
District Energy – Geothermal – Sewer Energy – Biomass – Industrial Waste Heat – Solar

# Clean Air Partnership

# Low Carbon Energy Systems 101

January 26, 2024

# Introductions

- President of Rathco ENG
  - P. Eng. and PMP with over 16 years' experience in energy and infrastructure projects
  - Expert in district energy system design
  - Have led energy projects across Canada
  - Background in Water and Wastewater Engineering

**John Rathbone, P. Eng., PMP**

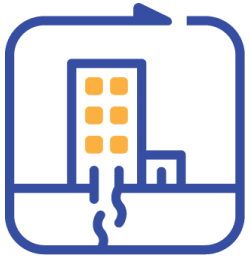
# Low & Zero Carbon Technologies

## Primary Disciplines

District Energy
- 3rd, 4th Gen
- 5th Ambient

Wastewater Energy Exchange

Industrial Waste Heat Capture



Geothermal
- Geoexchange
- Surface Water
- Open Loop

Biomass

Air Source Heat Pumps

## Complimentary Disciplines

Energy From Waste

Biogas

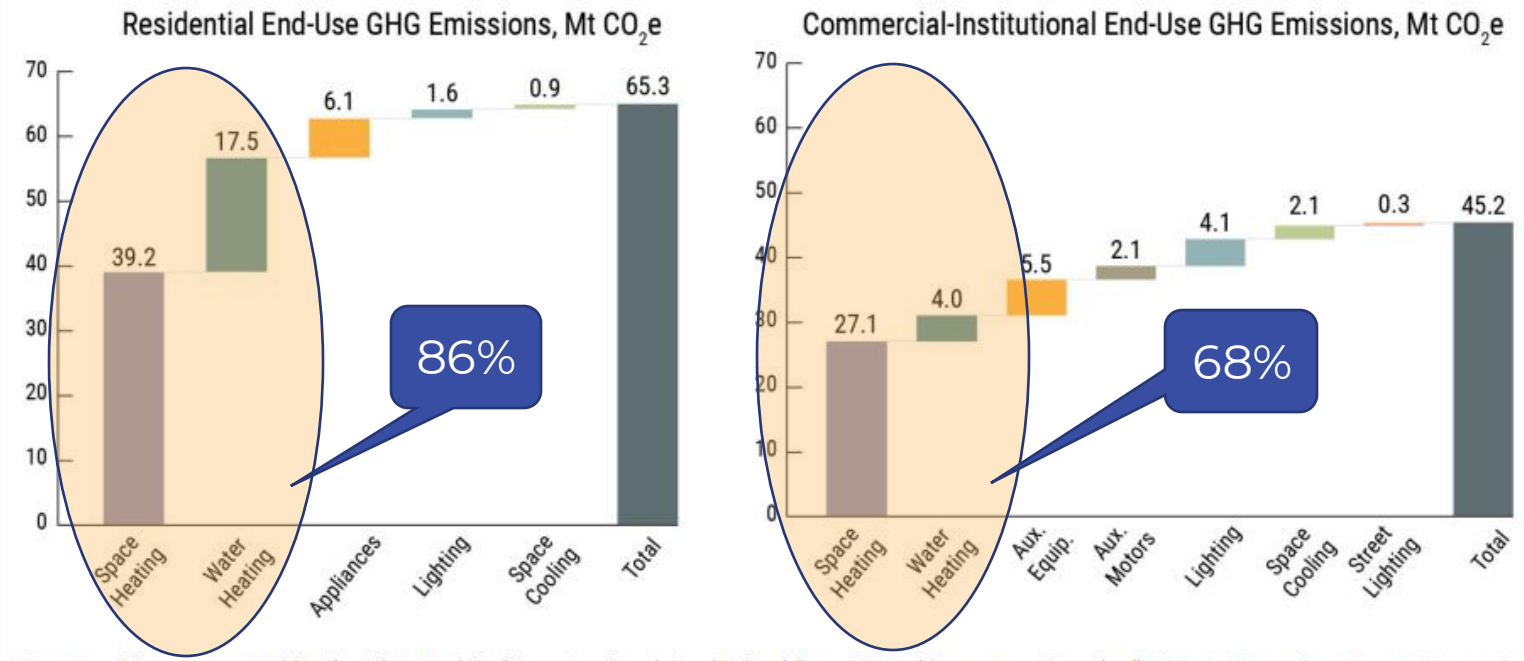
Solar PV

Solar Thermal

# Drivers & Challenges

## Energy End Use In Our Buildings

**Figure 5 – Residential and Commercial-Institutional GHG Emissions by End-Use (2015)**

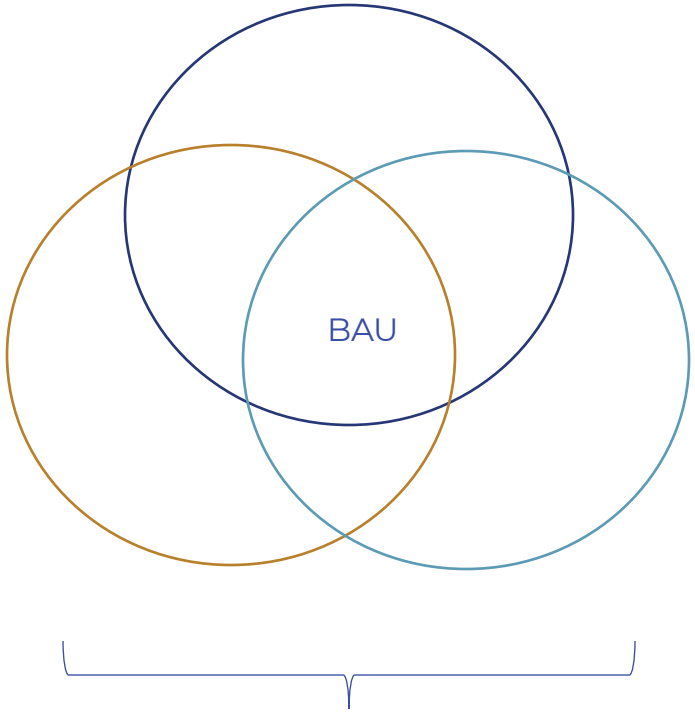



Source: Figure prepared by the Library of Parliament using data obtained from Natural Resources Canada, "Table 2: Secondary Energy Use and GHG Emissions by End-Use, Residential - Canada and Table 2: Secondary Energy Use and GHG Emissions by Activity Type – Including Electricity-Related Emissions," Comprehensive End Use Database, accessed on 29 January 2018

# Opportunities & Challenges

Status Quo Bias

Choice Overload Bias




Optimism Bias

**By Overcoming Inherent Bias we can Move to Better Solutions**

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# What is an Air Source Heat Pump?



# Where are ASHPs Being Deployed

- Mostly being utilized for decarbonization of single buildings either new build or increasingly retrofits. Also now being deployed in district solutions such as at TRU University.

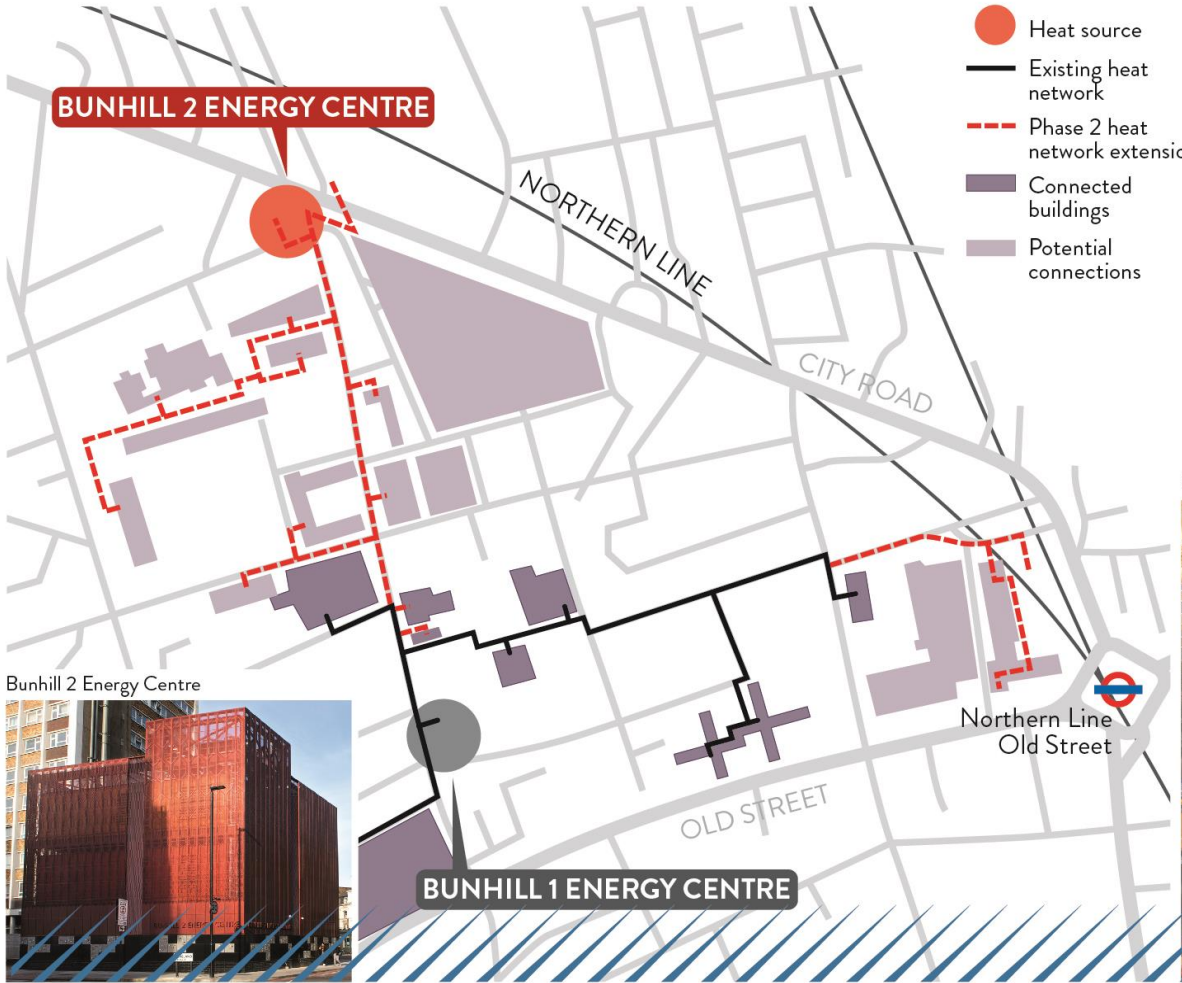
Pros:

- Lower Initial Capital Cost than other solutions
- In the GTA the limitation is mostly roof space and structural load

- Cons:
  - Cold Weather operation for large commercial units is still limited (though the market is evolving quickly)
  - Less efficient than other solutions which typically can result in higher operating costs and lower emissions savings

# Atypical ASHP

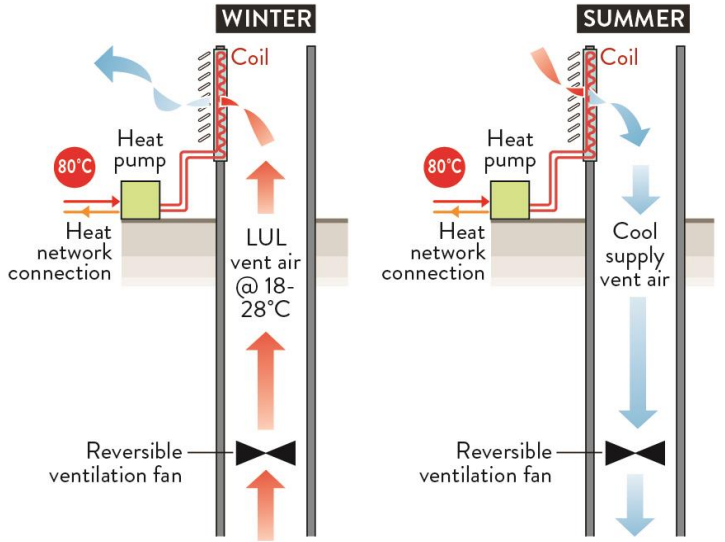
## WASTE HEAT RECOVERY - BUNHILL PHASE 2




Bunhill 2 Energy Centre



### VENTILATION SHAFT HEAT PUMP OPERATION




Boiler craned into position

Preparing foundations at top of vent shaft

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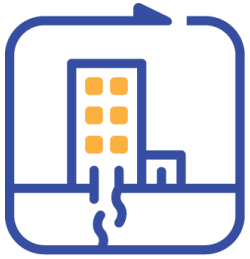

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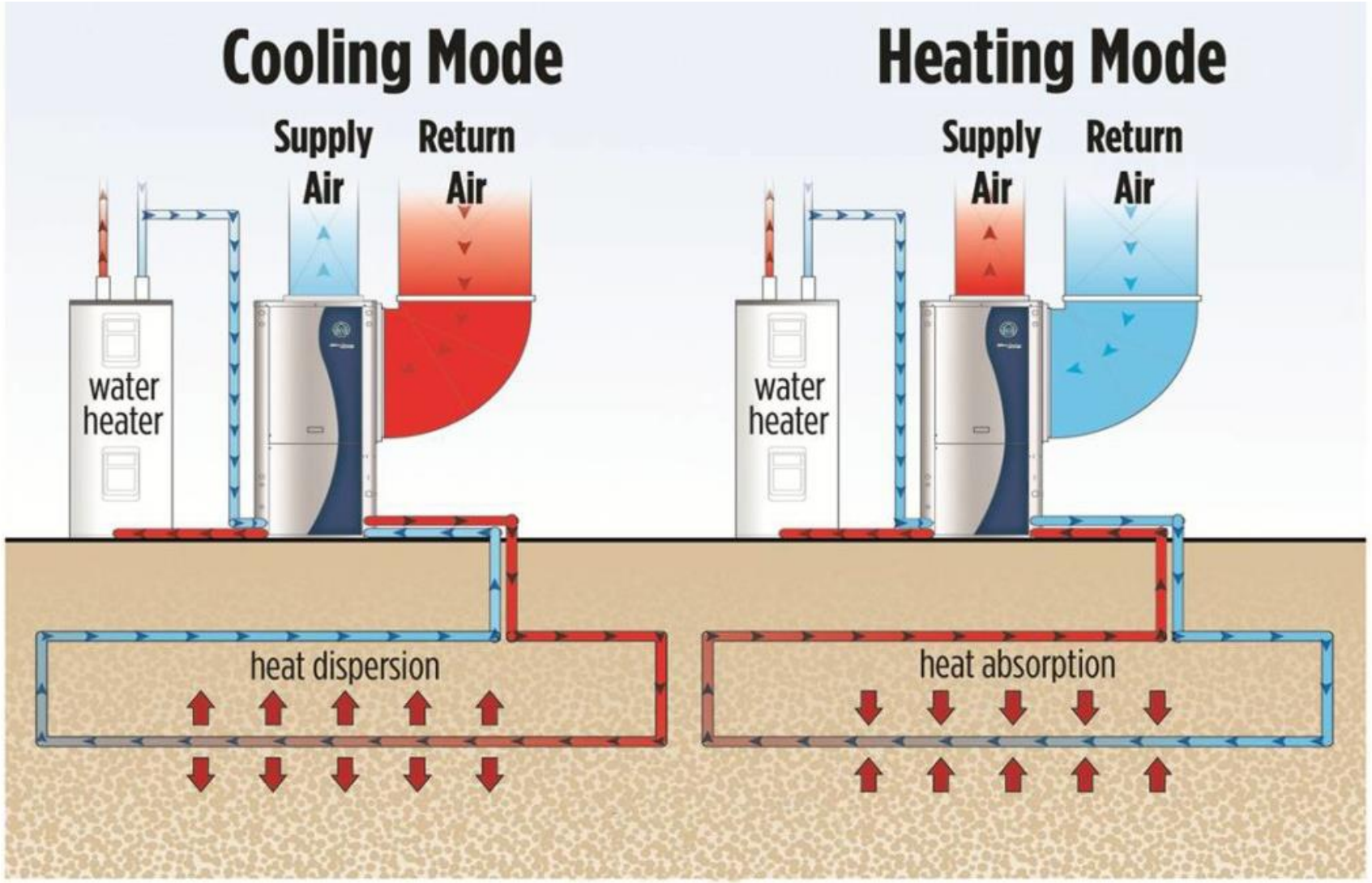
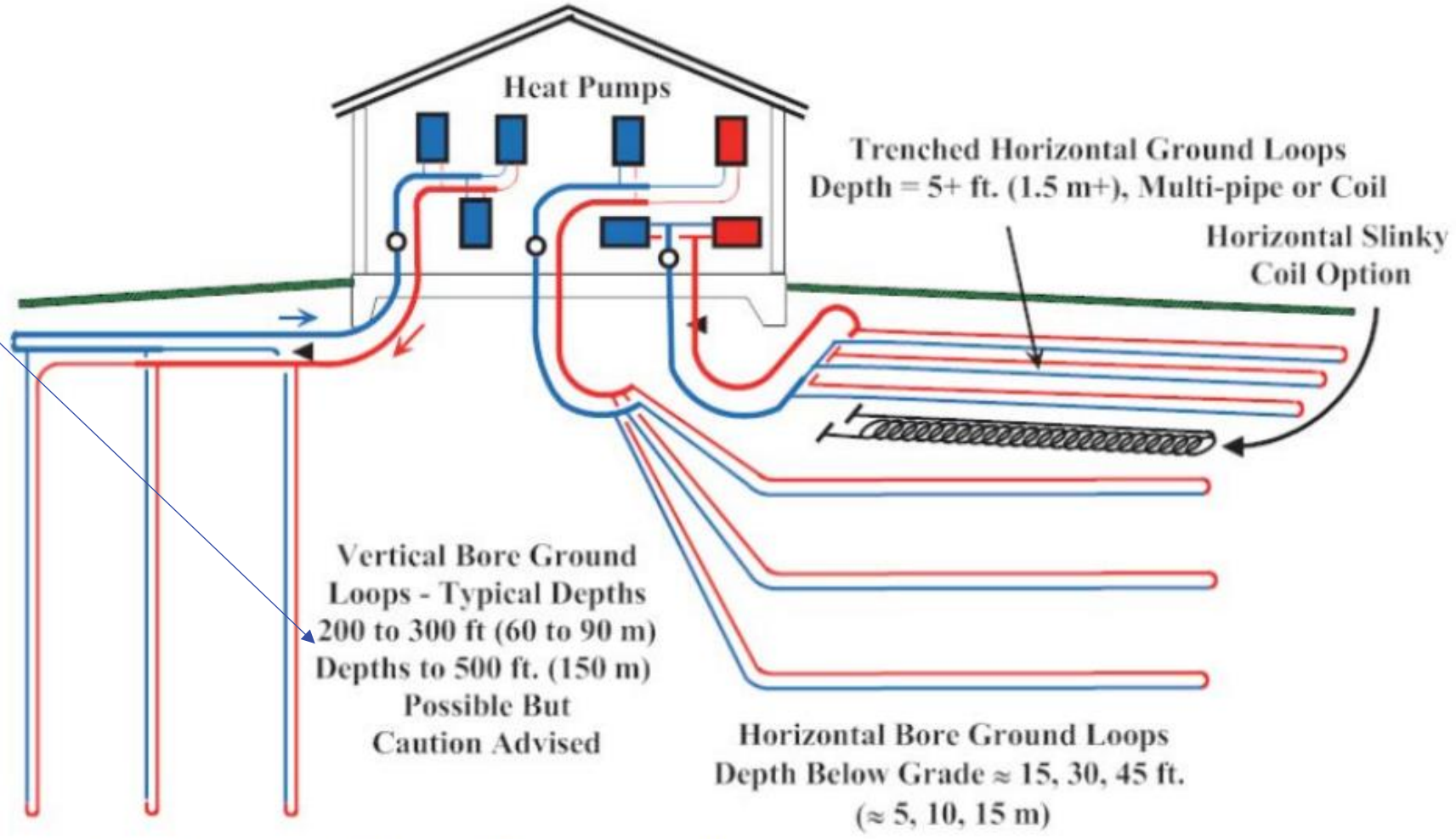
# What is Geo-Exchange?



# What is Geo-exchange - 2

In the GTHA – our boreholes often go to 850 ft – we have some of the most experienced drillers in North America working on projects here.




*Geothermal Heating and Cooling – Kavanaugh and Rafferty*

# Geo-Exchange

- Mostly being utilized for decarbonization of single and multi-building new developments. Deployed at scale in district solutions such as at Princeton University and multiple new developments across the GTA.

Pros:

- High efficiency year round
- Typically lower operating costs than other solutions
- High Emissions reductions

- Cons:
  - High Initial Capital Cost
  - Site Dependent Resource

# Geo-Exchange

**Etobicoke**

**145 Boreholes at 850 ft**

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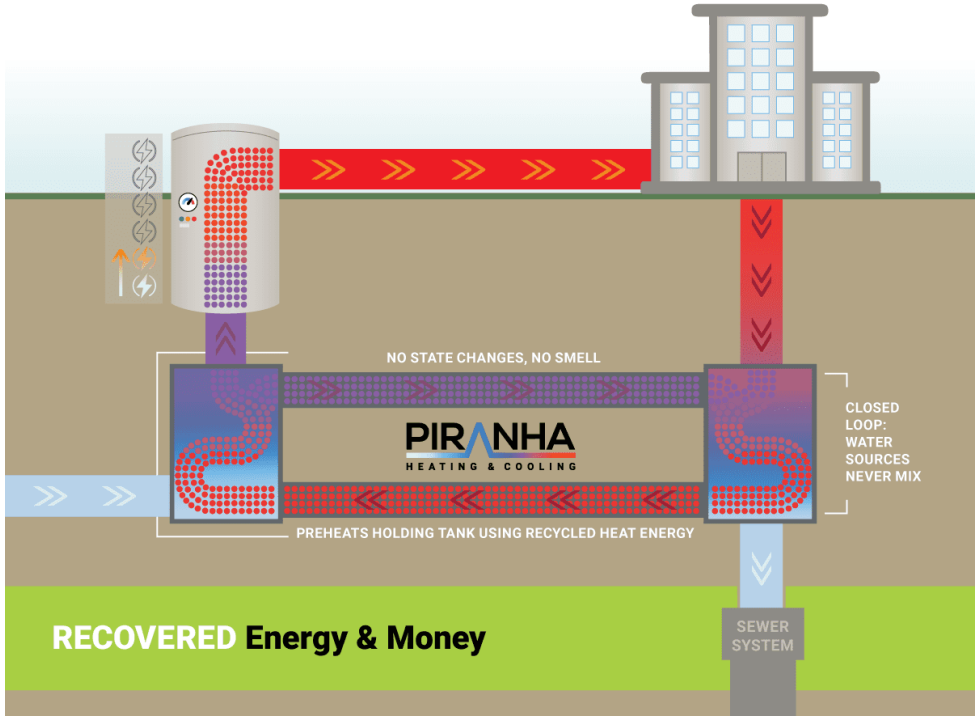
# Wastewater Energy Exchange?





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# Wastewater Energy Exchange

- Decarbonization of single and multi-building new developments. Deployed at scale in district solutions such as at South East False Creek, and in retrofits such as at Toronto Western Hospital

- Pros:
  - High efficiency year round
  - Typically lower operating costs than other solutions
  - High Emissions reductions

- Cons:
  - Med-High Initial Capital Cost
  - Highly Site Dependent Resource

# WasteWater Energy Exchange at Scale

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# What is Waste Heat?

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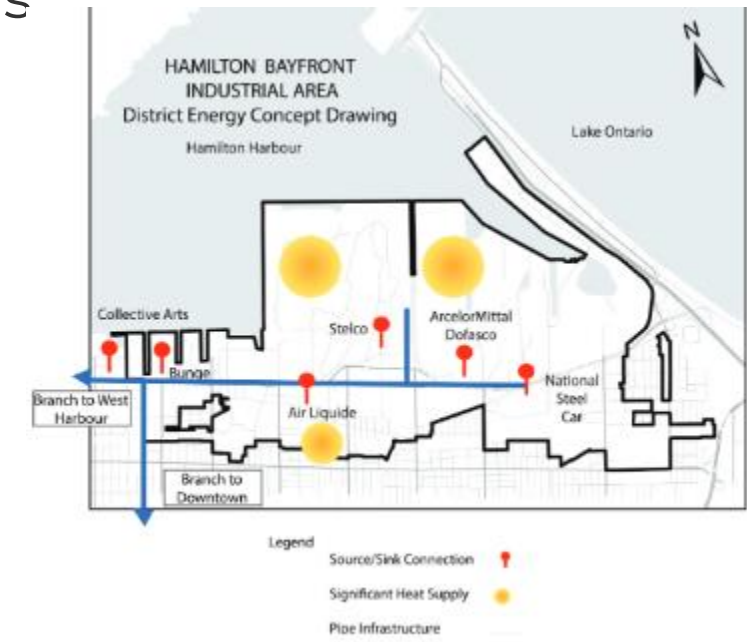
# Waste Heat Recovery

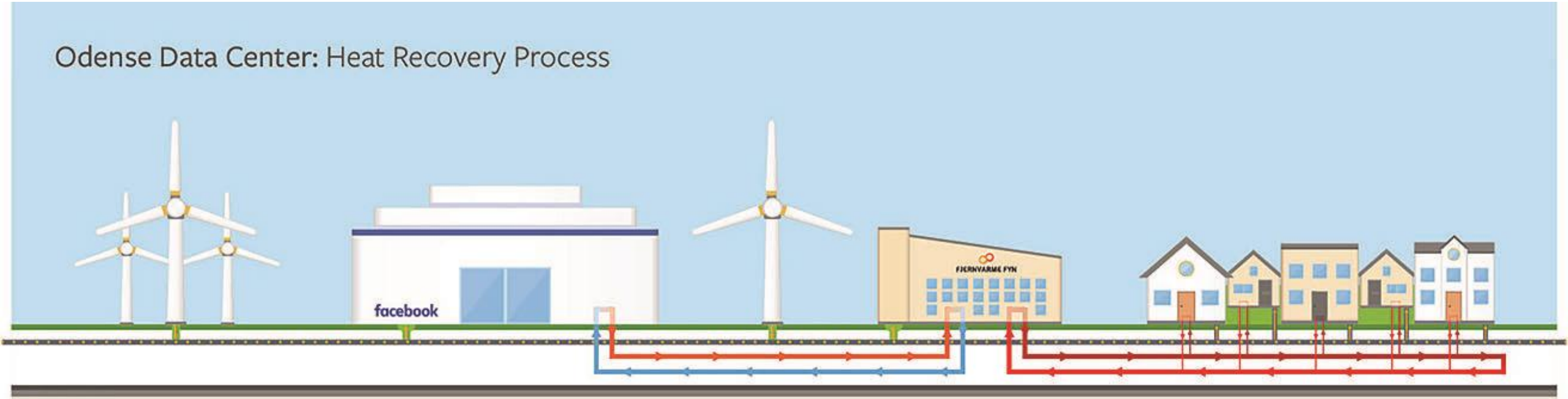
- Deployed at scale in district solutions such as at Odense District Heating, and under study in Hamilton.

- Pros:
  - High efficiency year round
  - Typically lower operating costs than other solutions
  - High Emissions reductions
  - Add value to supplier

- Cons:
  - Med-High Initial Capital Cost
  - Highly Site Dependent Resource



# DataCentres



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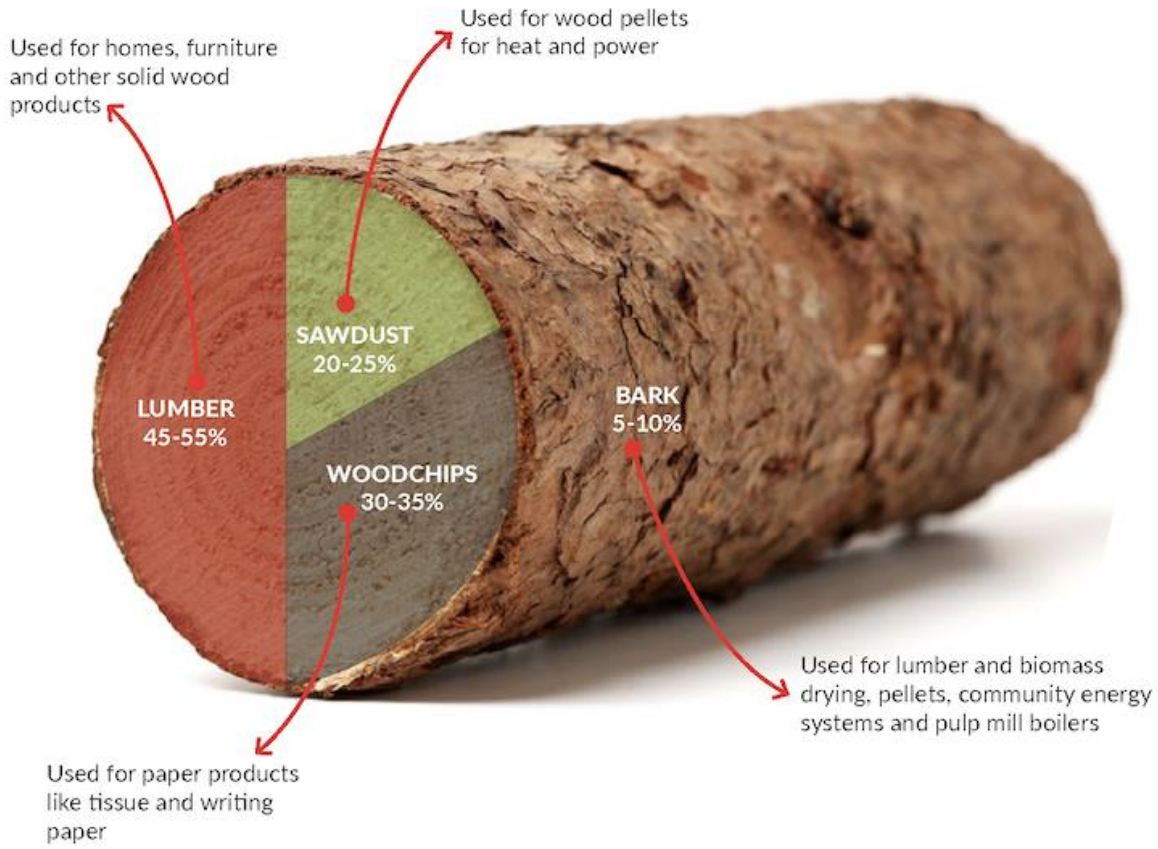
# What is Biomass?

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# Biomass

- Deployed at scale in district solutions such as at Simon Fraser University, Copenhagen (Amager Bakke), and multiple other large scale DE systems.

- Pros:
  - High efficiency year round
  - Potential for Co-generation
  - Can produce steam for legacy systems if needed
- Cons:
  - High Initial Capital Cost
  - Needs scale to make the economics work
  - Logistically challenging

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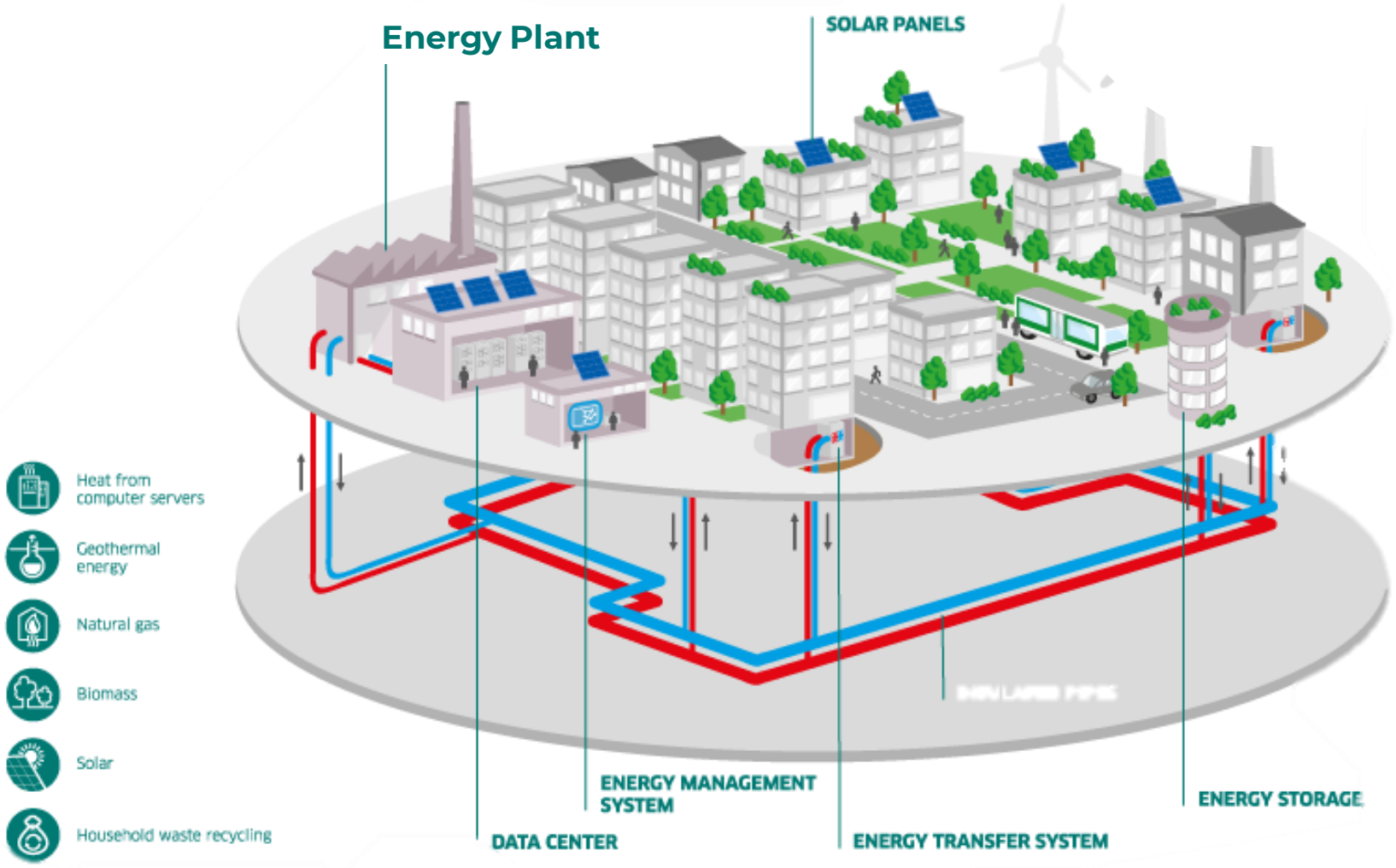
# What is a District Energy System

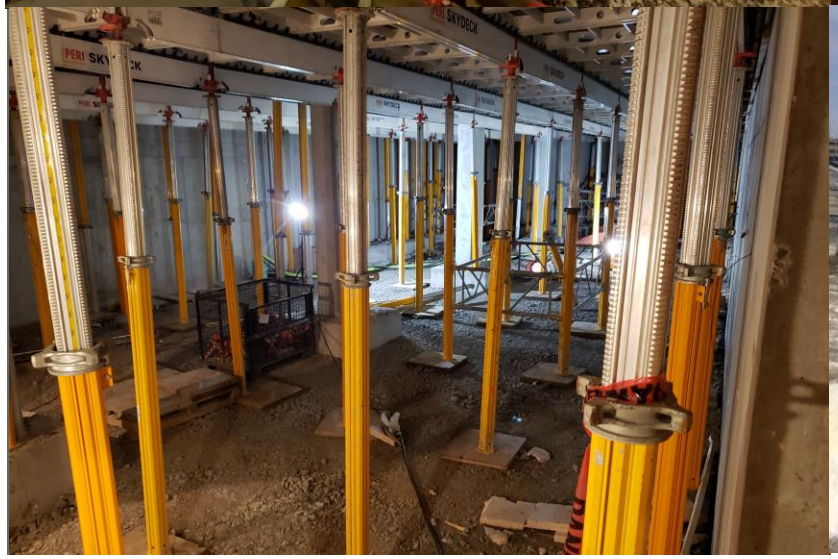





Source: Engie

# District Energy in North America

- Pittsburgh
- Vancouver
- Chicago
- Toronto
- Los Angeles
- Houston
- New Orleans
- Seattle
- Las Vegas
- New York
- Colleges
- Universities

**Top Left**
Inventory control, reducing waste material

**Top Right**
Weld quality control & documentation

**Bottom Left**
Adapting to site conditions.

**Bottom Right**
Adapting to extreme site conditions.

# The Evolution of District Energy

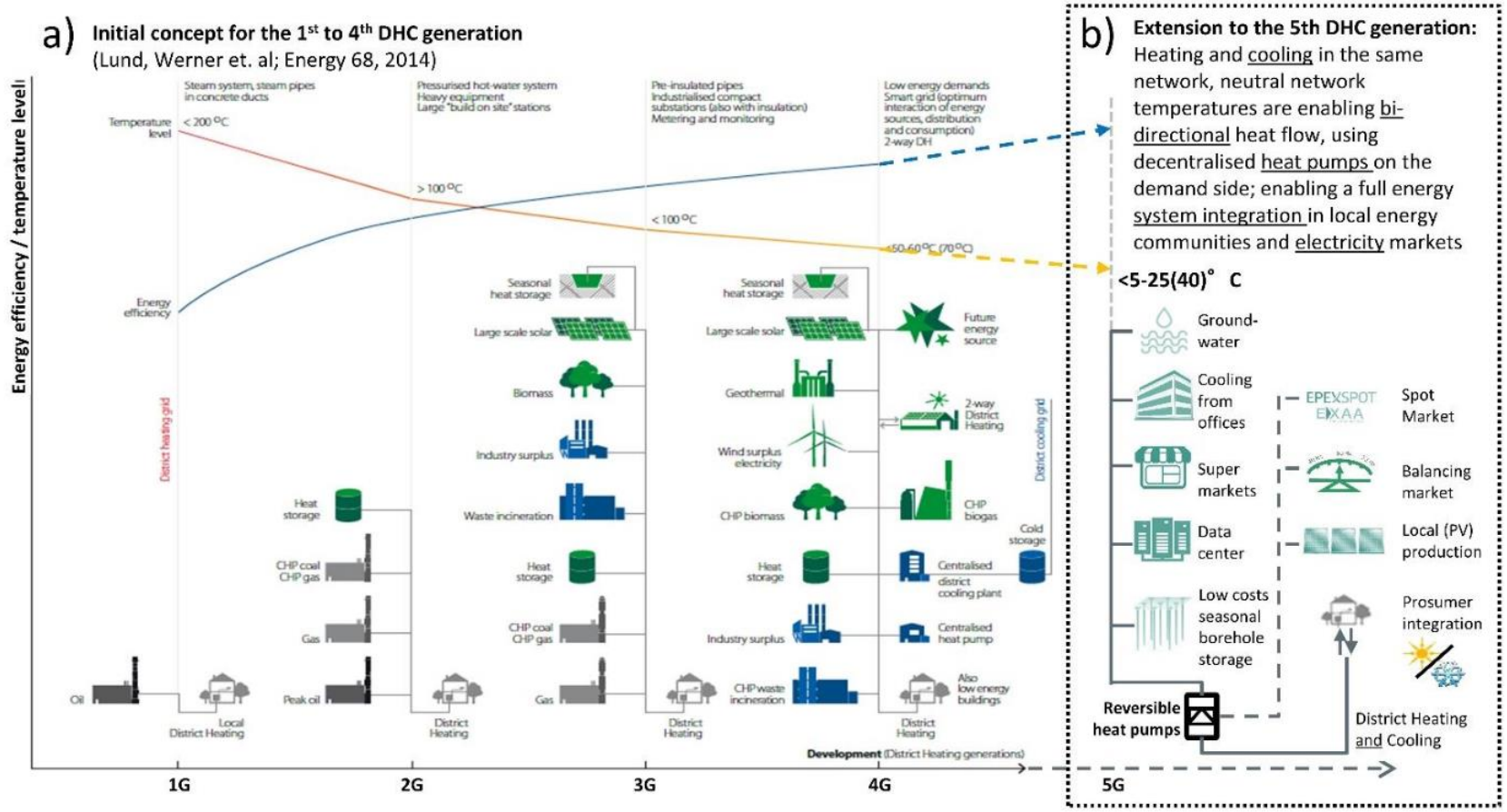


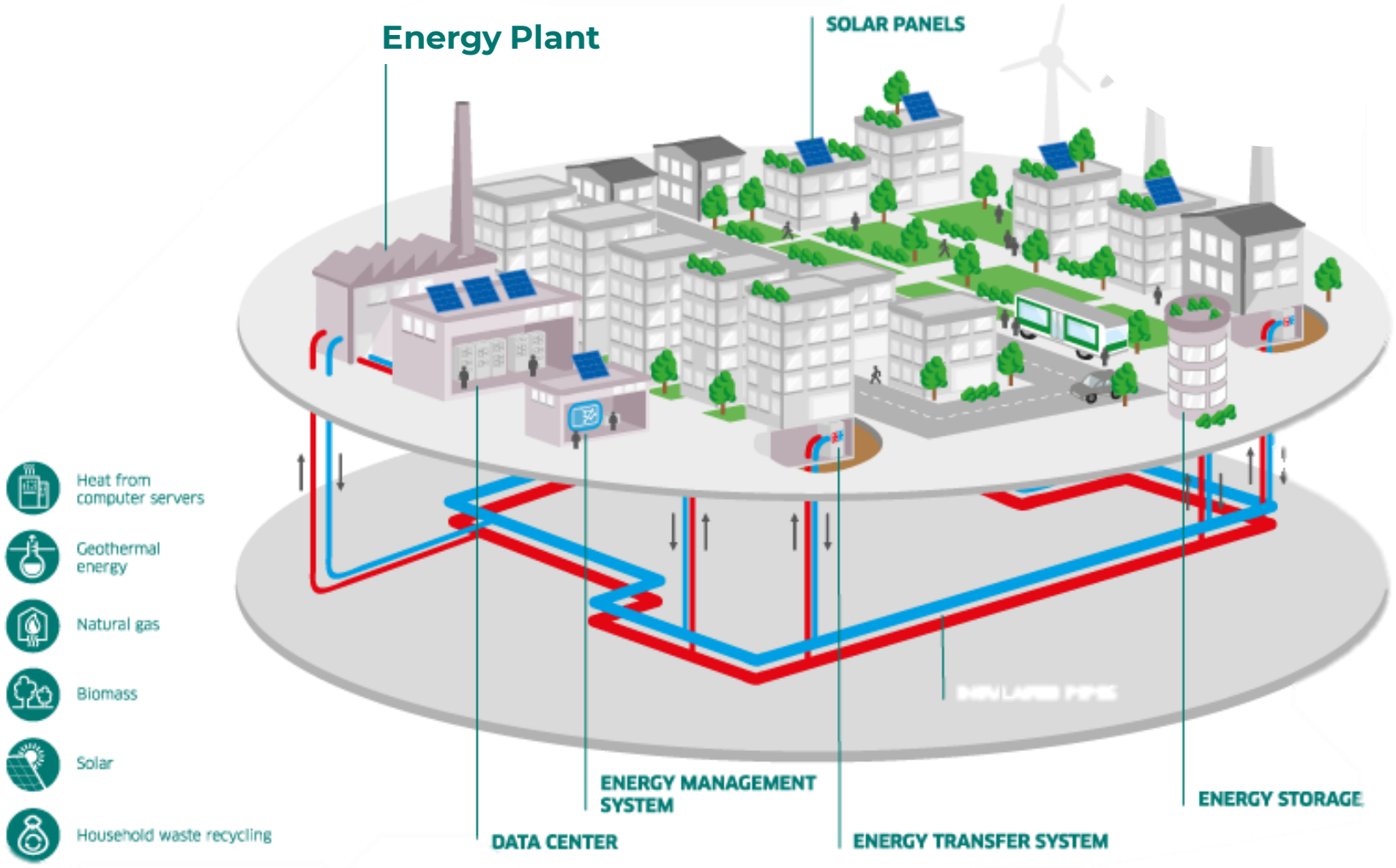

*Figure 4: a) the concepts for the 1st to 4th generations of DHC networks from Lund et al[57], b) extension*

# Examples

| Generation | | Locations | Notes |
|---|---|---|---|
| 1 G | Steam | New York, Toronto, York U | Most, older city and campus district heating systems in the US and Canada are somewhere here |
| 2G | High Temperature Hot Water | Older Campuses across the US and Canada, Eastern Europe | |
| 3G | Hot Water systems | Scandinavia, St. Paul, Hamilton | Most Existing Systems are here – transitioning to 4G or 5G |
| 4G | Low Temperature Hot Water | Zibi – Ottawa, Princeton, | New systems from the past 10 years are trending into this category |
| 5G | Ambient Loops | Okotoks, Zibi - Gatineau | New Development Sites in North America |
| District Cooling | Cool Water | Toronto, Large Scale DC in the Hotter Climates | Nearly all new DE systems in climates requiring cooling provide both heating and cooling. |

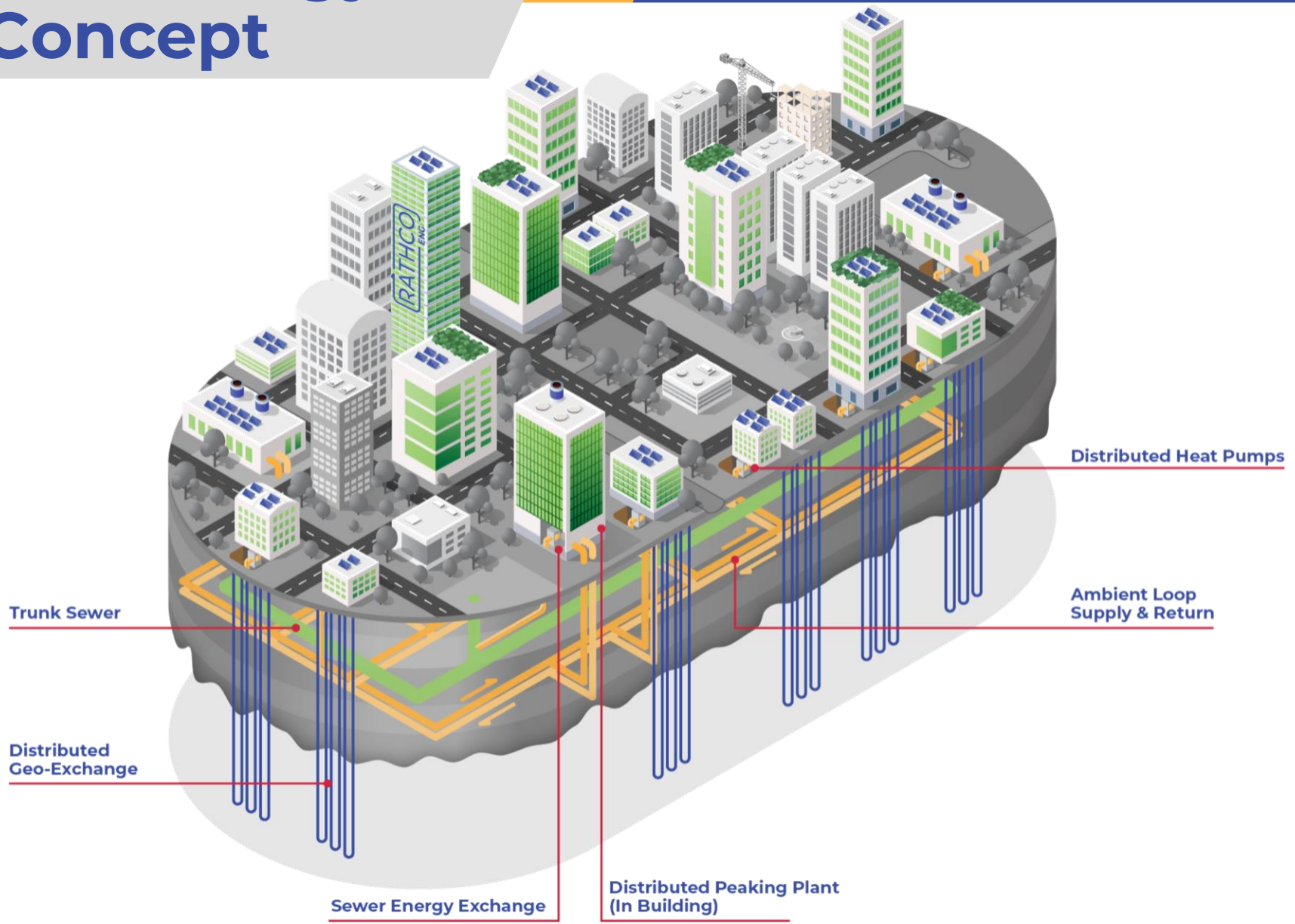
# 1G – 4G



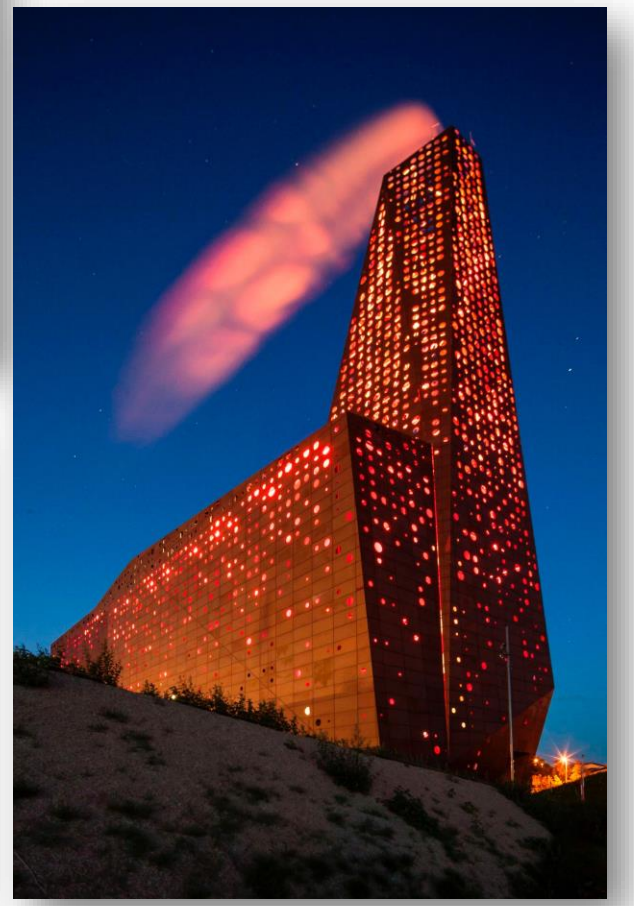



Source: Engie

# 5th Generation District Energy Concept



# DES Around the World



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# Thank you all