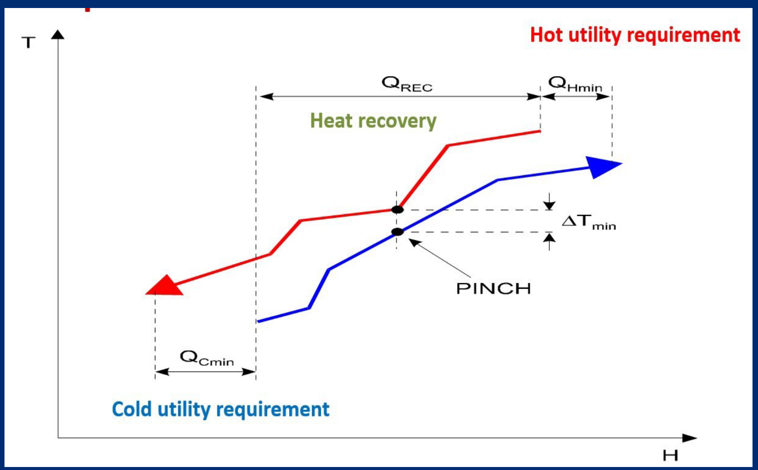
NYSERDA Heat Recovery Program

Heat Recovery System Examples

HeatRecovery@nyserda.ny.gov

Heat Recovery and Reuse



Pinch Analysis – Composite Curve

A concept by which a building's rejected thermal energy is identified and a project is devised and implemented to capture and redirect it or store it for use elsewhere.

Follow these steps to identify heat recovery opportunities:

1. **Identify rejected heat and find heat sinks that could reuse it.** Document the size and location of all sources of rejected heat from equipment or processes within the property, and the location, medium and temperature of thermal energy needed at each heat sink to offset primary energy consumption.

2. **Design the connection infrastructure** and select an optimized path between the rejected heat source and heat sink. Determine the length of the connection infrastructure, and if heat pump or heat exchanger can be used.

3. **Qualify and quantify** whether the rejected heat source offers a practicable solution to offset primary energy consumption. Is there enough reusable heat to justify the project?

1. Review and identify rejected heat

Identify rejected heat from equipment or processes within buildings

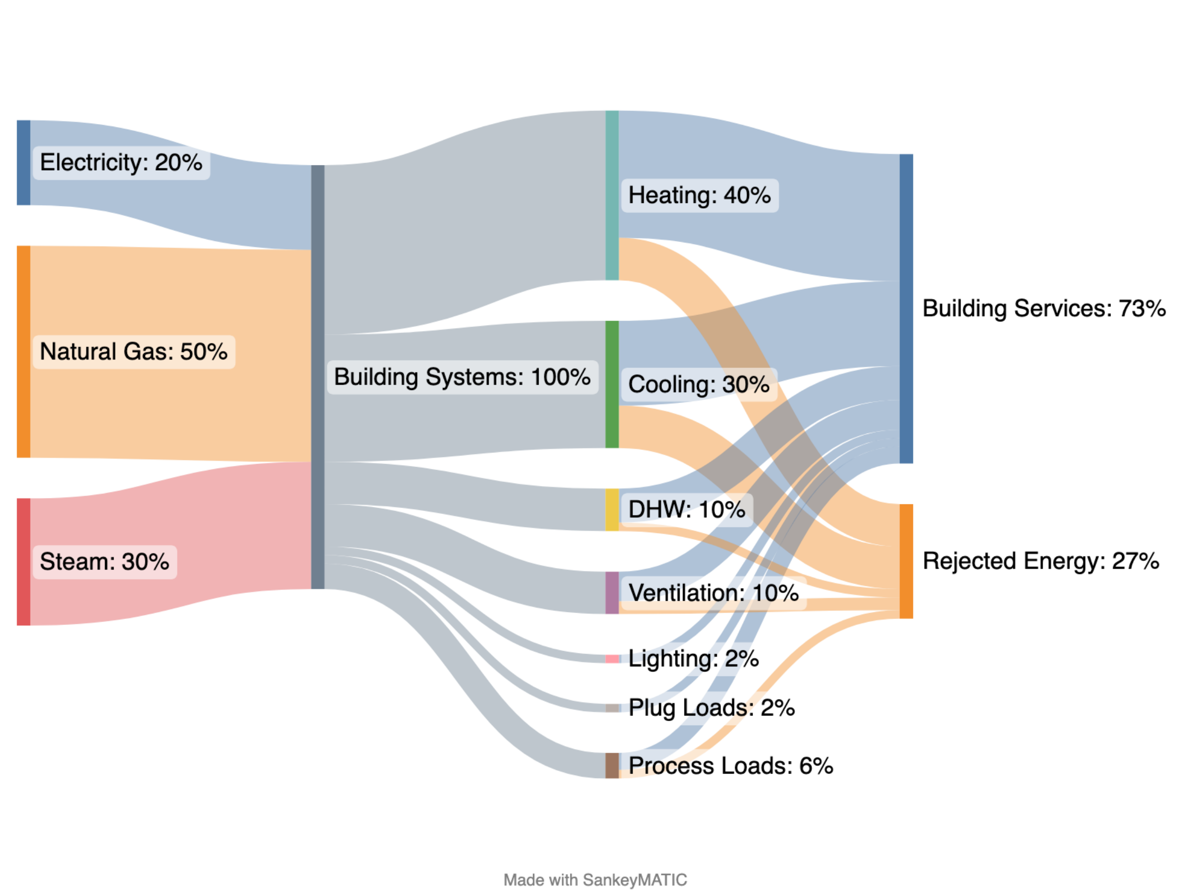
Cooling produces heat

Heat is lost through ventilation…

…or goes down the drain

Internal processes also produce heat

Heat can be stored



2. Design the connection infrastructure

Determine heat recovery system design components

Rejected Heat Source

- Exhaust Ventilation
- Condenser Water/ Cooling System
- Refrigeration
- Dehumidification
- Data Center/ Computer Room
- Wastewater
- Process Heat

Heat Transfer Technology

- Passive
  - Heat Exchanger
  - ERV
- Active
  - Heat Pump

Transfer Medium

- Water
- Refrigerant
- Forced air
- Steam

Heat Sink

- Space Heating
- DHW
- Dehumidification
- Process Heat

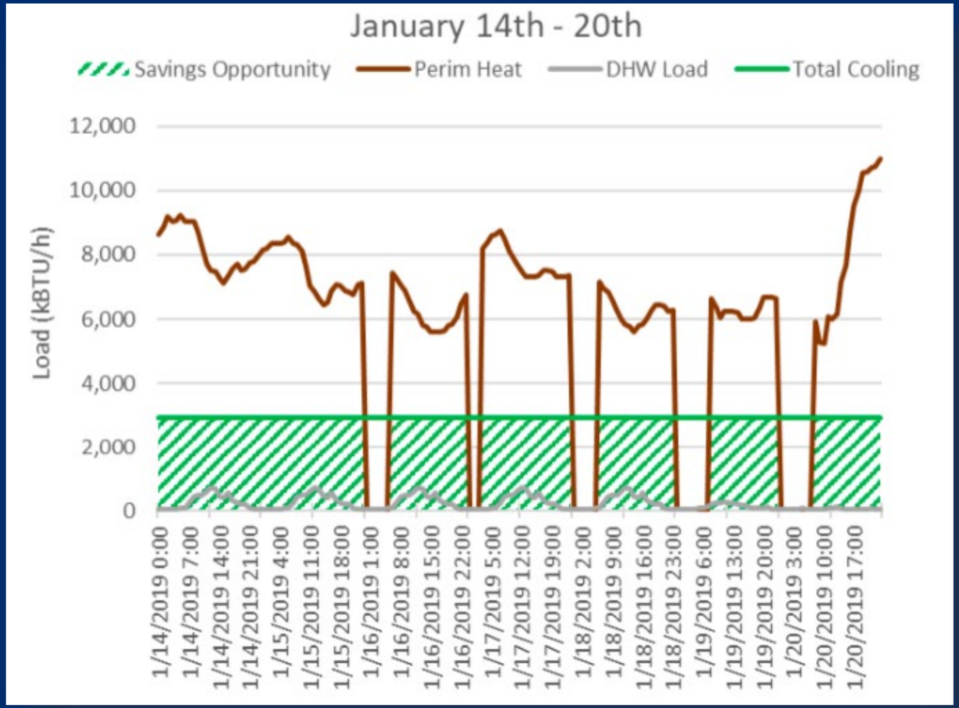
3. Qualify and Quantify

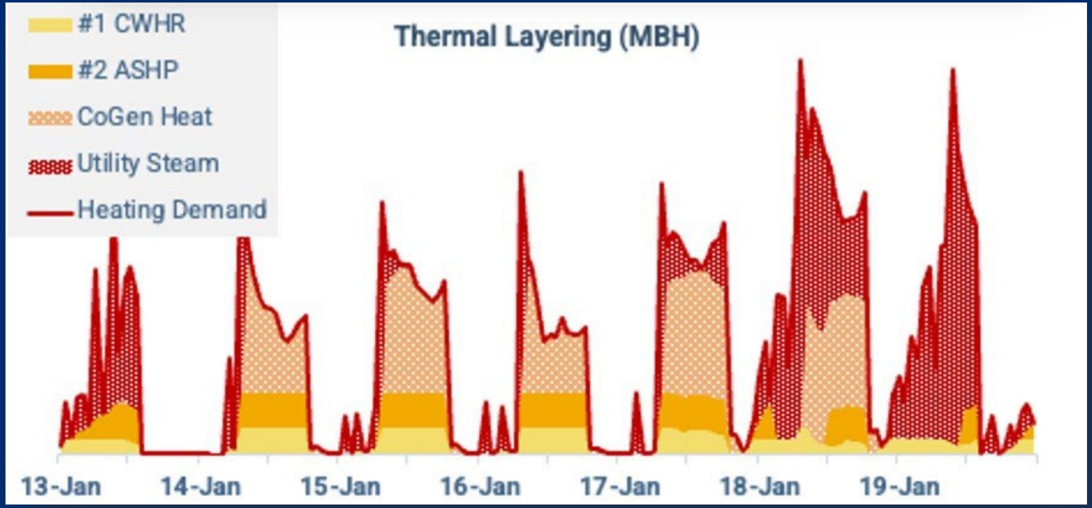
Diagram energy flows and quantify the opportunity

Determine whether the rejected heat source offers a practicable solution to offset primary energy consumption.

- Is there enough reusable heat to justify the project?
- Can thermal energy storage enhance the usability of the recaptured heat?

At right are two examples of winter daily load profiles for commercial buildings demonstrating the savings opportunity of condenser water heat recovery projects to offset heating demand from the primary energy fuel. The daily load profiles also demonstrate how the heat recovery system will operate.





Heat Recovery System Examples

Heat Recovery System Examples

Heating
Cooling
Ventilation

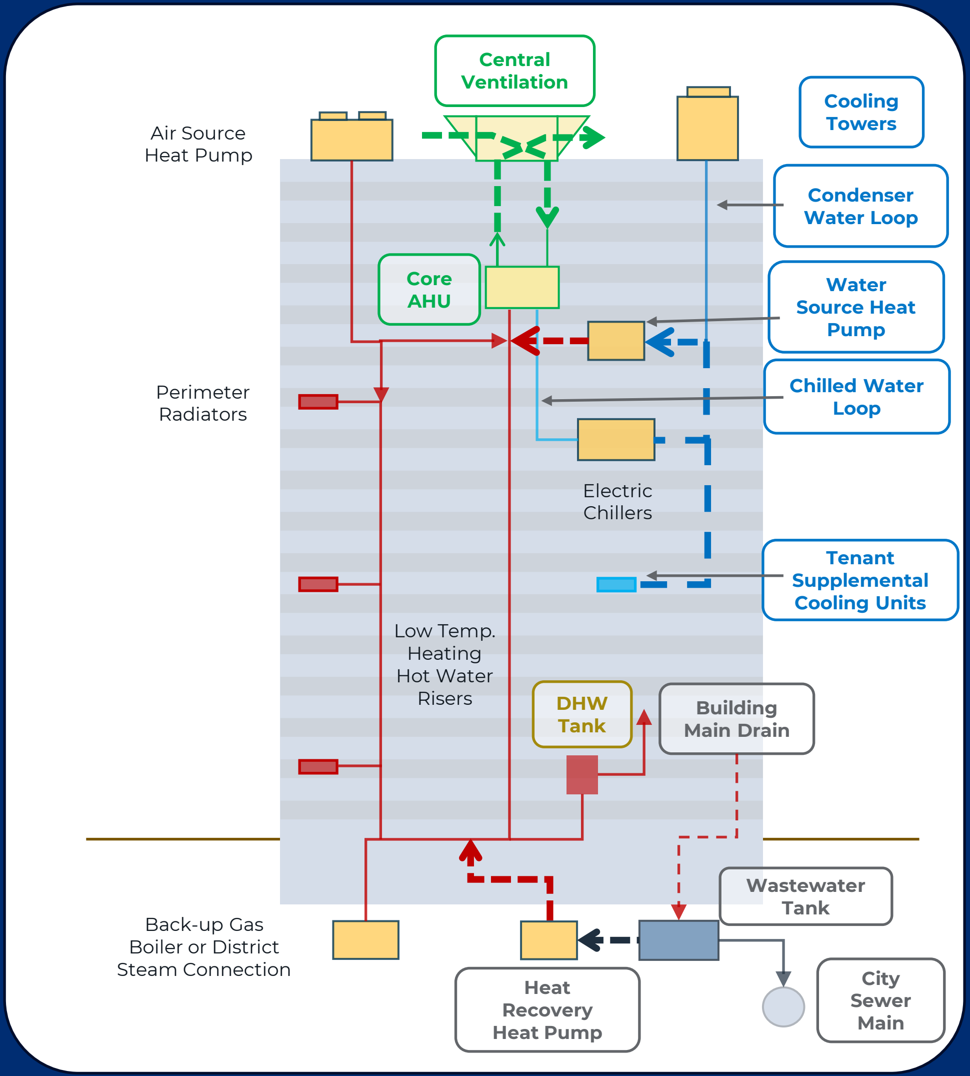
Condenser Water Heat Recovery

Energy Recovery Ventilator

Wastewater Energy Transfer System

Tenant Supplemental Cooling Units

Thermal Storage



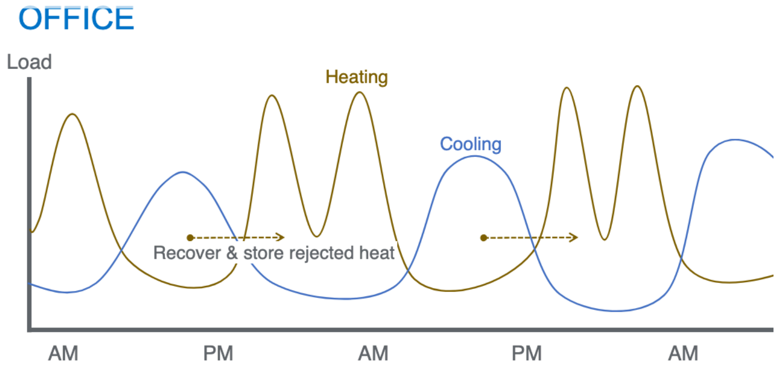
Cooling Process

Capture the heat before releasing it into the atmosphere and redistribute it for heating uses. Overlay disaggregated 8760-hour thermal load models to identify and take advantage of coincident heating and cooling events.

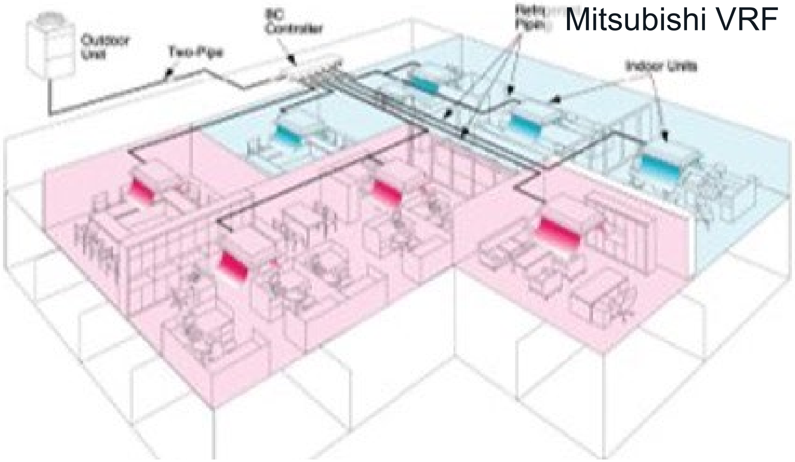
- **Heat recovery chillers** from different sources: condenser water loop, refrigeration systems, data centers/computer rooms, transit tunnel, etc. Reversible chillers can switch modes serving two purposes with the same equipment.
- **VRF systems** with heat recovery enabled
- **Thermal Energy Networks** with distributed WSHPs on ambient/CW loops
- **Water-cooled AC** dumping heat into a hydronic system instead of into the atmosphere to potentially be reused

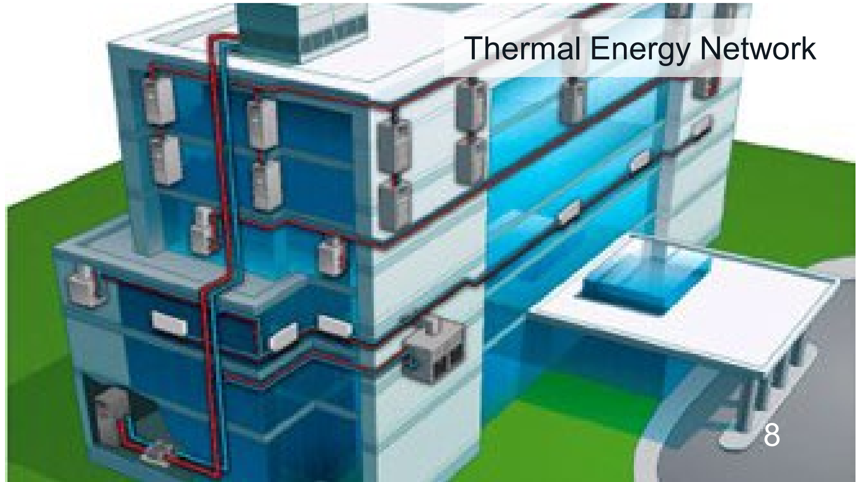
** Product images are provided as illustrative examples only.*

Office Building Heating and Cooling Load Profiles



Illustrative example. Actual time-of-use, disaggregated load profiles should be reviewed for waste, recovery system sizing.





Ventilation Exhaust

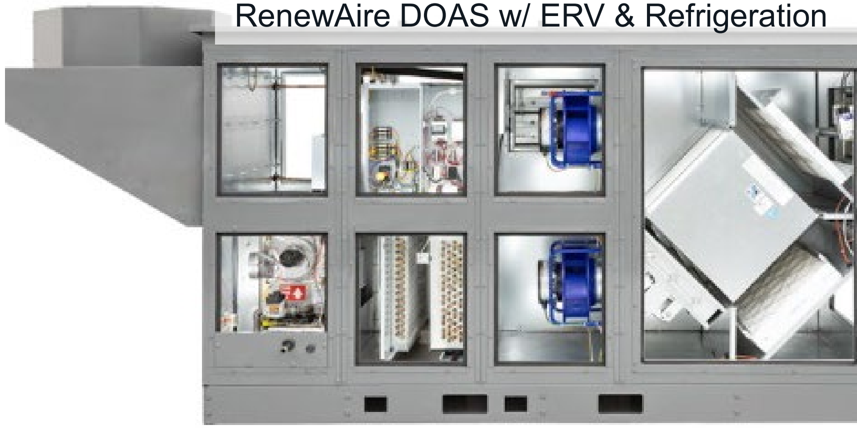
Fresh air is fundamental to healthy buildings. Use exhaust ventilation to temper fresh air or recover exhaust heat for other heating applications such as DHW production.

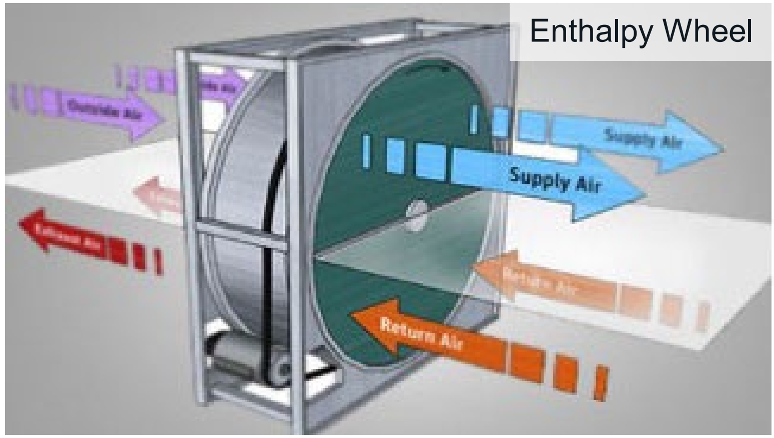
Heat Recovery Types:

- Passive: crossflow, enthalpy wheels
- Active: heat pumps, "runaround" loop

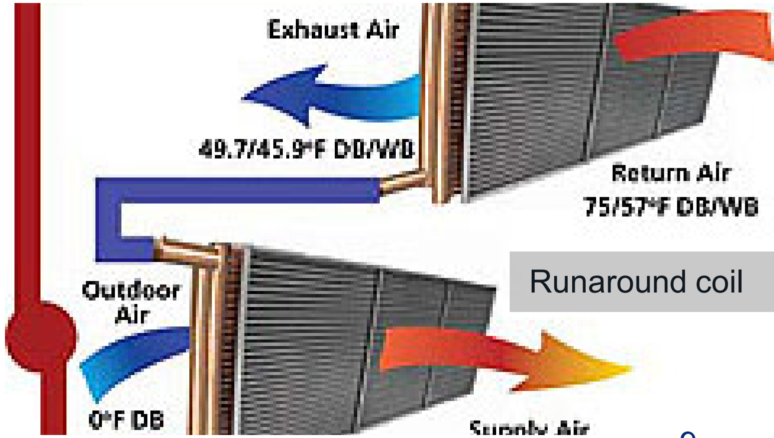
Considerations:

- Humidity control: ERV vs. HRV
- Centralized vs. Decentralized systems
- Exhaust locations
- Bundle ventilation improvements with envelope tightness improvements
- Consider IAQ implications of gas cooking


RenewAire DOAS w/ ERV & Refrigeration



Enthalpy Wheel



Runaround coil

* *Product images are provided as illustrative examples only.*

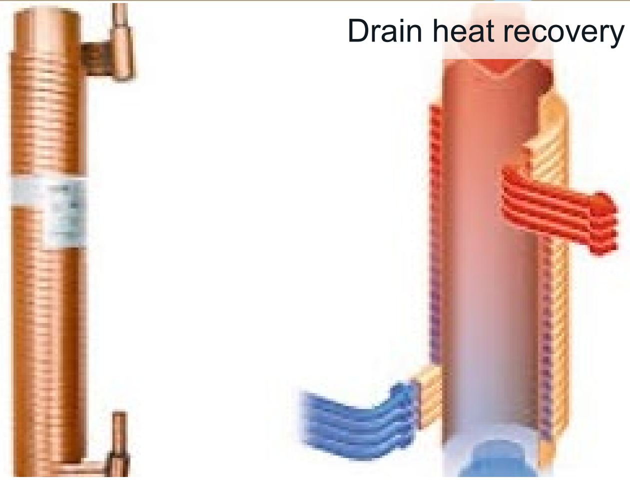
Wastewater

Extract heat from wastewater and redirect it to other uses, such as DHW

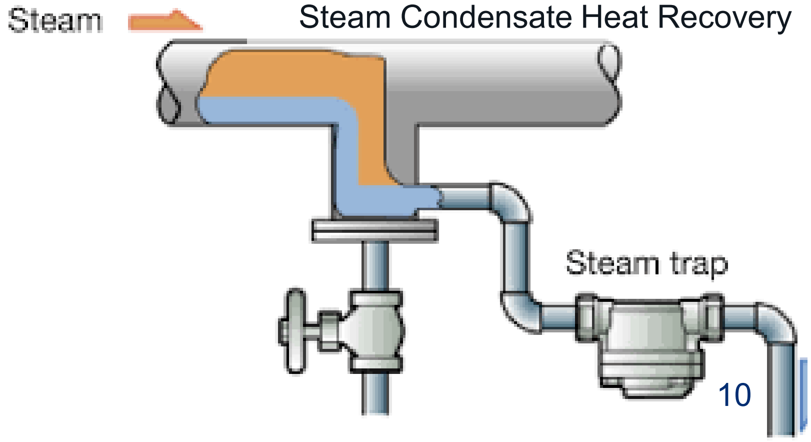
- **Energy wastewater heat pump:** recover heat from wastewater at building scale before it exits the building
- **Drain heat recovery coil:** preheat fresh water by coiling it around the drain pipe to recover waste heat before going into the water heater
- **Steam condensate heat recovery:** buildings supplied by district steam in NYC must quench steam condensate before disregarding it into the sewage

Sharc Energy Wastewater Heat Pump

Drain heat recovery coil



Steam Condensate Heat Recovery



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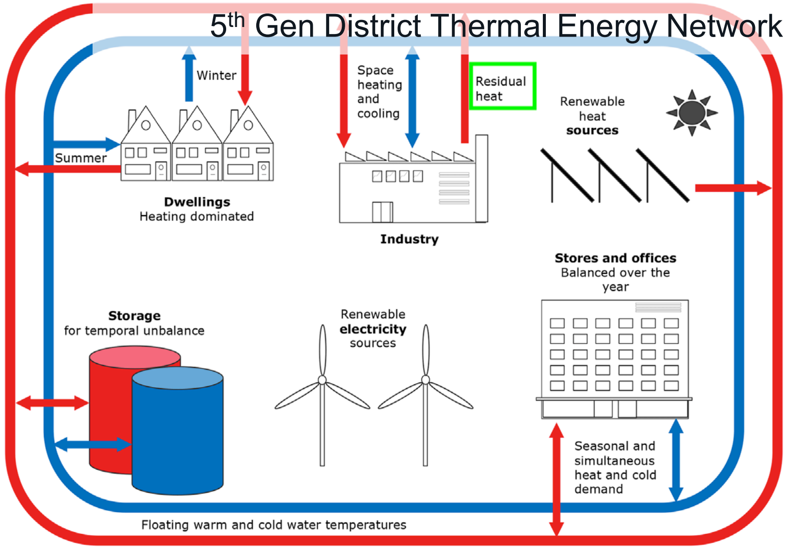
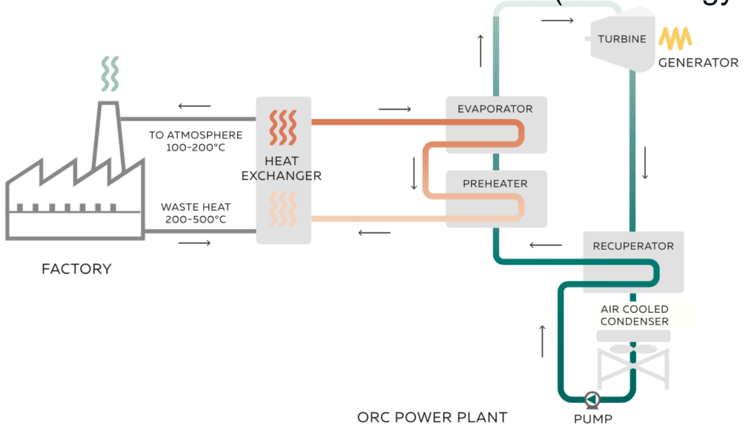
Process Waste Heat

Capture the waste heat from industrial or other processes to be reused

- The extracted heat can be repurposed within a plant's process streams or injected into a district thermal energy network to supply neighboring buildings
- The excess heat can be reused to produce electricity on-site, using for example the Organic Rankine Cycle (ORC)



Organic Rankine Cycle Heat Recovery for Industrial Process (from Exergy ORC)



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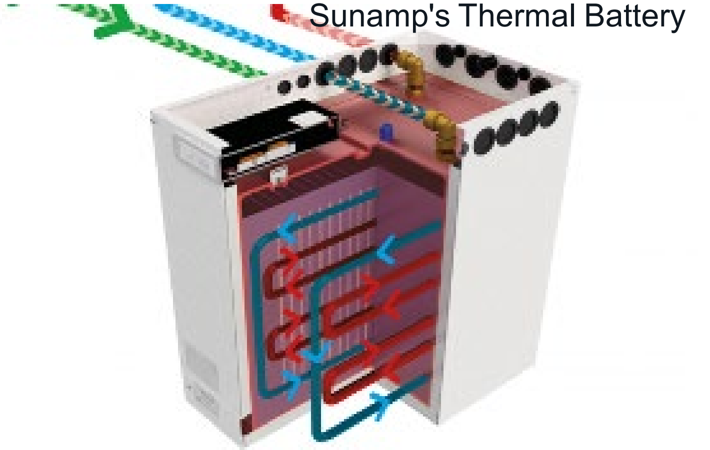
Thermal Storage

Incorporate thermal storage technology into designs to save recovered heat for when its most needed, such as peak load

- **Centralized storage:** ice tanks, PCM tanks, water tanks, molten salt
- **Decentralized storage:** DHW tanks, small PCM
- **Advanced Geothermal**
- **Passive/thermal mass:** concrete, PCM wall panels


Calmac's Ice Storage


Sunamp's Thermal Battery

Condenser water tank for Time Independent Energy Recovery (TIER)

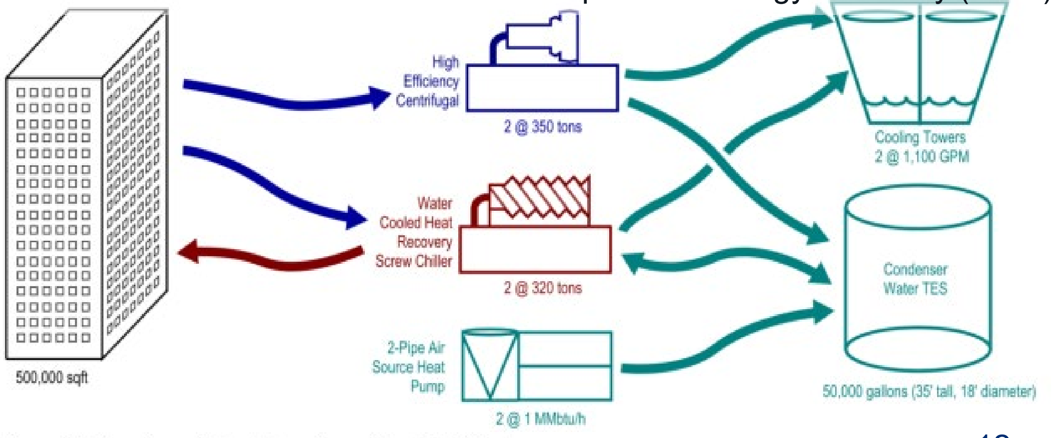
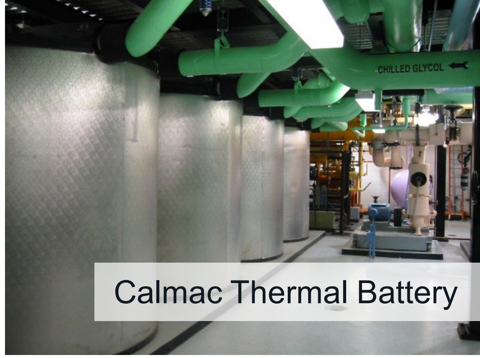


Figure 2. Direction of Heat Transfer with a TIER System

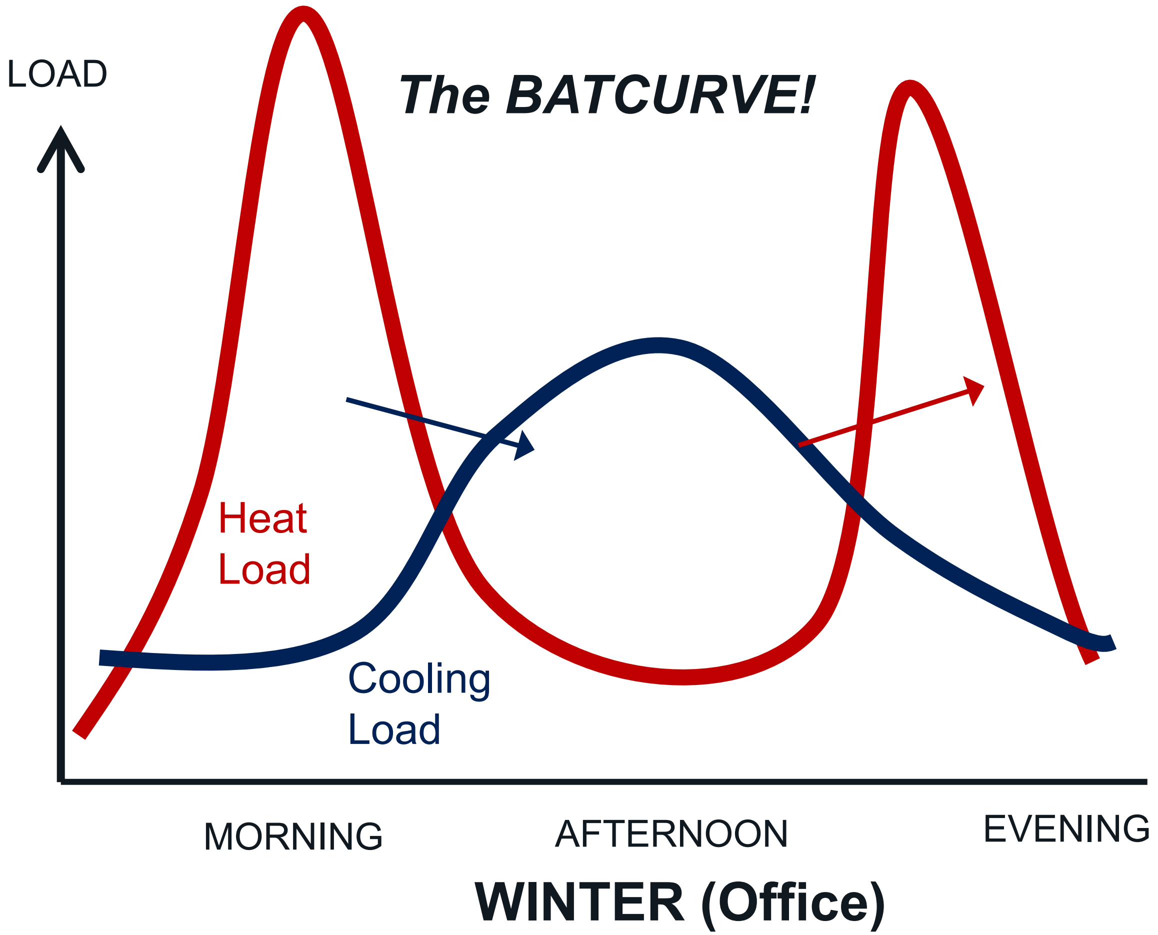
** Product images are provided as illustrative examples only.*

Heat Recovery opportunities in commercial buildings: *daily differentials*

- Eliminate “economizer” waste. Rejecting heat is wasting energy
- Thermal storage can help mitigate peaks and avoid The Batcurve
- Storage source heat pumps on a thermal network
- Overlay disaggregated 8760 thermal loads to identify thermal coincidences:
- Core vs perimeter zones
- East vs west zones
- Include opportunistic heat sources!



Calmac Thermal Battery



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Heat Recovery opportunities in multifamily buildings

DHW Opportunities

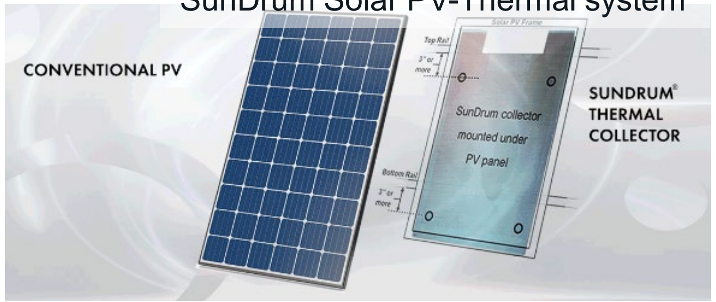
- Wastewater heat recovery
- Additional storage – optimize storage size for equipment efficiency (e.g. larger storage beneficial for heat pump water heaters)
- Reduce recirculation energy: e.g. thermostatic balancing valves, variable speed recirculation
- Solar Thermal
- PV-Thermal heat pump

Space Heating Opportunities

- Heat recovery from exhaust air to supply air (including bathroom and kitchen exhaust)
- Other heat sources – adjacent buildings, ground-source, wastewater

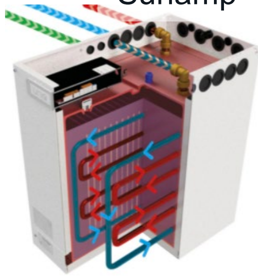
Aermec Air-to-Water Heat Pump

SunDrum Solar PV-Thermal system



Sharc Piranha

Sunamp



RenewAire DOAS w/ ERV & Refrigeration

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Eligible Solutions

Some examples of solutions include, but are not limited to the following:

Cooling and Dehumidification Process Heat Recovery

- Comfort treatment of heating, cooling and dehumidification
- Condenser water heat recovery, using heat recovery chillers or water source heat pumps (WSHP) to extract heat from condenser water loop before exhausting heat into the atmosphere with cooling towers or dry coolers
- Distributed WSHPs on ambient/condenser water loops enabling heat sharing across the building
- Other refrigeration, data center, or cooling heat recovery through VRF systems or hydronic system heat extraction
- Heat recovery from dehumidification process, or using recovered heat for the reheat coils

Ventilation Exhaust Heat Recovery

- Exhaust and ventilation airstreams
- Integrating Energy Recovery Ventilator (ERV) to existing or modified building ventilation systems
- Installing “Run Around Coil” to building ventilation exhaust
- Exhaust-air heat pump, using air-source heat pumps to recover thermal energy from exhaust airstreams

Wastewater Heat Recovery

- Discharged wastewater
- Wastewater heat pump, recovering heat from wastewater at building scale before it exits to the municipality’s sanitary sewer main
- Drain Water Heat Recovery Coil: preheat fresh makeup water by coiling it around a primary drain pipe to recover waste heat before going into the water heater
- Steam condensate heat recovery prior to rejecting condensate into the sanitary sewer

Process Waste Heat Recovery

- Capturing the waste heat generated by industrial or other processes to be reused within a plant’s process streams or injected into a district thermal energy network to supply neighboring buildings
- The excess heat can also be reused to produce electricity on-site, using the Organic Rankine Cycle (ORC)
- Byproduct wasted energy from building equipment and systems
- Heat rejected by data processing equipment and data centers
- Heat byproducts from refrigeration, air/gas compression, energy production, energy conversion, and other processing plants
- Solar energy incident on the building's exterior surface and fenestration
- Infrastructure below ground

Thermal Storage to Enhance Heat Recovery Systems

- Solutions include: Ice tanks, Phase Change Material (PCM), water tanks, condenser water storage, molten salt, geothermal, etc.
- Ice heating: using the process of making ice to produce usable heat. This enables the use of the ice storage tank for heating purposes and maximizes its utility

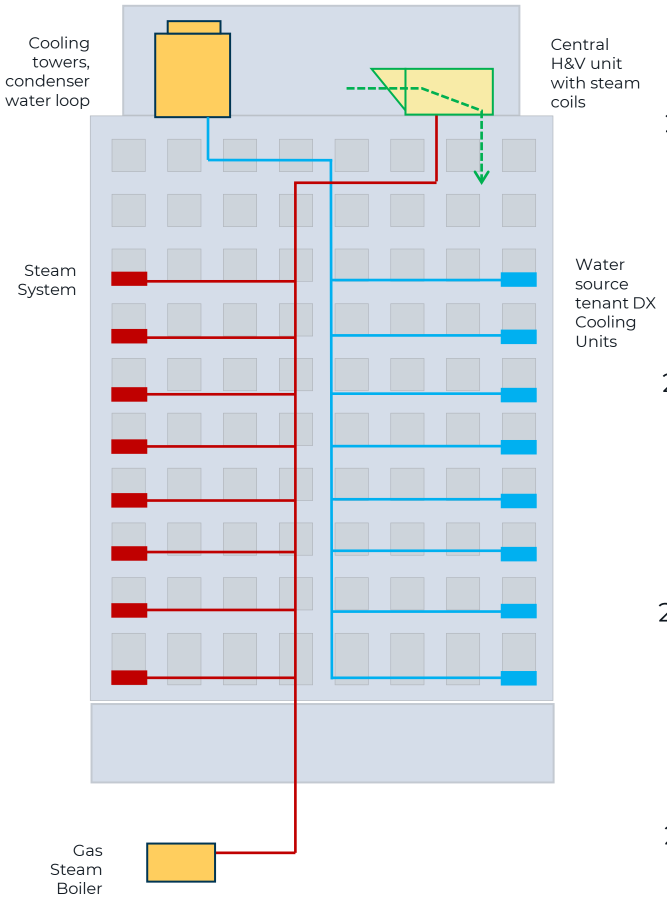
Case Studies

For additional examples, check out the Resource Efficient Decarbonization Guide at: https://www.nyserda.ny.gov/All-Programs/Empire-Building-Challenge/Empire-Building-Challenge-Projects

EBC Project: 345 Hudson (by Hudson Square Properties)

Key Takeaways: Eliminate on-site fossil fuel usage, phased-in implementation based on tenant turnover, lower distribution temperatures, minimize wasted heat, heat sharing

BEFORE



2022:
- **Install Ambient Loop Hydronic Spine**
  Convert existing condenser water loop.

2023:
- **Tenant Conversion Phase 1**
  Remove steam radiators and water source DX cooling units
  Install 4-pipe hydronic, WSHP, fan-coil, radiant options
- **Install Central ASHP and Adiabatic Dry Cooler**
  Central plant to maintain design temp. for hydronic loop

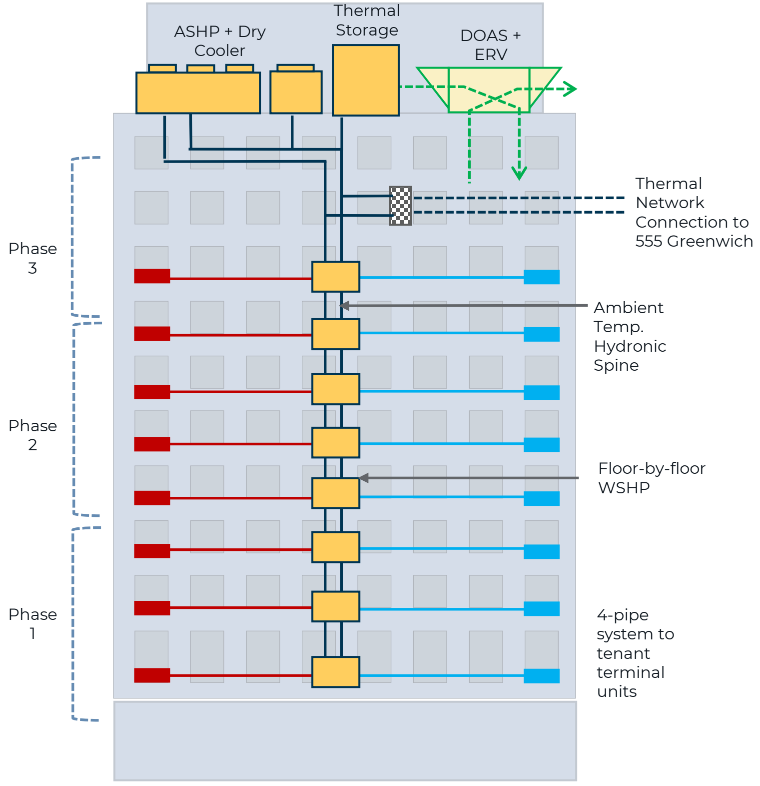
2024:
- **Install Central DOAS+ERV**
  Fresh air supply with minimum 85% heat recovery
- Provisional: **Thermal network connection to neighbor**
  new building with geothermal piles

2025:
- Provisional: Install rooftop **Thermal Storage**
  to supplement central plant
- Provisional: **Envelope Improvements**
  Replace windows to improve air infiltration and reduce load

2027:
- **Tenant Conversion Phase 2**
  Phase-in tenant floor work based on tenant turnover lease

2029:
- **Tenant Conversion Phase 3**

AFTER

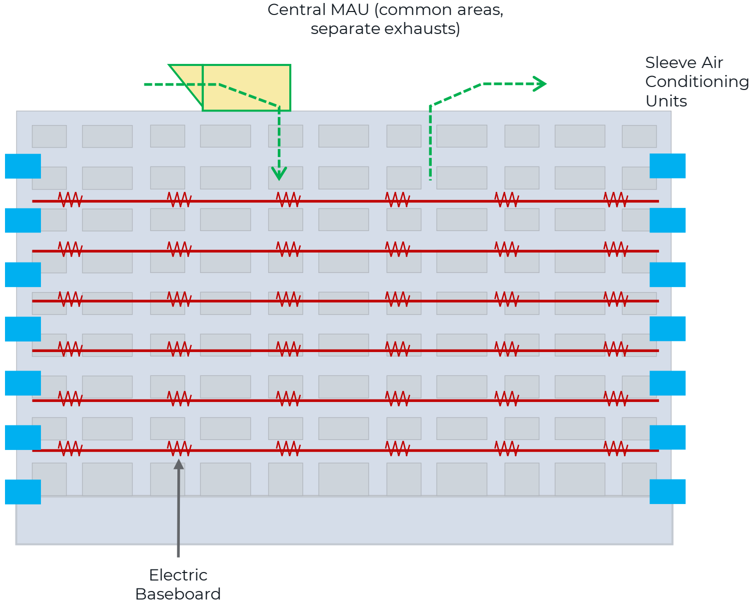


Heating
Cooling
Ventilation

EBC Project: Whitney Young Manor (by Omni NY)

Key Takeaways: Affordable Housing Recapitalization, Tenant Total Cost Reduction, Failing Envelope, New hydronic distribution system, Minimize wasted heat

BEFORE



2024:

Envelope Improvements
EIFS over uninsulated masonry, new windows, new roof

Dual-Temp Hydronic System
New 2-pipe hydronic piping drilled through common areas.

Central ASHP
Install 2 ASHPs to produce low temperature hot water and chilled water for in-unit FCUs

Back-up Gas Boiler
For use during power outages and extreme cold events

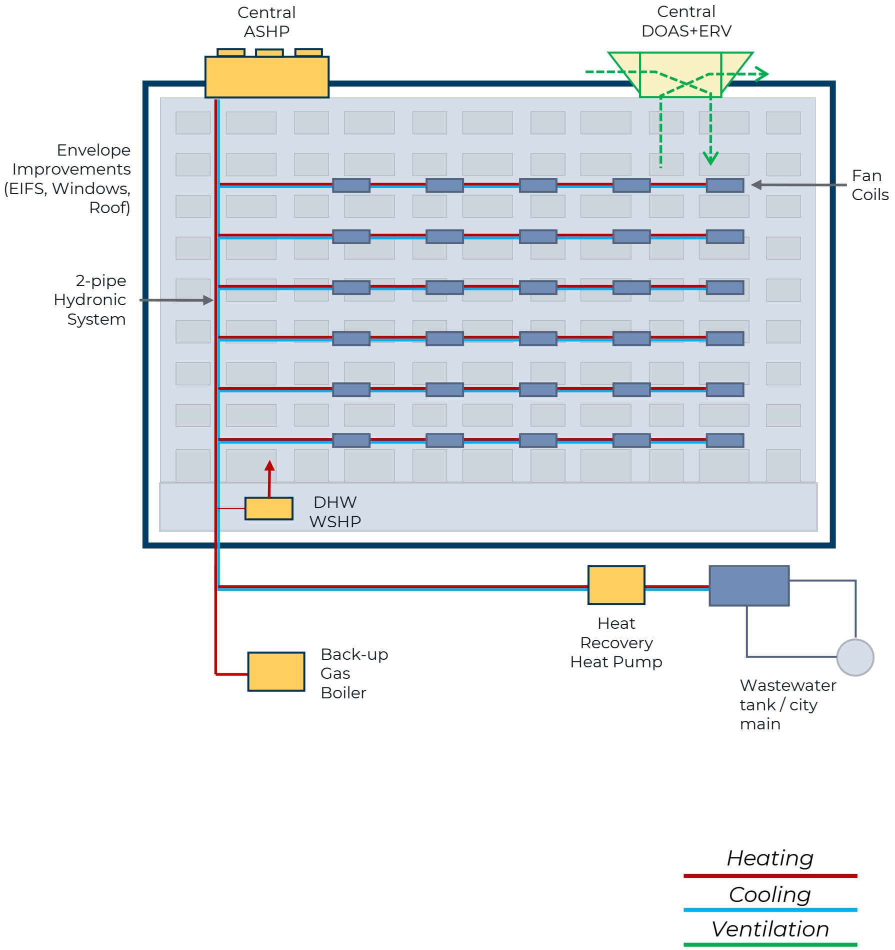
Fan Coils installed in units

Central DOAS+ERV
Heat pump DOAS with ERV to supply tempered air to units via common areas,

WSHP for DHW
Install modular WSHPs supplied by hydronic loop. The system will operate in heat recovery mode during cooling season

Wastewater Energy Transfer (WET) System
Install 18,000 gal sewage tank and use Sharc Energy heat pumps to recover heat and supplement central ASHPs

AFTER



Let’s work together to make Heat Recovery a common solution for building decarbonization

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