GSHP Saves the World

Why are GSHP systems ideal for building decarbonization?

Geothermal: The Genius Renewable

Live at Groundwater Week in partnership with NGWA

Las Vegas, NV
December 5-7, 2023
CEUs for this workshop

Be sure to scan the QR for Tuesday, Wednesday, and Thursday workshops to get points towards your IGSHPA certification CEUs.
GSHP Saves the World
Why are GSHP systems ideal for Building Decarbonization?

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Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
AGENDA

• Decarbonization Policy Drivers
• Greenhouse Gas (GHG) Emissions and Your Regional Electrical Grid
• Review of Building Heating Load Profiles
• GHG Heating Emissions Comparison: Which Mechanical System is Lowest?
• Q/A
“Our industry is responsible for 40% of global carbon emissions. It is our responsibility to reduce emissions and contribute to a sustainable future.”

Jo de Silva
Global Sustainable Development Leader, Arup Fellow
INFRASTRUCTURE: COMMON AREAS OF VULNERABILITIES & OPPORTUNITIES.
Nested Scales Of Influence
City And State Policy Drivers
National Building Performance Standards

Source: DOE Office of Energy Efficiency & Renewable Energy

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Decarbonization
Local Policy Taking The Reigns
Northern California Jurisdictions with Decarbonized Reach Code

Image created by Redwood Energy 9/1/2020 (source: http://www.buildingdecarb.org/active-code-efforts.html)

California Jurisdictions with Decarbonized Reach Code

Image created by Redwood Energy 9/1/2020
(source: http://www.buildingdecarb.org/active-code-efforts.html)
Michigan will implement ambitious clean energy mandates with goal of carbon-free electricity by 2040

Connecticut, New York, Oregon and Minnesota all share Michigan’s timeline of being carbon-free by 2040 while Rhode Island has set a goal of using 100% renewable energy by 2033, according to the Clean Energy States Alliance.

Source: Michigan.gov
City and State Policy Drivers
Omaha Leading the Southwest Power Pool

EPA Announces $3M Each to Missouri and Nebraska to Fund Innovative Projects That Tackle Climate Pollution

March 27, 2023

Contact Information
Shannan Beisser (beisser.shannan@epa.gov)
816-520-1949

LENEXA, KAN. (MARCH 27, 2023) – Today, the U.S. Environmental Protection Agency (EPA) announced $3 million each to Missouri and Nebraska to develop innovative strategies to cut climate pollution and build clean energy economies across these states.

Earlier this month, EPA announced the availability of the funds, which are a part of the first allotment of funding from the Climate Pollution Reduction Grants (CPRG) program created by President Biden’s Inflation Reduction Act. All 50 states, District of Columbia, and Puerto Rico are eligible to receive $3 million in CPRG planning grants.

“These $3 million Climate Pollution Reduction Grants will allow Missouri and Nebraska to plan for climate impacts with the speed in which this pressing issue demands,” said EPA Region 7 Administrator Meg McCollister. “We hope that all states will follow their lead in leveraging the historic Inflation Reduction Act funds to protect communities and create jobs.”

The Missouri Department of Natural Resources (MoDNR) and the Nebraska Department of Environment and Energy (NDEE) will participate in this new program that provides flexible planning resources for the states to develop and implement scalable solutions that protect people from pollution and advance environmental justice.
## SEC Filing for Publicly traded Companies

**ESG Reporting and Climate Risk Analysis Drive the Market**

<table>
<thead>
<tr>
<th>Year</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021 Report (filed in 2022)</td>
<td>Proposed release</td>
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<tr>
<td>2022 (filed in 2023)</td>
<td>All disclosures excl. Scope 3 for larger accelerated filers</td>
</tr>
<tr>
<td>2023 (filed in 2024)</td>
<td>All disclosures for large accelerated filers with limited assurance</td>
</tr>
<tr>
<td>2024 (filed in 2025)</td>
<td>All disclosures excl. Scope 3 for accelerated filers</td>
</tr>
<tr>
<td>2025 (filed in 2026)</td>
<td>All disclosures for nonaccelerated filers</td>
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<tr>
<td>2026 (filed in 2027)</td>
<td>All disclosures excl. Scope 3 for smaller reporting companies</td>
</tr>
<tr>
<td>2027 (filed in 2028)</td>
<td>Large accelerated filers with reasonable assurance</td>
</tr>
<tr>
<td></td>
<td>Accelerated filers with reasonable assurance</td>
</tr>
</tbody>
</table>

Source: Deloitte

Source: US Environmental Protection Agency

Annual Conference, December 6 - 8, 2022 – Las Vegas, NV
Understanding GHG Emissions

WHAT CONTRIBUTES TO EMISSIONS?

SCOPE 1
Direct emissions from sources owned or controlled by a community.

SCOPE 2
Indirect emissions from purchased electricity, steam, heat, and cooling.

SCOPE 3
All other emissions associated with a community’s activities and operations.

Carbon dioxide, Sulfur hexafluoride, Methane, Nitrous oxide, Hydrofluorocarbons, Perfluorocarbons.

Source: Diagram based on Greenhouse Gases Diagram from EPA
Understanding GHG Emissions

**SCOPE 1 EMISSIONS**

Direct emissions:
- Natural Gas Boiler

**SCOPE 2 EMISSIONS**

Indirect emissions:
- Electric Boiler
- Air Source Heat Pump
- Ground Source Heat Pump

Source: Diagram based on Greenhouse Gases Diagram from EPA
Understanding your Regional Grid

National Climate Zone Map

Climate Zone Map from IECC 2021

Annual Conference, December 6 - 8, 2022 – Las Vegas, NV
Understanding your Regional Grid

Regional Grid Operators (Black Outlines) vs. Climate Zone (Color Fill)
Understanding your Regional Grid: Marginal Emissions

Grid Marginal Emissions Rate: 8 am Pacific (Wattime September 27th, 2023)

Source: Wattime

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Understanding your Regional Grid: Marginal Emissions

Grid Marginal Emissions Rate: 5 pm Pacific (Wattime September 26th, 2023)

PV Offline
Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

Regional Elect. Grid
Weather Location
Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

Regional Elect. Grid
Weather Location

Time of Day

Months of Year
Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

Regional Elect. Grid
Weather Location

GHG Emissions Intensity

Time of Day

Months of Year

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

Period of Higher Emissions

Period of Lower Emissions

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Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

**AVERAGE MOER: CALIFORNIA ISO NORTHERN**

SAN FRANCISCO INTL AP - CA USA
ANNUAL TIMEPLOT

**CO2 lbs/MWh**
ANNUAL AVERAGE: 804

**PV ONLINE**

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
MIN. HEAT PUMP COP FOR CARBON EQUIVALENCY

\[
\text{ELECTRICAL GRID MARGINAL EMISSION RATE} \div \text{NATURAL GAS EMISSION RATE} \div \text{BOILER EFFICIENCY}
\]
Understanding your Regional Grid: Marginal Emissions
Targeting Heat Pump Performance That Will Decarbonize

Minimum COP for Carbon Equivalency (HP vs NG)

San Francisco Int'l Ap - CA USA
Annual Timeplot

Lower COP Required

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Understanding your Regional Grid: Marginal Emissions

Annual Marginal Operating Emissions Rate (MOER)

Average MOER: ERCOT North Central

Dallas-Fort Worth Int'l Ap - TX USA

Annual Timeplot

Higher MOER

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Understanding your Regional Grid: Marginal Emissions

Targeting Heat Pump Performance That Will Decarbonize

MINIMUM COP FOR CARBON EQUIVALANCY (HP vs NG)
DALLAS-FORT WORTH INTL AP - TX USA
ANNUAL TIMEPLOT

COP ANNUAL AVERAGE: 2.29

HIGHER COP REQUIRED

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Understanding your Regional Grid: Average Emissions
Estimate of Carbon Intensity at State Level

Source: Egrid 2023
Understanding your Regional Grid: Average Emissions

Estimate of Carbon Intensity at State Level

BOTH CLIMATE ZONE 5A – COOL HUMID

Emissions Intensity

Source: Egrid 2023

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Understanding Your Regional Grid


- **Renewables**: 52%
- **Fossil Fuel**: 48%

**NEW YORK**

Source: eia.gov 2023

+50% Renewables

Annual Conference, December 6 - 8, 2022 – Las Vegas, NV
Understanding Your Regional Grid


- **New York**
  - Renewables: 52%
  - Fossil Fuel: 48%

- **Michigan**
  - Renewables: 33%
  - Fossil Fuel: 67%

**+50% Renewables in New York**

**+50% Fossil Fuel in Michigan**

Source: eia.gov 2023

Annual Conference, December 6 - 8, 2022 – Las Vegas, NV
Understanding Your Regional Grid


Source: eia.gov 2023

NEW YORK

- Coal
- Natural Gas
- Other Fossil Fuel
- Nuclear
- Hydro
- Wind
- Solar
- Other Renewable

No Coal
Understanding Your Regional Grid


**NEW YORK**
- No Coal

**MICHIGAN**
- ~30% Coal

Source: eia.gov 2023
Understanding Your **CHANGING** Regional Grid


NEW YORK

- **Renewables, 70%**
- **Fossil Fuel, 30%**

MICHIGAN

- **Renewables, 50%**
- **Fossil Fuel, 50%**

Source: eia.gov 2023

Annual Conference, December 6 - 8, 2022 – Las Vegas, NV
Understanding Your **CHANGING** Regional Grid

**2040 Grid Source Energy Mix: New York vs Michigan**

- **New York**: 100% Renewables
- **Michigan**: 100% Renewables

Source: eia.gov 2023
Summary GHG Emissions and Electrical Grid

• GHG emissions can be generated directly or indirectly
• GHG emissions vary based on regional electrical grid fuel source
• Marginal emissions are useful for comparing design decisions
• Target Heat Pump COP for carbon equivalency depends on regional grid
Building Heating Load Profiles

• **Sources**
  - Energy model
  - Existing utility data

• **Uses**
  - Sizing geothermal exchange systems
  - **Greenhouse Gas Comparison**
Building Heating Load Profiles

CUSTOM ARCHITECTURE MODEL

ENERGY MODEL + RESULTS

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Building Heating Load Profiles

PRE-BUILT PROTOTYPE BUILDING
CUSTOM ARCHITECTURE MODEL

ENERGY MODEL + RESULTS
# Building Load Profiles: DOE Reference Buildings

<table>
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<tr>
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Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
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Building Load Profiles: Weather Files

Buffalo, New York

Climate Zone: 5A_Cool Humid

Wide, Even Distribution

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office
ASHRAE 90.1-2016
54,000 gsf
Medium Office

HVAC:
Dx Cooling + Nat. Gas Heating

Zone:
Elect. Resistance Reheat

Water Heater:
Central Nat. Gas

*Dx = Direct Expansion
Climate Zone 5A – 2016 Medium Office
Identify Heating Load Trends

SPACE HEATING
Peak Hour: 653 kBtuh
12 Btuh/sf

DOMESTIC HOT WATER
Peak Hour: 26 kBtuh
0.5 Btuh/sf
Climate Zone 5A – 2016 Medium Office
Identify Heating Load Trends

**SPACE HEATING**

Peak Hour: 653 kBtuh
12 Btuh/sf

**DOMESTIC HOT WATER**

Peak Hour: 26 kBtuh
0.5 Btuh/sf

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Climate Zone 5A – 2016 Medium Office
Identify Building Load Trends

BUILDING COOLING
1,027 kBtuh
19 Btuh/sf
86 Tons
626 sf/Ton

BUILDING HEATING
662 kBtuh
12 Btuh/sf

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Climate Zone 5A – Test What If Scenarios

**Building Heating – 2016**
- Peak: 662 kBtu/h
- 12 Btu/h/sf

**Building Heating – 2004**
- Peak: 1,076 kBtu/h
- 20 Btu/h/sf (60%+ Increase)

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
# Building Load Profiles: DOE Reference Buildings

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Midrise Apartment
ASHRAE 90.1-2016
34,000 gsf
Midrise Apartment

HVAC: 
Dx Cooling + Nat. Gas Heating

Water Heater: 
Central Electric

*Dx = Direct Expansion
Climate Zone 5A – Midrise Apartment

**SPACE HEATING PEAK**

Peak Hour: 221 kBtuh

**DOMESTIC HOT WATER**

Peak Hour: 111 kBtuh

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Climate Zone 5A – Midrise Apartment

**TOTAL BUILDING COOLING**
- 252 kBtuh
- 8 Btuh/sf
- 21 Tons
- 1,450 sf/Ton

**TOTAL BUILDING HEATING**
- 321 kBtuh
- 11 Btuh/sf
GHG Heating Emissions Comparison: Which Mechanical System is Lowest?

Compare Heating Emissions:
- Natural Gas Boiler
- Air Source Heat Pump
- Ground Source Heat Pump

ASHP Heating COP

Reduction in Performance

Outdoor Temperature (F)
Run the “Carbon App”
Run the “Carbon App”

Detroit, Michigan
Buffalo, New York
Both Climate Zone 5A – Cool Humid

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Cold Climate: ASHP Heating COP Comparison

NEW YORK
CLIMATE ZONE 5
~2.7 ASHP COP

MICHIGAN
CLIMATE ZONE 5
~2.7 ASHP COP
Cold Climate: Grid Comparison – Annual MOER
Cold Climate: Grid Comparison – Annual MOER
Cold Climate: Grid Comparison – Annual MOER

NEW YORK
LESS FOSSIL FUEL GRID
ANNUAL MOER = ~900

MICHIGAN
MORE FOSSIL FUEL GRID
ANNUAL MOER = ~1,600

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Cold Climate: Grid Comparison – Min. HP COP

NEW YORK
LOWER
REQUIRED HEAT PUMP COP
COP = 1.8

MICHIGAN
HIGHER
REQUIRED HEAT PUMP COP
COP = 3.2
HEATING PERFORMANCE COMPARISON: CLIMATE ZONE 5

![Graph showing heating COP for different systems across months from January to December. The graph compares NAT. GAS BOILER, ASHP, and GSHP systems.](image-url)
Cold Climate: Medium Office Heating Load

HEATING PROFILE

ANNUAL TIMEPLOT

ANNUAL TOTAL: 463,806 kBtuh/yr

0 100 200 300 400 500 600 700

SmithGroup

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: Natural Gas Heating Emissions

HEATING EMISSIONS - NAT GAS

ANNUAL TIMEPLOT

ANNUAL TOTAL: 67,901 CO2 lbs/yr

CO2 lbs

0 50 100 150 200

SMITHGROUP

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: Gas vs ASHP - MICHIGAN

EMISSIONS SAVINGS - NAT GAS vs ASHP
DETROIT-YOUNG INTL AP - MI USA
ANNUAL TIMEPLOT

ANNUAL TOTAL: -24,564 CO2 lbs/yr

CO2 lbs
-100 -50 0 50 100

SMITHGROUP

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: Gas vs ASHP – NEW YORK

EMISSIONS SAVINGS - NAT GAS vs ASHP
BUFFALO NIAGARA INTL AP - NY USA
ANNUAL TIMEPLOT

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: ASHP CO2 Emissions Takeaway

NEW YORK
LESS CO2 EMITTED

MICHIGAN
MORE CO2 Emitted

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: Gas vs GSHP – MICHIGAN

EMISSIONS SAVINGS - NAT GAS vs GSHP

ANNUAL TOTAL: 13,652 CO2 lbs/yr

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Medium Office: Gas vs GSHP – NEW YORK

EMISSIONS SAVINGS - NAT GAS vs GSHP
BUFFALO NIAGARA INTL AP - NY USA
ANNUAL TIMEPLOT

ANNUAL TOTAL: 37,410 CO2 lbs/yr

CO2 lbs

SMITHGROUP

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: GSHP CO2 Emissions Takeaway

**NEW YORK**
**LESS CO2 EMITTED**

**MICHIGAN**
**LESS CO2 EMITTED**

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Medium Office: Annual Heating Emissions Comparison

![Bar Chart](chart.png)

**Emissions CO2 (lbs/year)**

- **Nat. Gas**
  - Michigan: [Value]
  - New York: [Value]

- **ASHP**
  - Michigan: [Value]
  - New York: [Value]

- **GSHP**
  - Michigan: [Value]
  - New York: [Value]
Medium Office: Annual Heating Emissions Savings vs Gas Boiler

![Bar chart showing emissions savings CO2 for different heating systems.](chart.png)
Cold Climate: Midrise Apartment Heating Load

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
Midrise Apartment: Annual Heating Emissions Savings vs Gas Boiler

![Graph showing emissions savings comparison between ASHP and GSHP in Michigan and New York.]
GSHP Saves the World

![Pie chart showing 98% GSHP and 2% everything else]
GSHP Saves the World

Annual Conference, December 5 - 7, 2023 – Las Vegas, NV
GSHP Saves the World
GSHP Saves the World

Why are GSHP systems ideal for Building Decarbonization?

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