Commercial Building Heat Pump Technology

MASSACHUSETTS CLEAN ENERGY CENTER

MassCEC's Mission

The Massachusetts Clean Energy Center's (MassCEC) mission is to accelerate the clean energy and climate solution innovation that is critical to meeting the Commonwealth's climate goals, advancing Massachusetts' position as an international climate leader while growing the state's clean energy economy.

VRF (Variable Refrigerant Flow) Heat Pumps

- Commercial-scale technology is very similar to the residential technology!
- Some commercial applications use residential-scale technology.
- Others use larger-scale technology referred to as “variable refrigerant flow” or “VRF.”
- This is confusing because residential-scale technology also has variable refrigerant flow, but that is industry terminology.

What's the difference?

CHARACTERISTIC	MINI-SPLIT	VRF
LEVEL OF CUSTOMIZATION	LOW	HIGH (APPLIED PRODUCT)
UNIT CAPACITY (BTU/HR)	UP TO 65,000	65,001 – 500,000
INDOOR HEADS PER OUTDOOR COMPRESSOR	UP TO 8	UP TO 60
PIPE CONFIGURATION	SEPARATE PIPE FOR EACH INDOOR HEAD	SINGLE PIPE NETWORK WITH BRANCHES FOR INDOOR HEADS
SIMULTANEOUS HEATING & COOLING	NOT AVAILABLE	AVAILABLE

VRF – Outdoor Unit

VRF – Many Indoor Unit Options

Ceiling-suspended unit

Wall-mounted unit

Vertical ducted unit

Concealed floor-standing unit

Floor-standing unit

High static ducted unit

Medium static ducted unit

Low profile ducted unit

1-way cassette

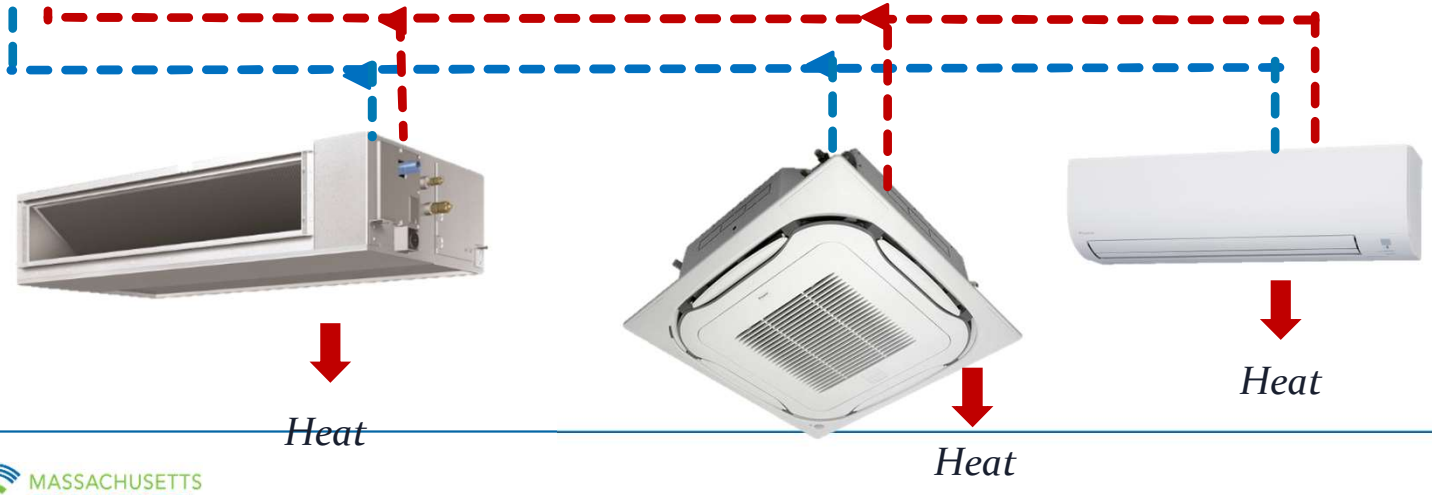
4-way large cassette

4-way small cassette

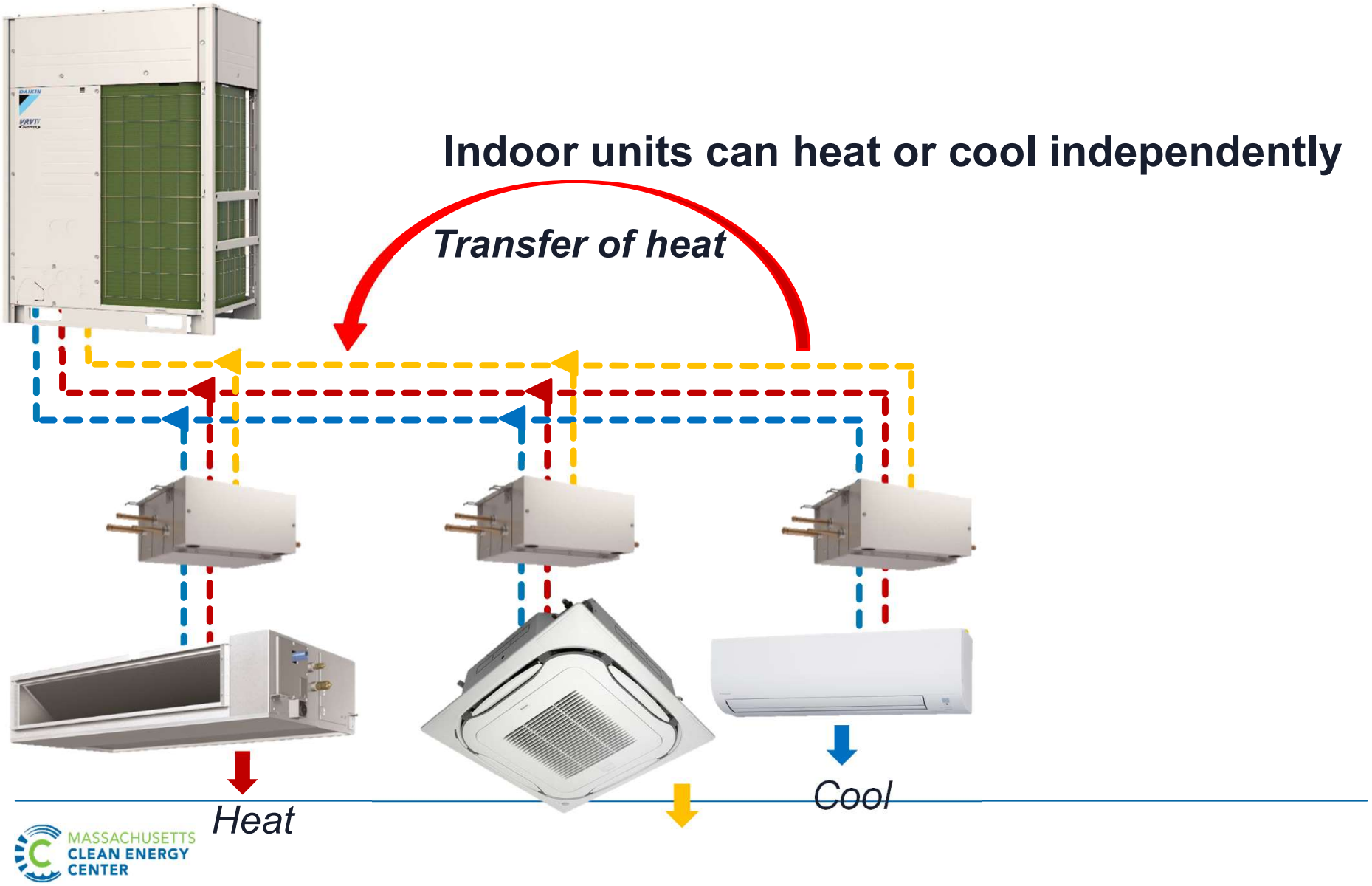
Heat Pump without Heat Recovery

heat pump

- System is either in heating OR cooling
- i.e. Indoor units cannot provide cooling if system is in heating
- *Fast & Automatic system switch over*
- Indoor units still have independent set point control



Heat Pump with Heat Recovery



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VRF Efficiency and Operating Costs

Cooling

- VRF more efficient than most conventional systems
- VRF less expensive to operate than most conventional systems
- VRF usually presents savings on the maintenance side (no water loop to maintain, less equipment and compressors to maintain, i.e. vs WSHPs)

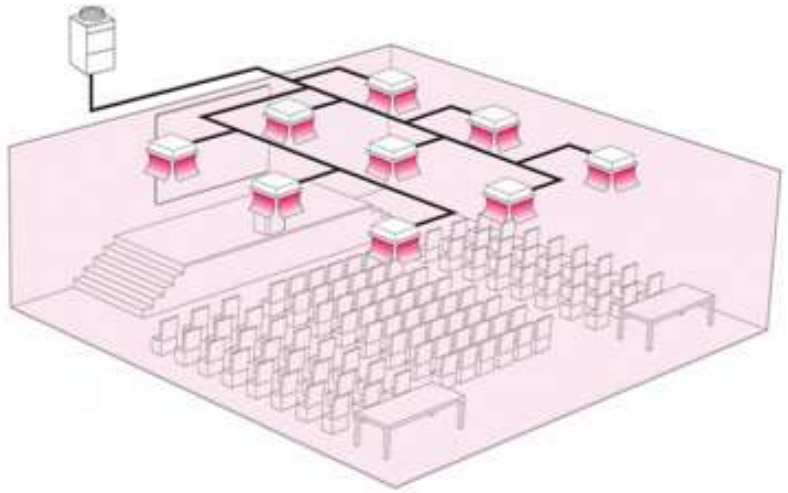
Heating

- VRF *much more* efficient than any alternative (by 3 to 5 times or more!)
- VRF much less expensive to operate than electric resistance heating
- VRF generally competitive with conventional systems (which use other fuels). Can vary with pricing.
- Similar saving potential on the maintenance side vs conventional systems

Combined: More efficient than all conventional systems
Often competitive operational costs

Benefits of Heat Pumps

- Comfort & flexibility
  - Individual zone control
  - Variety of indoor unit options
  - Flexible piping
- Small physical footprint
  - Outdoor and indoor units connected via refrigerant pipes
  - Minimal visual impact
- High efficiency
  - Lower operating costs

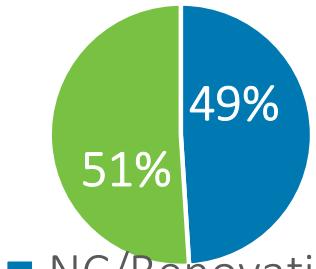


MassCEC VRF Program Snapshot

- Program Goal: Develop VRF industry and market to decarbonize heating in commercial buildings
- All systems met 100% of the heating and cooling loads for the portions for the buildings that they serve.
- May 2017 – June 2019
- Program ended due to funding limitations
- Mass Save is now offering strong commercial heat pump incentives

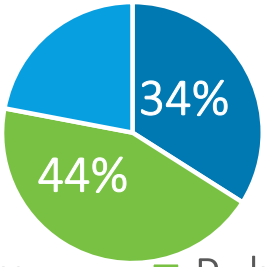
MassCEC VRF Program Stats	
Number of Projects	107
Total Awards	$5,995,000
Average Capacity	585 MBH
Cost (50th Percentile)	$695/MBH (heating)
Cost (25th Percentile)	$589/MBH (heating)
Rebate as % of Costs	15-20%

Project Type



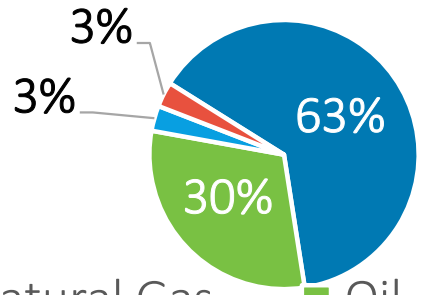
NC/Renovation
Retrofit

Building Sector



Comm
Public/NP
Aff Housing

Offset Fuel



Natural Gas
Oil
Electric
Propane/Other

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Lowell VRF Case Study

- 19th century textile mill complex
- 143,000 square feet
- 50 commercial tenants (including conference center, café, fitness center, & university research facility)

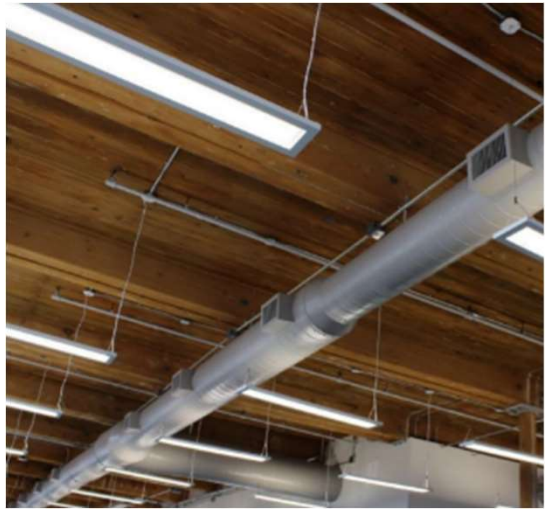
Customer experience:

- VRF equipment was more flexible than alternatives for a space-constrained project, with cheaper, faster, less invasive installation.
- Modular heat pumps offer flexibility as tenants change

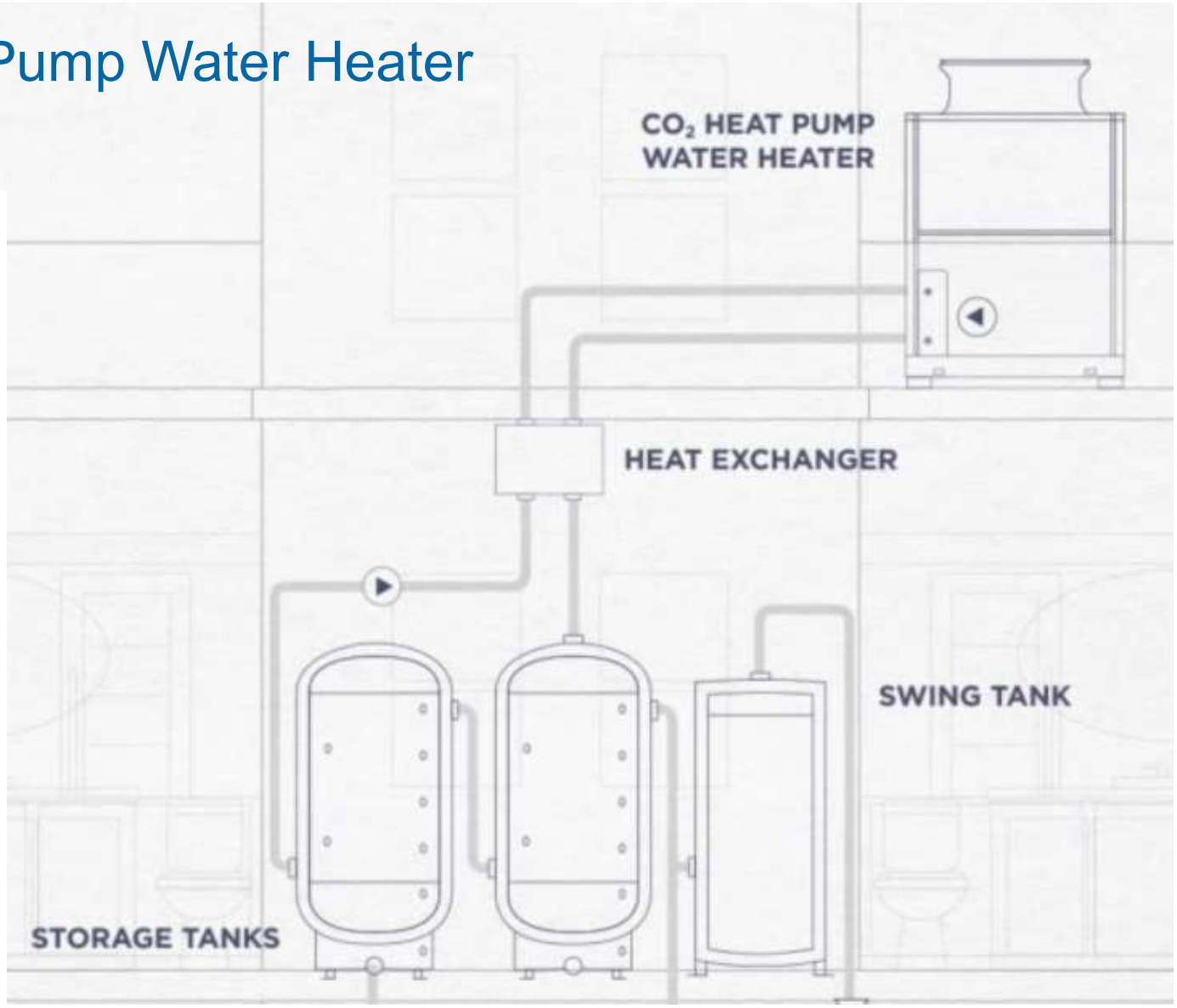
Previous HVAC: Gas-fired Modine heat exchangers 10-ton direct exchange air handler units with cooling coils

Heat Pumps:

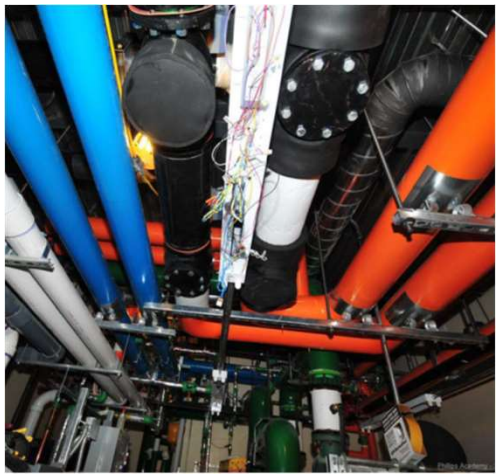
- 12 Daikin VRV system (97 tons) with 2/3rds of air handlers (remaining 1/3rd of air handlers were a separate phase)
- Reused the existing ductwork
- Installed 2019
- Heat Pump Cost: : $209,406
- Estimated Alternative Cost: Not available, but traditional HVAC would have cost more due to required infrastructure modifications



Commercial Heat Pump Water Heater

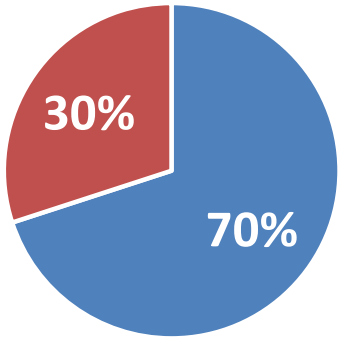


Ground-Source Heat Pump - Commercial Snapshot

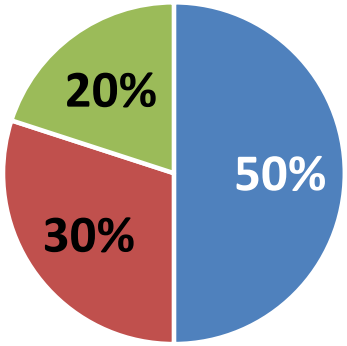


Timeline	Sept 2013 – June 2020
Number of Projects	16
Total Awards	$1,714,000
Average Capacity	1,900 MBH
Cost (50th Percentile)	$998/MBH (heating)
Cost (25th Percentile)	$817/MBH (heating)

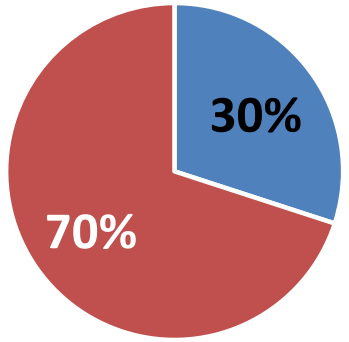
Project Type



Building Sector



Offset Fuel



BETA: Commercial Buildings

- Goal: support commercial building owners and developers in preparing to electrify their buildings

1. Develop electrification-over-time plans for a range of commercial building typologies
2. Develop and curate a resource hub with best practice approaches and industry resources for building transitions
3. Investigate and surface financial product needs and solutions to support building retrofits

➢ Ensure resources complement City of Boston ordinance and emerging state-wide building emissions cap

Networked Geothermal District

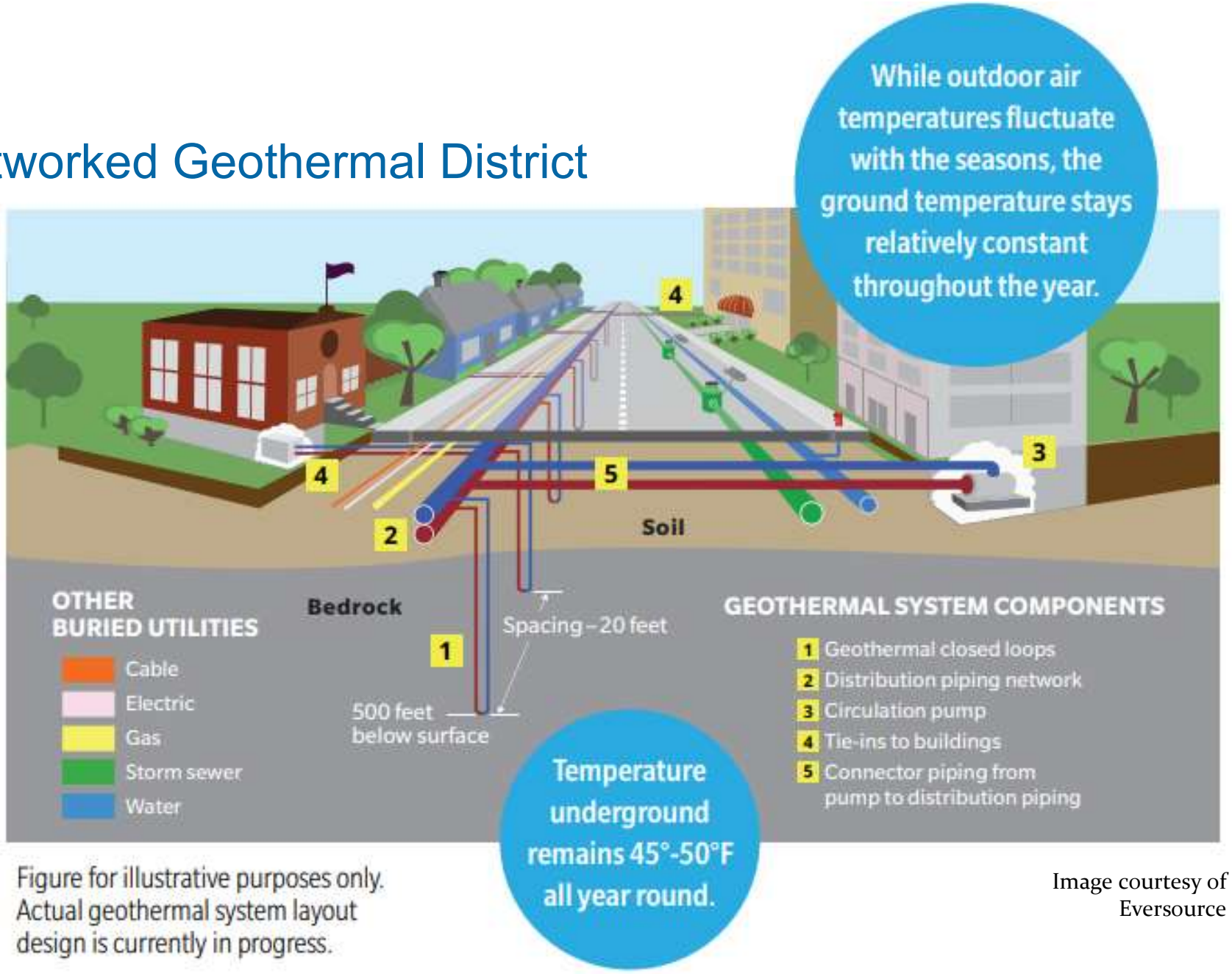
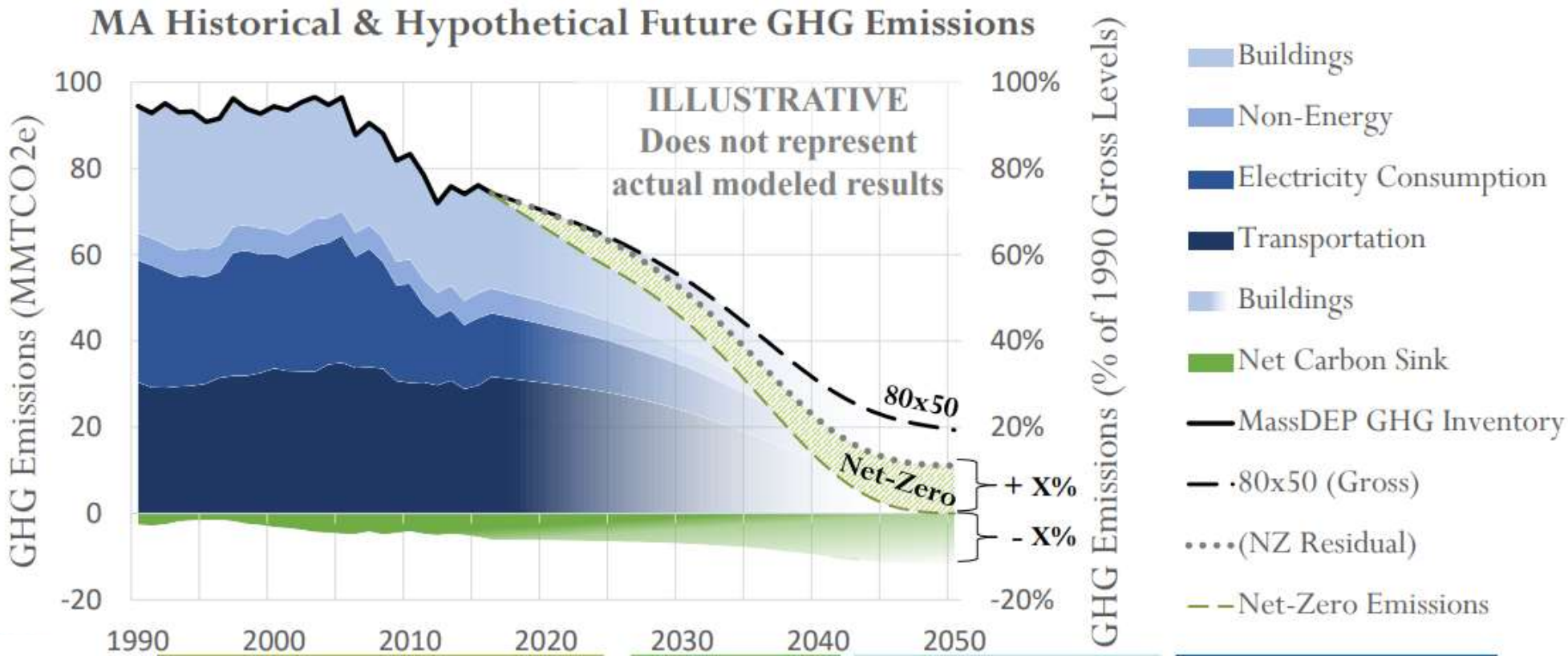


Figure for illustrative purposes only. Actual geothermal system layout design is currently in progress.

Image courtesy of Eversource

Appendix

Goal: net zero greenhouse gas emissions by 2050



Massachusetts Interim Clean Energy & Climate Plan for 2030

- 1 million homes and ~350 million sf of commercial space retrofitted with clean heating and high-performance building envelope