A Diagnostic Review of Building Energy Performance
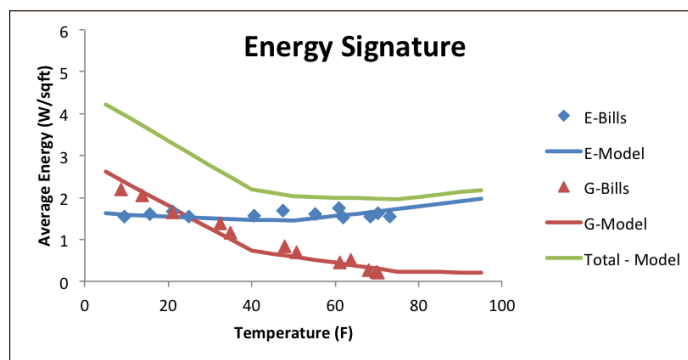
What is FirstView®?

The new FirstView software tool and suite of services from New Buildings Institute allow for a quick initial diagnostic review of a building's energy performance. Just as a prism can be used to break light into its component parts, the FirstView tool disaggregates monthly utility bills into end-use information in key areas, including heating, cooling, hot water heating, and plugs and lights. The resulting information provides an action-oriented benchmark, performance diagnostics and a common, yet detailed, framework for comparing building performance.

What is an Energy Signature?

An Energy Signature is a graph of monthly energy use (vertical axis) in relation to outside temperature (horizontal axis) for the same period. Higher energy use is expected during hot and cold periods, with lower energy use expected during the mild temperature periods.

The FirstView tool uses actual utility bills and a few building characteristics (like use, size and zip code) to plot a "best fit" line that represents a building's energy performance at various temperatures. An Energy Signature reveals key performance indicators as an algebraic function, for example the slope of the heating curve or the height of the electric baseload.

What is the difference between the FirstView software and the ASHRAE inverse modeling approach?

Although both the FirstView tool and the ASHRAE Inverse Modeling Toolkit (IMT) use energy signatures to visualize a building's energy use, the fundamental approaches differ. The IMT is essentially a statistical method of analyzing energy, using a regression algorithm to determine the relationship between temperature and energy use. In contrast, the FirstView tool uses a physics based building energy model to estimate energy use as a function of temperature. This method accounts for all energy sources (typically electricity and gas) and the interactions between different fuels. Once the energy model is properly calibrated to match utility bills (a process that the FirstView tool completes automatically) it provides a powerful mechanism for exploring the energy use of your building.

How has the FirstView tool been tested?

The FirstView tool's calculation engine has been used on more than 1,000 buildings. These analyses range from individual buildings to large data sets on behalf of the USGBC's Building Performance Partnership (BPP) program and the Oregon Cool Schools Initiative.

The California Energy Commission Public Interest Energy Research program has also funded the FirstView tool's development. With PIER funding, NBI conducted a 'deep dive' into a group of 22 recently certified LEED buildings in California. For those with available monthly energy bills, NBI compared the results of the FirstView tool with inspections conducted during a walk through audit of the buildings. A high degree of correlation was found in the results at a fraction of the cost and effort as the walk-through efforts. PIER also funded the development of a beta webtool tested by more than 40 commercial building professionals ranging from owners to designers to energy engineers. Read more at http://www.newbuildings.org/firstview-case-studies.

What type of comparisons do FirstView software and services enable?

The FirstView tool uses an Energy Signature plot to analyze performance patterns of the building. Using algebraic equations commonly used in energy modeling, the FirstView tool acts like a prism, revealing the component parts of energy end use in the areas of heating, cooling, electric baseload and gas baseload. The Energy Signature plot enables multiple comparisons, including automated diagnostics, a peer building comparison, a design model comparison trending analysis.

1. **Automated Diagnostics.** The FirstView webtool automatically compares mathematic parameters revealed in the Energy Signature to thresholds in six key performance areas: occupant load, heating and ventilation, cooling efficiency, controls, reheat, and gas baseload. Staff at New Buildings Institute with decades of experience set these diagnostic thresholds for particular building types. This enables the tool to quickly and automatically identify poor, average or high performance and directs attention to particular areas that warrant more attention.

2. **Peer Building Comparison.** With the data that is commonly used to calculate an Energy Use Index, the FirstView tool goes beyond a static benchmarking score to graphically illustrate how a reference building compares to peers. For this, NBI staff defines a comparison 'spectrum' of performance based on results from hundreds or thousands of previous runs using the tool. Currently, NBI has a high performance office spectrum, an average performance office spectrum and a spectrum for K-12 schools. NBI can create a custom spectrum once a sufficient amount of data is aggregated.

3. **Design Model Comparison.** The FirstView webtool can co-plot energy model predictions along with measured results. The energy signature enables a tempature normalized comparison between predicted modeled data (using TMY data) and utility bills using actual weather observations). While the idealized assumptions of an energy model often predict energy use that is lower than measured values, it serves as a useful target.

4. **Trending.** Using multiple years of utility bills, the FirstView tool's calculation engine can plot energy signatures for consecutive years to compare performance. This can

be analyzed against specific information known about the building, such as changing vacancy rates or building system upgrades, to reveal underlying performance from year to year on the same plot. This feature is not yet available on the webtool.

How are the FirstView tool's diagnostics generated?

Parameters for specific diagnostic categories are generated using past FirstView tool results and New Buildings Institute staff's experience in building science research. After reviewing more than a thousand FirstView tool runs, along with decades of work in high performance buildings, NBI sets thresholds for each diagnostic category. The FirstView tool mathematically compares the results for a particular building to the thresholds to recommend targeted areas for energy savings.

Technically, how does the FirstView software work?

For a comprehensive analysis of how the FirstView software works, please refer to the RESOURCES section of the website. http://newbuildings.org/sites/default/files/FirstViewTool_NBI_aceee2010.pdf

What is an aggregated building data set, and how can it be used as a benchmarking tool?

An aggregated building data set, commonly referred to as a 'spectrum' by NBI, is a sample set of buildings that serve as a benchmark for comparison. Spectrums are peer buildings provided by NBI that are provided by NBI that include at least 10 buildings and do not reveal identifying details such as building name, specific location or exact size. NBI intends to eventually collect enough aggregated data to expand comparison groups for users. For example, a user might be able to select a spectrum that represents 50 San Francisco area office buildings between 25,000 and 50,000 square feet.

As a service, NBI can help groups create their own spectrum, or users can use any of the three that NBI currently has available, including high performance office, average office and K-12 schools.

What is a 'spectrum'?

Using FirstView software and services, you can compare the energy signature of an individual building to a range of performance representing comparable peer buildings. This peer benchmarking or collective range of performance for an aggregated group of buildings, is referred to as a 'spectrum'. The shaded area of the spectrum represents the range of data for a specified subset that have used the FirstView tool. As more projects use the FirstView tool, NBI will be able to provide more refined spectrums focused more closely on individual project types and characteristics.

NBI currently offers three spectrums for comparison. The first, 'Average Office', is based on the FirstView tool's analysis from office buildings. The spectrum is plotted to represent buildings that perform in the 25th (better) to 75th (worse) percentile of this group. The median EUI of these buildings is 66kBtu/sf. Median square footage is 130,248, and median Energy Star Score (when available) is 86.

The second spectrum represents 'High Performance Office' buildings. This spectrum is plotted to represent buildings that perform in the 10th (better) to 25th (worse) percentile of the same building group. A third spectrum for average K-12 schools is also available, where applicable. As a service, NBI can create a custom spectrum for portfolio owners or special districts once enough data has been aggregated.
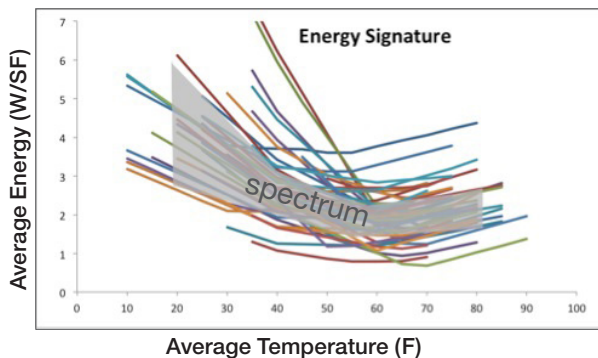
What data inputs do I need to make the FirstView tool work?

Data needed to run the FirstView tool includes one year of utility bills, zip code, building type and building square footage. The FirstView webtool is limited to buildings with minimal process loads (e.g., kitchen equipment or excess hot water demands of an exercise center) and a full year's occupancy.

How can data be input into the FirstView webtool?

The current web-based version of the FirstView webtool requires manual entry of individual building data. While automated downloading of data from utility bills is not yet available to users of the web-tool, custom solutions such as downloading from EPA Portfolio Manager, tailored to your organizations needs are possible. Please contact us at firstview@newbuildings.org for more information.

Is data input into the FirstView webtool confidential?

New Buildings Institute will not reveal any identifying information input into the FirstView webtool. Aggregated data may be used for research purposes, but will never reveal information about individual buildings. A comparison data set (referred to as a 'spectrum' by NBI) will include at least 10 buildings and does not reveal any identifying details such as building name, specific location and exact size.

Do I need submeters and interval data?

No. The only energy use data required for a FirstView tool analysis is your monthly utility bills. FirstView tool reports are not intended to replace the more complex, detailed and costly outputs from building automation, submeters or energy information systems. Instead, the FirstView tool provides a quick level of insight that can be applied to most buildings, even those that often do not have such systems

How are renewables handled?

The primary goal of the FirstView tool is to account for the energy used within a building, regardless of generation method. Therefore, on site renewable energy should be treated just like energy purchased from the utility. For example, let's consider a set of bills:

	December 2011	June 2011
Meter 1 (grid purchased electric)	10,000 kWh	-5,000 kWh
Meter 2 (Solar PV array)	5,000 kWh	15,000 kWh
Total usage input to the FirstView tool	15,000 kWh	10,000 kWh

and cannot afford to dedicate resources to detailed data analysis. After the FirstView tool has identified areas for further investigation, additional analysis tools or on-site auditing can be better directed and deployed with greater efficiency. This includes a more detailed review of sub-metering data, if available.

What if my building has multiple electric meters, or uses more than two fuels?

The FirstView tool requires that users input at least 12 months of utility bills so that it accurately defines building performance over a range of temperatures. If a building has multiple electric meters or uses more than two fuels, these values must be combined before they are entered into the FirstView webtool.

How do I account for oil or propane deliveries?

The FirstView tool relies on actual energy used, not delivered. Therefore oil and propane deliveries will need to be adjusted into monthly usage. Feel free to contact NBI for additional guidance on how these fuels can be accommodated. You can reach us at firstview@newbuildings.org.

Does the FirstView tool work in all climate zones?

Yes, the FirstView tool works in all climate zones. Furthermore, the FirstView tool's energy signature is an expression of the building's characteristics and not the climate zone. In other words, since the FirstView tool normalizes for building size and temperature, even buildings in totally different climate zones can be easily compared.

How is gas use addressed on the Y axis?

Gas energy use, typically expressed in therms or Btus, is converted and expressed in the same units as the electric to facilitate the whole building energy balance analysis. Both fuels are combined in the plots that the FirstView tool creates.

What does Average Energy on the Y axis mean?

The vertical axis for energy use is expressed in Normalized W/SF. In this sense, normalized means the energy use is normalized both to building size and to the number of days in a month. Normalizing in this way makes the data inter-comparable between cases of different billing periods and building sizes and expands opportunities for comparisons. We have chosen to express the energy use in W/SF, but equivalent units of kWh/(Day*SF) or Therms/(Day*SF) could also be used.

Let's consider an example for a 10,000 SF building: In April 2011, the electric bill indicates 25,000 kWh of usage. Since April has 30 days, this is 25,000/30 = 833.3 kWh/day. We can then convert days to hours with 833.3/24 = 34.7 kWh/h or 34.7 kW. The final step is to normalize by building size and convert kW to W, which gives 34.7*1000/10,000 SF= 3.47W/SF. If for some reason this bill was for a period of only 15 days, the Average Energy would be doubled, or 6.9W/SF.

Does the FirstView tool work for non-office building types?

The FirstView software works for many, but not all, building types. This includes office buildings, K-12 schools, libraries, fire stations and some retail. The FirstView tool may not be appropriate for laboratories, hospitals, grocery stores or other buildings with large process loads. Also, the FirstView tool may not be appropriate for multifamily buildings where the whole-building data is difficult to collect.

What if my building has large process loads?

Although the underlying energy model used by the FirstView tool can be used to analyze buildings with consistent large process loads, the current web tool does not offer this functionality. If your building has modest process loads the FirstView tool's analysis should not be affected. However, buildings with large process loads may cause the FirstView tool to not allocate the process load energy accurately. For example, the model may assume that the large electric baseload from a datacenter provides sufficient heat to displace the need for a gas furnace. However, the datacenter may be designed such that the waste heat is vented outside your building and does not contribute to the heating/cooling load. Additionally, if your process load fluctuates, the driving factor behind that fluctuation , such as a production schedule in a machine shop, will not be captured in the FirstView tool's model.

What types of automated responses does the FirstView tool make?

The FirstView tool provides automated responses for the following key performance indicators:

- Occupant load
- Heating and ventilation
- Cooling efficiency
- Controls
- Reheat
- Gas baseload

For more information about the automated responses generated by the FirstView tool, see Understanding FirstView Results http://newbuildings.org/sites/default/files/UnderstandingFirstView.pdf

How does the FirstView tool compare to other modeling packages, such as eQuest or EnergyPlus?

Other modeling tools are primarily intended for use during building design. These models are extremely detailed and provide a comprehensive framework for modeling hourly energy use, with the primary purpose of sizing HVAC equipment and predicting comparative energy use.

The intention of the FirstView software and services is quite different. In this case the building is already constructed and operating. Often the as-built condition has changed from the original model and operating conditions may differ from the assumptions used during design. In many existing building cases a design model was not generated or cannot be found. Even if a model is available, a thorough audit and experienced modeling engineer would be required to properly calibrate the model to as-operated conditions. Each team may use a different approach and arrive at different conclusions. The FirstView tool automates this process, providing a consistently calibrated energy model that can be compared from one building to the next. The FirstView tool's approach aims to provide a lot of useful information at a low cost.

Who is using the FirstView software and services?

The U.S. Green Building Council is using FirstView software and services to provide analysis of all commercial buildings in their Building Performance Partnership program. The Oregon Department of Energy used the FirstView tool for a portfolio-level analysis of public schools. In that project, special considerations were made for the seasonal occupancy of schools.

Where do I go for a second view?

FirstView sotware and services provides an initial diagnostic look at how buildings use energy. With that information, owners, operators and designers can make more informed decisions on how to prioritize their next steps. This might include conducting a more targeted audit, changing operating practices or working to minimize particular areas of a building's energy use. NBI has many resources to assist through our Advanced Building® suite of tools. www.advancedbuildings.net

New Buildings Institute

New Buildings Institute (NBI) is a nonprofit organization working collaboratively with commercial building professionals and the energy industry to improve the energy performance of commercial buildings.