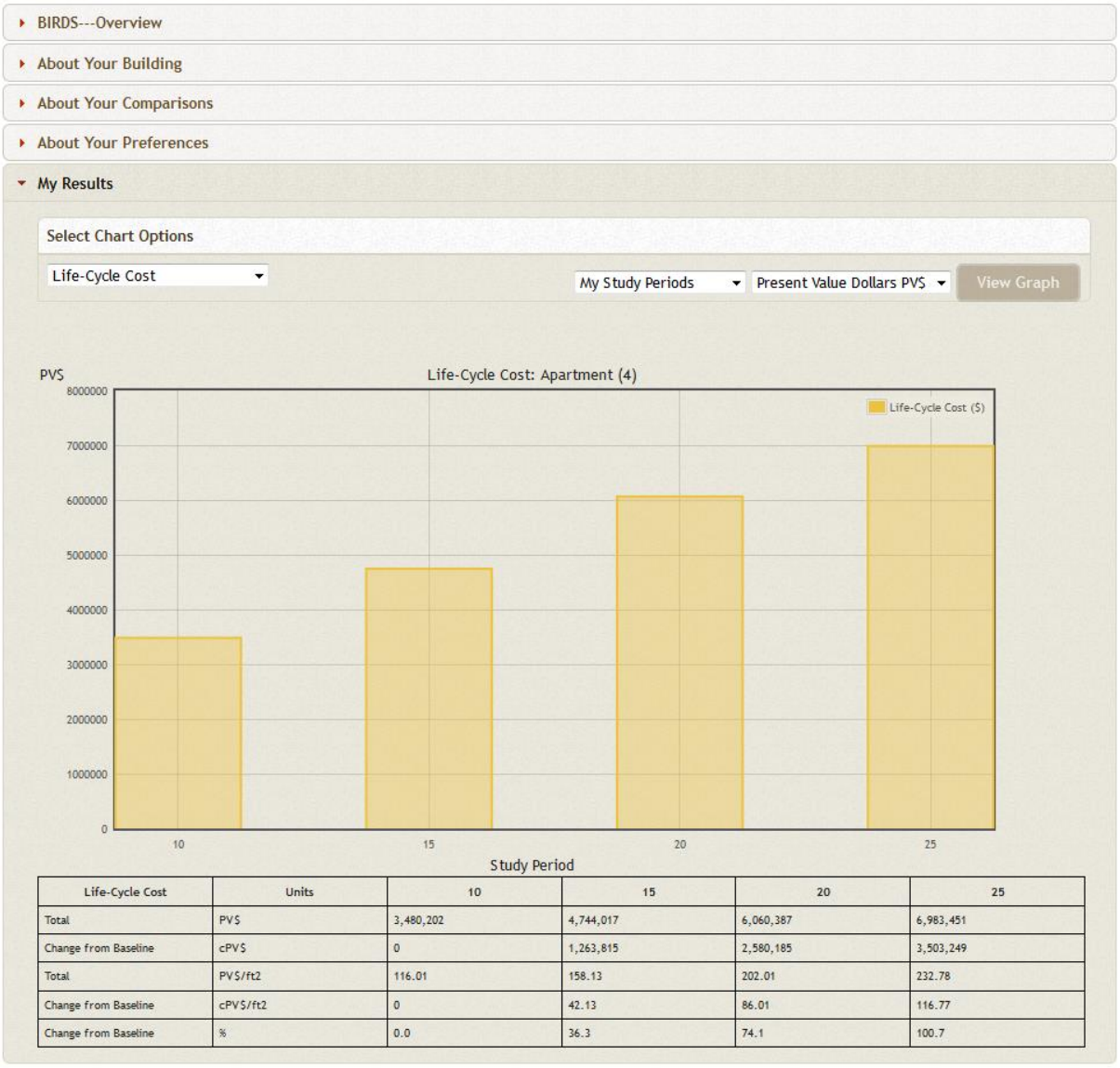


Figure 1-8 Selecting Chart Options

Once the user has made these selections, the user presses the "View Graph" button. The graph with corresponding data table is displayed. Figure 1-9 shows an example of the Life-Cycle Cost results with a graph of the total life-cycle costs in present value dollars for a 4-story apartment building built to meet *ASHRAE 90.1-1999* across the different study periods selected by the user

(10, 15, 20, and 25 years). As can be seen in the graph, total present value life-cycle costs increase as the study period increases in length, which is a result of additional operational energy costs and maintenance, repair, and replacement costs during those additional years.



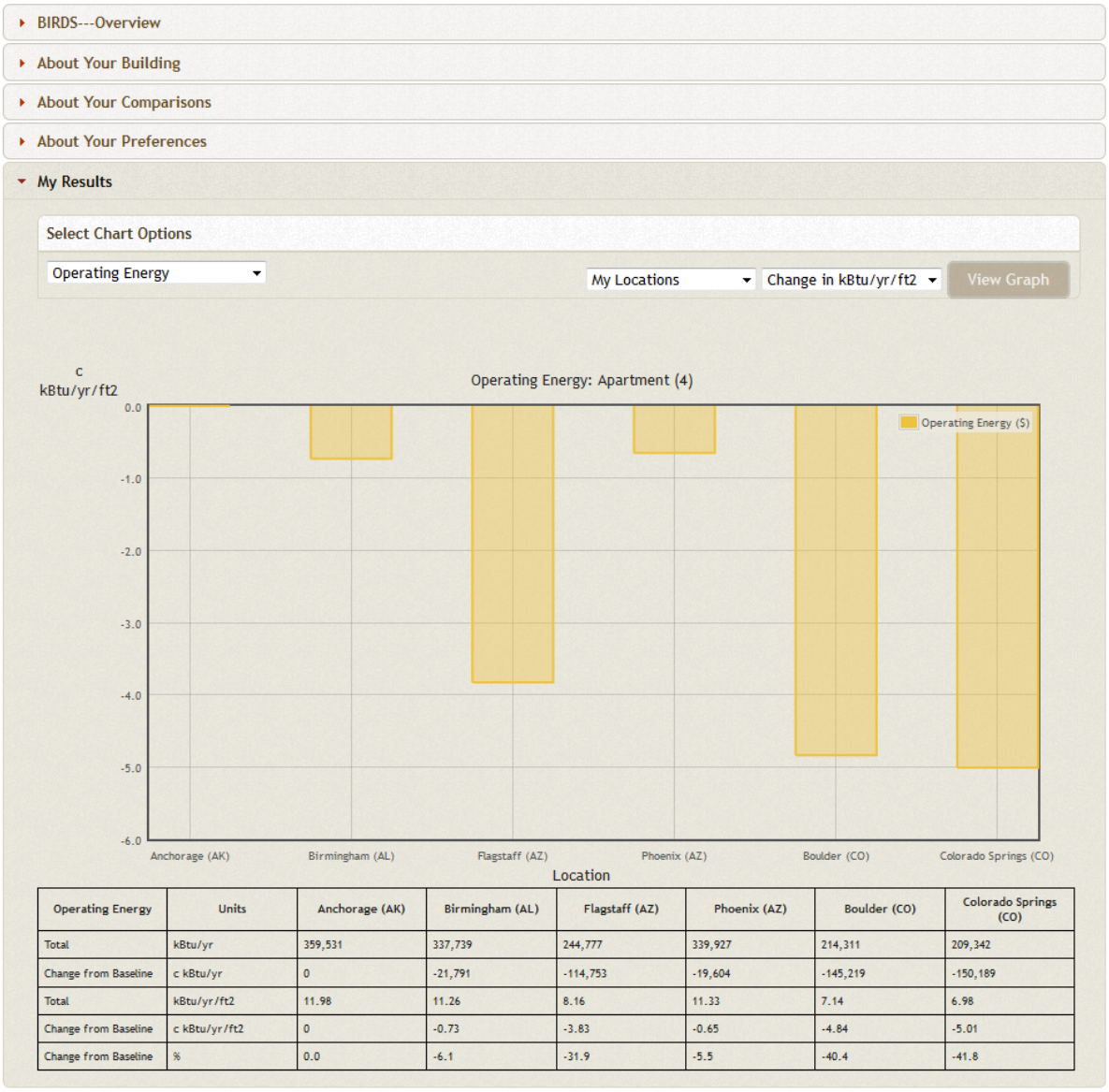
Life-Cycle Cost	Units	10	15	20	25
Total	PV$	3,480,202	4,744,017	6,060,387	6,983,451
Change from Baseline	cPV$	0	1,263,815	2,580,185	3,503,249
Total	PV$/ft2	116.01	158.13	202.01	232.78
Change from Baseline	cPV$/ft2	0	42.13	86.01	116.77
Change from Baseline	%	0.0	36.3	74.1	100.7

Figure 1-9 Life-Cycle Cost Graph

The data table is more comprehensive, and includes all of the potential metrics available for comparisons across study periods for the baseline location, which include total life-cycle costs, change in total life-cycle costs relative to the 10-year baseline, total life-cycle costs per square foot of floor area, change in total life-cycle costs from the baseline per square foot of floor area, and percentage change in life-cycle costs relative to the 10-year baseline.

Figure 1-10 shows an example of the Operating Energy results with a graph of the change in annual energy consumption per square foot of floor area for a 4-story apartment building built to

meet *ASHRAE 90.1-1999* across the different locations selected by the user, including cities in Alabama, Alaska, Arizona, and Colorado. As can be seen in the graph, Anchorage, Alaska consumes more energy per unit of floor area than any of the other cities considered in the analysis. Colorado Springs consumes 5 kBtu/year/ft^2 less energy than the same building in Anchorage.

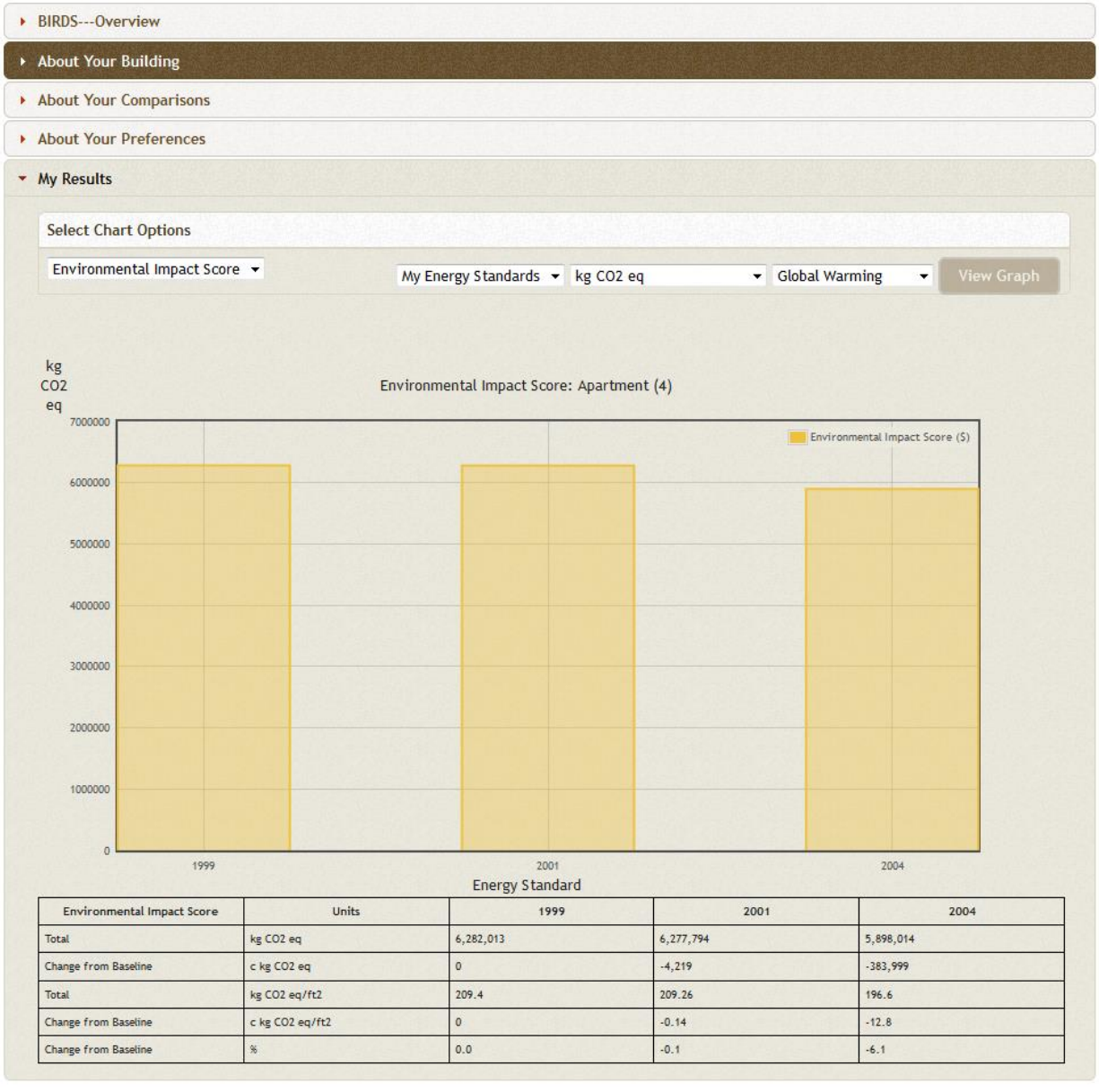


Operating Energy	Units	Anchorage (AK)	Birmingham (AL)	Flagstaff (AZ)	Phoenix (AZ)	Boulder (CO)	Colorado Springs (CO)
Total	kBtu/yr	359,531	337,739	244,777	339,927	214,311	209,342
Change from Baseline	c kBtu/yr	0	-21,791	-114,753	-19,604	-145,219	-150,189
Total	kBtu/yr/ft2	11.98	11.26	8.16	11.33	7.14	6.98
Change from Baseline	c kBtu/yr/ft2	0	-0.73	-3.83	-0.65	-4.84	-5.01
Change from Baseline	%	0.0	-6.1	-31.9	-5.5	-40.4	-41.8

Figure 1-10 Operating Energy Consumption Graph

The data table shows all the metrics a user can use for comparisons: total annual energy consumption, change in total annual energy consumption, total annual energy consumption per square foot of floor area, change in total annual energy consumption per square foot of floor area, and percentage change in energy consumption relative to the baseline.

When the EIS Chart is selected an additional drop down menu is displayed that allows the user to select either the EIS or the total flows for one of the 12 environmental impact categories. Figure 1-11 shows a graph of the total global warming potential impacts in kilograms of CO_2e emissions. The newest edition of *ASHRAE 90.1* considered in the analysis (*ASHRAE 90.1-2004*) realizes the lowest impact on global warming potential. The data table shows all the metrics a user can use for comparisons: total CO_2e flows, change in total CO_2e flows, total CO_2e flows per square foot of floor area, change in total CO_2e flows per square foot of floor area, and percentage change in total flows relative to the total flows for the baseline.



Environmental Impact Score	Units	1999	2001	2004
Total	kg CO2 eq	6,282,013	6,277,794	5,898,014
Change from Baseline	c kg CO2 eq	0	-4,219	-383,999
Total	kg CO2 eq/ft2	209.4	209.26	196.6
Change from Baseline	c kg CO2 eq/ft2	0	-0.14	-12.8
Change from Baseline	%	0.0	-0.1	-6.1

Figure 1-11 Environmental Impact – Global Warming Potential Graph

Limitations and Future Research

BIRDS is limited in scope and would be strengthened by including uncertainty analysis, expanding the database and metrics, and adding design flexibility to the tool.

Uncertainty analysis is needed for at least three elements of the analysis. First, consider the assumed discount rate. Although 3 % is a reasonable discount rate, in real terms, for federal government investment decisions, it may be too low of a value for an expected real return on an alternative investment in the private sector. Sensitivity analysis on the assumed discount rate is needed to determine the robustness of the cost results. Second, the current analysis assumes that building cooling loads are met by equipment running on electricity while heating loads are met by equipment running on natural gas, which is not the typical fuel mix for some areas of the nation. The database should be expanded to include alternative fuel source options, such as heating oil use in the New England area. Third, the BIRDS environmental impact scores do not incorporate uncertainty analysis as required by international standards (ISO, 2006). While incorporating uncertainty analysis is problematic due to a lack of underlying uncertainty data, this omission should be brought into the interpretation of the BIRDS results.

Additional data are needed to refine and expand the BIRDS database. The 11 prototypical buildings analyzed in this study may not be representative of the entire building stock for each building type. For example, all high-rise buildings are not 100 % glazed. For this reason, the results should be considered as general magnitudes for making reasonable comparisons instead of hard numbers. Future research should include additional prototypes, such as the DOE Benchmark Buildings, in the database. Additionally, since existing buildings account for nearly the entire building stock, prototypes for energy retrofits to buildings should be incorporated into the BIRDS database as well. The state average energy cost rates and energy-related carbon emissions rates do not control for local variation in energy tariffs or electricity fuel mixes. By using utility-level energy cost and emissions rate data, the accuracy of the estimates in BIRDS could be improved.

The analysis in this study ignores the impacts that plug and process loads have on the reductions in energy use. Buildings with greater plug and process loads will realize smaller percentage changes in energy use because the energy efficiency measures considered in this study focus on the building envelope and HVAC equipment, holding constant the energy use from other equipment used in the building. As building energy efficiency improves, the plug and process loads become a larger fraction of the overall energy load. Future research should consider the impact the assumed plug and process loads have on the overall energy savings realized by energy efficiency improvements to buildings.

Properly interpreting the BIRDS environmental performance results requires placing them in perspective. The environmental impact scores assess the life-cycle impacts of operating energy

use based on inventories of localized energy simulation results and regional electricity grids. All other elements of the scores—including a building's use of materials and its water consumption over the study period—are based on U.S. average life-cycle inventory data for prototypical buildings. The baseline data for these buildings represent status quo building technologies as of 2002, the year of the latest available input-output data from the U.S. Bureau of Economic Analysis. To account for evolution in status quo technologies over time, future versions of BIRDS should incorporate newer releases of these data as they become available.

The BIRDS results do not apply to buildings constructed in other countries where industry practices, fuel mixes, environmental regulations, transportation distances, and labor and material markets may differ. Furthermore, all buildings of a given type are not created equal. Building designs, sizes, useful lives, materials compositions, and costs will all vary for an individual building. The BIRDS results for a building prototype do not necessarily represent the performance of an individual building of that type. Future versions of the tool should permit flexibility in building design and use of materials.

The BIRDS LCAs use selected inventory flows converted to selected local, regional, and global environmental impacts to assess environmental performance. Those inventory flows which currently do not have scientifically proven or quantifiable impacts on the environment are excluded, such as mineral extraction and wood harvesting which are qualitatively thought to lead to loss of habitat and an accompanying loss of biodiversity. If the BIRDS user has important knowledge about these issues, it should be brought into the interpretation of the BIRDS results.

The Environmental Problems approach that BIRDS uses for impact assessment does not offer the same degree of relevance for all environmental impacts. For global and regional effects (e.g., global warming and acidification) the method may result in an accurate description of the potential impact. For impacts dependent upon local conditions (e.g., smog, ecological toxicity, and human health impacts) it may result in an oversimplification of the actual impacts because the indices are not tailored to localities.

Life cycle impact assessment is a rapidly evolving science. Assessment methods unheard of a decade ago have since been developed and are now being used routinely in LCAs. While BIRDS incorporates state-of-the-art impact assessment methods, the science will continue to evolve and methods in use today—particularly those for land and water use—are likely to change and improve over time. Future versions of BIRDS should incorporate these improved methods as they become available.

During the interpretation step of the BIRDS LCAs, environmental impact results are optionally combined into a single environmental performance score using relative importance weights. These weights necessarily incorporate values and subjectivity. BIRDS users should routinely test the effects on the environmental impact scores of changes in the set of importance weights.

Energy, environmental, and economic performance are but three attributes of building performance. The BIRDS model assumes that its building prototypes all meet minimum technical performance requirements. However, there may be significant differences in technical performance not evaluated in BIRDS, such as acoustic or fire performance, which may outweigh energy, environmental, and economic considerations.