Getting to Fifty:
Moving Toward Low-Energy Commercial Buildings

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ABSTRACT

The Energy Policy Act of 2005 (EPACT 2005) provides tax incentives for buildings designed to use 50% or less of the energy of typical code buildings. Upon passage of this important legislation, the New Buildings Institute (NBI) developed an initiative to first, determine how many recently constructed buildings would meet this standard, and second, develop a set of linked strategies to encourage and support the development of additional buildings that are designed to use 50% or less of the energy of typical construction, referred to as low-energy buildings.

The NBI research indicated that, over the past several years, only about 1 new building in 1,000 is built to a level of efficiency that would qualify for the EPACT 2005 standard. While few in number, these low-energy buildings represent a variety of building types and sizes built across the country, supported by a wide mix of owners and design teams. The barriers to the widespread design and construction of low-energy buildings do not appear to be technical in nature, nor do they appear to be financial; more likely, they are related to the motivation of owners and the skill sets of design and construction teams.

This paper explores the nature of these low-energy buildings and examines the strategies developed by a national team of experts to remove real-world obstacles and dramatically improve energy performance.

Introduction

In late 2006, New Buildings Institute began researching new commercial buildings in the United States which were designed to be significantly more energy efficient than typical construction. This exercise was driven in part by New Buildings Institute's (NBI) interest in supporting the Energy Policy Act of 2005, which includes tax deductions for new buildings designed to use 50% less energy than buildings constructed to ASHRAE 90.1 – 2001 levels. Another motivator was the need to identify the types of energy efficiency strategies adopted in the marketplace by designers and/or owners of these extremely energy-efficient buildings (referred to as low-energy buildings).

NBI is not the only organization interested in buildings that reduce energy use by 50%. The 2030 Challenge is a global initiative stating that all new buildings and major renovations reduce their fossil-fuel GHG-emitting consumption by 50% by 2010, incrementally increasing the reduction for new buildings to carbon neutral by 2030. The 2030 Challenge has received support from the American Institute of Architects (AIA) and the US Conference of Mayors, among others. The US Green Building Council (USGBC) recognizes energy efficiency as part of its LEED program, and many gold and platinum LEED buildings are designed as low-energy buildings. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is planning to produce a series of *Advanced Energy Design Guides* focused on achieving a 50% energy reduction. The U.S. Department of Energy has a goal of Zero Energy

Buildings by 2025, and funds a variety of activities that support low-energy buildings in the near-term. While the baseline definitions of these buildings are all slightly different, with the 2030 Challenge referencing the average building stock and others referencing various versions of model national codes, the research indicated that there is a small world of buildings that meet any of the definitions of 50% better energy performance.

The Buildings Base

NBI reviewed a wide variety of databases, including U.S. Green Buildings Council, American Institute of Architects, the High Performance Buildings Database and a wide variety of individual case studies and assembled an on-line database known as *Getting to Fifty* (www.gettingtofifty.org). The *Getting to Fifty* (GT50) database includes over 100 buildings, with the United States as the primary market focus. As the data sources varied, information should generally be considered as self-reported, and only a small minority of the buildings had third-party post occupancy assessments of performance. In terms of energy performance, most buildings only provided modeled or anticipated performance.

The database includes a broad mix of building types - office, education and medical/ lab are the most common. There are examples of housing, retail, public assembly and warehouse buildings as well, as shown in Figure 1.

Figure 1. Projects by Building Type

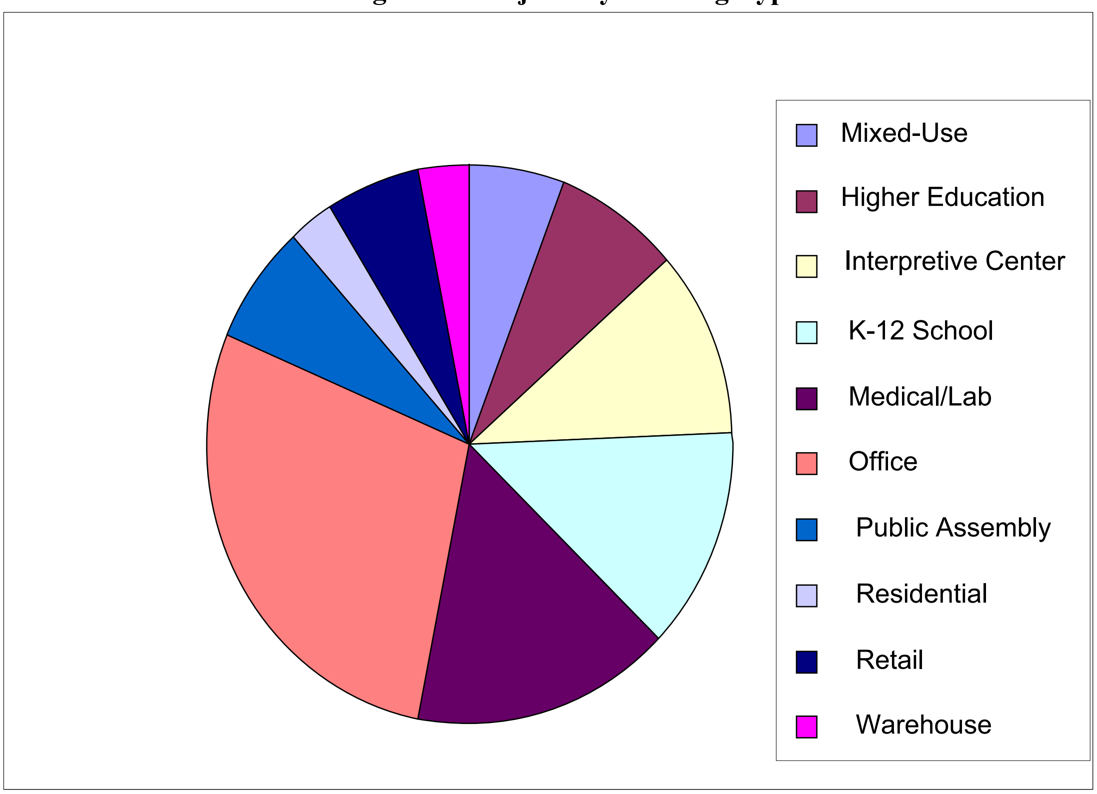
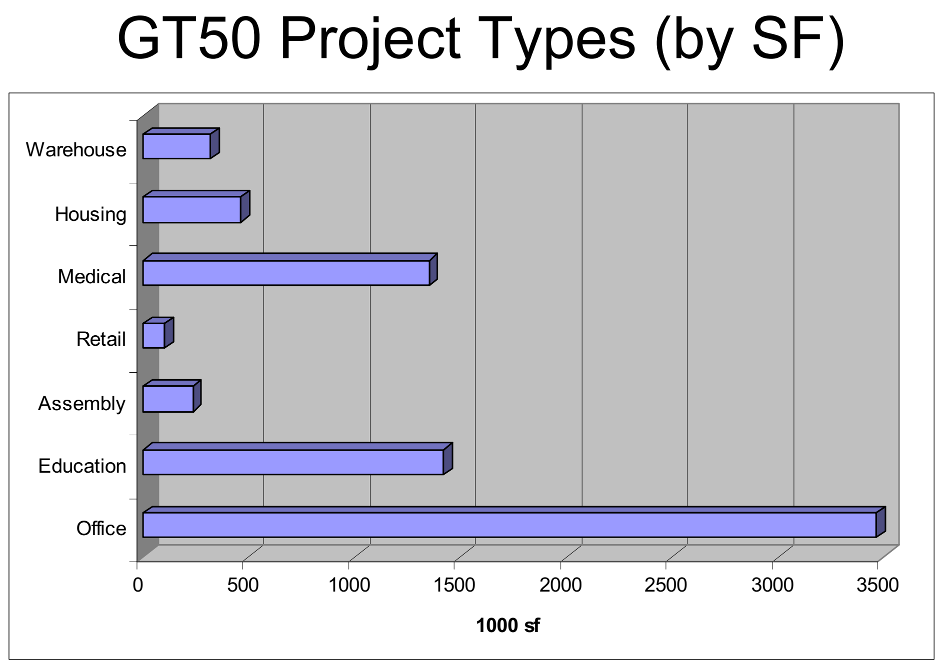
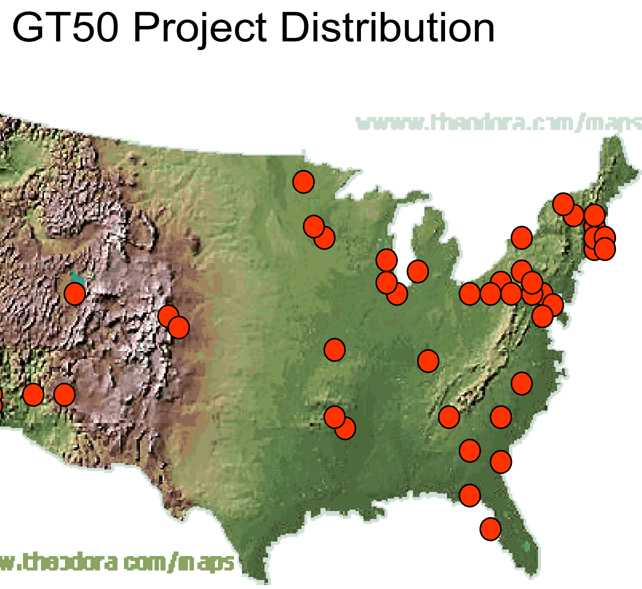


Figure 2. Getting to Fifty Project Types



Projects were identified in most areas of the country, but with a concentration in the Northeast U.S. and the west coast. Distribution of continental US projects found to date is shown in Figure 3:

Figure 3. Getting to Fifty Project Distribution



In addition to good type and geographic distribution, the GT50 Database buildings are a representative cross-section of sizes, costs and EUI's in each building class.

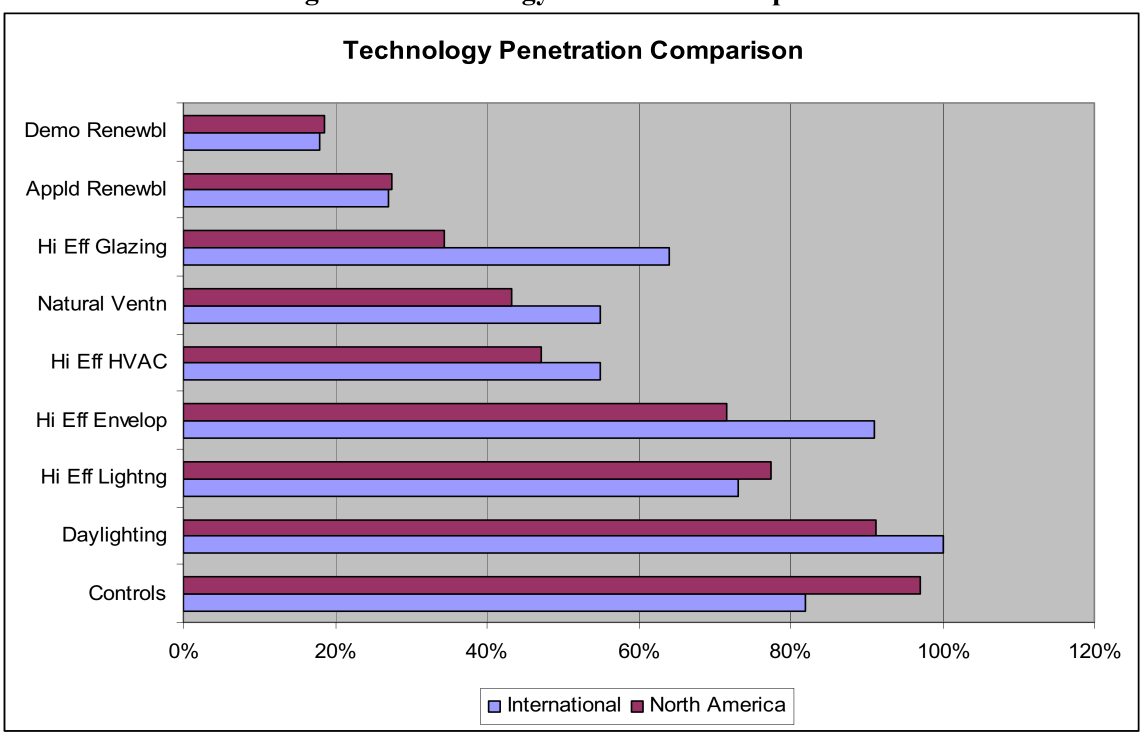
Table 1. Average Values from the GT50 Database, North American Only

Building Type	*Size (1000s SF)*	*Cost ($/SF)*	*EUI (KBtu/SF/Yr)*
Mixed Use	35	$156	35
Higher Education	62	$232	51
Interpretive Center	11	$313	47
K-12 School	109	$117	27
Medical/Lab	147	$236	203
Office	168	$158	47
Public Assembly	18	$200	24
Residential	145	$195	41
Retail	17	$128	47
Warehouse	73	$118	4

Technology Characteristics. NBI identified commonly used technologies by frequency of use. Given the diversity of source information and the prominence of high-profile measures (such as PV), some common measures (such as variable frequency drives) are likely underreported. Details on other measures may be quite variable; for example while many buildings noted daylighting design or natural ventilation, the details of the actual design elements could not be consistently captured in the GT50 database. However, links to detailed case studies and articles were included for users of the dataset who desired more information on specific design strategies. The penetration rates for both the North American and international projects are shown below. Daylighting and advanced controls were the most common measures, referenced in over 90% of the North American buildings, followed by high-efficiency windows and improved envelope performance features in over 70%. Some additional technology details are:

- Daylighting typically included controlling electric lighting through dimming or step relay controls, with many systems including occupancy control.
- Control of lighting and HVAC was mentioned as important in most cases.
- High-efficiency equipment was usually called out in the mechanical systems.
- High-performance glazing was the most frequently mentioned shell element.
- Cool roofs were more typically used in warmer climates.
- While a few technologies, such as insulation levels and cool roofs, demonstrate a climatic tendency, the majority seem independent of climate.

Figure 4. Technology Penetration Comparison



Findings from the data review. Overall, key findings of the investigation of the most efficient buildings in North America data review included:

- Buildings designed to this level of efficiency represent fewer than 1 in 1,000 of buildings designed and constructed in the US annually.
- High performance design intent is not limited by size, per-square-foot cost or geography. The range of building types and sizes was large, from warehouses to medical office buildings, and from a few thousand to nearly 1,000,000 square feet.
- Although low-energy designed buildings were found across the country, There appears to be a concentration in Northeast and West Coast state; states that also, perhaps not coincidentally have strong energy efficiency programs. Fewer buildings were located in hot, humid climates.
- The most common efficiency design features listed were daylighting and advanced control strategies (referenced in nearly all projects), while innovative features such as natural ventilation and underfloor air/displacement ventilation were present in 20%-40 % of the projects.
- A few projects reduced designed energy use by 70%-80 %, a level that could easily lead to a net-zero-energy building with a moderate size photovoltaic array.
- There is strong representation from offices and schools while other markets are not well represented given their size, e.g. retail and warehouses.

Expanding the Market for Low Energy Buildings

Currently, there is limited practical guidance for design teams who may be ready to consider improvements to performance which would make their buildings 50% more efficient than code. The uncertainties and time requirements of researching and implementing new approaches, and the associated performance risks, continue to be real-world obstacles to improved energy performance. With these issues in mind, NBI initiated a national meeting to help determine how to spread the skills, motivation and support that could create a new generation of low-energy buildings and accelerate low-energy buildings into the marketplace. The meeting, called the *Getting to Fifty* Summit, was a working meeting, designed to develop concepts and networks that would progress toward solutions after the gathering's conclusion. Specific questions focused on the following areas:

- What additional technical guidance needs to be developed?
- How can training be developed and supported for design professionals?
- What are the best strategies to increase owner interest?
- How can emerging technologies and design practices be accelerated into the market?
- How can existing resources be linked to support the goal?
- What other gaps and/or barriers exist that might impede progress towards the *Getting to Fifty* goal?

Sixty key decision makers, advocates and design professionals met in March 2007 at the Emory University Conference Center in Atlanta, Georgia, for a two-day retreat to work through detailed strategies and enhance linkages between organizations and resources. Attendees included representatives from:

- *Government*: US Environmental Protection Agency, California Energy Commission, New York State Energy Research & Development Authority
- *Design Professional Organizations*: American Institute of Architects, American Society of Heating, Refrigerating and Air-Conditioning Engineers, US Green Building Council, Illuminating Engineering Society of North America
- *Energy Efficiency Advocates/Policy*: Natural Resources Defense Council, American Council for an Energy Efficient Economy, Alliance to Save Energy, 2030 Challenge
- *Utilities*: National Grid, Pacific Gas & Electric, Northeast Energy Efficiency Partnerships, Northwest Energy Efficiency Alliance
- *Department of Energy National labs*: Lawrence Berkeley National Laboratory, Pacific Northwest National Laboratory, Oak Ridge National Laboratory and National Renewable Energy Laboratory
- *Business Organizations*: Development community, design firms, Wal-Mart
- Selected exemplary practitioners and university faculty, including Carnegie Mellon University and the University of Oregon.

The opening reception focused on presenting examples of low-energy buildings from around the country, many of which were designed or managed by attendees at the Summit. All attendees gathered together on the first evening for discussion and PowerPoint presentations. The remainder of the meeting consisted primarily of facilitated, small-group working sessions designed to identify ways to accelerate building energy efficiency. The initial small groups focused on five areas:

- Design Strategies
- Research and Technology
- Public Policy
- Owners and Operators
- Education and Training

Summit participants developed a remarkably broad and inclusive of over 100 options to accelerate the efficiency of commercial buildings, with a range of recommendations encompassing policy, education, marketing, and research and development. These options were sorted and organized overnight, and prioritized through a group exercise the next morning. The Summit then reorganized into “affinity groups” around a set of the highest priority strategies to develop additional networks and initial action plans.

An intentional aspect of the GT50 Summit was enhancing development of networks around topic areas to encourage the development of ongoing action. Initial meetings of these “affinity groups” focused on particular topics convened briefly at the Summit to develop the first steps of action plans. The seven topics below represent recommendations receiving the most votes during earlier discussions and activities. Note that three of the seven focus on measuring and using building performance information in case studies, building the business case, and reviewing actual performance; indicating that measured performance needs additional attention from several perspectives.

- ***It is critical to build the business case for high-performance buildings.*** Owners are the decision makers regarding building priorities and required financial performance. They need stronger, more specific communications and visible leadership from their own community.

- ***Tax incentives and progressive codes and standards are the public policy tools that will have the greatest impact in supporting the development of low-energy buildings.*** Extension and expansion of the EPACT 2005 tax deductions are needed. Codes and standards must move more aggressively to reduce the energy use of buildings.
- ***Early design process improvements can improve information, choices and commitments related to building performance.*** Several specific early action steps that would improve design choices were developed at the Summit.
- ***Plug-and-play integrated technology packages can capture the next step in efficiency for lighting, heating, ventilation and cooling.*** Examples of work underway are the US Department of Energy (DOE) Commercial Lighting Initiative, California Energy Commission (CEC) PIER Advanced Rooftop Unit with automated, embedded diagnostics, and, at the whole building level, ASHRAE's Advanced Energy Design Guides and NBI's Advanced Buildings: Core Performance.
- ***Climate-responsive design is the design element most likely to lead to buildings with very low energy requirements.*** Daylighting, natural ventilation and evaporative cooling represent complex interactions of technology, building form, controls and people. These interactions require both research and educational strategies to maximize their impact.
- ***Feedback on measured building performance needs to be improved from several perspectives.*** In order to improve the next design, design teams need feedback on the performance of previous design choices. Owners and operators need feedback on current performance to improve building operations. Measured performance also tells us if the low-energy design is yielding low-energy use and if it is not, why.
- ***Building case studies and post-occupancy evaluations are needed to reduce real and perceived risks of low-energy buildings.*** A tiered strategy of case studies was conceived at the Summit, all of which include energy, financial and occupant comfort information. More support is needed for case study development and post-occupancy evaluations.

NBI views the GT50 Summit as a starting point for an enhanced network to create a new class of low-energy buildings. The GT50 Summit was an experiment in collaboration; Could a large group of organizations and individuals all committed to higher standards of energy efficiency in commercial buildings come together and blend efforts to accelerate the integration of this new class of buildings into the existing market landscape? The response of the group was a resounding "yes," while the resultant enthusiasm and list of next steps point to new ways of approaching and stimulating the market.

Moving Forward: Measured Performance Activities after the GT50 Summit

A better set of data on measured performance on this new generation of low-energy buildings was major underlying theme of several of the recommendations coming from the GT50 Summit. While NBI was involved in developing building performance reviews prior to the GT50 Summit, activities following the summit have accelerated. While a specific activity at NBI was review of the measured energy use of LEED-NC buildings (covered in a separate paper in these proceedings), in December of 2007, NBI hosted a national measured performance meeting supported by ASHRAE, USGBC, EPA and the Energy Foundation. This was another working meeting, aimed at coordinating a wide variety of national activities and generating additional strategies to improve measured performance information. The working sessions focused on meeting the needs of three key audiences: building owners/financial, design teams, and efficiency program/policy.

Owners/ Financial

Owners need accessible, understandable performance reporting, in a way that can increase awareness and overcome misperceptions regarding what's possible and how to accomplish it. This would include actual energy consumption reporting from more buildings and better reporting communication channels, including standard, credible benchmarks and metrics.

Data on occupant comfort and productivity that would be valuable and credible to the owner/financial community includes empirical data of marketplace acceptance of green building, such as sales prices, rental rates and tenant turnover and better identification of the linkages between occupant comfort survey results and productivity, absenteeism, and other business metrics.

Tenants and owner also need information and communications that provide performance feedback to those who have control over energy use.

Design Community

The design community needs performance dashboards with multiple levels of metrics for relevance to designers, including defining key metrics beyond whole building EUI such as by responsibility (e.g. designers / owners / tenants) and by major end use category, e.g. lighting and plug loads. The design community is also interested in information on the relation of design process and technologies to building outcomes and a "tuned-up" modeling process to better predict energy use.

Policy / Program

The overarching goal was identified as better metrics to measure progress towards the ultimate net-zero performance goal, and to support continuous improvement of programs and policies. This would include a systematic national data collection effort, providing baseline / benchmark results and going deeper than the current Commercial Buildings Energy Consumption Survey (CBECS 2007) and national metered end-use data at various levels of depth.

National Steering Committee on Measured Performance

Following this working meeting discussed above, a National Steering Committee on Measured Performance has been formed, with ASHRAE, AIA, EPA and NBI contributing to initial planning work. The purpose of the Measured Performance Steering Committee is to articulate an agenda and coordinate activities to improve measured performance information. Achieving this purpose will include identifying key parts of the agenda that are already underway at various organizations, coordinating activities to make measured performance information more useful, securing support for aspects of the agenda that are currently unfunded, and developing mechanisms to increase utilization of measured performance information by a variety of audiences.

A first Steering Committee meeting was held on April 2, 2008. A key element of discussion was the need for measured performance on our newest buildings, for both individual building evaluation and aggregate benchmarking of today's green construction techniques. Components of the solution, currently being reviewed and refined, include:

- Focus first on buildings of greatest interest, such as those participating in programs such as LEED, utility efforts, and public projects. Define the core set of data that these buildings should provide, and provide a model for future broader collection. Start from a useful data perspective, not a census perspective.
- Promote significantly more contributions of measured performance to the DOE/Building Green High Performance Buildings Database, to make measured performance case studies accessible.
- Define the core set of measured performance data that should always be reported.
- Mine existing data sets, such as Energy Star's Portfolio Manager and utility company data collections for insights on trends and benchmarks.

The Steering Committee work is ongoing, and hopes to provide a platform to coordinate and initiate the development of better data to support progress on low-energy buildings.

Conclusions

The broad conclusion drawn from this set of projects is that low-energy buildings of various types and sizes can be built today across the country, supported by a wide mix of owners and design teams. Currently, just a few buildings attempt to reach a performance level that uses 50% less energy than standard, code based energy performance. The barriers to the widespread design and construction of low-energy buildings are not technical in nature, nor do they appear to be financial, but are more likely related to the motivation of the owners and the skill set of the design and construction teams.

A second important conclusion is that this class of low-energy buildings is poorly understood. With some notable exceptions, actual performance (including energy performance, financial performance, occupant satisfaction and marketplace acceptance) is largely unverified; real-world performance information is needed to reduce uncertainties in the market, and facilitate market expansion.

Improving energy efficiency in new construction should be a fundamental tenet of programs and policy to mitigate climate change. A wide variety of activities are needed to validate and stimulate early market actions to accelerate commercial building energy performance.