Green Buildings in the U.S. and China: Bridging the Energy Performance Gap

中美绿色建筑：缩小建筑能效差异

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Overview

Buildings and Climate Change

As the world develops strategies to address climate change and rising energy demand, the United States and China, which together account for over 40% of greenhouse gas emissions, will play key roles. Globally, the built environment accounts for 39% of anthropogenic greenhouse gas emissions. This study is part of a larger collaboration with students at the Nanjing University School of the Environment in China to analyze and improve the performance of buildings designed to be energy efficient.

Problem Statement

Operational energy demand data indicates green buildings are not meeting energy performance predictions. This discrepancy between predicted and actual performance is commonly referred to as the performance gap. By utilizing a customized systematic tool called Post-Occupancy Evaluation, local case studies identify causes of the gap and inform recommendations to improve the performance of green buildings. Case studies include LEED-certified buildings on the UC Santa Barbara main campus and in the "Eco-Zone" of Suzhou Industrial Park in Suzhou, China. Results identify large system issues, such as heating system failures and management policies regarding computer data protection, as substantial factors contributing to the performance gap. Procedures developed in this research enable building managers to pin-point problems and design effective solutions to help ensure green buildings perform as efficiently as possible, thereby reducing the contribution of greenhouse gas emissions from the building sector.

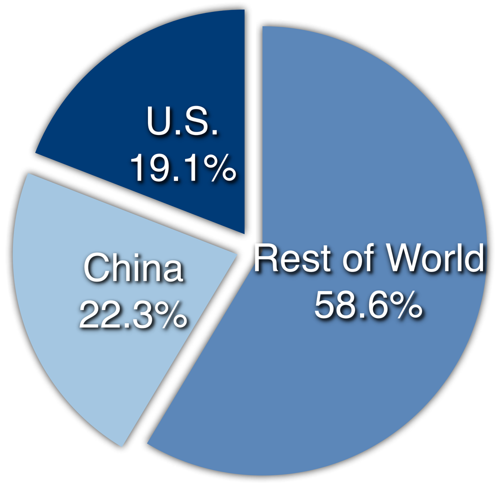


Figure 1: World carbon dioxide emissions. Source: US DOE Buildings Energy Data Book (2008).

Energy Performance Analysis

The Performance Gap

To analyze the systems driving the performance gap and establish effective solutions to major causes, we established the following methodology:

1. Convert energy consumption data of main electricity, chilled water, natural gas, and renewable energy from utility bills into standard Energy Use Intensity (EUI) units.
2. Analyze energy simulation model reports for predicted EUI.
3. Administer Post-Occupancy Evaluation (POE).
4. Compare POE results with performance gap system data breakdown and identify problem areas.

As outlined in the conclusions section, we developed a streamlined energy performance audit for future analyses by green building managers.

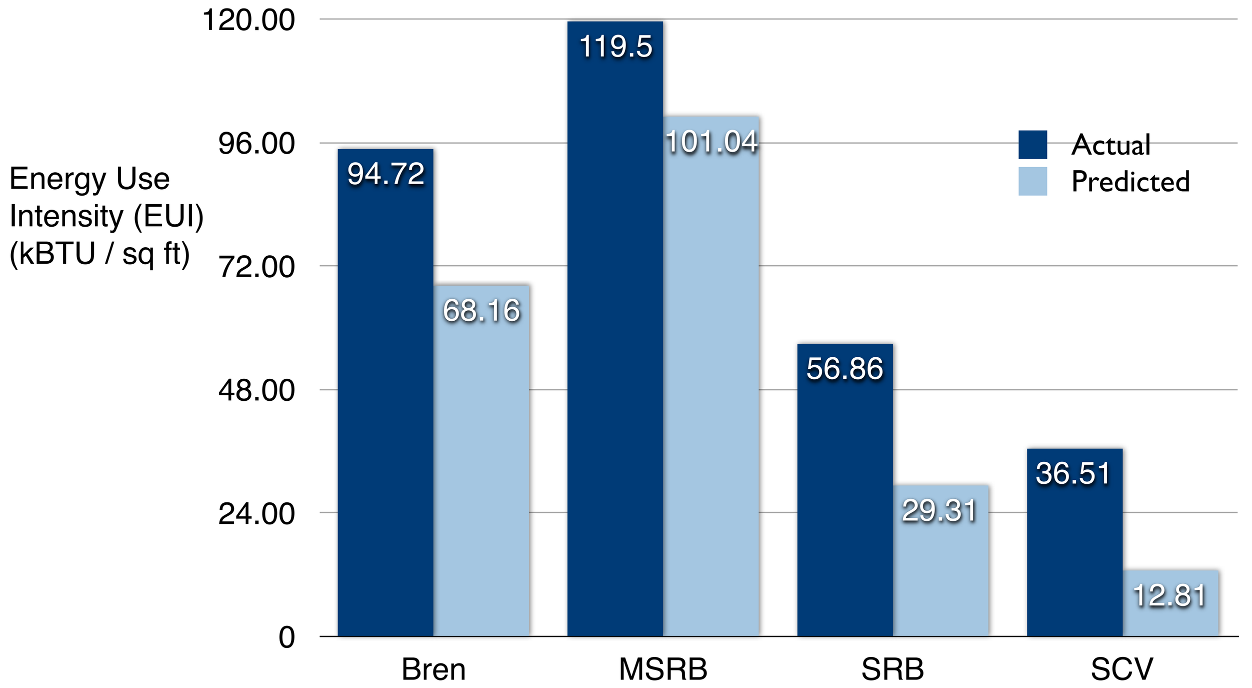


Figure 2: Energy performance gap of case studies.

Post-Occupancy Evaluation

POE is the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied to evaluate critical aspects of building performance.

✓386 paper surveys delivered (45% response rate).
✓1143 online surveys delivered (22% response rate).
✓15 interviews conducted with building and facility managers.
✓123 rooms observed for walkthrough audits across all buildings.

Primary drivers identified:

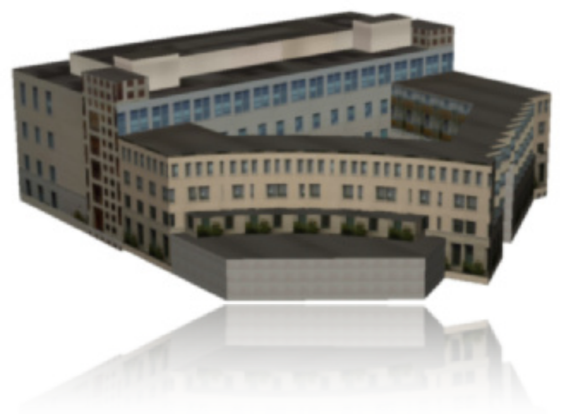
- Modeling simulation inputs
- Occupant behavior
- Management and control
- Construction quality

Case Study Results

Bren Hall

Gap = 39%
Identified Driver – Management / Policy

- Building IT policy prevents shutdown of computers.
- Causes following increases compared to model:
  - 255,858 kWh
  - $28,144
  - 94 tons CO_2e emitted



Marine Science Research Building

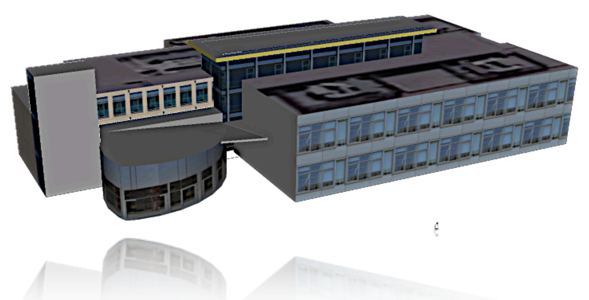
Gap = 18%
Identified Driver – Commissioning

- Commissioning identified faulty wiring in reheat valves and chilled water valve stuck open.
- After addressed, resulted in:
  - 44% energy efficiency improvement
  - $60,300 annual savings

Student Resource Building

Gap = 94%
Identified Driver – Construction Quality

- Radiant heat flooring system caused floor tiles to crack.
- UCSB facilities decided to shut system down.
- Other systems compensated and operated above design specifications to heat building.
- Result: Natural gas consumption over 500% above predicted.



San Clemente Villages

Gap = 185%
Identified Driver – Poor Modeling Sophistication

- LEED does not require the energy model to include receptacle and lighting loads for multi-family high rise residential buildings.
- Receptacle load alone accounts for 47% of actual energy use.

Nanjing University Collaboration

The current stage of our collaboration is outlined below. The next steps in our research will continue into through June 2012 when our group will travel to Nanjing University to present and discuss our results.

Completed:

- Energy use intensity (EUI) calculated from utility expenditure history.
- Customized occupant survey translated into Mandarin, fielded, and analyzed.

Ongoing:

- Refining walkthrough methodology given restricted permissions.
- Obtaining modeling data and Three-Star certification documents.
- Obtaining past utility statements.
- Adapting specialized decision tree for Chinese green building managers.

Figure 3: Suzhou Industrial Park, Suzhou, China. Source: Nanjing University (2012).

Conclusions

Future Management

Our analysis determined an overarching approach to reducing the energy performance gap does not exist.

- As the gap involves multiple stakeholders (building managers, consultants, government employees and policy makers), a bottom-up approach is most effective.
- Decision makers should prioritize cost-effective and simple measures to reduce the gap. A traditional POE approach does not accomplish this.
- The following decision tree provides stakeholders with a tool to efficiently evaluate building performance, identify areas of concern, and propose solutions to reduce the performance gap. It allows for simple and fast periodical building evaluations.

By utilizing this streamlined approach, managers can implement solutions to maximize green building efficiency and reduce greenhouse gas emissions.

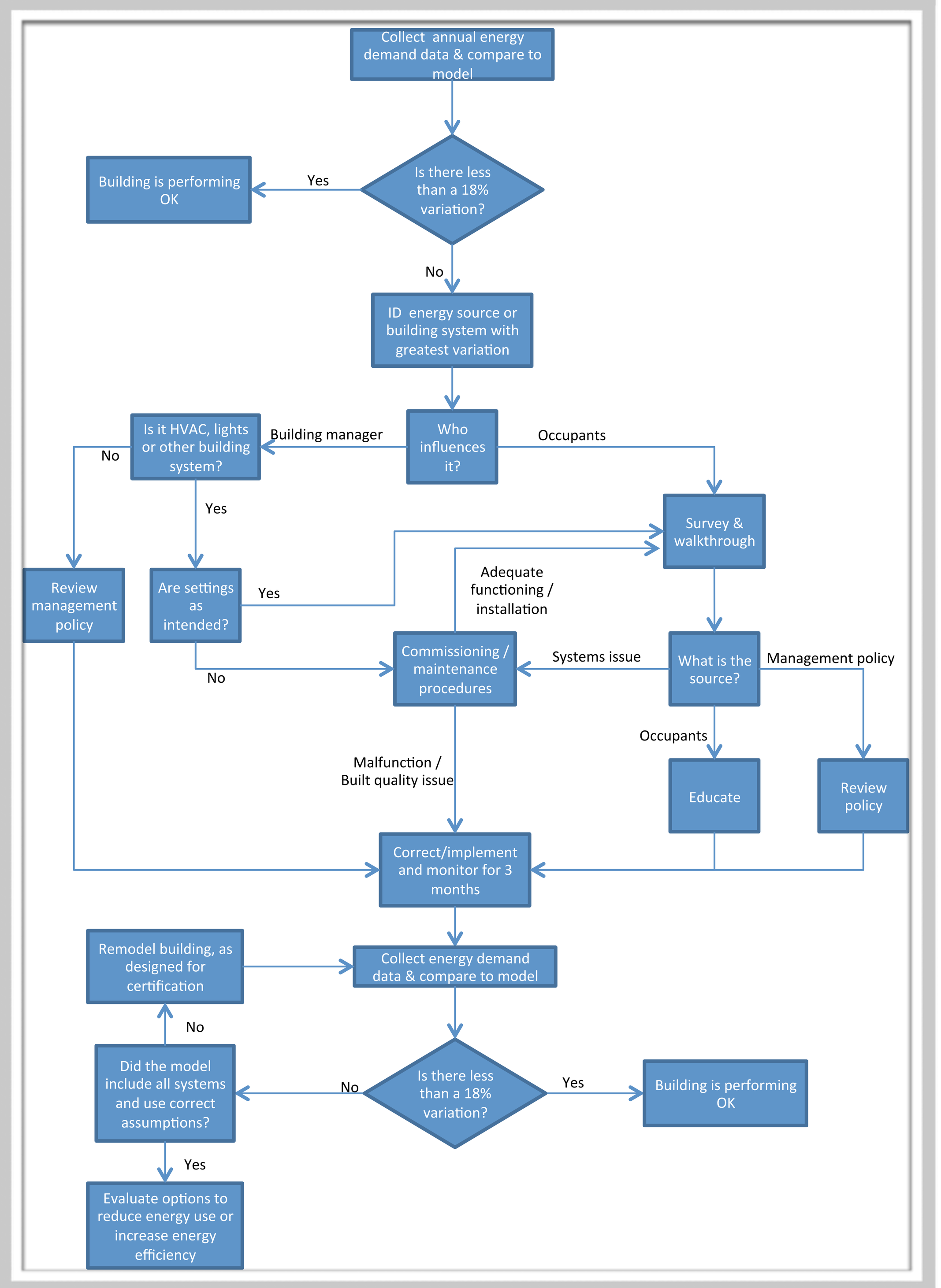


Figure 4: Specialized green building manager decision tree.

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