Bloomington Faculty Council
Energy Management and Utilities Analysis
February 18, 2020

Thomas A. Morrison
Energy Management & Utilities Overview

- LEED at IU
- Bloomington Campus Distribution Systems
- New Systems Implementation
- Emerging Energy Technologies
- Carbon Footprint Reduction
Leadership in Energy and Environmental Design (LEED) Certification

LEED's point-based rating system evaluates buildings for their performance in seven categories:

- Sustainable sites
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation
- Regional priority credits

Bloomington LEED-Certified Projects

Gold: 60 to 79 points
- 3rd and Union Apartments
- Cyberinfrastructure Building
- Hodge Hall
- Global and International Studies Building
- Jacobs School of Music East Studio Building
- Ray E. Cramer Marching Hundred Hall
- Paul H. O'Neill School of Public and Environmental Affairs Addition
- Simon Skjodt Assembly Hall Renovation
- Spruce Hall

Silver: 50 to 59 points
- Innovation Center
- Multidisciplinary Science Building II
- Research and Teaching Preserve
- Tulip Tree Apartments

Certified: 40 to 49 points
- Forest Dining Hall
IU University-Wide
Purchased Fuels and Utilities – FY 2019

Energy Use Percentage
- Electric – 33.7%
- Steam – 33.1%
- Chilled Water – 23.5%
- Natural Gas – 9.5%
- Other – 0.1%
  Diesel Fuel
  Propane

Cost Percentage
- Electric – 46.2%
  $37,832,236
- Steam – 20.1%
  $16,445,556
- Chilled Water – 18.7%
  $15,339,285
- Sewer – 7.8%
  $6,348,958
- Other – 7.2%
  Natural Gas
  $2,604,505
  Water
  $2,582,041
  Storm Drainage
  $343,066
  Irrigation
  $190,308
  Fire Protection
  $132,939
  Diesel Fuel
  $60,018
  Propane
  $21,664
  Refuse
  $1,582
  TOTAL
  $81,902,248
IU Bloomington
Purchased Fuels and Utilities – FY 2019

Energy Use Percentage
- Electric – 27.6%
- Steam – 40.6%
- Chilled Water – 24.4%
- Natural Gas – 7.2%
- Other – 0.1%
  Diesel Fuel
  Propane

Cost Percentage
- Electric – 46.6% $16,892,209
- Steam – 24.6% $8,926,436
- Chilled Water – 12.6% $4,553,036
- Sewer – 8.3% $3,234,655
- Other – 7.2%
  Water $1,190,600
  Natural Gas $1,046,993
  Storm Drainage $163,272
  Irrigation $127,047
  Fire Protection $64,003
  Diesel Fuel $31,124
  Propane $21,664
  TOTAL $36,251,041
<table>
<thead>
<tr>
<th>Campus</th>
<th>MMBTU per SF</th>
<th>Cost per SF</th>
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<tbody>
<tr>
<td>IU South Bend</td>
<td>0.09</td>
<td>$1.33</td>
</tr>
<tr>
<td>IU Southeast</td>
<td>0.10</td>
<td>$1.68</td>
</tr>
<tr>
<td>IU Kokomo</td>
<td>0.11</td>
<td>$1.85</td>
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<tr>
<td>IU BLOOMINGTON</td>
<td>0.11</td>
<td>$2.05</td>
</tr>
<tr>
<td>IUPUI</td>
<td>0.15</td>
<td>$2.27</td>
</tr>
<tr>
<td>IU Northwest</td>
<td>0.16</td>
<td>$2.62</td>
</tr>
<tr>
<td>IUPUC</td>
<td>0.15</td>
<td>$3.13</td>
</tr>
<tr>
<td>IU East</td>
<td>0.13</td>
<td>$3.40</td>
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</tbody>
</table>
IU Bloomington Campus
Electricity Snapshot: 7-Year Trend

Cost +3%
Usage -8%
IU Bloomington Campus
Electricity Monthly Use and Cost: 7-Year Trend

Cost +3%
Usage -8%
Reducing Cost of Electricity, Revisited (4/19)

While Rates Have Continued To Increase, Usage Has Continued To Decrease

- Controlling Cost Example: IU Bloomington
  - Consumption per square foot has decreased more than 10% over last 6 years
    » 3% reduction in 2019 from 2018 consumption

- Local Rate Has Increased Annually since 2015
  - *Blended Electricity Rate* (Peak + Standard Monthly Charge)
  - 14% increase over last seven years

![Graph showing consumption and rate trends]
IU Bloomington Campus
Natural Gas Snapshot: 7-Year Trend
BLOOMINGTON CAMPUS DISTRIBUTION SYSTEMS

Chilled Water & Steam Distribution
IU Bloomington Campus
Central Chilled Water Distribution

- N. Woodlawn Chiller
- Chilled Water Plant
- MAC Chiller
- Union Street Chiller
- Forest Quad Chiller

- Existing Chilled Water System
- Chilled Water Completed Since 2008
- Future Chilled Water Projects

17.35 Miles of Piping
Serves 84 Buildings
(10,723,559 sq ft)
IU Bloomington Campus
Central Chilled Water Line Projects: 2008 through 2020

- 10 Projects

- 8,500 linear feet of pipe

- Total Spend = $9.1M
  - $1.7M on additional distribution connections
  - $7.4M on additional chillers
    » 500 TON chiller at Forest Ave. plant
    » 2500 TON chiller at M100 plant
    » 900 TON chiller at N. Woodlawn Ave. plant

- Payback Period:
  - Approximately 7.3 years
IU Bloomington Campus – Central Chilled Water Production
Potential Impact of Climate on Capacity

Annual Cooling Degree Days

<table>
<thead>
<tr>
<th>Year</th>
<th>Cooling Degree Days</th>
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<tbody>
<tr>
<td>2010</td>
<td>1445</td>
</tr>
<tr>
<td>2011</td>
<td>1279</td>
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<tr>
<td>2012</td>
<td>1404</td>
</tr>
<tr>
<td>2013</td>
<td>984</td>
</tr>
<tr>
<td>2014</td>
<td>895</td>
</tr>
<tr>
<td>2015</td>
<td>1041</td>
</tr>
<tr>
<td>2016</td>
<td>1327</td>
</tr>
<tr>
<td>2017</td>
<td>1088</td>
</tr>
<tr>
<td>2018</td>
<td>1621</td>
</tr>
</tbody>
</table>

Cooling degree days = the number of degrees by which the average daily temperature is higher than 65°F.
IU Bloomington Campus
Annual Cooling Degree Days Trending Upward

[Bar graph showing annual cooling degree days from 2011 to 2030, with a trend line indicating upward trend.]
IU Bloomington Campus
Steam Distribution

Central Heat Plant

Existing Steam System
Steam Completed Since 2008
Future Steam Projects

22.35 Miles of Piping
Serves 116 Buildings
(12,682,844 sq ft)
IU Bloomington Campus
Steam Line Projects: 2008 through 2020

- 37 Projects
  - 31 Projects completed
  - 6 Projects scheduled in 2020

- 22,350 linear feet of pipe impacted
  - 17,850 linear feet to date
  - 4,500 linear feet in 2020

- Total Spend = $27.3 M
  - $19.2 M to date since 2008
  - $8.1 M projected through 2020

- Payback Period:
  - Approximately 7.5 years
New Systems Implementation
Success in availability & timeliness of data across campuses
IU Bloomington – Report Data Analysis

FY2019 Total Utility Cost: Most Expensive Buildings

Color Intensity by ANNUAL COST
Size by SQFT

<table>
<thead>
<tr>
<th>Rank</th>
<th>Building Name</th>
<th>Annual Cost ($)</th>
<th>Size (SqFt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Data Center</td>
<td>$1,519,655</td>
<td>81,186</td>
</tr>
<tr>
<td>2</td>
<td>Wells Library</td>
<td>$1,301,265</td>
<td>557,828</td>
</tr>
<tr>
<td>3</td>
<td>Jordan Hall</td>
<td>$1,248,087</td>
<td>322,524</td>
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<tr>
<td>4</td>
<td>IN Memorial Union</td>
<td>$1,228,515</td>
<td>431,388</td>
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<tr>
<td>5</td>
<td>Simon Msc Lbr Rec</td>
<td>$1,047,620</td>
<td>231,539</td>
</tr>
<tr>
<td>6</td>
<td>Simon Hall (Science)</td>
<td>$981,635</td>
<td>141,094</td>
</tr>
<tr>
<td>7</td>
<td>Chemistry</td>
<td>$963,554</td>
<td>183,387</td>
</tr>
<tr>
<td>8</td>
<td>Wright Quad</td>
<td>$782,672</td>
<td>295,971</td>
</tr>
<tr>
<td>9</td>
<td>Multi Science 2</td>
<td>$756,300</td>
<td>131,074</td>
</tr>
<tr>
<td>10</td>
<td>Memorial Stadium</td>
<td>$714,477</td>
<td>551,875</td>
</tr>
</tbody>
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*Excludes production facilities
IU Bloomington – Success Story

Bill Flag Feature Alerts Utilities of Excess Water Use

- **December 11, 2019 2:33 pm**
  - UIG reviews and approves CBU invoice for November

- **December 19, 2019 10:34 am**
  - Utility Analyst uploads CBU water bill data into EnergyCAP

- **December 19, 2019 11:18 am**
  - EnergyCAP bill flag feature alerts analyst of increase in consumption over prior month

- **December 24, 2019 9:07 am**
  - Supervisor reports that toilet is repaired and water meter shows return to normal flow

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**Monthly Use**

![Graph showing water usage by month with a peak in November at 58,000 GAL and a recent usage of 2,000 GAL.](chart.png)
Emerging Energy Technologies
Viable Renewable Alternatives for Energy Diversity
IU Bloomington Campus - Utility Project Highlight
Outside Lighting Conversion to Controlled LED

2100+ Campus Lights to be converted to LED
- High Pressure Sodium Lights Converted to LED Lights
- 66% Energy Savings
- 40% of campus lights have been converted to date
- Projecting 80% converted by end of 2020 and 100% by end of 2021

Benefits
- Improved safety
- Control and Maintenance Alerts
- Dimming capability
- Energy Consumption by Light Fixture
- IUPD Emergency Control
- 10 Year Warranty

PROJECT PAYBACK PREDICTIONS
Projected Annual Savings: $157K
Payback Period: ~8.7 years
COMBINED HEAT and POWER = the use of a heat engine to make both electricity and useful heat at the same time

In most heat engines, approximately half of the available energy is wasted as excess heat. By capturing the excess heat, a combined heat and power plant may reach an efficiency of up to 70%, compared with 40% for conventional plants.
IU Bloomington Campus - Combined Heat and Power
Potential Energy Savings

Anticipated Monthly Demand Trend
Average monthly power generation: 13 MW

Payback Period: ~ 6.4 years
IU Bloomington Campus – Solar Energy Production
Costs Able to be Reduced Via Solar Photovoltaic Systems

Sample of Five Installations

Average Annual Electricity Cost Savings: $5,900

Return on Investment; Projected Payoff Period

<table>
<thead>
<tr>
<th>Installation</th>
<th>Project Cost</th>
<th>Estimated Payoff Period</th>
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</thead>
<tbody>
<tr>
<td>Indiana Memorial Union</td>
<td>$12,425</td>
<td>24 years</td>
</tr>
<tr>
<td>Briscoe Quad</td>
<td>$256,000</td>
<td>42 years</td>
</tr>
<tr>
<td>Tulip Tree Apartments</td>
<td>$56,750</td>
<td>36 years</td>
</tr>
<tr>
<td>E-House</td>
<td>$22,735</td>
<td>23 years</td>
</tr>
<tr>
<td>Central Heating Plant</td>
<td>$11,874</td>
<td>29 years</td>
</tr>
</tbody>
</table>
IU Bloomington Campus – Solar Effectiveness Impacted By Season

Peak Billing Cycle and Seasonal Impact on Solar-Generated Cost Savings

- 74% of Cost Savings Occurs at Peak Bill Cycle Each Month
- *Winter Segment* (Oct.-Mar.) **37% less** energy produced vs. *Summer Segment* (Apr.-Sept.)

Indiana, Compatibility with Solar Energy Production

How Indiana ranks among all 50 states

- Percent of Days that are “sunny” 41\textsuperscript{st}
- Total number of “clear” days/year 39\textsuperscript{th}
- Total Hours of Sunshine: 42\textsuperscript{nd}
IUB Solar – Geographic Location Impacts Efficiency, Payback

IUB solar not generating significant energy at peak periods

- Output was less than 20% of system capability 43% of monthly peak periods
- Output 50% or greater only 33% of those monthly peak periods.

Projected Payoff Periods (adjusted for inflation)

<table>
<thead>
<tr>
<th></th>
<th>Current Estimated Payback</th>
<th>At Constant Maximal Production</th>
<th>At “Summer” Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indiana Memorial Union</td>
<td>24 years</td>
<td>14 years</td>
<td>20 years</td>
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<td>13 years</td>
<td>21 years</td>
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Solar Payback Based on Peak Sunlight & Local Cost of Electricity

Output Efficiency Depends on “Peak Sunlight” Hours

Solar intensity must be strong enough to be captured by solar panels

Average Number of Peak Sunlight Hours/Day

- San Diego, CA: 5.7
- Denver, CO: 5.6
- Miami, FL: 5.2
- Charlotte, NC: 5.0
- Kansas City, MO: 4.9
- Houston, TX: 4.8
- Minneapolis, MN: 4.6
- Philadelphia, PA: 4.6
- Concord, NH: 4.6
- Seattle, WA: 4.4
- **Bloomington, IN**: 4.2
- Syracuse, NY: 4.1

Payback Period Shorter When Electricity Rates Higher

Average Electricity Rates (cents/kWh) by Region

- San Diego, CA: 5.7 cents/kWh
- Denver, CO: 5.6 cents/kWh
- Miami, FL: 5.2 cents/kWh
- Charlotte, NC: 5.0 cents/kWh
- Kansas City, MO: 4.9 cents/kWh
- Houston, TX: 4.8 cents/kWh
- Minneapolis, MN: 4.6 cents/kWh
- Philadelphia, PA: 4.6 cents/kWh
- Concord, NH: 4.6 cents/kWh
- Seattle, WA: 4.4 cents/kWh
- **Bloomington, IN**: 4.2 cents/kWh
- Syracuse, NY: 4.1 cents/kWh
Larger systems at higher cost, longer payback period

More energy produced, more cost savings during periods with greatest sunlight energy

Will continue to reassess as cost/watt continues to decrease
Solar Installation Examples
Energy Storage System (ESS)
Utilizes Lithium Ion Batteries to Store Power Generated by Solar for Future Use
Solar Hot Water System

- Brings heating water to distribution temperature more economically than boiler alone
  - Uses solar to heat water in storage tank, which can then be stored at higher temperature until sent to boiler for final heating and distribution
  - Saves energy that would have been used by boiler to heat water to distribution temperature
Thermal Storage

- Allows chilled water to be produced at most economically feasible time
  - Example: Store chilled water until low demand times (overnight) to produce chilled water at lower cost
Carbon Footprint Reduction
Reduction of Carbon Footprint
Combined Annual Emissions Reduced 23% Over Past Decade; Projected 31% Reduction by 2040

Definitions
- **Scope 1** (*Direct GHG*)
  - Central Heating Plant
  - Refrigerant/chemical emissions
  - Landscaping fertilizer (N)
  - University Fleet/Fuels
- **Scope 2** (*Indirect GHG*)
  - Purchased electricity
  - Purchased steam
  - Other energy sources
  - Renewable power generated on campus*

(*calculated emission factor of zero)
Reduction of Carbon Footprint
IU FY19 Greenhouse Gas Emissions by Source

- Purchased electricity is largest source of greenhouse gas emissions
  - Electricity produced by third party (not IU)

Purchased Electricity (Scope 2) 72%
On-Campus Stationary (Scope 1) 24%
Transmission and Distribution Losses 4%