Overcoming the Hurdles of Laboratory Electrification

2021 Getting to Zero Forum | October 29, 2021
Speaking Today

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Agenda

• Why electrify?
• What makes laboratories different from other building types?
• Hurdles to overcome in laboratory electrification
• Technologies and solutions
Why electrify?
Why Decarbonize?

Carbon Dioxide

DIRECT MEASUREMENTS: 2005-PRESENT

Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA

Global Temperature

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA’s Goddard Institute for Space Studies (GISS). Credit: NASA/GISS

19 of the warmest years on record have occurred since 2000
**Why Electrify?**

EIA forecasts slower growth in natural gas-fired generation while renewable energy rises.

In 1990 coal made up 52% of electricity generation and has since declined to make up only 23%.
Natural Gas Bans

Berkeley became first US city to ban natural gas. Here's what that may mean for the future

The California city on Tuesday voted to ban natural gas hook-ups in new buildings, in a historic move

40+ California local governments have adopted zero-emissions codes
Natural Gas End Uses in Buildings

- Water Heating
- Space Heating
- Process Loads
- Cooking

Pie chart showing:
- Space Heating: 25%
- Lighting: 10%
- Total Energy Use: 6,963 trillion Btu

What makes laboratories unique?
Typical Commercial & Residential Building

Winter = Space Heating

Summer = Space Cooling

Chattanooga, TN Typical Winter Day End Use

Chattanooga, TN Typical Summer Day End Use

Source: NREL, End-Use Load Profiles for the US Building Stock.
What makes laboratories unique?

- High air change rates
- Heavy equipment loads
- Process loads
- 24/7 operation
- Precise space temperature and humidity control
Simultaneous Heating and Cooling

Daily Average Cooling and Heating Load in San Francisco

- Cooling Loads [kBtu]
- Heating Loads [kBtu]

Space Heating and Space Cooling
Energy End Uses and Metrics

Typical Lab Energy Use Breakdown

Typical Lab Energy Cost Breakdown

Typical Lab CO2 emissions Breakdown
Hurdles to Overcome
Hurdles of Laboratory Electrification

Impact to electrical service size

Limited Available Solutions

Equipment Space Constraints
Technologies & Solutions
Efficiency in Electric Heating

Relative Efficiency of Heating Based on Source Temperature

Higher Efficiency

Lower Efficiency

-20°F
0°F
20°F
40°F
60°F
80°F
100°F
120°F
140°F

Winter Air
Winter Geo
Exhaust Air
Transpired Solar
Solar HW
Winter Geo
Wastewater Recovery
Simultaneous Heat & Cool

Electric Resistance
Source Temperature
Heat Source
Efficiency in Electric Heating

Electric Resistance Heating

COP = 1

Coefficient of Performance
COP = Energy Out
    Energy In

Air-Source Heat Pump

COP = 2-3 at 40F and below
Space Constraints
Simultaneous Heating and Cooling

Energy, BTU

Energy, BTU
Simultaneous Heating and Cooling

- Heat Recovery Chiller Load
- Water-Cooled Chiller Load
- Remaining Heating Load

- Heat Recovery Chiller
  - 35%
- Water-Cooled Chiller
  - 65%
- Remaining Heating
  - 54%
Using the building as your heat source

Winter
Outdoor Temp = 35°F

Supply Air In 35°F
35°F → 60°F = 25°F ΔT

Heating Coil

60°F

Heat Recovery Coil

70°F

Exhaust Air Out 35°F

70°F → 35°F = 35°F ΔT
+25% Comp. Heat

Indoor Temp = 70°F
Air-Source Heat Recovery

Run-around Loop

Exhaust Air Heat Recovery
Advanced Simultaneous Heating & Cooling

False cooling of the building exhaust air provides an all-electric heating source.

Building Electrification

- Air Source Heat Pump
- To AHUs and Fan Coil Units
- CHWS
- Exhaust Air
- Exhaust Air Heat Rejection Coil
- AHU
- Outside Air
- Supply Air

Heating Mode
Domestic Water Heating

- Electric resistance (tankless or storage)
- Heat pump water heater
- Solar thermal
Process Loads

Sterilizer

Glass Washer

Humidification

Humidified Air, Leaving Temp approximate to Entering temp
Recap

- Prioritize reuse and efficiency
- Balance space constraints with available technologies
- Limit increase on electrical service size
Thank You!