Building Decarbonization
Heat Pump Systems

June 17, 2020

Peter Rumsey, PE, Fellow ASHRAE, LEED BD&C
Point Energy Innovations, Inc

peter@pointenergyinnovations.com

Copyright 2020
Building Energy Consumption

Residential Buildings
- 52% Fossil Fuels Combustion
- Electricity

Commercial Buildings
- 34% Fossil Fuel Combustion
- Electricity

Source: US EIA
Building Heating is 12% of California’s Carbon Footprint
Methane Leakage…

“There’s nothing natural about natural gas”
Outdoor Air Quality:
Burning Fossil Fuels in Buildings is a Big Part of California’s Ozone/PM2.5 Problem

Nitrous Oxide (NO$_x$) in California

- **Power Plants**: 18 tons/day
- **Buildings**: 107 tons/day
- **Light-Duty Vehicles**: 118 tons/day

Source: CARB
Path to Decarbonized Buildings

- Typical Building
- Low Energy Building
- All Electric Building
- Decarbonized Building
Building Electrification

Hot Water

Space Heat

Cooking
Electric systems provide heat more efficiently

- **Natural Gas Boiler**: 1 therm input → 0.8 therms heating
- **Electric Resistance Heater**: 1 kWh input → 1 kWh heating
- **Electric Heat Pump**: 1 kWh input → 3-4.5 kWh heating
Fuel (Gas) 118 units

Boiler

Combustion Losses 18 units

Heat From Surroundings (Water or Air) 67 units

Fuel (Electricity) 33 units

Heat Pump

100 units Heating Energy
Resource to Room Efficiency

Natural Gas
125 units input

- Refining + Transportation: 6 units
- Distribution Losses: 1 unit
- Combustion Losses: 18 units
- Ambient Energy: 67 units

100 units Heating Energy

Natural Gas-based Electricity
74 units input

- Refining + Transportation: 4 units
- Distribution Losses: 2 units
- Combustion Losses: 35 units
- Ambient Energy: 67 units

100 units Heating Energy

Renewable Electricity
35 units input

- Distribution Losses: 2 units
- Ambient Energy: 67 units

100 units Heating Energy
Natural Gas

139 lbCO₂ / MMBtu of heat

Natural Gas-based Electricity

82 lbCO₂ / MMBtu of heat

Renewable Electricity

0 lbCO₂ / MMBtu of heat
Residential Heat Pumps
Heat Pumps

Hot Water

Heating and Cooling
Ductless Minisplit
Commercial Heat Pumps
Air Source VRF Systems
Ground Source Heat Pump
Multifamily Residential: PTHP

Packaged Terminal Heat Pump (PTHP)

- “All-in-one” heating and cooling system
- Great for dense or high rise multifamily and hotel application
- Air-conditioning only versions are known as PTACs (Packaged Terminal Air Conditioners)
- Low cost and easy installation
Commercial Application - Air Source Heat Pump

Output:

Hot Water for Space Heating

Domestic Hot Water
Commercial Application - Heat Recovery Chiller

Chilled Water

Hot Water
Heat Pumps in Cold Conditions

- Defrost Cycle
- Heating Elements at Evaporator
- Electric backup
Refrigerants

Source: Daikin
## Commercial Heat Pump Suppliers

<table>
<thead>
<tr>
<th>Large:</th>
<th>VRF:</th>
<th>DHW:</th>
<th>GSHP:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multistack</td>
<td>Mitsubishi</td>
<td>Sanden</td>
<td>Florida HP</td>
</tr>
<tr>
<td>Aermec</td>
<td>Samsung</td>
<td>Rheem</td>
<td>WaterFurnace</td>
</tr>
<tr>
<td>Nyle</td>
<td>LG</td>
<td>AO Smith</td>
<td>Trane</td>
</tr>
<tr>
<td>Colmac</td>
<td>Daikin</td>
<td>Stiebel Eltron</td>
<td>Carrier</td>
</tr>
<tr>
<td>Climacool</td>
<td></td>
<td>GE</td>
<td></td>
</tr>
<tr>
<td>Artichill</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There are many suppliers of heat pump systems. This is a partial list only and does not necessarily represent an endorsement of a given product.
Electric Resistance Boiler
Peak Load
590 kW

Electric Heat Pump
Peak Load
170 kW

Cooling System
Peak Load
200 kW

100,000 SF building in a moderate climate
Commercial Domestic Hot Water
Commercial Application - Heat Pump DHW

1. Sun heats air
2. Energised air inducted into heat pump
3. Energy transferred to heat cold water
4. Cold air expelled

Water Tank
Hot Water Outlet
Condenser Coil
Insulation
Cold Water Inlet
Other Commercial Centralized DHW Systems
Heat Pumps in Action
Before - Propane Furnace

After - Electric Heat Pump
New Multifamily Residential University of California at San Francisco
Central DHW
Multi Pass | Parallel Tanks
California Growing Pains

Multi Pass - NOT ALLOWED

- Hot Water to Building
- Cool Air Out
- Hot Water Storage
- Cold Water In
- Warm Air In

Single Pass - ALLOWED

- Hot Water to Building
- Cool Air Out
- Hot Water Storage
- Cold Water In
- Warm Air In
140°F

Heat Pump Water Heater
New Office Building, Menlo Park, CA
Historic Renovation
Bank of Italy Building, San Jose, CA
Top Five Lessons Learned

All electric technology is ready for prime time

Adds less than 1% to construction costs and dropping

Electric systems save operating costs

Gas systems don’t run without electricity

Electric systems can be backed up by solar batteries
The Designer’s Carbon Footprint
CARBON EMISSION RESPONSIBILITY

AVERAGE PERSON

980 METRIC TONS OF CO2

VS

BUILDING DESIGNER

1.15 MILLION METRIC TONS OF CO2
Cost of a Building Designer’s Education:

$100,000 COLLEGE TUITION

Building Designer’s Potential Impact:

$1.97 MILLION POTENTIAL SAVINGS FOR ONE BUILDING
Thank you

For further information please contact
Peter Rumsey - peter@point.energy