

NIST Technical Note 1880

Building Industry Reporting and Design for Sustainability (BIRDS) Tutorial for New Residential Database

Joshua Kneifel
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U.S. Department of Commerce
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Abstract

Building stakeholders need practical metrics, data, and tools to support decisions related to sustainable building designs, technologies, standards, and codes. The Engineering Laboratory of the National Institute of Standards and Technology (NIST) has addressed this high priority national need by extending its metrics and tools for sustainable building products, known as Building for Environmental and Economic Sustainability (BEES), to whole buildings. Whole building sustainability metrics have been developed based on innovative extensions to life-cycle assessment (LCA) and life-cycle costing (LCC) approaches involving whole building energy simulations. The measurement system evaluates the sustainability of both the materials and the energy used by standardized buildings over time. It assesses the “carbon footprint” of buildings as well as 11 other environmental performance metrics, and integrates economic performance metrics to yield science-based measures of the business case for investment choices in high-performance green buildings.

Building Industry Reporting and Design for Sustainability (BIRDS) applies the new sustainability measurement system to an extensive whole building performance database NIST has compiled for this purpose. The BIRDS new residential building database includes energy, environmental, and cost measurements, covering 10 single-family dwellings (5 one-story and 5 two-story of varying conditioned floor area) in 228 cities across all U.S. states for a total of 9120 new residential building combinations for study period lengths ranging from 1 year to 40 years. The sustainability performance of buildings designed to meet current state energy codes can be compared to their performance when meeting three alternative building energy standard editions to determine the impact of energy efficiency on sustainability performance. The impact of the building location and the investor’s time horizon on sustainability performance can also be measured.

This document is a tutorial to assist BIRDS users in understanding and using the BIRDS New Residential Buildings Database Web Interface, including detailed definitions for and explanation for the purpose of each input and output option.

Keywords

Building economics; economic analysis; life-cycle costing; life-cycle assessment; energy efficiency; residential buildings

Preface

This study was conducted by the Applied Economics Office (AEO) in the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST). The BIRDS new residential database web interface is designed to assess the sustainability performance (energy, environmental, and cost impacts) of the adoption of new residential building designs. The intended audience is users of BIRDS, such as researchers and decision makers in the residential building sector, and others interested in building sustainability.

Disclaimers

The policy of the National Institute of Standards and Technology is to use metric units in all of its published materials. Because this report is intended for the U.S. construction industry that uses U.S. customary units, it is more practical to include U.S. customary units as well as metric units. Measurement values in this report are therefore stated in metric units first, followed by the corresponding values in U.S. customary units within parentheses.

Acknowledgements

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List of Acronyms

Acronym	Definition
AEO	Applied Economics Office
BEES	Building for Environmental and Economic Sustainability
BIRDS	Building Industry Reporting and Design for Sustainability
CO ₂ e	carbon dioxide equivalent
EIS	Environmental Impact Score
EL	Engineering Laboratory
EPA	Environmental Protection Agency
FAQ	Frequently Asked Questions
HVAC	Heating, Ventilation, and Air Conditioning
IECC	International Energy Conservation Code
I-O	input-output
ISO	International Organization for Standardization
LCA	Life-Cycle Assessment
LCC	Life-Cycle Cost
NIST	National Institute of Standards and Technology
NZERTF	Net-Zero Energy Residential Test Facility
SFD	Single-Family Detached

1 Introduction

A wave of interest in sustainability gathered momentum in 1992 with the Rio Earth Summit, during which the international community agreed upon a definition of sustainability in the Brundtland report: “meeting the needs of the present generation without compromising the ability of future generations to meet their own needs” (Brundtland, 1987). In the context of sustainable development, needs can be thought to include the often-conflicting goals of environmental quality, economic well-being, and social justice. While the intent of the 1992 summit was to initiate environmental and social progress, it seemed to have instead brought about greater debate over the inherent conflict between sustainability and economic development.

This conflict is particularly apparent within the construction industry. Frequently, well-intentioned green development plans are not executed for economic reasons, and economic development plans fail to materialize over concerns for the environment and public health. Thus, an integrated approach to sustainable construction—one that simultaneously considers both environmental and economic performance—lies at the heart of reconciling the conflict. For this reason, building stakeholders need practical metrics, data, and tools to support decisions related to sustainable building designs, technologies, standards, and codes that consider both the environmental and economic dimensions of sustainability.

The Engineering Laboratory (EL) of the National Institute of Standards and Technology (NIST) has addressed this high priority national need by extending its metrics and tools for sustainable building products, known as Building for Environmental and Economic Sustainability (BEES) (BEES 2010), to whole buildings. Whole building sustainability metrics have been developed based on innovative extensions to life-cycle assessment (LCA) and life-cycle costing (LCC) approaches involving whole building energy simulations. The measurement system evaluates the sustainability of both the construction materials and the energy used by a building over time. It assesses the “carbon footprint” of buildings as well as 11 other environmental performance metrics, and integrates economic performance metrics to yield science-based measures of the business case for investment choices in high-performance green buildings. The BEES approach does not consider the social dimension of sustainability due to the current lack of rigorous measurement methods.

The approach developed for BEES has now been applied at the whole building level to address building sustainability measurement in an integrated manner that considers complex interactions among building materials, energy technologies, and systems across dimensions of performance, scale, and time. Building Industry Reporting and Design for Sustainability (BIRDS) applies the new sustainability measurement system to an extensive whole building performance database NIST has compiled for this purpose (BIRDS 2014). The energy, environment, and cost data in BIRDS measure building operating energy use through detailed energy simulations, building materials use through innovative life-cycle material inventories, and building costs over time. BIRDS v1.0 included energy, environmental, and cost measurements for 11 building prototypes

in 228 cities for a total of 12 540 new commercial and non low-rise residential building designs across all U.S. states for 9 study period lengths. All the variables shown in Figure 1-1 are accounted for in the BIRDS database. See Lippiatt et al. (2013) for additional details.

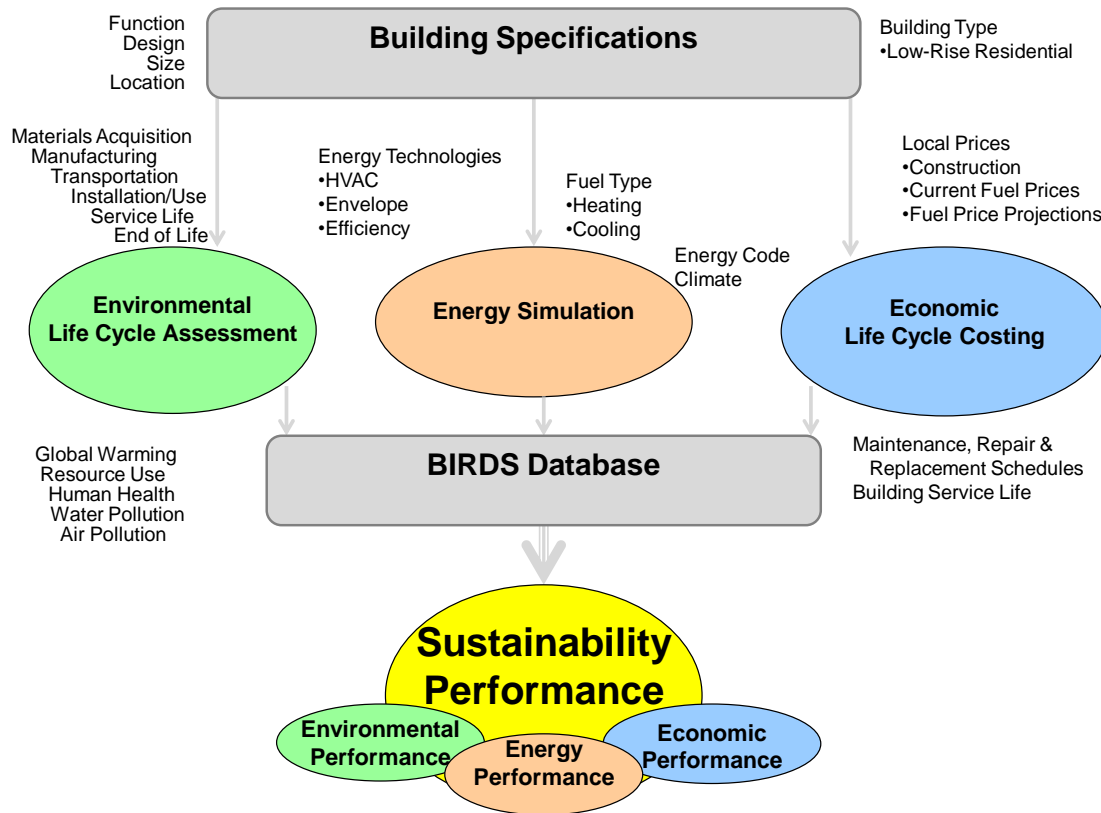
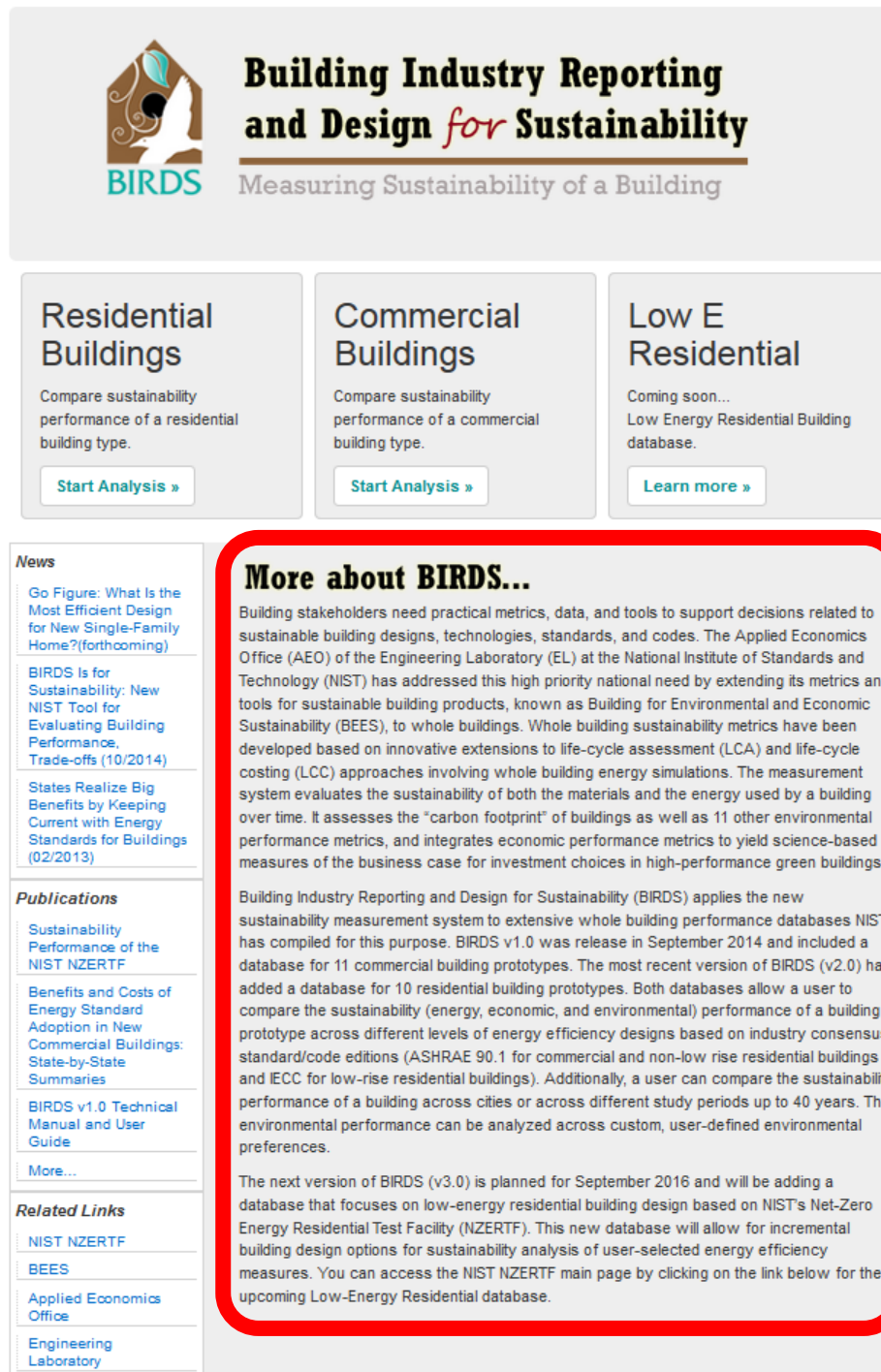


Figure 1-1 BIRDS Sustainability Framework

Similarly, the new residential building database incorporated into BIRDS v2.0 includes energy, environmental, and cost measurements covering 10 single family dwellings (5 one-story and 5 two-story of varying conditioned floor area) in 228 cities across all U.S. states for a total of 9120 new buildings for study period length ranging from 1 year to 40 years. The sustainability performance of buildings designed to meet current state residential energy codes (based on building requirements defined in the International Energy Conservation Code (IECC)) can be compared to their performance when built to three alternative building energy standard editions to determine the impact of energy efficiency on sustainability performance. The impact of the building location and the investor's time horizon on sustainability performance can also be analyzed. This document displays the capabilities of the BIRDS new residential buildings database through a detailed tutorial. See Kneifel et al. (2015) for additional details related to the underlying assumptions, data sources, and approaches implemented to develop the BIRDS new residential database.

2 BIRDS New Residential Buildings Database Tutorial

A user begins on the BIRDS main webpage, which is a “one-stop shop” for information related to BIRDS. In the center of the webpage, there is an introduction to the purpose and capabilities of the BIRDS databases (highlighted in Figure 2-1).



The screenshot shows the BIRDS main webpage. At the top is the BIRDS logo, which features a stylized house with a bird inside, and the text "BIRDS" below it. To the right of the logo is the title "Building Industry Reporting and Design for Sustainability" in a large, bold font, with "for Sustainability" in a smaller, italicized font. Below the title is the subtitle "Measuring Sustainability of a Building".

Below the header are three main sections:

- Residential Buildings**: "Compare sustainability performance of a residential building type." with a "Start Analysis »" button.
- Commercial Buildings**: "Compare sustainability performance of a commercial building type." with a "Start Analysis »" button.
- Low E Residential**: "Coming soon... Low Energy Residential Building database." with a "Learn more »" button.

On the left side, there are three sections:

- News**: A list of recent news items, including "Go Figure: What Is the Most Efficient Design for New Single-Family Home?(forthcoming)", "BIRDS Is for Sustainability: New NIST Tool for Evaluating Building Performance, Trade-offs (10/2014)", and "States Realize Big Benefits by Keeping Current with Energy Standards for Buildings (02/2013)".
- Publications**: A list of publications, including "Sustainability Performance of the NIST NZERTF", "Benefits and Costs of Energy Standard Adoption in New Commercial Buildings: State-by-State Summaries", and "BIRDS v1.0 Technical Manual and User Guide".
- Related Links**: A list of links to "NIST NZERTF", "BEES", "Applied Economics Office", and "Engineering Laboratory".

On the right side, there is a large red-bordered box titled "More about BIRDS...". It contains the following text:

Building stakeholders need practical metrics, data, and tools to support decisions related to sustainable building designs, technologies, standards, and codes. The Applied Economics Office (AEO) of the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST) has addressed this high priority national need by extending its metrics and tools for sustainable building products, known as Building for Environmental and Economic Sustainability (BEES), to whole buildings. Whole building sustainability metrics have been developed based on innovative extensions to life-cycle assessment (LCA) and life-cycle costing (LCC) approaches involving whole building energy simulations. The measurement system evaluates the sustainability of both the materials and the energy used by a building over time. It assesses the "carbon footprint" of buildings as well as 11 other environmental performance metrics, and integrates economic performance metrics to yield science-based measures of the business case for investment choices in high-performance green buildings.

Building Industry Reporting and Design for Sustainability (BIRDS) applies the new sustainability measurement system to extensive whole building performance databases NIST has compiled for this purpose. BIRDS v1.0 was release in September 2014 and included a database for 11 commercial building prototypes. The most recent version of BIRDS (v2.0) has added a database for 10 residential building prototypes. Both databases allow a user to compare the sustainability (energy, economic, and environmental) performance of a building prototype across different levels of energy efficiency designs based on industry consensus standard/code editions (ASHRAE 90.1 for commercial and non-low rise residential buildings and IECC for low-rise residential buildings). Additionally, a user can compare the sustainability performance of a building across cities or across different study periods up to 40 years. The environmental performance can be analyzed across custom, user-defined environmental preferences.

The next version of BIRDS (v3.0) is planned for September 2016 and will be adding a database that focuses on low-energy residential building design based on NIST's Net-Zero Energy Residential Test Facility (NZERTF). This new database will allow for incremental building design options for sustainability analysis of user-selected energy efficiency measures. You can access the NIST NZERTF main page by clicking on the link below for the upcoming Low-Energy Residential database.

Figure 2-1 BIRDS Main Webpage - Introduction

On the left hand side of the main page, a user can access information related to BIRDS, including recent news, related publications, and other related links (highlighted in Figure 2-2). Recent news will include news articles, press releases, and announcements related to BIRDS. The most recent and/or most downloaded BIRDS-related publications are shown, which a link to the NIST publication database to allow for a complete search of BIRDS publications. Related links include BIRDS’s “sister software” – BEES – that allows for comparison of individual building products and the NIST Net Zero Energy Residential Test Facility (NZERTF) main page as well as access to the Applied Economics Office and the Engineering Laboratory at NIST.

If the user is interested in additional information not available from the BIRDS main page or have comments to improve BIRDS, a user can contact NIST at either birds@nist.gov or joshua.kneifel@nist.gov.

The screenshot shows the BIRDS Main Webpage. On the left, there is a sidebar with three sections: 'News', 'Publications', and 'Related Links'. The 'Related Links' section is highlighted with a red box and contains the following links: NIST NZERTF, BEES, Applied Economics Office, and Engineering Laboratory. The main content area on the right is titled 'More about BIRDS...' and contains two paragraphs of text. The first paragraph describes the Applied Economics Office (AEO) of the Engineering Laboratory (EL) at NIST and its role in developing sustainable building products. The second paragraph describes the Building Industry Reporting and Design for Sustainability (BIRDS) system and its application in building performance databases. The third paragraph describes the next version of BIRDS (v3.0) and its focus on low-energy residential building design.

News

- [Go Figure: What Is the Most Efficient Design for New Single-Family Home?\(forthcoming\)](#)
- [BIRDS Is for Sustainability: New NIST Tool for Evaluating Building Performance, Trade-offs \(10/2014\)](#)
- [States Realize Big Benefits by Keeping Current with Energy Standards for Buildings \(02/2013\)](#)

Publications

- [Sustainability Performance of the NIST NZERTF](#)
- [Benefits and Costs of Energy Standard Adoption in New Commercial Buildings: State-by-State Summaries](#)
- [BIRDS v1.0 Technical Manual and User Guide](#)
- [More...](#)

Related Links

- [NIST NZERTF](#)
- [BEES](#)
- [Applied Economics Office](#)
- [Engineering Laboratory](#)

More about BIRDS...

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The next version of BIRDS (v3.0) is planned for September 2016 and will be adding a database that focuses on low-energy residential building design based on NIST’s Net-Zero Energy Residential Test Facility (NZERTF). This new database will allow for incremental building design options for sustainability analysis of user-selected energy efficiency measures. You can access the NIST NZERTF main page by clicking on the link below for the upcoming Low-Energy Residential database.

Figure 2-2 BIRDS Main Webpage – Related Links

Above the introduction are links directing you to each of the BIRDS databases (highlighted in Figure 2-3). The Residential Buildings and Commercial Buildings “Start Analysis >>” links direct you to the new residential database and new commercial buildings database, respectively. Each database allows for sustainability comparison across different building designs based on building energy code/standard. The current Low Energy Residential “Learn More >>” link directs the user to the NIST NZERTF webpage, where the user can access specifications, performance data, publications, and other information about the NZERTF. Once the Low Energy Residential database web interface is released (planned for September 2016) The link will eventually be changed to the “Start Analysis >>” link directing the user to the low-energy residential database, which will allow a user to compare the sustainability performance of incremental changes in energy efficiency measures adopted in a single-family dwelling based on the NZERTF ranging from 2003 IECC to the NZERTF design.

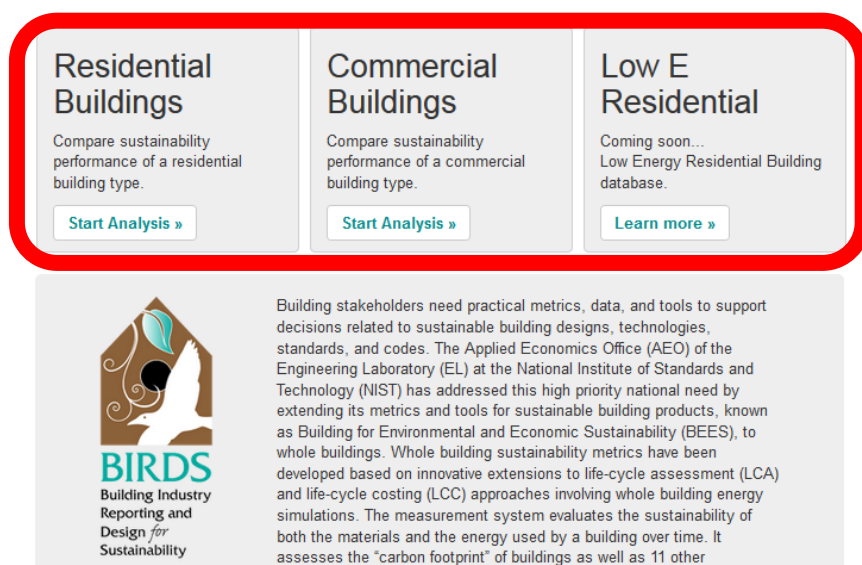


Figure 2-3 BIRDS Main Webpage – Database Links

For this tutorial, the user selects the Residential Buildings “Start Analysis >>” link and is directed to the BIRDS New Residential database web interface (highlighted in Figure 2-4).

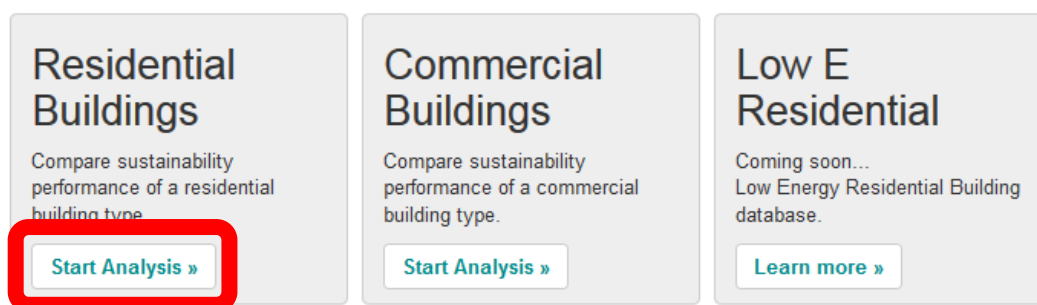


Figure 2-4 BIRDS Main Webpage – Start Analysis

The **New Residential** web interface defaults the user to Step 1 as shown in Figure 2-5. There are four steps in completing and viewing sustainability comparisons:

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.

At any step in the process, the user can access the BIRDS Home webpage, BIRDS New Residential database documentation, this tutorial, and the BIRDS FAQ at the top-right corner of the page as shown in Figure 2-5.

The screenshot displays the BIRDS - Residential Buildings web interface. At the top right, a navigation bar contains links: Home | View Documentation | View Tutorial | View FAQ. The main heading is "BIRDS - Residential Buildings +". Below this, a vertical sidebar on the left lists four steps: "Step 1: Select Your Building" (highlighted with a red box), "Step 2: Select Your Comparisons", "Step 3: Select Your Environmental Preferences", and "Step 4: View Results". The main content area for Step 1 is titled "My Building Prototype" and includes a sub-instruction: "Select the Number of stories and the square footage of the building prototype you want to evaluate." Below this instruction are three dropdown menus: "Select Building Type", "Select Number of Stories", and "Select Size (ft2)". An information icon (i) is located to the right of these menus. A blue callout box on the right side of the form contains the text: "← Click the information icons throughout the application for further explanation."

Figure 2-5 BIRDS New Residential Interface – Initial View

The remainder of this tutorial will walk the user through a detailed example and the resulting comparisons available to the user. Note that there are a variety of values that the user must select in order to view results, but BIRDS v2.0 includes further information (by clicking on the information icons) and default values (where determined necessary) to assist a user in making those selections.

2.1 Step 1: Selecting Your Building

The user completes “Step 1: Select Your Building” by selecting the building characteristics from the drop-down menus as shown in Figure 2-6 that best match to the building the user wants to analyze. The selections are sequential, and must be selected from left to right. The user first selects the Building Type, which currently only allows for the selection of **Single Family**

Detached dwellings (i.e. houses). Second, the user selects the Number of Stories, which currently includes 1-story or 2-stories.¹ Finally, the user selects the Size (ft²). There are five different “sizes” for both 1-story and 2-story single-family detached dwellings. Note that future versions of the new residential database could include low-rise multifamily dwellings (apartment buildings and condominiums) and/or semi-detached dwellings (townhouses).

BIRDS - Residential Buildings +

[Home](#) | [View Documentation](#) | [View Tutorial](#) | [View FAQ](#)

Step 1: Select Your Building ▼

Select the Number of stories and the square footage of the building prototype you want to evaluate.

My Building Prototype

Select Building Type ▼ Select Number of Stories ▼ Select Size (ft2) ▼ ⓘ

← Click the information icons throughout the application for further explanation.

Step 2: Select Your Comparisons ▼

Step 3: Select Your Environmental Preferences ▼

Step 4: View Results ▼

Figure 2-6 Selecting Building Type

For this tutorial, assume that the user is considering building a 1-story, 149 m² (1600 ft²) house as shown in Figure 2-7. Note that by clicking on the information icon (circled in red) the building details are expanded to be viewed by the user, which includes additional information such as orientation, floor height, percent fenestration, and heating and cooling equipment types. Since this is the first time an information icon appears, a text box has been included to alert the user of the information icon buttons. Note that future versions of the database may include additional options for the user (e.g. fuel type for heating). After selecting the building type, stories, and size the user wants to analyze, it is time to select what the user wants to compare.

¹ No 3-story houses are considered because they account for less than 4 % of all detached housing in any Census Division.

BIRDS - Residential Buildings +

Step 1: Select Your Building

Select the Number of stories and the square footage of the building prototype you want to evaluate.

My Building Prototype

Single-Family Detached

1

1600

Single-Family Detached

Stories:
1

Size (ft2):
1600

Orientation:
Due South (0)

Shape (Ratio):
Rectangular (2.56 to 1)

Floor Height:
8

Foundation:
Slab on Grade

Window Percent:
15

Heating Equipment:
Furnace - Gas

Cooling Equipment:
Central AC

Click the information icons throughout the application for further explanation.

Step 2: Select Your Comparisons

Step 3: Select Your Environmental Preferences

Step 4: View Results

Figure 2-7 Building Prototype Details

2.2 Step 2: Selecting Your Comparisons

Clicking on the “Step 2: Select 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 2-8 (highlighted in red). These are the baseline values that will be used for all comparisons, and must be selected before moving on. Note that all baseline values must be defined or an error will occur, and you will be diverted back to this step to select missing values. The information icon next to “Baseline Values” includes definitions of each baseline value that must be selected to assist a user that is not familiar with these factors. There is an additional information icon next to “Select Standard Edition” that includes a map with current state residential energy codes (as of July 2014).

BIRDS - Residential Buildings +

[Home](#) | [View Documentation](#) | [View Tutorial](#) | [View FAQ](#)

Step 1: Select Your Building ▼

Step 2: Select Your Comparisons ▼

Which building settings would you like to compare side by-side?
Your baseline settings will be used for the reference building in all comparisons.

Building Prototype:

Baseline Values ⓘ

Select State ▼ Select A City ▼ Select Code Edition ⓘ Select Study Period ▼

1. Alternative Location(s) ⓘ

Select up to 5 state/city combinations Currently selected locations:

Click on a state and then check the box for the desired city.

Alaska
Alabama
Arkansas
Arizona
California
Colorado
Connecticut
D.C.
Delaware
Florida
Georgia
Hawaii
Iowa
Idaho
Illinois
Indiana
Kansas
Kentucky
Louisiana
Massachusetts
Maryland
Maine
Michigan
Minnesota
Missouri

2. Alternative Energy Standard(s) ⓘ

☐ 2003 - IECC
☐ 2006 - IECC
☐ 2009 - IECC
☐ 2012 - IECC

3. Alternative Study Period Year(s) ⓘ

<input type="checkbox"/> 1	<input type="checkbox"/> 11	<input type="checkbox"/> 21	<input type="checkbox"/> 31
<input type="checkbox"/> 2	<input type="checkbox"/> 12	<input type="checkbox"/> 22	<input type="checkbox"/> 32
<input type="checkbox"/> 3	<input type="checkbox"/> 13	<input type="checkbox"/> 23	<input type="checkbox"/> 33
<input type="checkbox"/> 4	<input type="checkbox"/> 14	<input type="checkbox"/> 24	<input type="checkbox"/> 34
<input type="checkbox"/> 5	<input type="checkbox"/> 15	<input type="checkbox"/> 25	<input type="checkbox"/> 35
<input type="checkbox"/> 6	<input type="checkbox"/> 16	<input type="checkbox"/> 26	<input type="checkbox"/> 36
<input type="checkbox"/> 7	<input type="checkbox"/> 17	<input type="checkbox"/> 27	<input type="checkbox"/> 37
<input type="checkbox"/> 8	<input type="checkbox"/> 18	<input type="checkbox"/> 28	<input type="checkbox"/> 38
<input type="checkbox"/> 9	<input type="checkbox"/> 19	<input type="checkbox"/> 29	<input type="checkbox"/> 39
<input type="checkbox"/> 10	<input type="checkbox"/> 20	<input type="checkbox"/> 30	<input type="checkbox"/> 40

Select All

Step 3: Select Your Environmental Preferences ▼

Step 4: View Results ▼

Figure 2-8 Selecting Baseline Values

For this tutorial, assume that the user is building the house in Boulder, Colorado.² Based on the map in the information icon, Colorado currently requires new residential construction to meet

² Results are based on state-level average electricity prices, city-specific weather data, building energy code-climate zone specific requirements, and local construction costs. See Kneifel et al. (2015) for additional details.

2003 IECC requirements. The user expects to live in the home for 5 years before reselling the house. Based on this information, the baseline values selected are the following as shown in Figure 2-9: Baseline Location is Boulder, Colorado, Baseline Code Edition is 2003 IECC, and Study Period is 5 years.

Once the baseline values have been defined the user can select one or more alternatives to compare to their baseline across the three factors. The user can click on the information icon to obtain additional information on each set of alternative values.

Under [1.] in Figure 2-9 (in red) the user can select alternative locations for comparison to the baseline location assuming the same code edition (2003 IECC) and study period (5 years). Assume the user wants to compare across locations is to see how much variation can occur in the results if the same house is constructed in different locations in a state to the same underlying code edition. In order to select alternative locations, the user must first select (by clicking on) a state from the scroll box. Then a checkbox list of available cities in that state will appear. When a user clicks the checkbox, the city/state combination will be added to the list to the right. Up to 5 alternative locations can be selected for comparison to the baseline location, as shown in Figure 2-9. In this example, the five remaining available cities in Colorado have been selected for comparison (Alamosa, Colorado Springs, Eagle, Grand Junction, and Pueblo). Boulder has been automatically removed from the alternative location list because it is the baseline location.

Under [2.] in Figure 2-9 (in orange) the user can select up to three alternative energy code editions from the checkbox list at the top right, which include *2003 IECC*, *2006 IECC*, *2009 IECC*, and *2012 IECC*. Since *2003 IECC* is the selected baseline code edition, it is not an option for selection as an alternative. For this tutorial, assume that the user wants to consider constructing the house to each of the newer editions of IECC to determine if newer editions lead to energy savings, and if so, the cost-implications from constructing to the more energy efficient designs.

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Step 1: Select Your Building ▼

Step 2: Select Your Comparisons ▼

Which building settings would you like to compare side by-side?

Your baseline settings will be used for the reference building in all comparisons.

Building Prototype:

Baseline Values ⓘ

Colorado ▼

Boulder ▼

2003 - IECC ▼



5 years ▼

1. Alternative Location(s) ⓘ

Select up to 5 state/city combinations

Currently selected locations:

Click on a state and then check the box for the desired city.

Alaska
Alabama
Arkansas
Arizona
California
Colorado
Connecticut
D.C.
Delaware
Florida
Georgia
Hawaii
Iowa
Idaho
Illinois
Indiana
Kansas
Kentucky
Louisiana
Massachusetts
Maryland
Maine
Michigan
Minnesota
Missouri

☒ Alamosa
☒ Colorado Springs
☒ Eagle
☒ Grand Junction
☒ Pueblo

1. Alamosa, CO
2. Colorado Springs, CO
3. Eagle, CO
4. Grand Junction, CO
5. Pueblo, CO

2. Alternative Energy Standard(s) ⓘ

☐ 2003 - IECC
☒ 2006 - IECC
☒ 2009 - IECC
☒ 2012 - IECC

3. Alternative Study Period Year(s) ⓘ

<input type="checkbox"/> 1	<input type="checkbox"/> 11	<input type="checkbox"/> 21	<input type="checkbox"/> 31
<input type="checkbox"/> 2	<input type="checkbox"/> 12	<input type="checkbox"/> 22	<input type="checkbox"/> 32
<input type="checkbox"/> 3	<input type="checkbox"/> 13	<input type="checkbox"/> 23	<input type="checkbox"/> 33
<input type="checkbox"/> 4	<input type="checkbox"/> 14	<input type="checkbox"/> 24	<input type="checkbox"/> 34
<input type="checkbox"/> 5	<input checked="" type="checkbox"/> 15	<input checked="" type="checkbox"/> 25	<input checked="" type="checkbox"/> 35
<input type="checkbox"/> 6	<input type="checkbox"/> 16	<input type="checkbox"/> 26	<input type="checkbox"/> 36
<input type="checkbox"/> 7	<input type="checkbox"/> 17	<input type="checkbox"/> 27	<input type="checkbox"/> 37
<input type="checkbox"/> 8	<input type="checkbox"/> 18	<input type="checkbox"/> 28	<input type="checkbox"/> 38
<input type="checkbox"/> 9	<input type="checkbox"/> 19	<input type="checkbox"/> 29	<input type="checkbox"/> 39
<input checked="" type="checkbox"/> 10	<input checked="" type="checkbox"/> 20	<input checked="" type="checkbox"/> 30	<input checked="" type="checkbox"/> 40

Select All

Step 3: Select Your Environmental Preferences ▼

Step 4: View Results ▼

Figure 2-9 Selecting Alternative Locations, Energy Standard Editions, and Study Periods

Under [3.] in Figure 2-9 (in purple) the user can select up to 39 alternative study periods in the checkbox list at the bottom right, which range from 1 year to 40 years and includes a “Select All” button for users that want to quickly and easily consider all study periods. For this tutorial, assume the user wants to consider longer study periods, in 5-year increments (10-years, 15-years,

20-years, 25-years, 30-years, 35-years, and 40-years) to see how the results will change if the house is owned for longer timeframes. The 5-year study period is the baseline and cannot be selected as an alternative. Once the user has defined the baseline values and the alternative values for comparison, the user needs to move onto Step 3 to define environmental preferences.

2.3 Step 3: Selecting Environmental Weighting Preferences

Clicking on the “Step 3: Select Your Environmental Preferences” displays an introductory paragraph. For further explanation of each of the environmental impact categories, click on the information icon in the text. The user must start by selecting their Baseline Environmental Weight Approach from the dropdown menu, which includes 5 options (four pre-defined and one user-defined) as shown in Figure 2-10 (in red). The weights for each of the four pre-defined approaches can be viewed by the user in the table on the right-hand side (in purple).

Explanations of the source of the BEES Stakeholder Panel and EPA Advisory Board weighting approaches can be found under the information icon. For this tutorial, assume that the user selects the BEES Stakeholder Panel as the baseline. Below the Baseline selection are check boxes for the alternative weighting approaches that will be available for comparison (in orange).

BIRDS - Residential Buildings +

Step 1: Select Your Building ▼

Step 2: Select Your Comparisons ▼

Step 3: Select Your Environmental Preferences ▼

Select your environmental preferences by setting the weights for each of the environmental impact categories.

BIRDS includes 12 environmental impact categories [i](#) for which the user can analyze the environmental performance of a building. BIRDS also allows a user to report a single, weighted average Environmental Impact Score (EIS). In order to calculate the EIS the user must define their preferences, or "weight set" regarding the relative importance of each environmental impact. The user can select one of the pre-defined weight sets or create their own weight set.

Baseline Environmental Weighting Approach [i](#)

Select a Weight ▼

Alternative Weighting Approach [i](#)

- ☐ BEES Stakeholder Panel
- ☐ Carbon Footprint Only
- ☐ EPA Advisory Board
- ☐ Equal Weights

Create Weighting Approach ☐

Pre-Defined Weightsets [i](#)

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

Step 4: View Results ▼

Figure 2-10 Selecting Environmental Weighting Preferences

If the user does not want to use any of the pre-defined weighting approaches, the user is given flexibility to create a custom weighting approach by checking the "Create Weighting Approach" checkbox, which can be used as the baseline or as an alternative weighting approach. As shown in Figure 2-11, checking the "My Weights" check 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. Assume the user wants to place equal weight (25 %) to only four

categories (global warming, acidification (i.e. acid rain), ozone depletion, and water consumption) and ignore other environmental impacts. Once a custom weighting approach is defined it will become a selection available in the Baseline Weighting Approach dropdown and as a checkbox in the Alternative Weighting Approach checkbox list. Assume that the user selects all available alternative weighting approaches, including the custom weighting approach. At this point, all the necessary user inputs have been defined and the user can now look at the results.

Step 3: Select Your Environmental Preferences

Select your environmental preferences by setting the weights for each of the environmental impact categories.

BIRDS includes 12 environmental impact categories for which the user can analyze the environmental performance of a building. BIRDS also allows a user to report a single, weighted average Environmental Impact Score (EIS). In order to calculate the EIS the user must define their preferences, or "weight set" regarding the relative importance of each environmental impact. The user can select one of the pre-defined weight sets or create their own weight set.

Baseline Environmental Weighting Approach

BEES Stakeholder Panel

Alternative Weighting Approach

☒ Carbon Footprint Only
☒ EPA Advisory Board
☒ Equal Weights
☐ My Weights

Create Weighting Approach

Carcinogenics

0

Global Warming

25

Acidification

25

Respiratory Effects

0

Non-Carcinogenics

0

Ozone Depletion

25

Eutrophication

0

Smog

0

Embodied Energy

0

Land Use

0

Water Consumption

25

Sum

100

Pre-Defined Weightsets

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 2-11 Selecting Environmental Weighting Approaches

2.4 Step 4: Viewing Results

Clicking on the “Step 4: View 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 2-12, the user must first select the “Chart Type” from the dropdown menu, then the “Baseline” for which 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 within BIRDS and not square meters because the tool is designed for use domestically, which predominantly uses I-P units instead of metric units. For additional information, a user can click on the information icons. Once the user has made these selections, the user presses the “View” button to see the results, at which point the graph with corresponding data table will be displayed.

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BIRDS - Residential Buildings +

Step 1: Select Your Building ▼

Step 2: Select Your Comparisons ▼

Step 3: Select Your Environmental Preferences ▼

Step 4: View Results ▼

Select Chart Options ⓘ

Select Chart Type ▼

Select Chart Type
Life-Cycle Cost
Operating Energy
Environmental Impact

Select a Baseline ▼ ⓘ

Select a Unit ▼

View

Select Chart Options ⓘ

Life-Cycle Cost ▼

Select a Baseline ▼ ⓘ

Select a Baseline
Study Periods
Locations
Energy Standards

Select a Unit ▼

View

Select Chart Options ⓘ

Life-Cycle Cost ▼

Energy Standards ▼ ⓘ

Select a Unit ▼

Select a Unit
Present Value Dollars PV\$
Change in PV\$
Present Value \$/ft2
Change in PV\$/ft2

View

Figure 2-12 Selecting Chart Options

Assume that the first comparison the user would like to view is the life-cycle costs of the baseline building design and study period across the selected locations. Figure 2-13 shows the Life-Cycle Cost results with a graph of the total life-cycle costs per ft² in present value dollars (PV\$) for the 5-year study period for a 1-story, 149 m² (1600 ft²) house built to meet 2003 *IECC* across the six locations selected by the user. As can be seen in the graph, total present value (PV) life-cycle costs (LCC) per ft² vary from \$250.80/m² (\$23.30/ft²) to over \$264.79/ m² (\$24.60/ft²). Even within the same state, constructing a house to the same energy standard can lead to different costs to the owner because of variations in code requirements by climate zone as well as local construction cost differences. The baseline value line, which is included to allow for easy comparisons across alternatives, shows that two cities realize lower life-cycle costs (LCCs) and three cities realize higher LCCs than Boulder.

Select Chart Options ⓘ

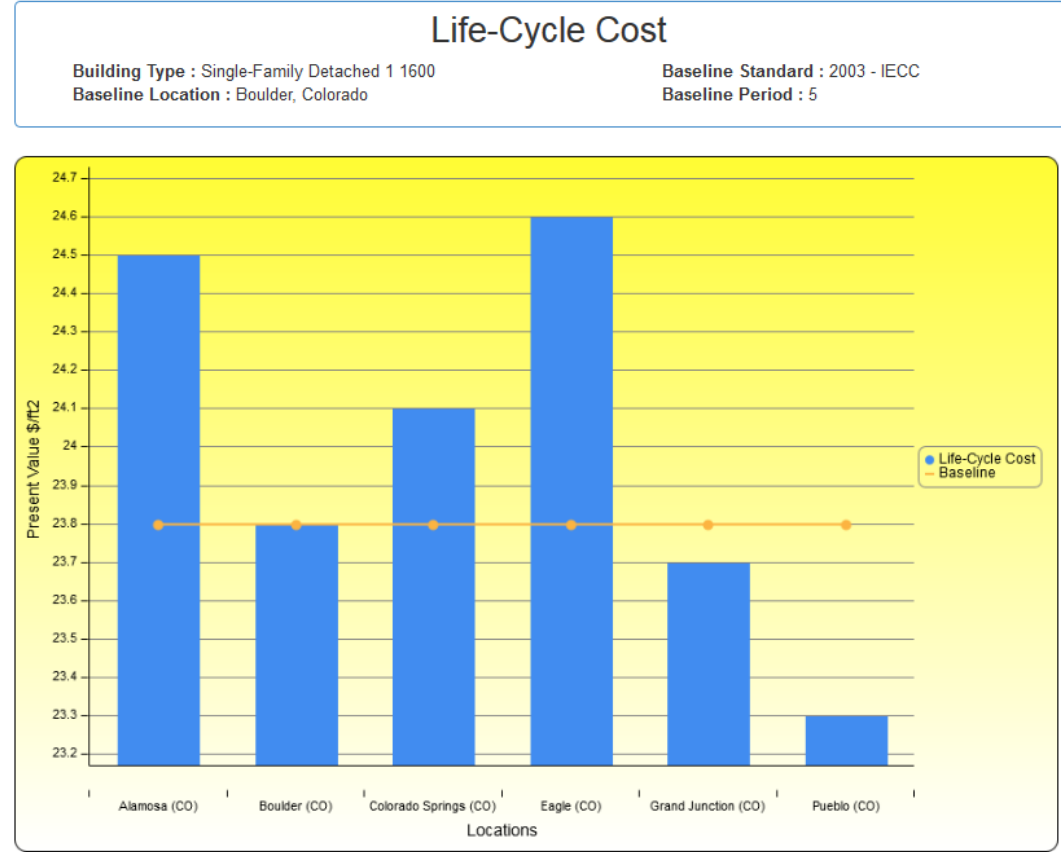
Life-Cycle Cost

Locations

 ⓘ

Present Value \$/ft2

View



Life-Cycle Cost	Unit	Alamosa (CO)	Boulder (CO)	Colorado Springs (CO)	Eagle (CO)	Grand Junction (CO)	Pueblo (CO)
Total	Present Value Dollars PV\$	39,179	38,135	38,484	39,348	37,876	37,353
Change from Baseline	Change in PV\$	1,044	0	348	1,212	-259	-783
Total	Present Value \$/ft2	24.5	23.8	24.1	24.6	23.7	23.3
Change from Baseline	Change in PV\$/ft2	0.7	0	0.2	0.8	-0.2	-0.5
Change from Baseline	%	2.7	0	0.9	3.2	-0.7	-2.1

Figure 2-13 Life-Cycle Cost Graph by Location for Baseline Assumptions

A user can interact with the graph by (1) scrolling over and viewing the value of each data point and (2) zooming in and out of a graph to focus on a portion of the data.

The data table displayed below the graph 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 selected baseline, total life-cycle costs per ft², change in total life-cycle costs from the baseline per ft², and percentage change in life-cycle costs relative to the baseline.

Next, the user decides to see how LCCs change as the study period increases in length. By changing the baseline across which to analyze the data from “Locations” to “Study Periods,” selecting Present Value \$/ft² and clicking “View,” the user can now see that that LCCs increase at a decreasing rate as the study period increases in length (see Figure 2-14). The reason for this trend is that the further into the future that costs are realized, the smaller the discounted present value of those costs.

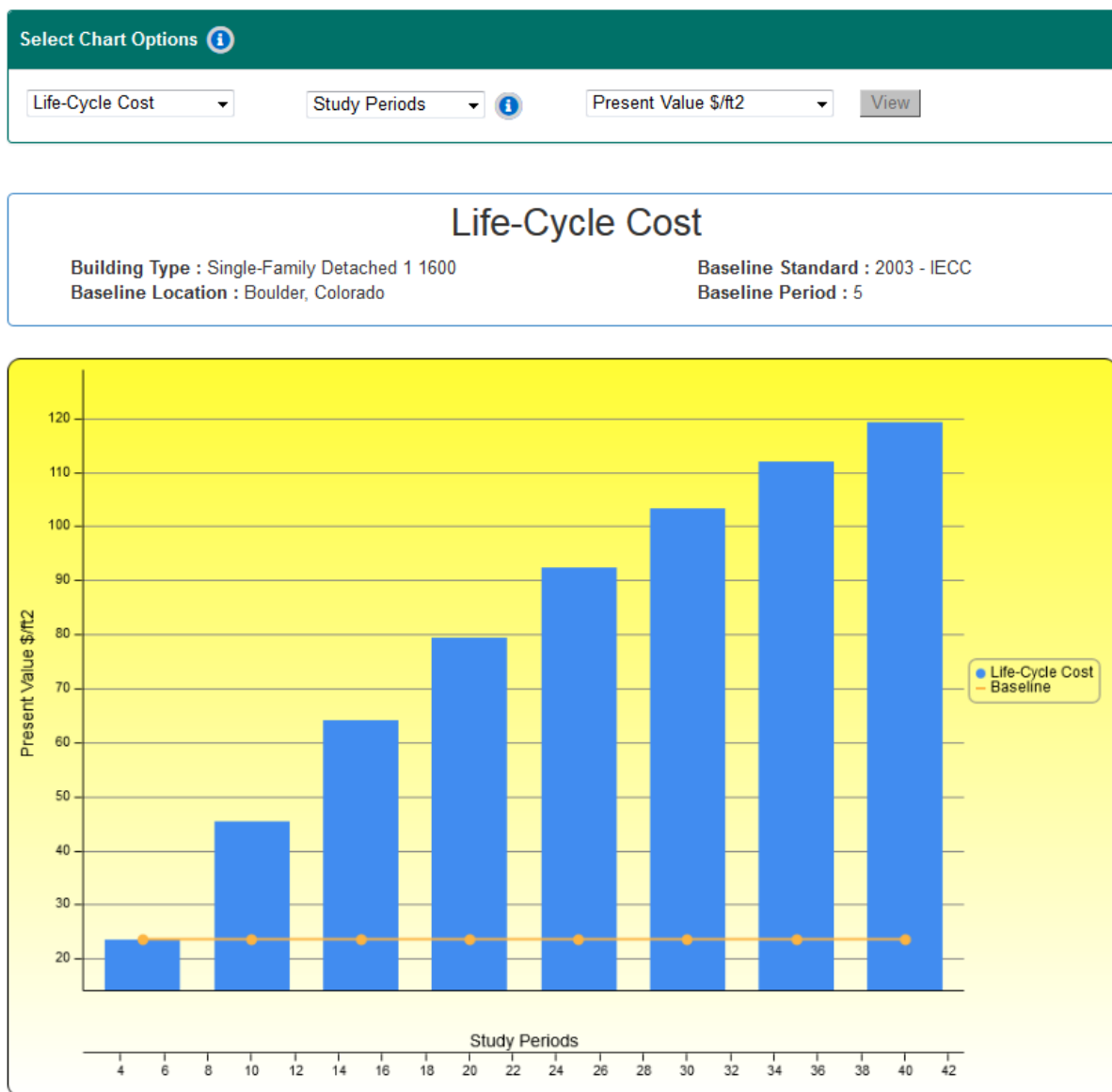


Figure 2-14 Life-Cycle Cost Graph by Study Period for Baseline Assumptions

Now the user shifts to focusing analysis on changing in the building design for the baseline location and study period. Figure 2-15 shows the Operating Energy results in annual energy consumption per ft² (in kBtu) across the four standard editions. Energy consumption is relatively constant across the baseline code edition (2003 IECC) and 2006 IECC and 2009 IECC, with 2006 IECC actually slightly increasing consumption and 2009 IECC slightly decreasing consumption (within +/- 0.3 kWh/m² (0.1 kBtu/ft²)). The 2006 IECC design could lead to an increase in energy consumption because of the change in climate zone characterization between 2003 IECC and 2006 IECC (there are fewer zones based on different combinations of heating degree days and cooling degree days). Constructing to meet the requirements in 2012 IECC leads to a 20 % reduction in energy consumption relative to 2003 IECC (48.6 kWh/m² (15.4 kBtu/ft²) versus 60.9 kWh/m² (19.3 kBtu/ft²)).

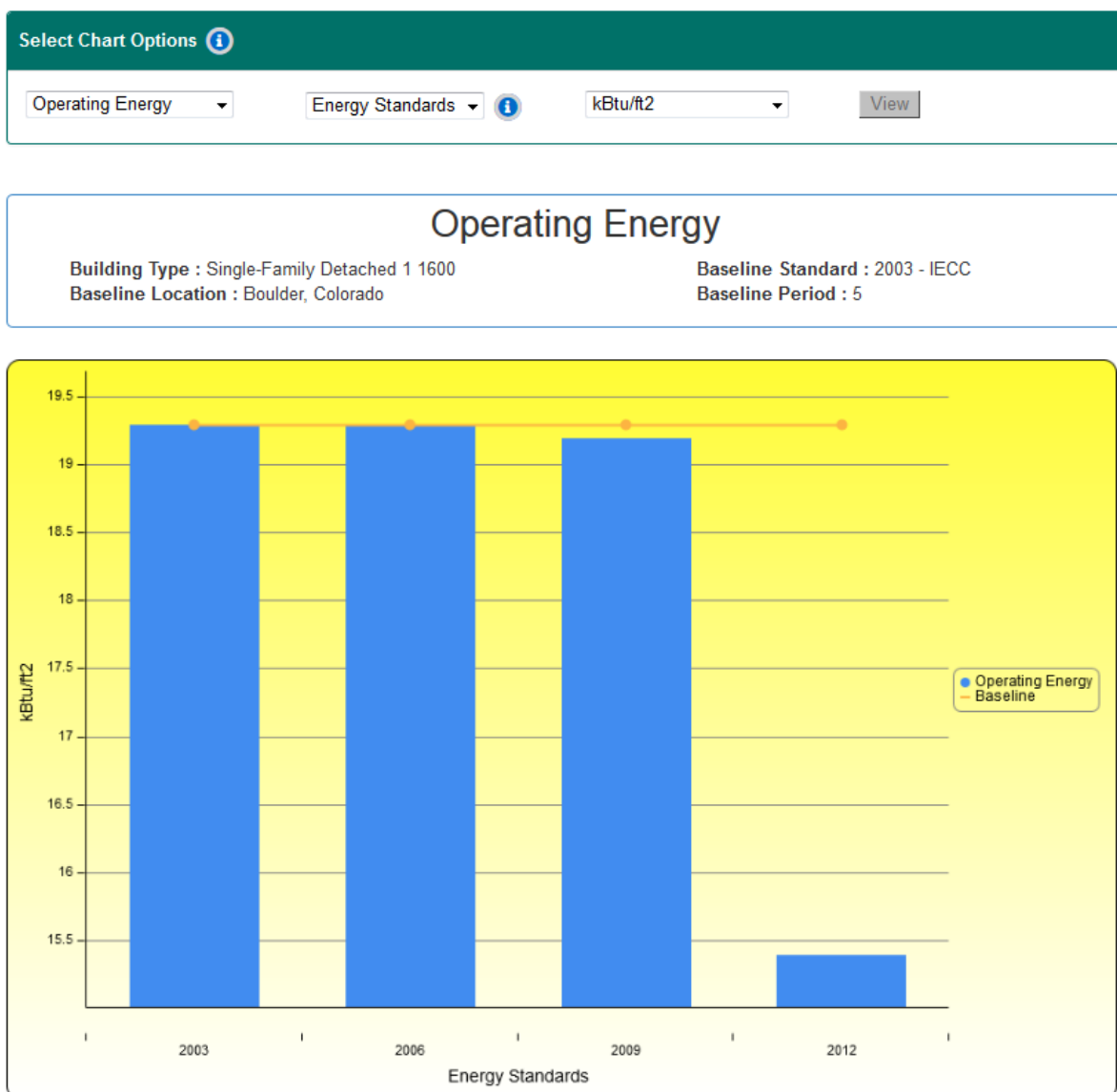


Figure 2-15 Annual Operating Energy Per ft² by Code Edition for Baseline Assumptions

Now the user wants to determine if the energy savings realized by constructing to 2012 IECC is cost-effective. By selecting Life-Cycle Cost – Energy Codes – Change in PV\$, the user can view how LCCs differ across code editions. Figure 2-16 shows that building to meet 2006 IECC leads to the greatest reduction in LCCs relative to building to meet 2003 IECC (baseline). However, as was shown in Figure 2-15, the 2006 IECC design consumes the most energy. The building requirements are more lax for 2006 IECC relative to 2003 IECC, leading to lower first costs that outweigh the higher energy costs realized by the design. The 2012 IECC design not only leads to the lowest energy consumption, it also leads to LCC savings (\$286) relative to the 2003 IECC design.

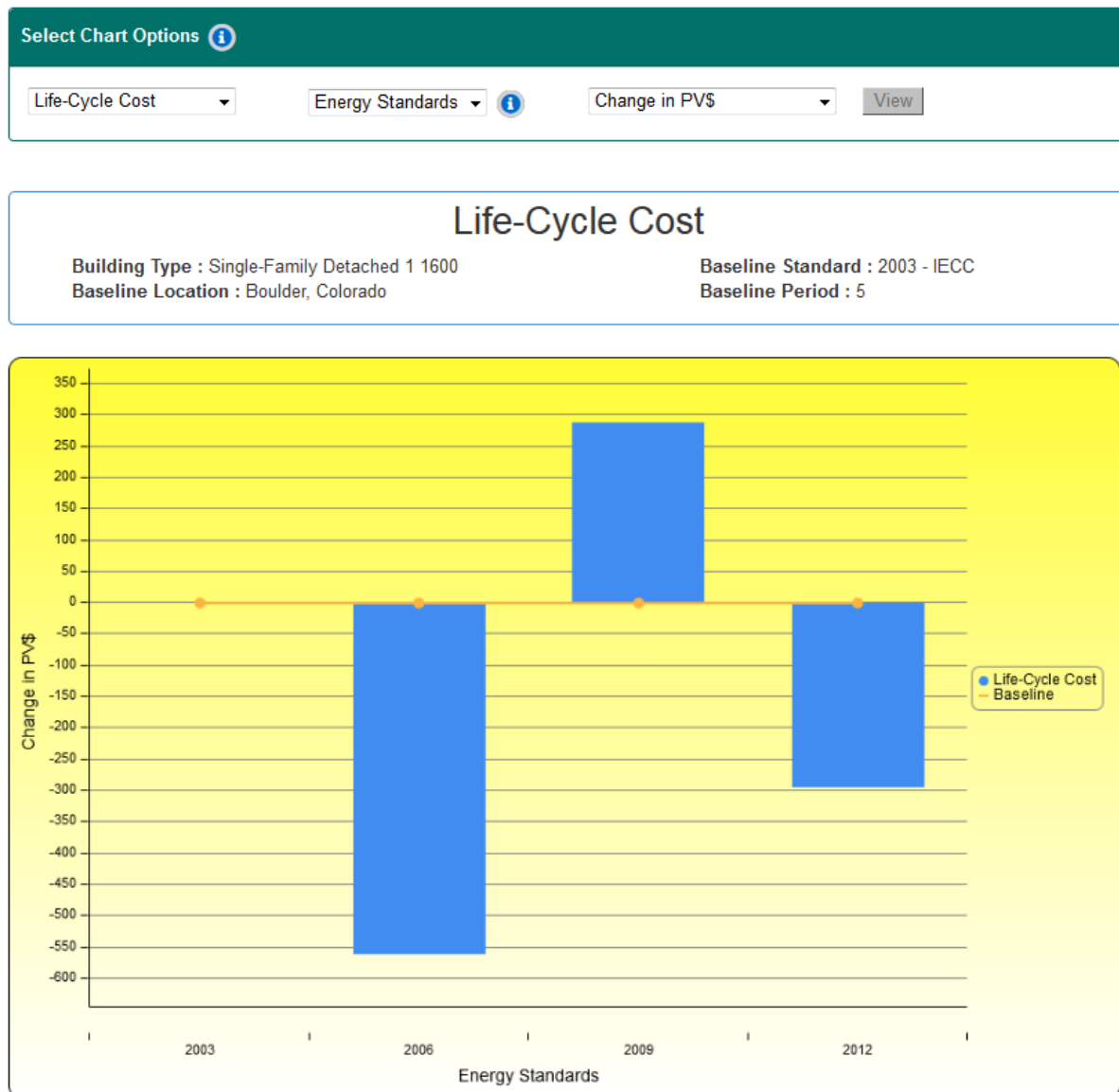


Figure 2-16 Change in Life-Cycle Costs by Code Edition for Baseline Assumptions

If the user is interested in seeing how the different building designs impact the life-cycle environmental performance of the house, then the user must make an additional selection, the environmental impact category, which can be either a single impact category or the weighted average impact (Environmental Impact Score – EIS) based on the baseline weighting approach (BEES Stakeholder Panel). In this case, assume that the user wants to look at the Environmental Impact Score. By selecting Environmental Impact-Energy Standard-All (weighted)-Environmental Impact Score, the user sees the results in Figure 2-17, which shown that the 2012 IECC design leads to the greatest reduction in Environmental Impact Score (0.74 or 4.3 %).

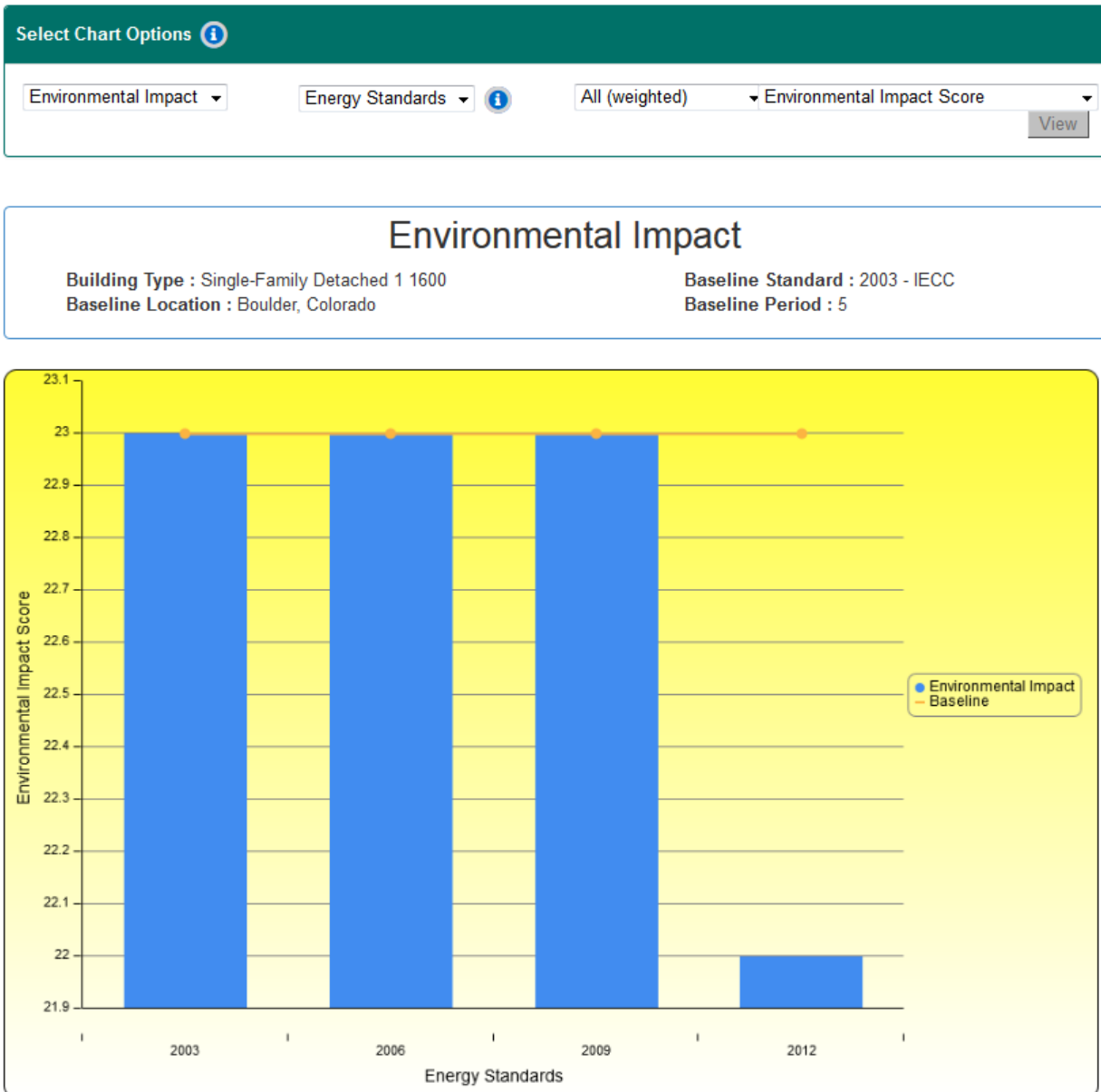


Figure 2-17 Change in Environmental Impact Score by Code Edition – for Baseline Assumptions

The user can also view each individual environmental impact category results. For example, Figure 2-18 shows a graph of the total global warming potential impacts in kilograms of CO₂e emissions. The 2012 IECC design leads to the lowest impact on global warming potential, with a reduction of 11 717 kg of CO₂e flows relative to the 2003 IECC design.

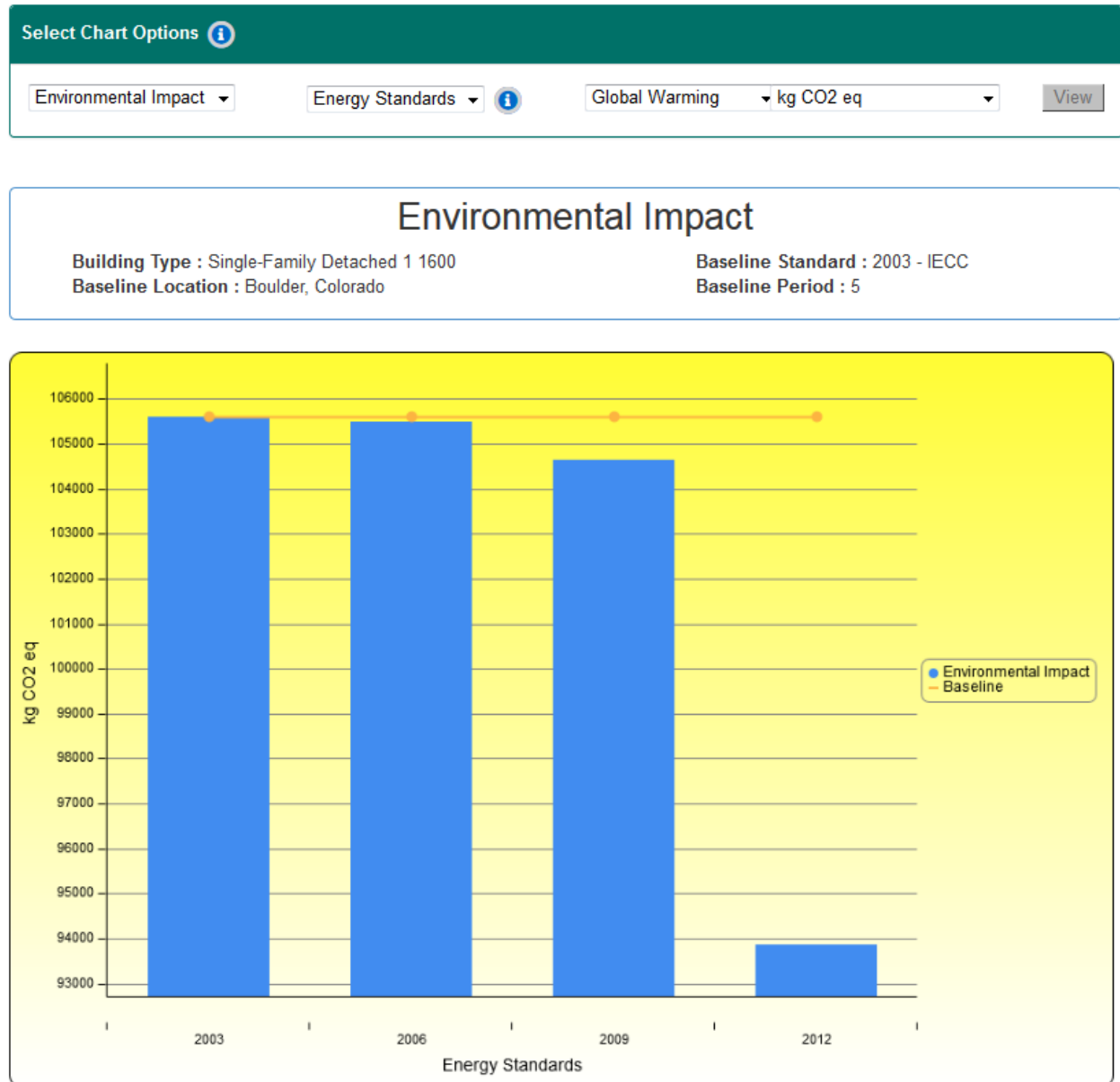


Figure 2-18 Change in Global Warming Potential by Code Edition – for Baseline Assumptions

3 Summary

This tutorial guides the user through a detailed example of analysis that can be completed using the BIRDS new residential database web interface. The energy, environmental, and economic performance of a wood-framed, single-family dwelling was compared across a number of factors. The life-cycle costs of the baseline building design (constructed to meet 2003 IECC requirements) was compared to the same building design located in 5 other cities across Colorado. The life-cycle costs of constructing to the same energy code edition can vary across cities within a state. Depending on the location. The life-cycle costs per unit of floor area were compared for Boulder as the study period length changed from 5 year to 40 years, showing that life-cycle costs increase as the study period length increases. All three areas of performance were analyzed for Boulder as the code edition to which the building was constructed changes to newer editions of the code. Relative to the baseline code (2003 IECC), the greatest change in operating energy consumption occurs from constructing to meet 2012 IECC requirements, which also realizes reductions in life-cycle costs, Global Warming Potential (i.e. “carbon”) and the Environmental Impact Score.

These are just some of the comparisons the user could make with BIRDS. The associated documentation (Kneifel et al. 2015) for the BIRDS new residential database will assist with any questions related to the underlying definitions, assumptions, data sources, and methodology. Future versions of BIRDS will update current databases with additional energy code editions and more features as well as an additional database that will include low-energy residential building designs. Please feel free to give your feedback on issues with BIRDS, information on how you use BIRDS, and/or what additional features you would like to have in future versions of BIRDS by sending an email to birds@nist.gov.

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