ENERGY EFFICIENCY AND OCCUPANT COMFORT IN UNC BUILDINGS

Caleb Cates, Katelyn Costa, Lila Fleishman, Andrew Flinchum, Jamie Linden, Sarah Lowder, Shane Shields, Michael Titus, Rachel Tove-White

ENST/ENVR 698—Environmental Capstone
Spring 2014
INTRODUCTION

- **CLIENT:** UNC-CH Energy Management
  - Monitoring, controlling, and reducing water and energy use
  - Vision: Continuously improve building performances

- **RESEARCH PROBLEM:** Follow-up studies on LEED and high-performance buildings have not been thoroughly conducted

- **RESEARCH QUESTION:** Understand variations in performance among different building types
INTRODUCTION

● **GOALS:**
  ○ Understand performances of buildings among use type
  ○ Explore performance of “high performers”
  ○ Integrate energy efficiency with occupant comfort
  ○ Discover gaps in UNC’s data collection

● **PRODUCTS:**
  ○ Presentation
  ○ Report
  ○ White papers
INTRODUCTION - WHITE PAPER EXAMPLE

From the UNC Sustainable Triangle Field Site Capstone

MORRISON: AN ANALYSIS OF ENERGY EFFICIENCY, TEMPERATURE, AND OCCUPANT COMFORT

S p r i n g 2 0 1 4

INTRODUCTION & OVERVIEW

Morrison is an award winning South Campus residence hall and home of UNC's Sustainability Learning Community. It has earned multiple awards, including the top energy reduction (18% reduction) in the 2013 Campus Conservation National and winning the EPAs first National Building Competition in 2010. The dorm is ten stories, and each floor has balconies leading out to suites on four separate sides. These balconies comprise a significant portion of the dorm floor space that is not being air conditioned or heated. Morrison also uses 172 rooftop solar thermal panels for hot water heating and uses real-time consumption monitors to monitor electricity, steam, and chilled water use in each of the building's twelve zones.

ENERGY DATA

Morrison is almost 50 years old, despite undergoing renovations in 2006. In 2013 it used 9,121,384 kWh of electricity, which is approximately 3.5 kWh per square foot. Though this residence hall used the most electricity of the three in this study, it is also the largest. Morrison uses significantly less energy per square foot than Carroll Hall, and a similar quantity to Ehringhaus, which is built in a similar style. Soaker and chilled water also showed higher efficiency than the other two dorms used for comparison. Morrison used 19,694,099 kWh for heating, 13,659,000 kWh for chilled water, and 15,194,000 kWh for steam.

TEMPERATURE DATA

A considerable amount of Morrison's floor space is non-air-conditioned balconies, with doors leading into each suite. On nice days, these doors are often left open, even if the heat or air-conditioning is running. Temperature measurements ranged from the mid 50s in unoccupied interior common rooms, to low 80s in the bedrooms exposed to warm outdoor air. Occupants tended to be at a comfortable level, around standard room temperatures, with most variation coming from the small rooms containing the vending machines, which revealed a sixteen degree range.

KEY INFORMANT INTERVIEWS

Lara Adams, Manager of UNC Energy Management Department

Though the selected key informant from Morrison was unavailable for interview, we were able to gain additional insights about the dorm from Lara Adams of UNC Energy Management. According to Adams, Morrison is the only one of the four South Campus dorm towers to have centrally controlled temperatures. This central control is in a much more efficient method of managing temperatures, and should decrease Morrison's energy use.

SUMMARY OF RESULTS

1. RECOMMENDATIONS

1. Provide reminders for residents to turn down their air conditioning while doors are open. Perhaps with stickers by the control and features on the RA boards.

2. Keep areas with high electrical loads, like the vending machines, well ventilated to reduce temperature variations.

3. Implement Morrison’s successful energy saving initiatives in other residence halls.

4. Most of the residents were generally comfortable in Morrison, with the majority of comments stemming for desires to have larger rooms. Many residents like having the balconies when they can prop their suite door open to enjoy weather on nice days.

“I want more control of heating and air.”

The use of natural light in the place of artificial light was rather uncommon, possibly because not enough light could filter into balcony-style rooms, where blinds typically remain closed to prevent passersby from looking into these rooms.

“Very nice and fresh.”
BACKGROUND

HIGHLIGHTS:

- UNC-CH has LEED-certified and LEED standard buildings with unknown performing status
- NC Senate Bill 668 specifies standards
- Energy use varies across building types
- Occupant comfort & behavior patterns are critical components
# METHODS - BUILDING SELECTION

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METHODS - BUILDING SELECTION
METHODS - DATA COLLECTION

**Energy Data:** utility bills & LEED templates; EnergyStar’s Portfolio Manager

**Temperature Data:** read with infrared temperature guns

**Occupant Survey:** investigated comfort; n=255

**Building Head Interviews:** more detailed information on building temperature controls
METHODS - FLOOR PLAN EXAMPLE

Actual Temperature Readings
1st Day: 3/20/14 (50° outside, sunny)
Indoor temp; reading marked in BLUE
2nd Day: 4/3/14 (60° outside, sunny)
Indoor temp; reading marked in GREEN

Genomic Science Building
Second Floor Plan
Bldg. #676
Observations:

- Lowest Total Energy Consumers: LEED Buildings
- Highest Total Energy Consumers: Labs
- Trends:
  - Labs use the most energy both in total and per square foot
  - The two LEED-certified buildings, Genome Sciences and NC Botanical Gardens, excel at energy efficiency
**DATA & ANALYSIS: OVERALL**

**OBSERVATIONS:**
- Lowest Total Energy Consumers: **LEED Buildings**
- Highest Total Energy Consumers: **Labs**
- Trends:
  - Labs use the most energy both in total and per square foot
  - The two LEED-certified buildings, Genome Sciences and NC Botanical Gardens, excel at energy efficiency

**SURPRISES:**
- Anomaly: Ehringhaus - oldest building in sample but one of least energy intensive per ft²
- Genetics consumed as much energy as the other 8 buildings combined
### DATA & ANALYSIS: CLASSROOMS/ADMINISTRATIVE

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OBSERVATIONS:

- Lowest Energy Consumer:
  - Total: NC Botanical
  - Per square foot: NC Botanical

- Highest Energy Consumer:
  - Total: Knapp-Sanders
  - Per square foot: Knapp-Sanders

- Trends:
  - Fedex and NC Botanical are well above the national median for energy consumption
  - Knapp-Sanders lags behind
    - Infrastructure and renovations
OBSERVATIONS:

- Lowest Energy Consumer:
  - Total: NC Botanical
  - Per square foot: NC Botanical

- Highest Energy Consumer:
  - Total: Knapp-Sanders
  - Per square foot: Knapp-Sanders

- Trends:
  - Fedex and NC Botanical are well above the national median for energy consumption
  - Knapp-Sanders lags behind
    - Infrastructure and renovations

SURPRISES:

- The highest energy consumer was still at the national median
## DATA & ANALYSIS: RESIDENTIAL

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DATA & ANALYSIS: RESIDENTIAL

OBSERVATIONS:

- Lowest Energy Consumer:
  ○ Total: Ehringhaus
  ○ Per square foot: Ehringhaus

- Highest Energy Consumer:
  ○ Total: Morrison
  ○ Per square foot: Carmichael

- Trends:
  ○ High use of district steam across all buildings
  ○ Heating/cooling units are especially important here
DATA & ANALYSIS: RESIDENTIAL

**Observations:**
- Lowest Energy Consumer:
  - Total: **Ehringhaus**
  - Per square foot: **Ehringhaus**
- Highest Energy Consumer:
  - Total: **Morrison**
  - Per square foot: **Carmichael**
- Trends:
  - High use of district steam across all buildings
  - Heating/cooling units are especially important here

**Surprises:**
- Per square foot, Ehringhaus uses slightly less energy than Morrison
## DATA & ANALYSIS: LABS

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DATA & ANALYSIS: LABS

OBSERVATIONS:

- Lowest Energy Consumer:
  - Total: Genome Sciences
  - Per square foot: Genome Sciences

- Highest Energy Consumer:
  - Total: Genetic Medicine
  - Per square foot: Genetic Medicine

- Trends:
  - Genome Sciences benefiting from LEED standards
  - Occupancy percentage plays a key role in energy usage
DATA & ANALYSIS: LABS

**OBSERVATIONS:**

- Lowest Energy Consumer:
  - Total: **Genome Sciences**
  - Per square foot: **Genome Sciences**

- Highest Energy Consumer:
  - Total: **Genetic Medicine**
  - Per square foot: **Genetic Medicine**

- Trends:
  - Genome Sciences benefiting from LEED standards
  - *Occupancy percentage* plays a key role in energy usage

**SURPRISES:**

- Genetic consumes the most energy
- Genome is performing better than projected
DATA & ANALYSIS: COMFORT

Observations:
- Trends:
  - Males report slightly higher average comfort than females.
  - Labs have the widest range of comfort

Average Comfort by Building Use and Gender (1-4 scale)

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<tr>
<td>Males</td>
<td>3.33</td>
<td>3.09</td>
<td>3.28</td>
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<tr>
<td>Female</td>
<td>3.12</td>
<td>2.73</td>
<td>3.19</td>
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Observations:

- Lowest Average Comfort:
  - Genetics
  - The 2 LEED buildings

- Highest Average Comfort:
  - Carmichael
  - Knapp-Sanders

- Trends:
  - Building with least efficiency had least comfort
  - Building with highest efficiency had 2nd least comfort
  - “High performers” all had comfort ratings under the average
A DEEPER LOOK: BOTANICAL

QUICK FACTS:
- Built 2007; opened 2010
- LEED Platinum
- Two geothermal heat pumps
- Solar PV array

OBSERVATIONS:
- Consumes half the national average
- Performs worse than expected
  - Heat pumps?
  - Humidity issues?

TEMPERATURE & COMFORT:
- Great daylighting
- Poor temperature
- Inaccurate thermostats
RECOMMENDATIONS

- **Classroom/Administrative:**
  - Consider giving more control back to occupants, particularly Botanical

- **Residence Hall:**
  - Further investigate why Ehringhaus is so efficient

- **Labs:**
  - Energy efficient systems such as those in Genome Sciences
  - Address energy use in Genetic Medicine

- **LEED Buildings:**
  - Genome Sciences
  - NC Botanical

- **Future Data Collection:**
  - Streamline compilation
  - Ensure data is available for every building
ACKNOWLEDGMENTS

Amy Bullington, Department of City and Regional Planning
Susan Caplow, Curriculum for the Environment and Ecology
Chris Martin, Energy Management
Jessica O’Hara, Energy Management
Elizabeth Shay, Institute for the Environment
QUESTIONS?