

Building Decarbonization Heat Pump Systems

June 17, 2020

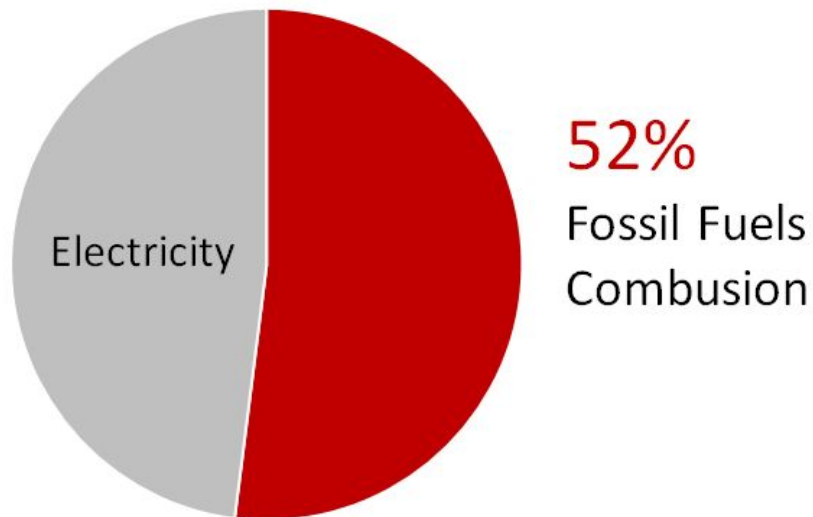
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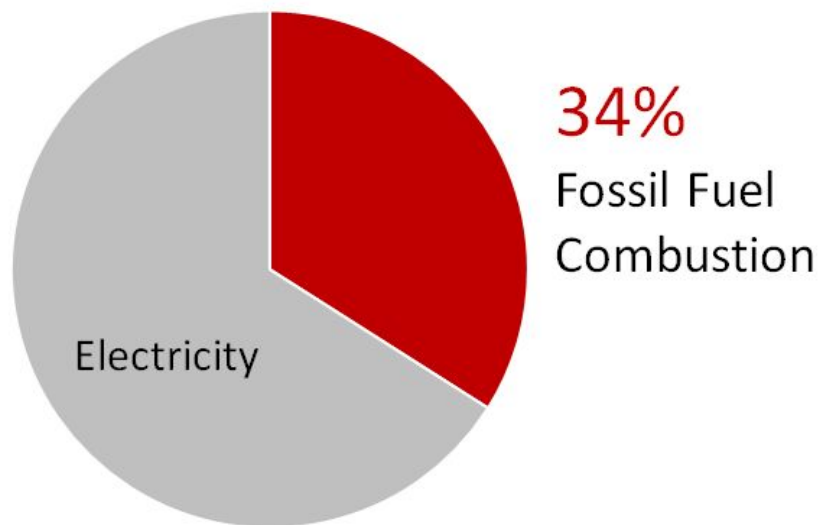
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Building Energy Consumption

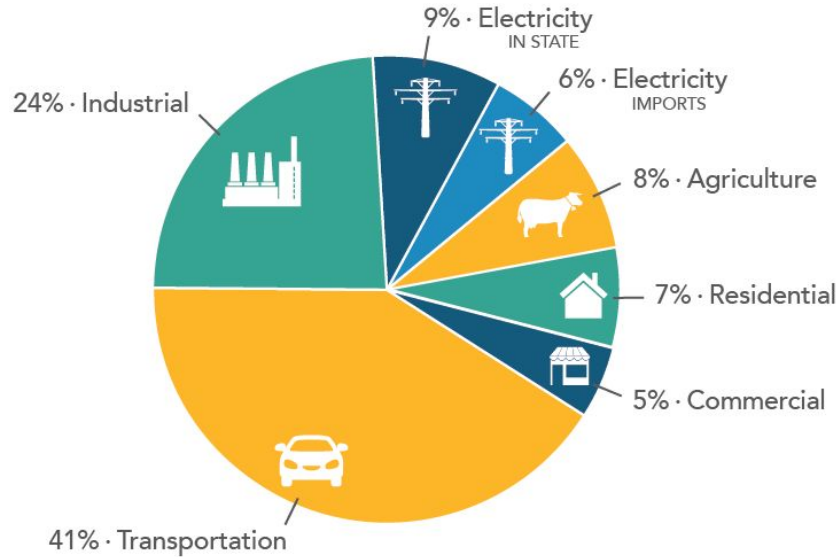
Residential Buildings



Commercial Buildings



Building Heating is 12% of California's Carbon Footprint



12%

Methane Leakage...



“There’s nothing natural
about natural gas”

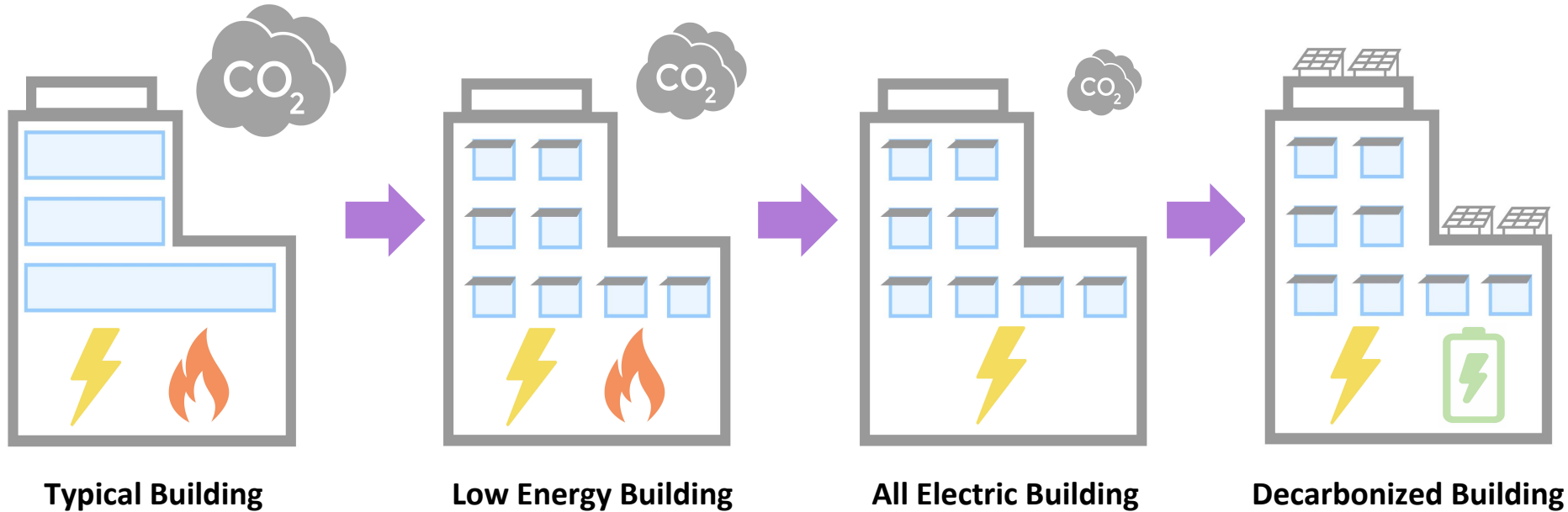


Outdoor Air Quality: Burning Fossil Fuels in Buildings is a Big Part of California's Ozone/PM2.5 Problem

Nitrous Oxide (NO_x) in California



Path to Decarbonized Buildings



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

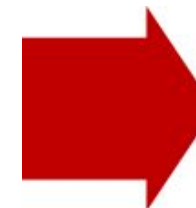
1 kWh input



1 kWh heating

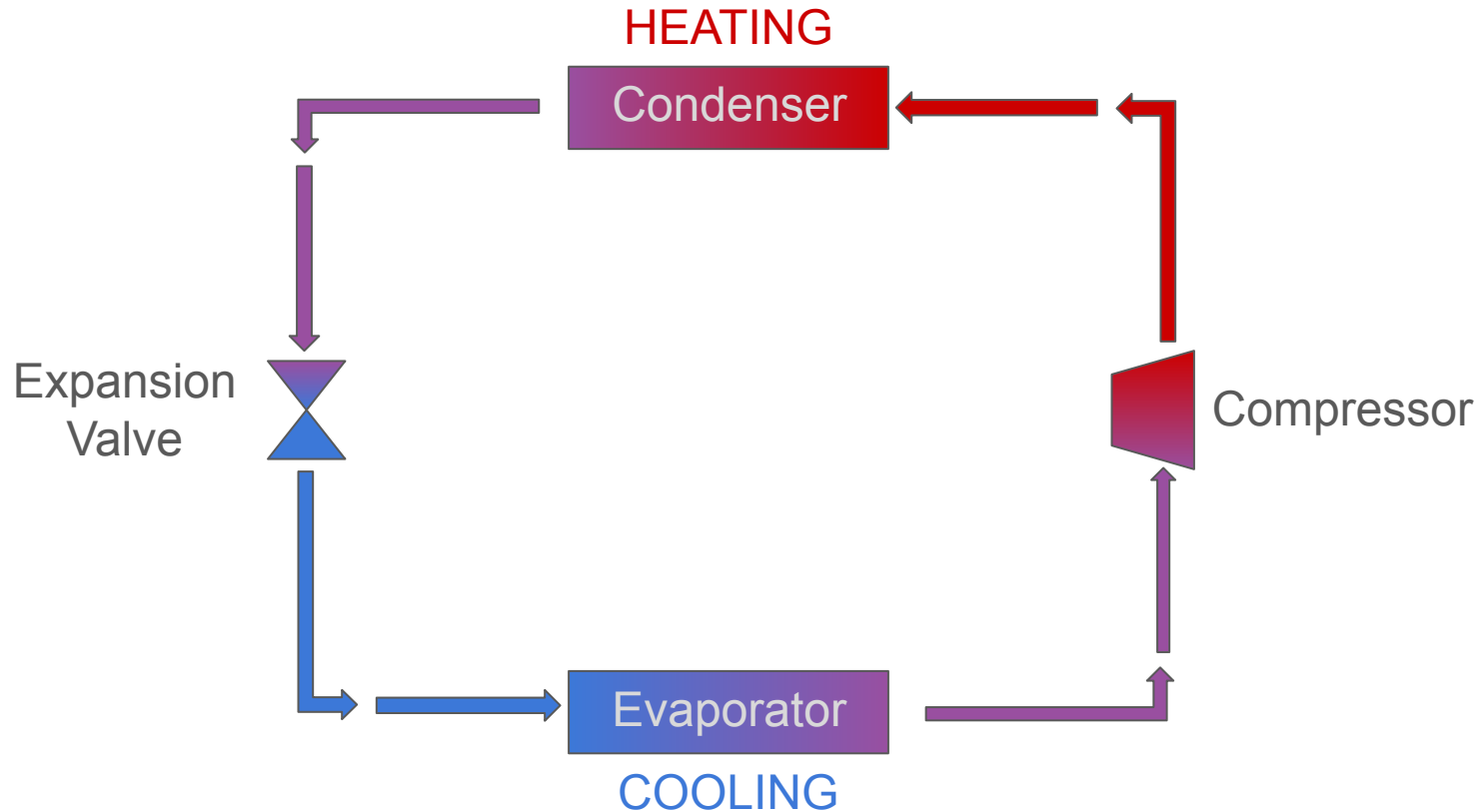
Electric Heat Pump

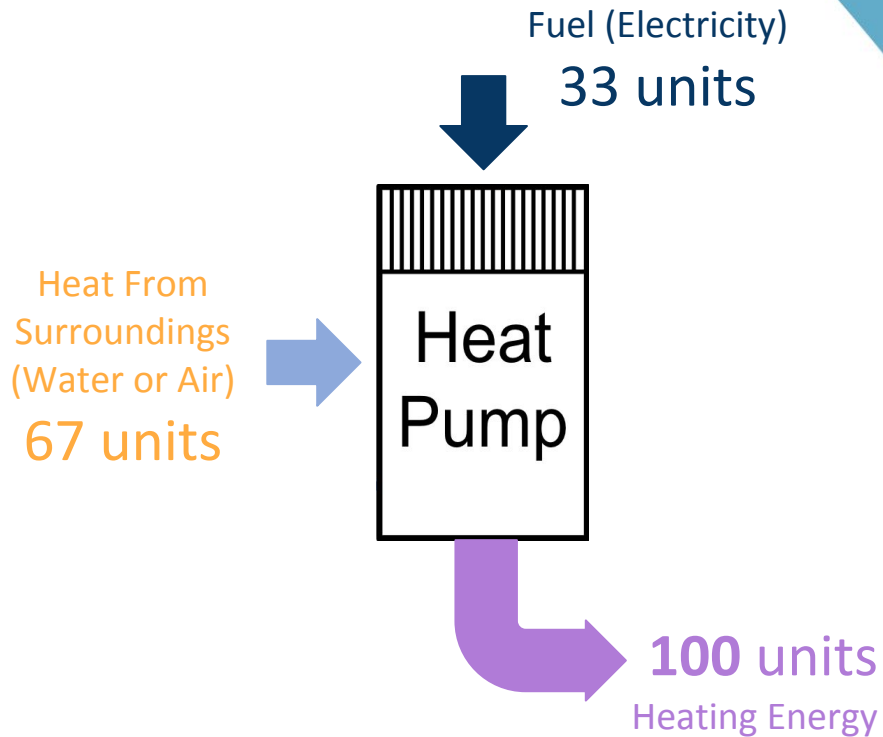
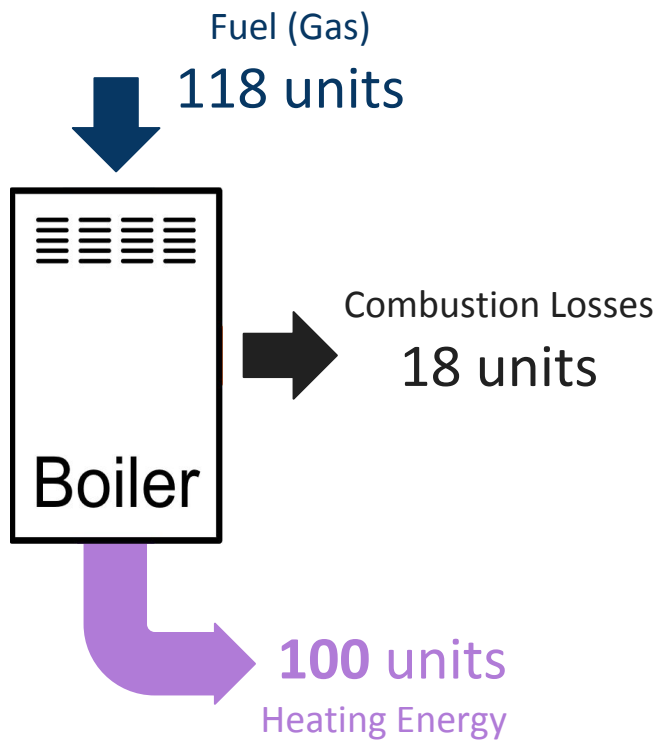
1 kWh input



3-4.5 kWh heating

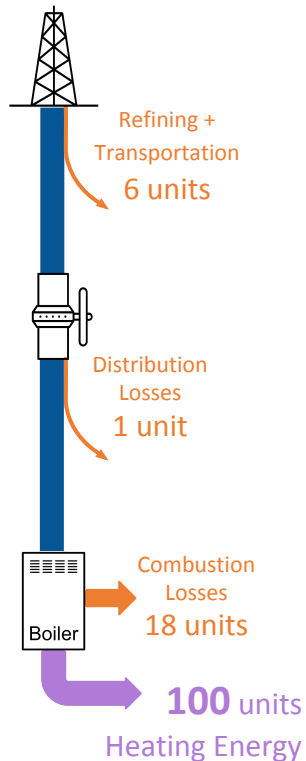
The Refrigeration Cycle



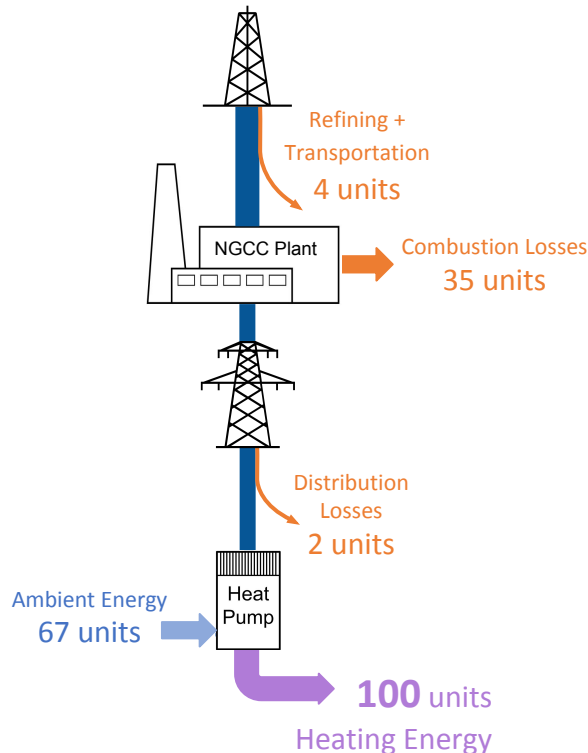


Resource to Room Efficiency

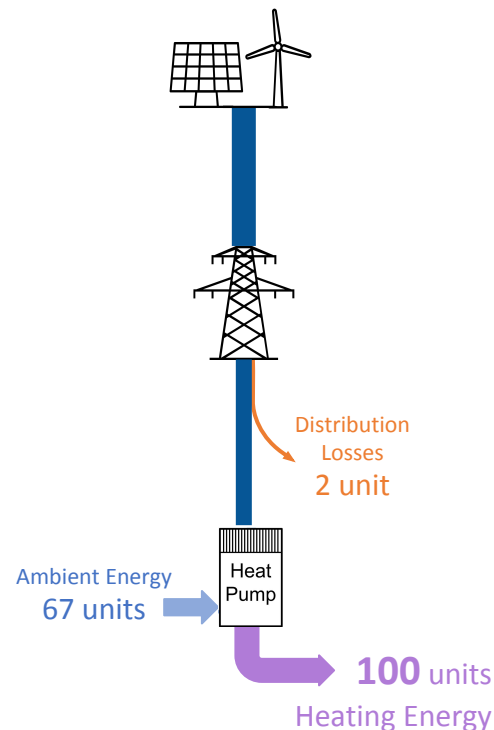
Natural Gas 125 units input



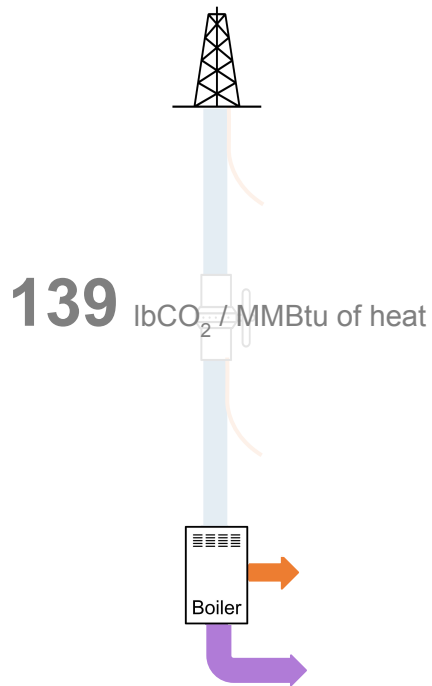
Natural Gas-based Electricity 74 units input



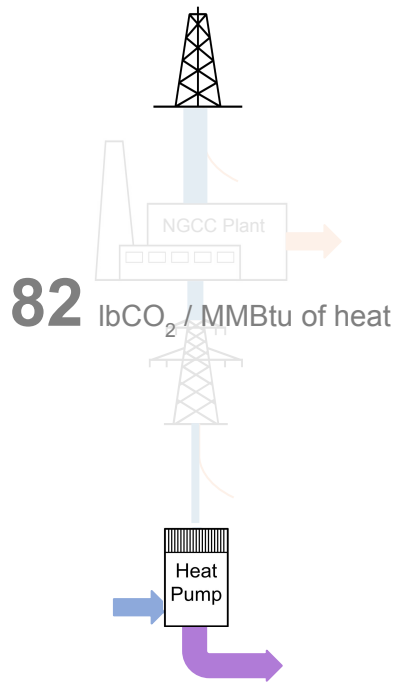
Renewable Electricity 35 units input



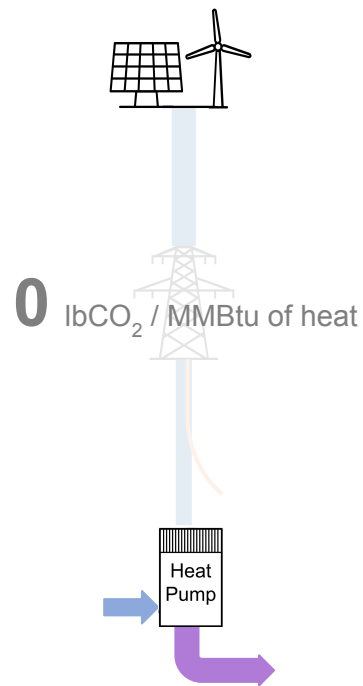
Natural Gas



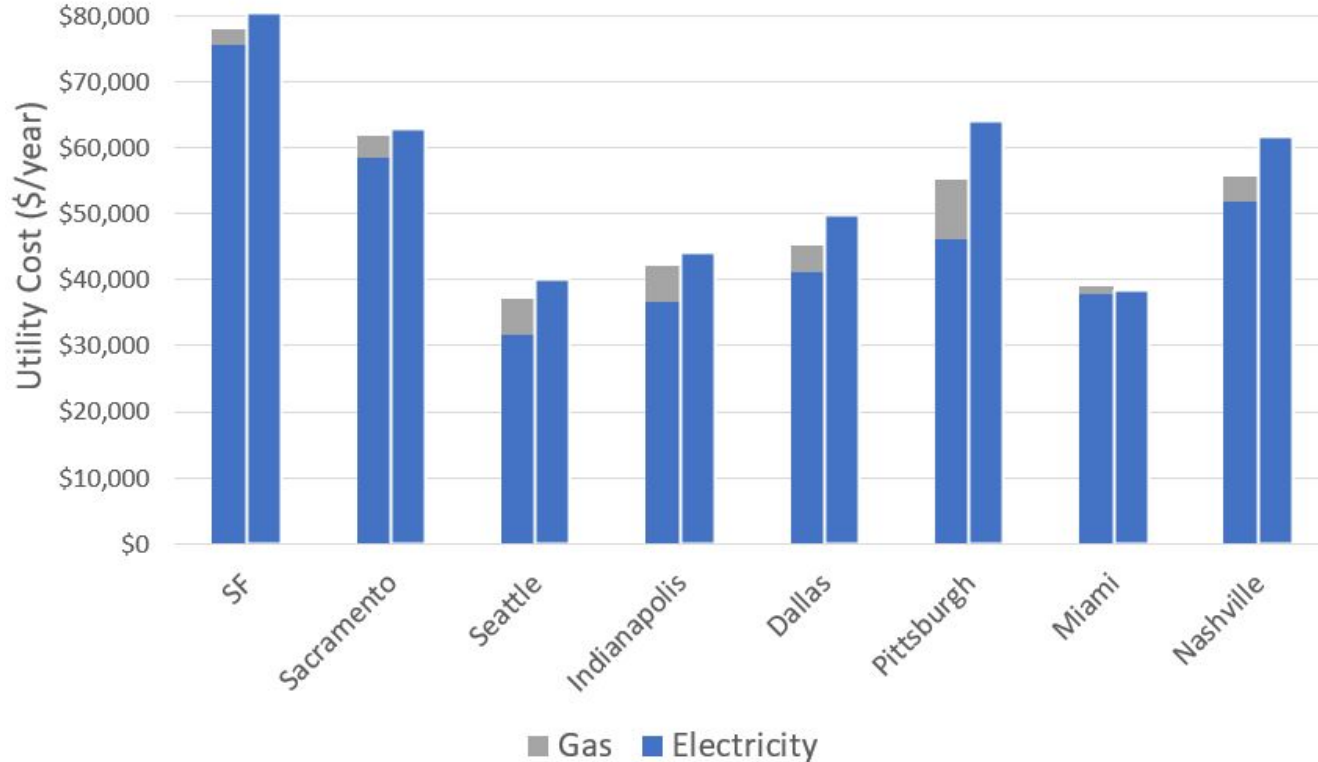
Natural Gas-based Electricity



Renewable Electricity



Cost Impacts - Office Building



Residential Heat Pumps

Heat Pumps



Hot Water



Heating and Cooling



Ductless Minisplit

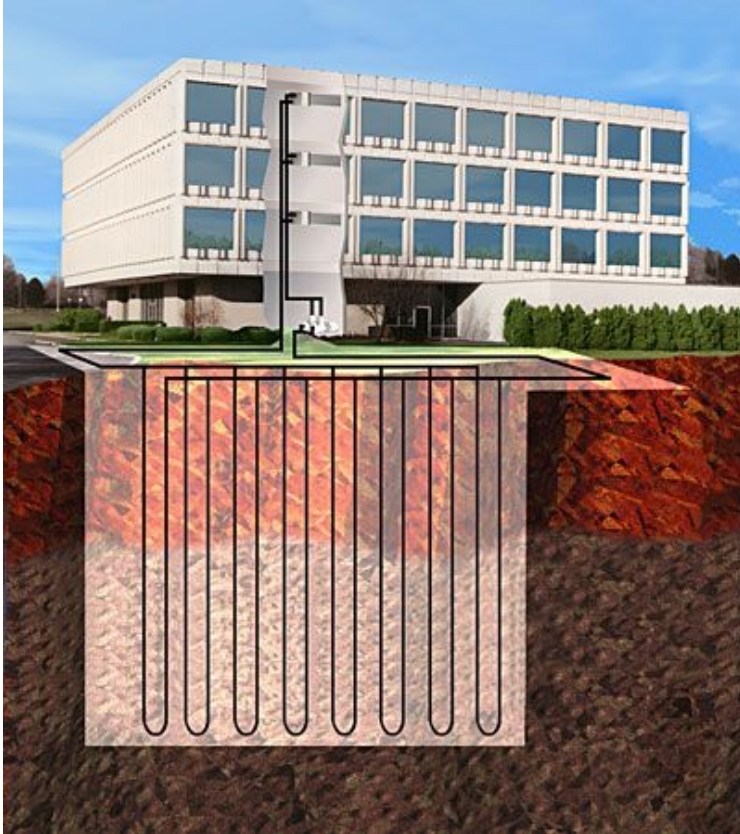


Commercial Heat Pumps

Air Source VRF Systems



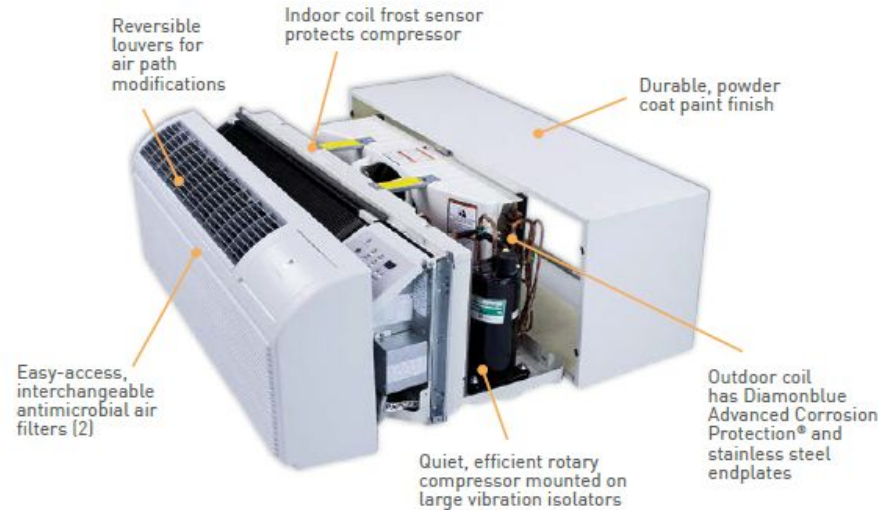
Ground Source Heat Pump



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

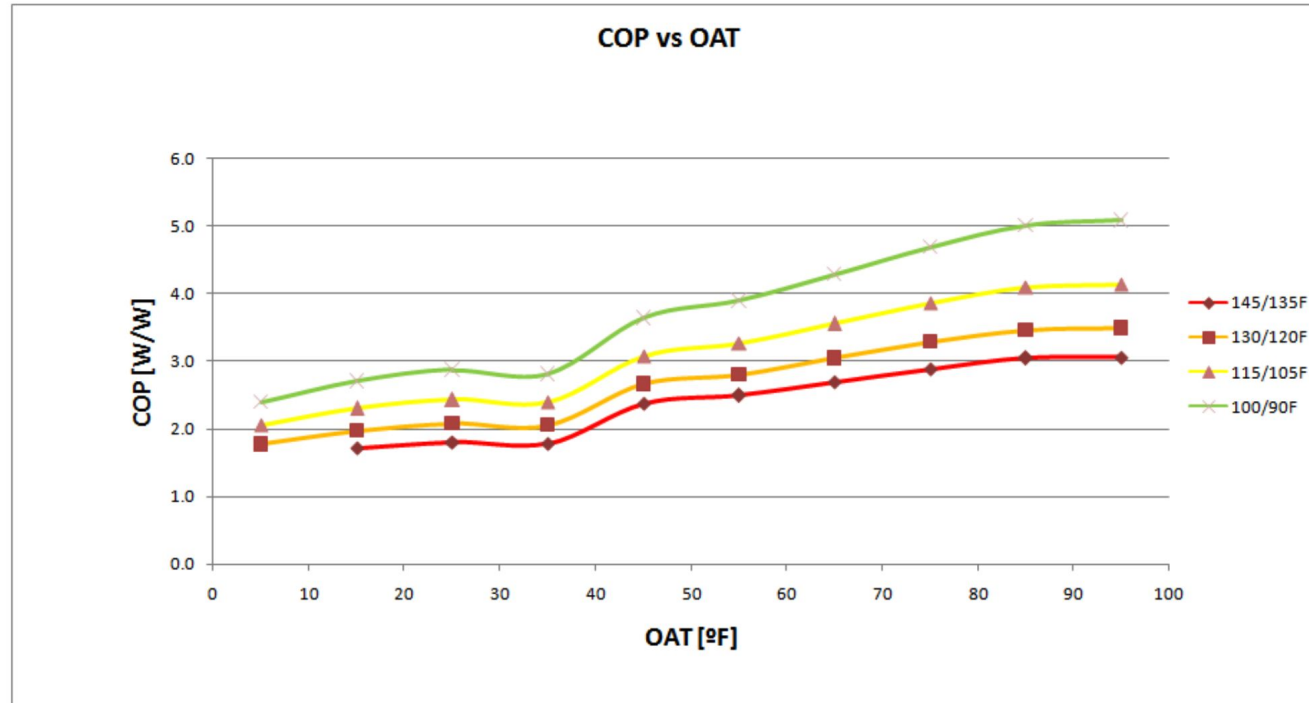
Commercial Application - Heat Recovery Chiller



Stanford Central Plant



Heat Pumps in Cold Conditions

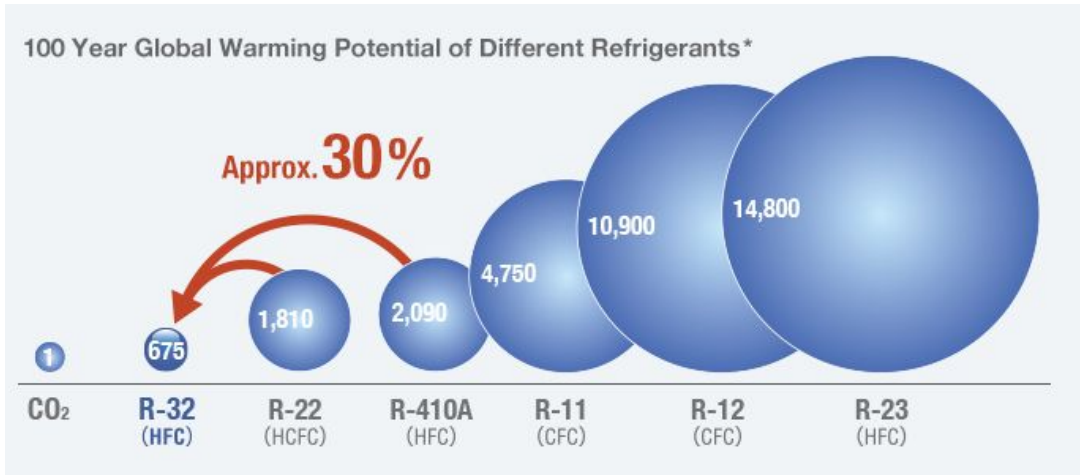


Defrost Cycle

Heating Elements
at Evaporator

Electric backup

Refrigerants



Source: Daikin

Refrigerant	ODP (R11=1.0)	GWP IPCC AR4 (CO ₂ =1.0)
R22	0.055	1810
R410A	0	2088
R407C	0	1770
R32	0	675
R1234yf	0	4
R290	0	6.3
CO ₂	0	1

Commercial Heat Pump Suppliers

Large:

Multistack

Aermec

Nyle

Colmac

Climacool

Artichill

VRF:

Mitsubishi

Samsung

LG

Daikin

DHW:

Sanden

Rheem

AO Smith

Stiebel Eltron

GE

GSHP:

Florida HP

WaterFurnace

Trane

Carrier

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

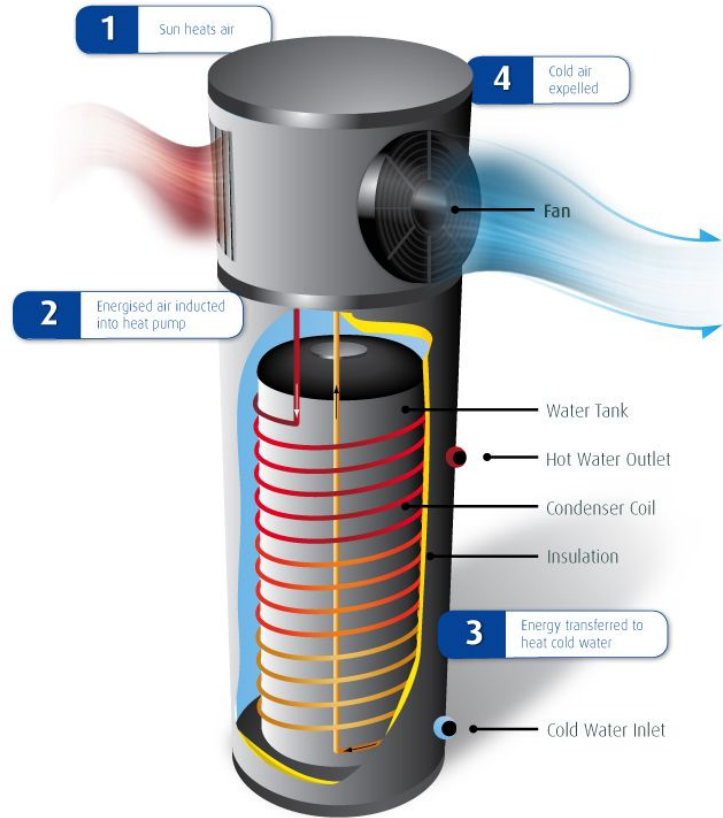
**Cooling System
Peak Load**

200 kW

100,000 SF building in a moderate climate

Commercial Domestic Hot Water

Commercial Application - Heat Pump DHW

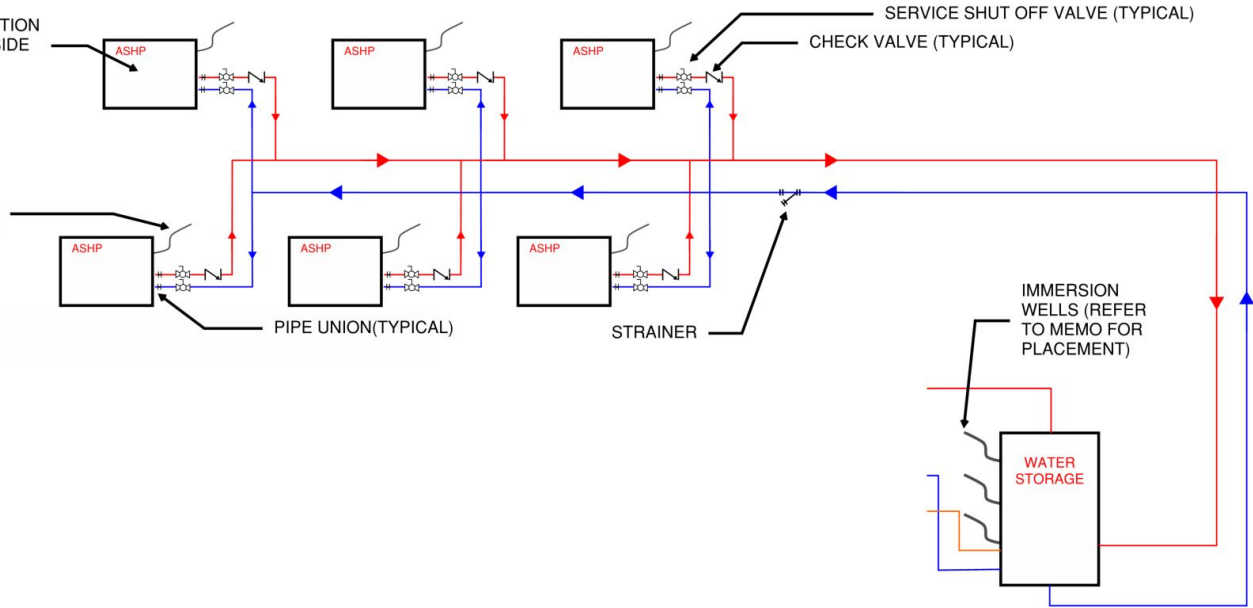


Other Commercial Centralized DHW Systems



THERE ARE CIRCULATION PUMPS LOCATED INSIDE THE SANDEN UNITS

CONTROL WIRE, ROUTE TO TEMPERATURE SENSOR, TERMINATE IN IMMERSION WELL IN TANK(TYPICAL)



Heat Pumps in Action



Before - Propane Furnace



After - Electric Heat Pump



Induction Stove



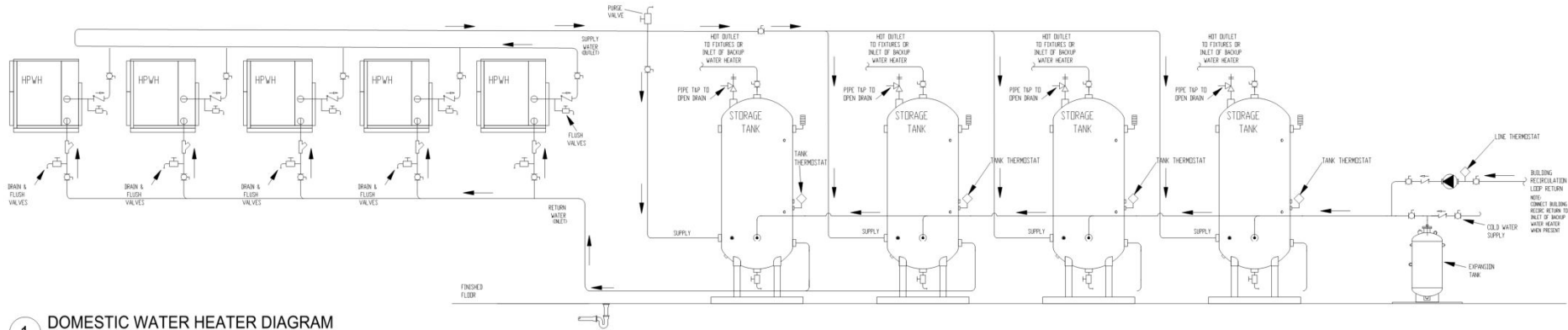
RIP - Propane Tank

New Multifamily Residential University of California at San Francisco



Central DHW

Multi Pass | Parallel Tanks



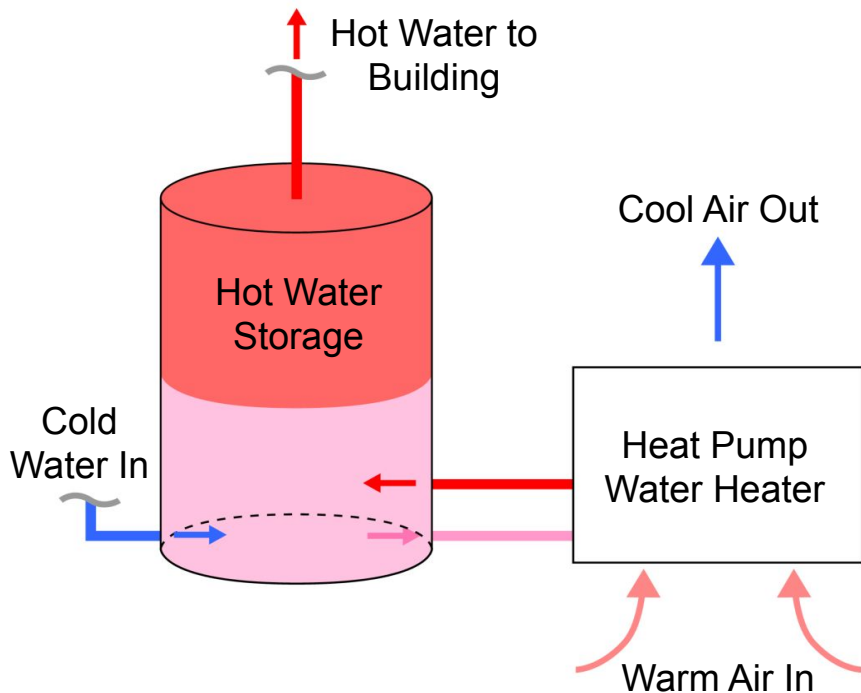
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DOMESTIC WATER HEATER DIAGRAM

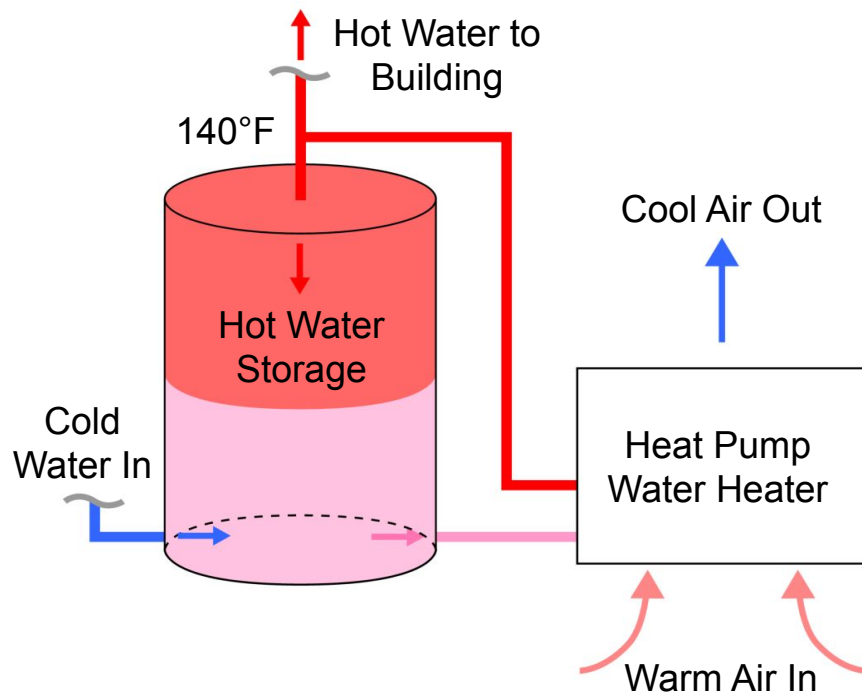
SCALE: N/A

California Growing Pains

Multi Pass - NOT ALLOWED



Single Pass - ALLOWED



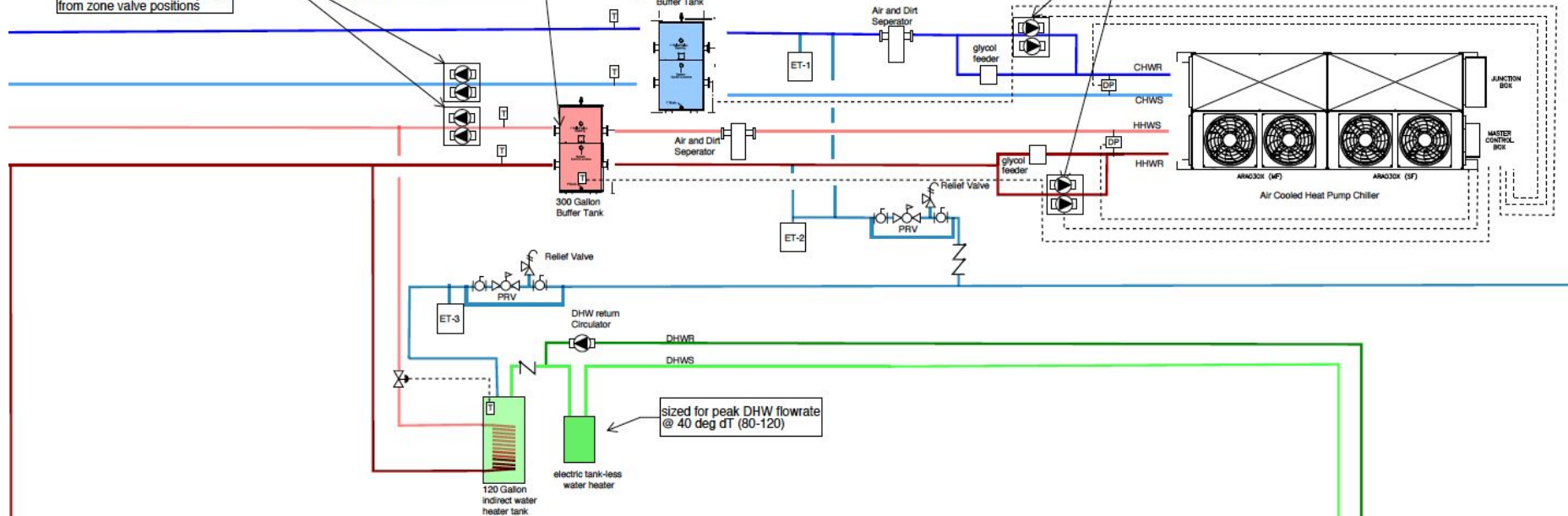
New Office Building, Menlo Park, CA



Secondary Circulator
Installed in weather resistant
ventilated pump enclosure
sized for circuit flow and head
of secondary circuit only.
controlled to trim and response
from zone valve positions

hydraulic separation buffer
tanks.
Provides bypass requirements
for chiller and thermal mass of
hydronic circuit.

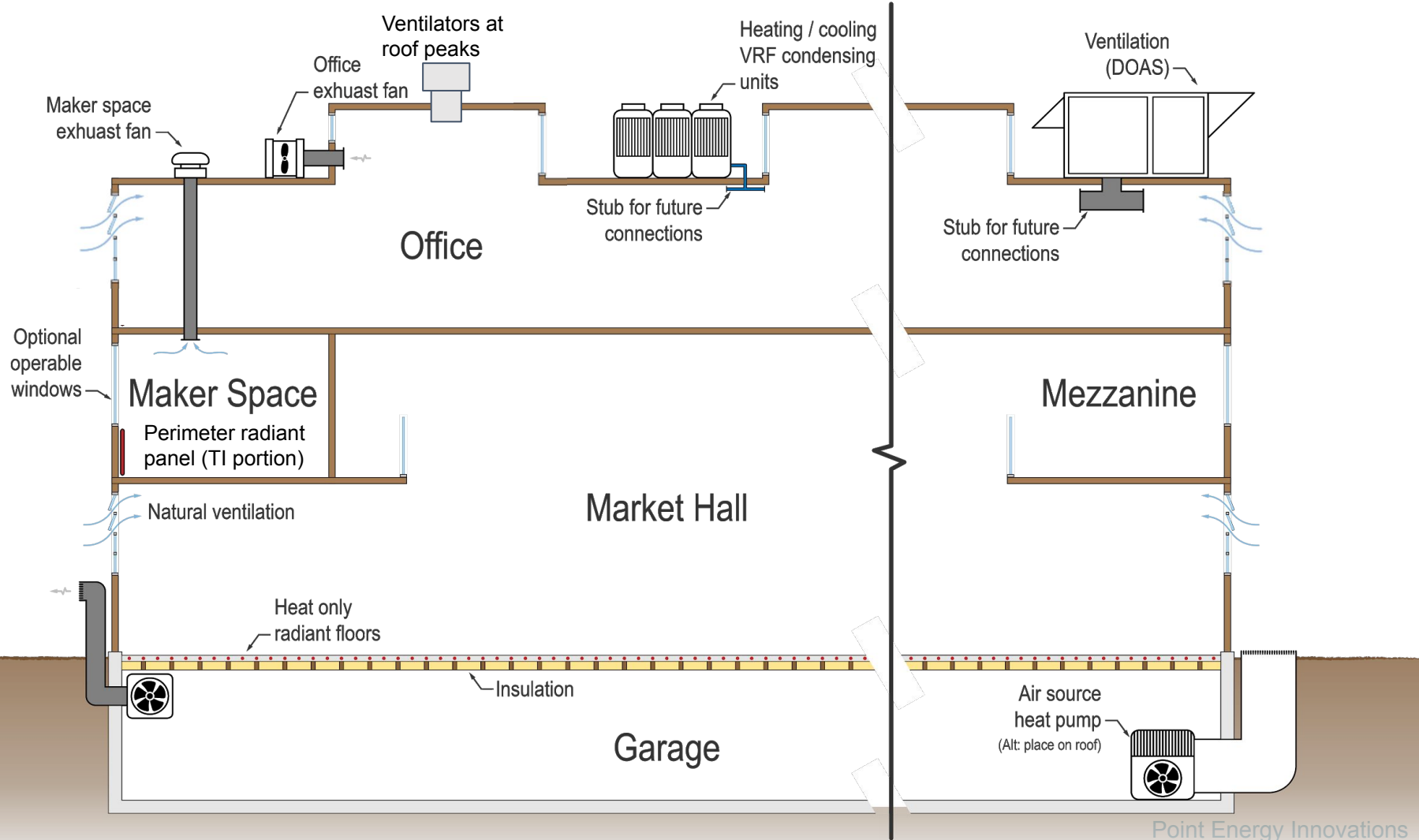
Primary Circulator
Installed in ventilated weather resistant pump
enclosure.
sized for chiller flow and head for chiller circuit
only.
controlled to dP, start/stop from chiller,
min/max flow for chiller, and buffer tank
charging.



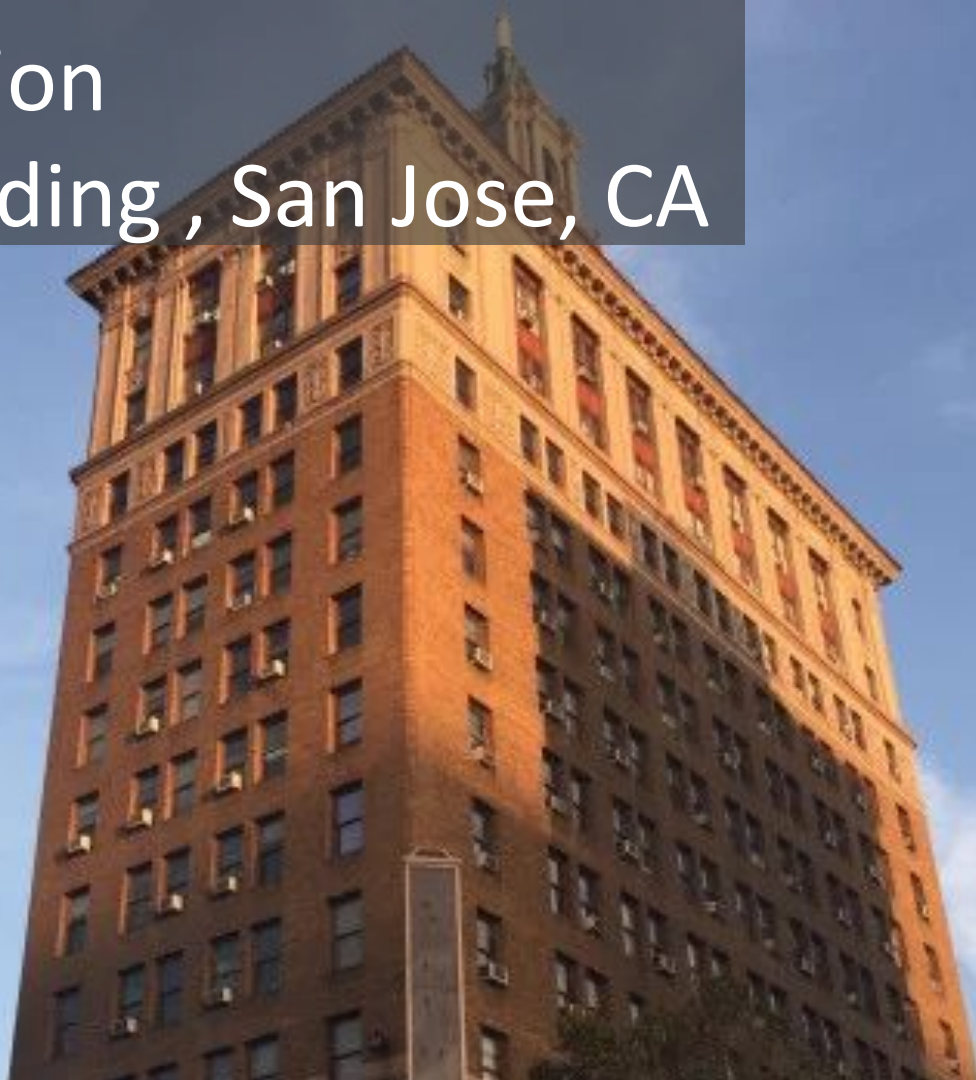
sized for peak DHW flowrate
@ 40 deg dT (80-120)

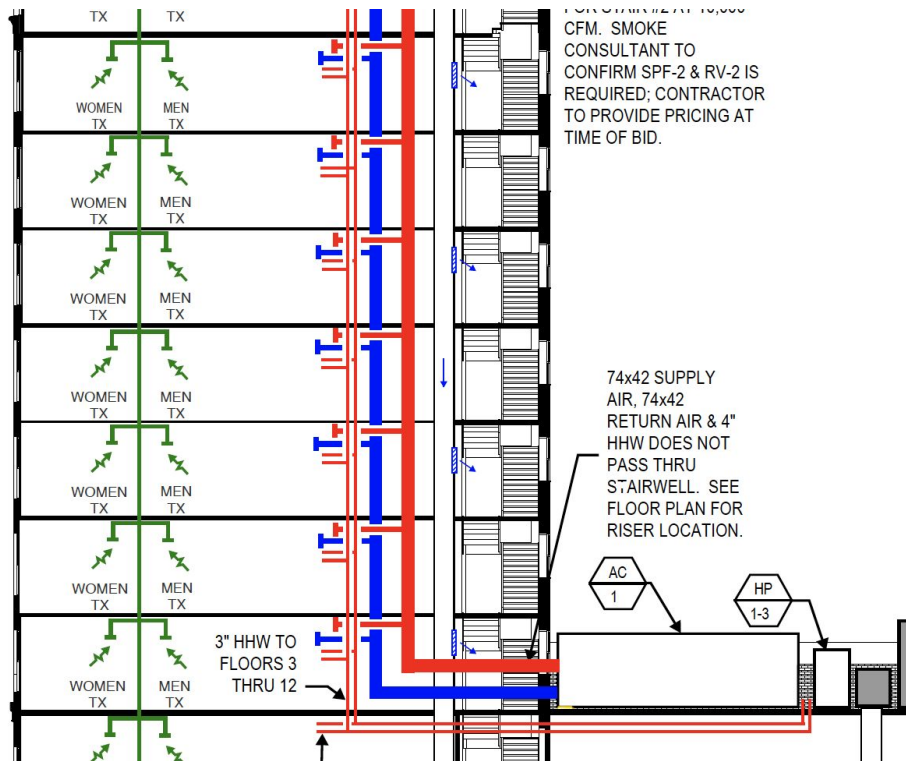
Pier 70 - Building 12





Historic Renovation Bank of Italy Building , San Jose, CA





74x42 SUPPLY
AIR, 74x42
RETURN AIR & 4"
HHW DOES NOT
PASS THRU
STAIRWELL. SEE
FLOOR PLAN FOR
RISER LOCATION.

3" HHW TO
FLOORS 3
THRU 12

56x24 SUPPLY AIR
SERVING LEVELS
2, UPPER +
— LOWER MEZZ & 1

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

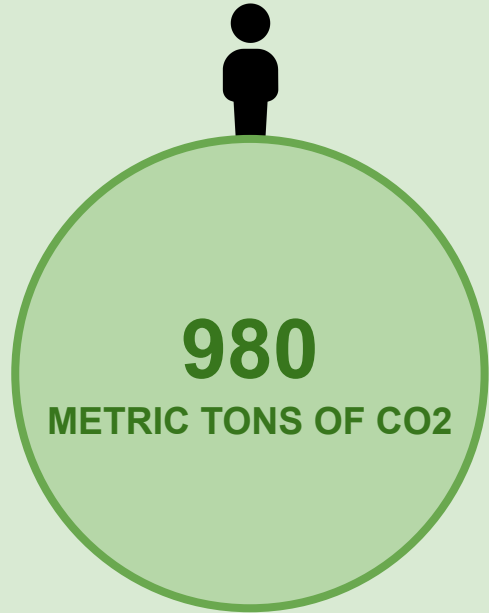
Gas systems don't run without electricity

Electric systems can be backed up by solar batteries

The Designer's Carbon Footprint

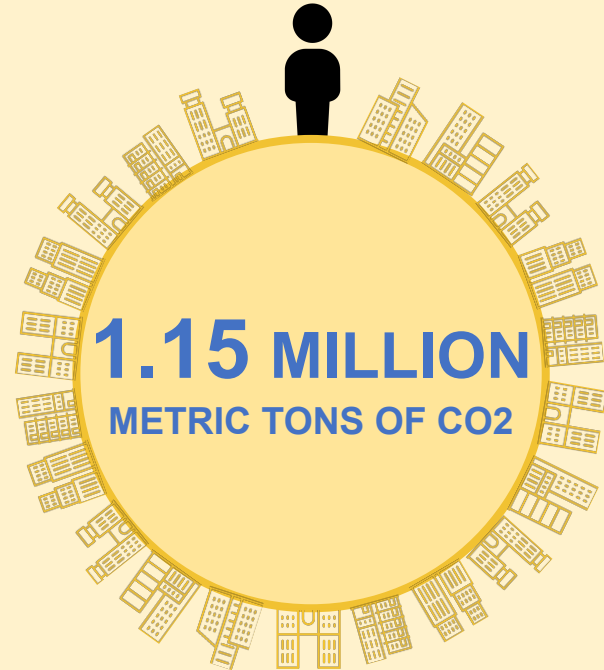
CARBON EMISSION RESPONSIBILITY

AVERAGE PERSON

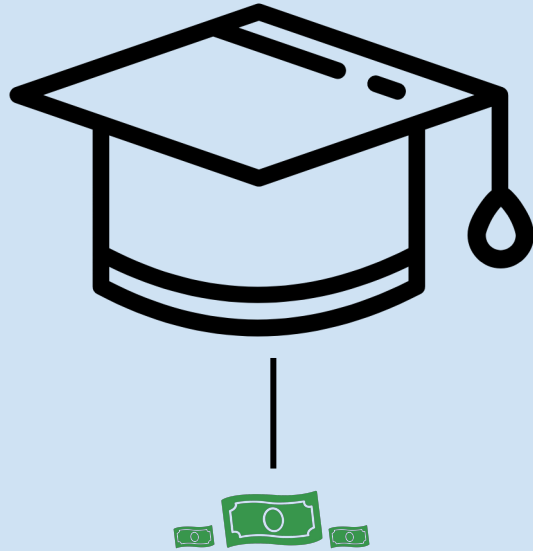


VS

BUILDING DESIGNER

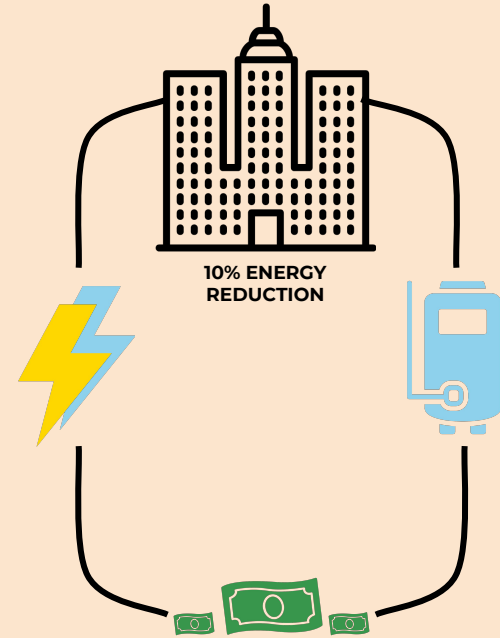


Cost of a Building Designer's Education



\$100,000
COLLEGE TUITION

Building Designer's Potential Impact



\$1.97 MILLION
POTENTIAL SAVINGS FOR ONE BUILDING

Thank you

For further information please contact
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