Campus Energy

Saluki Energy Forum
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Global Warming

Limiting global warming to 1.5°C, compared to 2.0°C, will lower risks to health, livelihoods, food security, water supply, human security, and economic growth.

IPCC, 2018: Global Warming of 1.5°C: Summary for Policymakers.
Global Warming

To limit global warming to near 1.5°C, global net anthropogenic CO₂ emissions must decline by about 45% from 2010 levels by 2030, reaching net zero around 2050.

IPCC, 2018: Global Warming of 1.5°C: Summary for Policymakers.
Global Greenhouse Gas Emissions

- Carbon Dioxide (fossil fuel and industrial processes): 65%
- Methane: 16%
- Nitrous Oxide: 6%
- F-gases: 2%
- Carbon Dioxide (forestry and other land use): 11%
- Other: 30%
- China: 30%
- United States: 15%
- EU-28: 9%
- India: 7%
- Russia: 5%
- Japan: 4%

US EPA: Global Greenhouse Gas Emissions Data
U.S. Greenhouse Gas Emissions

Sources/Sinks by IPCC Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Emissions (Tg CO₂ eq. / year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>6077</td>
</tr>
<tr>
<td>Agriculture</td>
<td>454</td>
</tr>
<tr>
<td>Industry</td>
<td>321</td>
</tr>
<tr>
<td>Waste</td>
<td>161</td>
</tr>
<tr>
<td>Land Use</td>
<td>-847</td>
</tr>
</tbody>
</table>

Energy Emissions by End-Use Sector

- Industrial
- Transportation
- Residential
- Commercial

Buildings: 35%

U.S. Primary Energy Use

U.S. Primary Energy Use by Source (Quads)

U.S. Primary Energy Use by Sector (Quads)

Buildings accounted for 38.7% of primary energy use in 2017

U.S. Buildings Energy Use

Energy Factors:
- Building activity
- Operating hours
- Climate zone
- Building age
- Materials
- Technology
- Electricity use

Amory Lovins, Rocky Mountain Institute, Reinventing Fire, 2011
SIUC Campus Facilities

• Main Campus
  • 90% of 8M Gross Square Feet
  • 53% of 454 Buildings
  • 13% of 8622 Acres

• District systems
  • Central Steam
    • 70 Buildings, 5.5M GSF (69%)
  • Central Chilled Water
    • 32 Buildings, 4.1M GSF (51%)

• Area Weighted Building Age
  • 50 years (1969)

• Academic: 230 Buildings, 4.85M GSF (61%)
• Non-State: 225 Buildings, 3.15M GSF (39%)
Campus Buildings’ Energy End Uses

SIUC Campus Energy End Uses

- Cooling: 33%
- Heating: 35%
- Lighting: 13%
- Plug loads/Equipment: 13%
- Fans/Pumps: 6%

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data
Campus Energy Flow

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data

- Energy Delivered To Campus: 1571
- Campus Steam Plant: 1147
- Campus Electricity: 423
- Chilled Water Plants: 660
- Chilled Water: 289
- Buildings: 1003
- Steam, Heating: 297
- Natural Gas: 55
- Diesel: 0.6
- Propane: 0.3
Campus Energy Flow

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data
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Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data

- Coal: 1180 Btu/year
- Natural Gas: 999 Btu/year
- Petroleum: 171 Btu/year
- Diesel: 0.7 Btu/year
- Propane: 0.3 Btu/year

- Offsite Electricity Generation: 400 Btu/year
- Electricity: 369 Btu/year
- Diesel: 478 Btu/year
- Propane: 54 Btu/year
- Natural Gas: 361 Btu/year
- Steam: 297 Btu/year
- Cooling: 280 Btu/year
- Buildings: 1003 Btu/year

- Campus Steam Plant: 1147 Btu/year
- Chilled Water Plants: 660 Btu/year
- Heat Rejected & Losses: 1927 Btu/year

- Energy Delivered To Campus: 1571 Btu/year

- Campus Electricity: 423 Btu/year

- Chilled Water: 289 Btu/year

- SIU Carbondale

Southern Illinois University

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data
Campus Energy Flow

Total Primary Energy: 2351

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data
Campus Primary Energy

2351 Billion Btu per year is a rate of energy use that could:

- Bring an Olympic-sized swimming pool to a boil in 3 hours
- Boil it dry in 23 hours
- Boil an 80 gallon bathtub dry every 10 seconds
Campus Energy Flow

Total Primary Energy: 2351

Energy Flows from Left-to-Right in Units of Billion (10^9) Btu/year, FY2017 Data

Building Energy Services = 43% of Primary Energy
1 unit of building energy saved = 2.35 units of primary energy saved
Campus Energy GHG Emissions

FY17 CO2 Emissions
164,027 Metric Tons

- Electricity 37%
- Coal 57%
- Nat. Gas 6%

CO2 Emissions Factors [kg/MMBtu]

- Nat. Gas 53
- LPG 62
- Fuel Oil (#2) 74
- Coal 94
- Electricity, Aggregate, Delivered 152
- Steam, Delivered 164
- CHW, Delivered 193
Campus Energy GHG Emissions

164,027 MT CO$_2$ per year is equivalent to:

GHG emissions from:
- 34,825 passenger vehicles (2 cars for every person on campus)
- 16,642 homes’ energy use (all the homes of every person on campus)
- 895 railcars’ worth of coal burned (train 9 miles long)

Carbon sequestered by:
- 193,047 acres of U.S. forest (more than 22x the area of campus)
Fuel Switching

Coal to Natural Gas

• Reduce 40,780 MT CO$_2$/y
  -25% of total emissions
• Increase cost $ 3.9M/y
  +168% of coal cost
• Requires new boiler investment

Purchase Renewable Electricity

• Purchased Electricity is 67% fossil fuel sourced
• Reduce 40,736 MT CO$_2$/y
  -25% of total emissions
• Increase cost $ 58,910/y
  +0.8% of electric cost
  (RECs @ $0.75/MWh)
Energy Efficiency

Definition

Providing same energy services with less primary energy by reducing waste.

Benefits

• Reduced cost
  • Less purchased energy
  • Less maintenance
  • Smaller equipment
• Reduces pollution
• Same or better services
Energy Efficiency

- Technology
- Controls
- Integrative Design

U.S. buildings’ energy-saving potential, 2010–2050

Amory Lovins, Rocky Mountain Institute, Reinventing Fire, 2011
Example – Compounding Losses

Coal To Electricity 31.2%

Total Efficiency
(31.2% x 2.5% x 50%)

0.4%

Electricity To Visible Light 2.5%

Light Utilization 50%
Example – Compounding Costs

Cleaner source...?

Conventional Generation & Distribution
x3.2 = 256 E

Source Energy
(1 x 2 x 40 x 3.2)
256

Dumb Light Bulb
x40 = 80 E

Light To Read
= 1 E

... or better system?

Bad Light Fixture
x2 = 2 E
Example – Impact of Efficiency on GHG
## Recent Campus Efficiency Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Annual Savings</th>
<th>Annual Rate of Return on Investment (ROI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retro-commissioning of HVAC building controls for scheduling</td>
<td>$286,000</td>
<td>209%</td>
</tr>
<tr>
<td>Variable speed drives for chilled water pumps</td>
<td>$56,200</td>
<td>33%</td>
</tr>
<tr>
<td>LED roadway lighting</td>
<td>$13,900</td>
<td>16%</td>
</tr>
<tr>
<td>Rec Center advanced HVAC controls</td>
<td>$75,000</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Combined</strong></td>
<td><strong>$431,000</strong></td>
<td><strong>38%</strong></td>
</tr>
</tbody>
</table>
Barriers to Efficiency

• Diffuse efficiency resource
  • Energy wasted along entire supply chain to services
  • Energy wasted continuously

• Technology & expertise intensive

• High initial costs, steady returns over time
  • Requires financing to balance cash flow

• Social costs of energy emissions not paid by energy users
Social Cost of Carbon

@ $40/MT CO₂:
Campus energy GHG emissions would cost an extra
$ 6.6M/y
+ 48% of FY2017 total utility costs

Institute for Policy Integrity, 2015, Expert Consensus on the Economics of Climate Change
Campus Efficiency Resource

Energy Star level performance could save 58% of energy use, worth $7.9M/y.
Energy Conservation

Definition

Making personal choices to reduce energy demand and to prevent energy waste.

Opportunities

- Informed customers’ behavioral changes could cut buildings’ energy by 10% at 1/3rd the cost of current energy.
- Turn off lights and equipment
- Report leaks
- Report comfort / HVAC problems

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Offsite Electricity Generation: 780
Renewables
Nuclear
Coal
Natural Gas
Petroleum

Heat Rejected & Losses: 1927
Buildings: 1003

Thank You for Listening
Questions?