BUILDINGENERGY NYC

Refrigerant Phaseout at The Beacon: Paths Considered and Paths Taken

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Refrigerant Phaseout at The Beacon Residential: Paths Considered and Paths Taken

A Case Study in Sustainable, Affordable High-Rise Design

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NYC Department of Housing Preservation & Development

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THE BEACON

Why Move Away From Conventional Refrigerants?

- **Environmental Impact:** High Global Warming Potential (GWP) of standard refrigerants (e.g., R-410A).
- **Health & Safety:** Fire risks associated with centralized systems; occupant health considerations.
- **Regulatory Pressure:** Federal, state, and NYC Local Laws (LL97, LL154) are phasing out high-GWP refrigerants; evolving DEC and HPD requirements.
- **Performance & Cost:** Required vented shafts are difficult to incorporate into our buildings. We also want to avoid typical compliance pitfalls and long-term vulnerability to regulation.

The Beacon Residential Team

Clients

- The Community Builders
- Ascendant Neighborhood Development

Consultants

- ZeroEnergy Design
- MaGrann Associates
- Dagher Engineering
- Silman Structural Solutions
- GEODesign, Inc
- Philip Habib & Associates
- Terrain-NYC
- Cany Architecture + Engineering
- Atelier Ten

Funding & Management

- New York City Department of Housing Preservation and Development (NYC HPD)
- New York State Energy Research and Development Authority (NYSERDA)

The Beacon Residential Program

Total Area

- 269,000 SF - Residential
- 66,500 SF - Adaptive reuse community facility

The Beacon Residential Program

Project Specs

- 282 affordable units
- 5,000 sq ft of indoor amenity space:
    - playroom
    - fitness room
    - reading lounge
    - laundry facilities
    - ample bike storage
- 6,000 sq ft of outdoor amenity space:
    - green roof terrace
    - private courtyard
    - north yard for communal gatherings and relaxation

The Beacon: Balancing Vision with Reality

Core Requirements

- All-Electric & Passive House Design, including DHW
- Affordability - Landlord-pays-heating model
- Health, Comfort, & Resilience
- Flood zone adaptation
- Embodied Carbon Reduction
- Enterprise Green Communities

Constraints

- Cost pressures - upfront cost versus payback period
- High Rise Construction
- Space limitations
- Extended project timeline has meant code changes (electrification & refrigerant limits) during design/ documentation

The Beacon Residential Research

NYSERDA Buildings of Excellence Awards

+ **2024 | Round 4 Winner**
  Innovative & replicable approaches to the new construction of carbon-neutral multifamily buildings
  - Selected for its carbon-neutral performance, profitability, broad replicability, and creation of a healthy, safe living environment for residents

+ **2023 | Round 3 Recipient**
  Early Design Support Grant
  - Awarded to integrate the most cost-effective, low-carbon solutions from the start of the design process

The Cost of Electrification

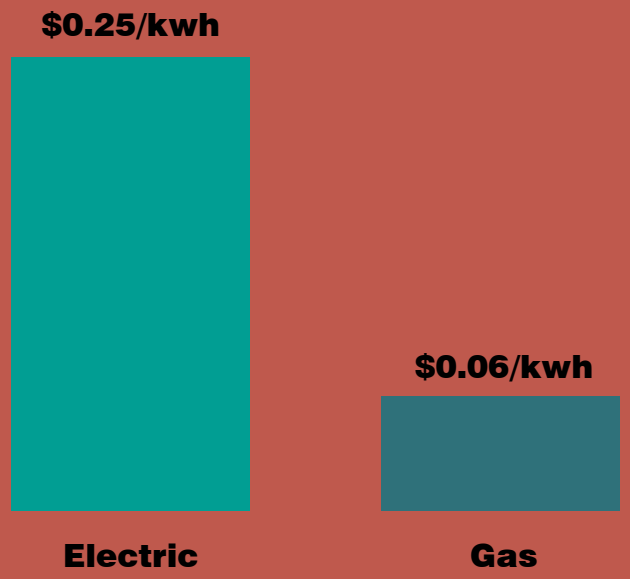


Figure 1 The utility gap penalty, where the cost per kWh of electricity is above 5x as expensive as gas

THE UTILITY GAP PENALTY

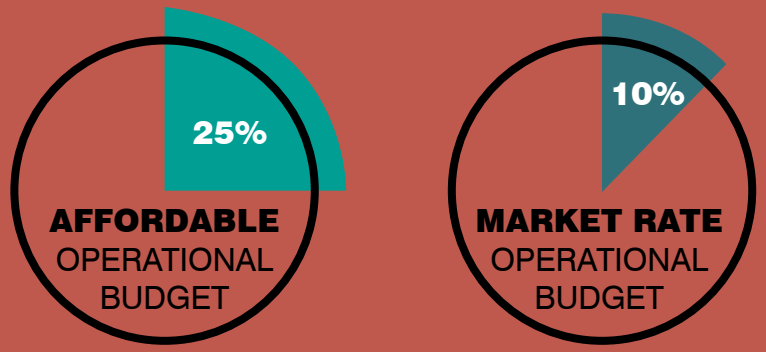


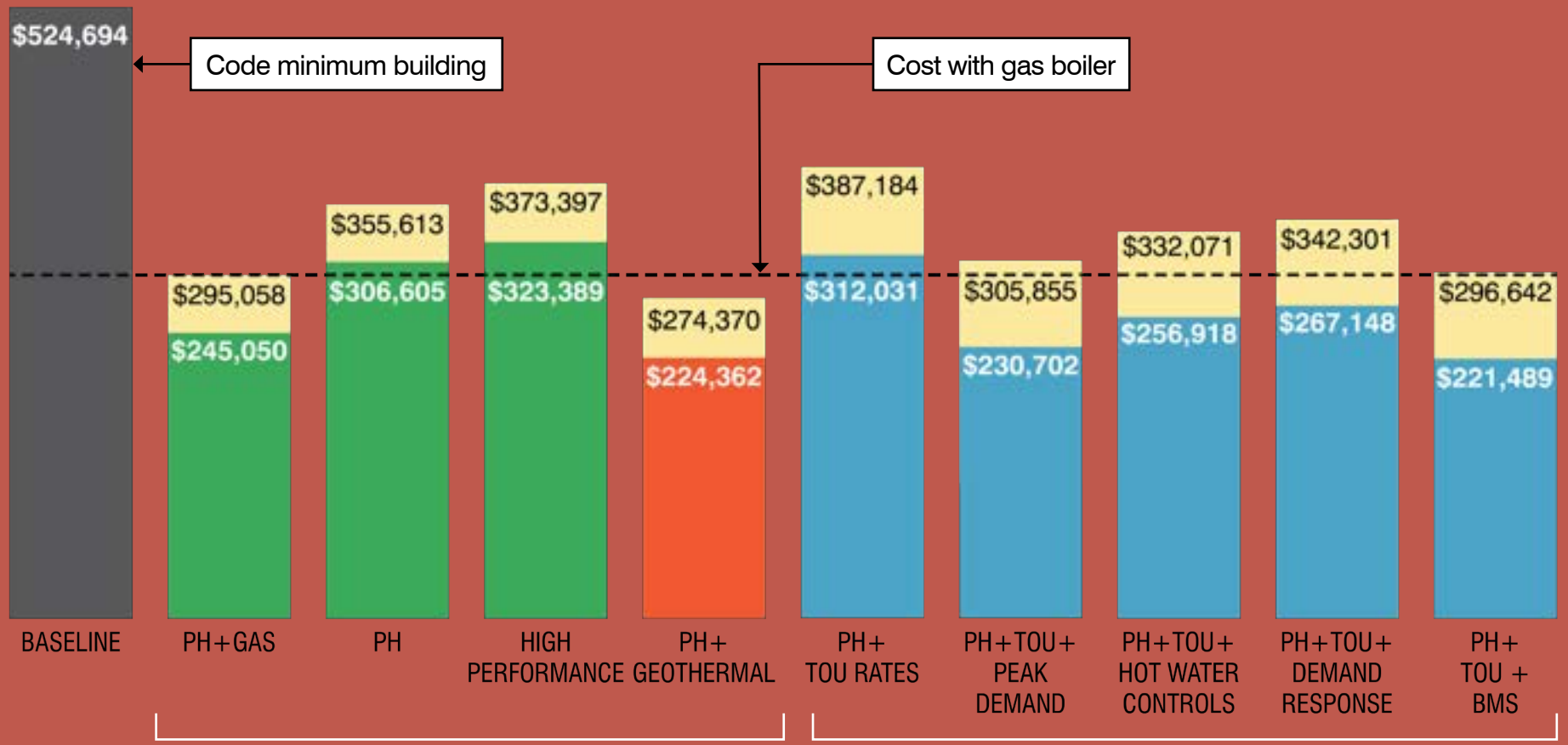
Figure 2 Proportion of utiltiy cost to overall operational budget, market rate vs. affordable

UTILITIES COST AND AFFORDABLE HOUSING

*Data from NYSERDA BOE study

Utility Cost Reduction Strategies

High utility costs in standard all-electric buildings threaten true affordability and strain community resources



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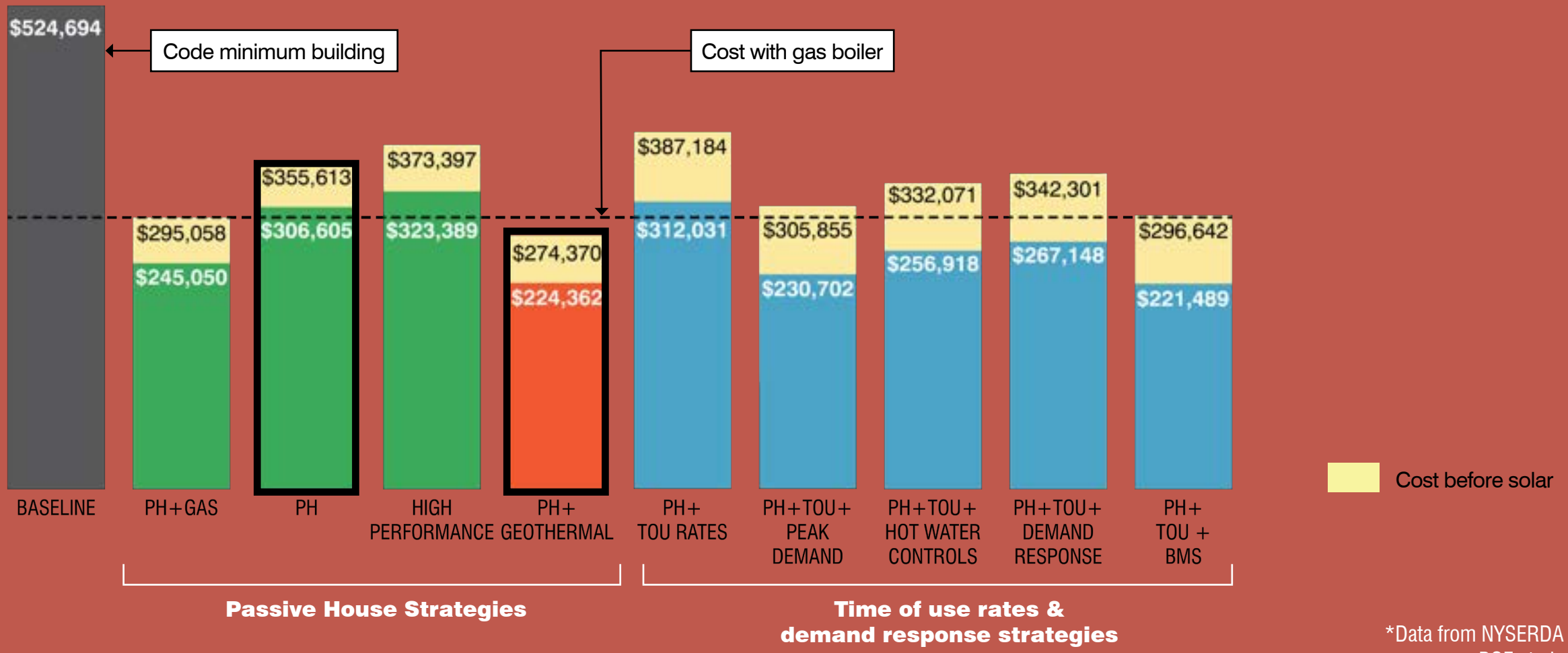
Utility Cost Reduction Strategies



*Data from NYSERDA BOE study

Why Passive House is the Foundation

- **A Holistic ‘Envelope First’ Approach:** The high-performance envelope is the primary system.
- This helps remoderate temperatures, reducing energy loads and allowing for downsized, simpler, and more efficient mechanical systems.
- **Key Benefit for Electrification:** Mitigates the ‘Utility Gap Penalty’ (electricity costs ~5x gas). This is critical for affordable housing viability.

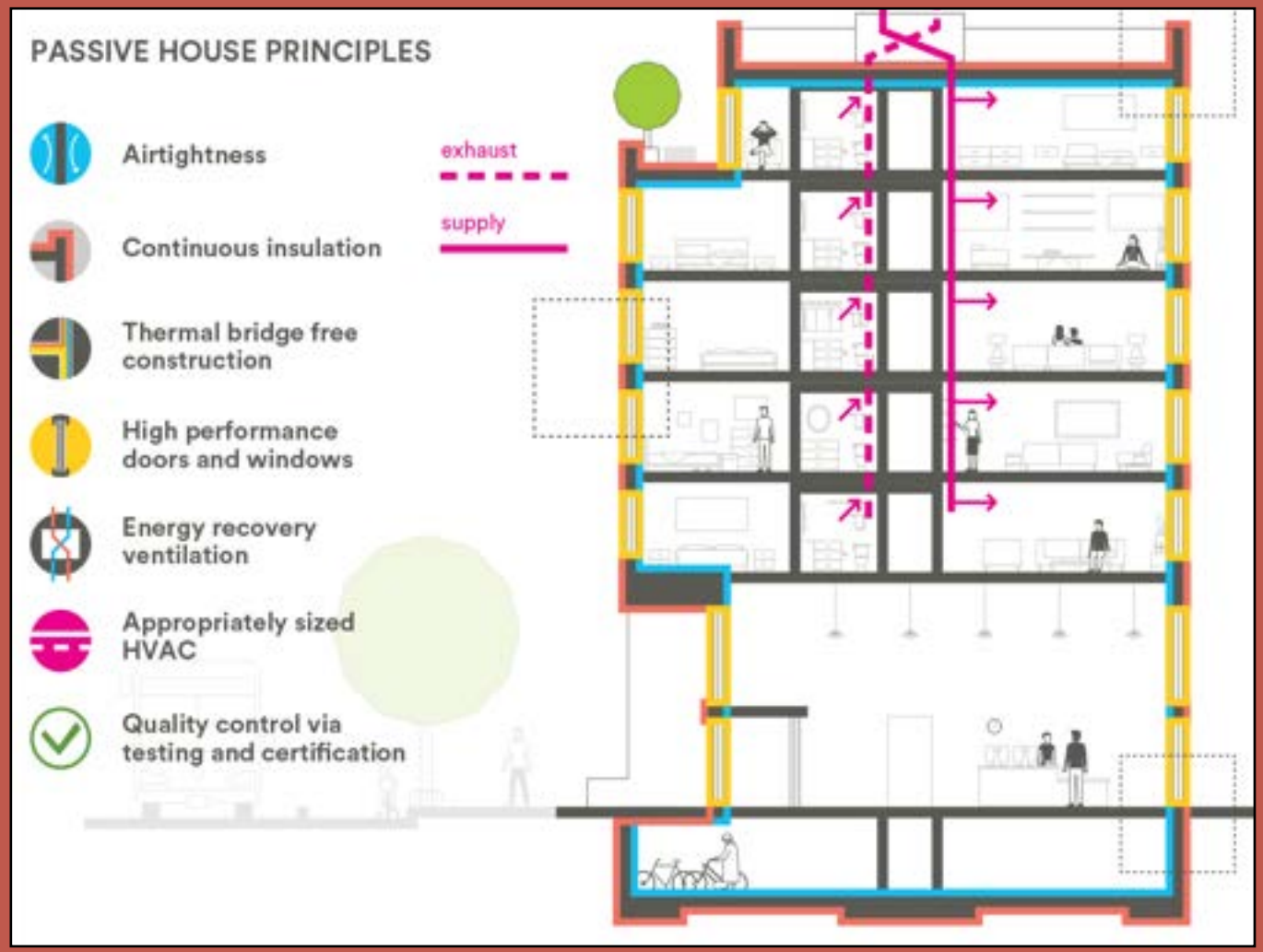


Image: Building Energy Exchange (Be-Ex)

Reducing Reliance on the Grid

- Combine Passive House with more efficient systems (i.e geothermal and renewables like solar and waste water heat recovery) to further overcome the utility gap penalty and reduce reliance on the grid
- With solar, Passive House can overcome the gap penalty by approximately 85% and provides up to 40% savings from a fully electric, non-Passive House building.
- Geothermal would then offer additional savings

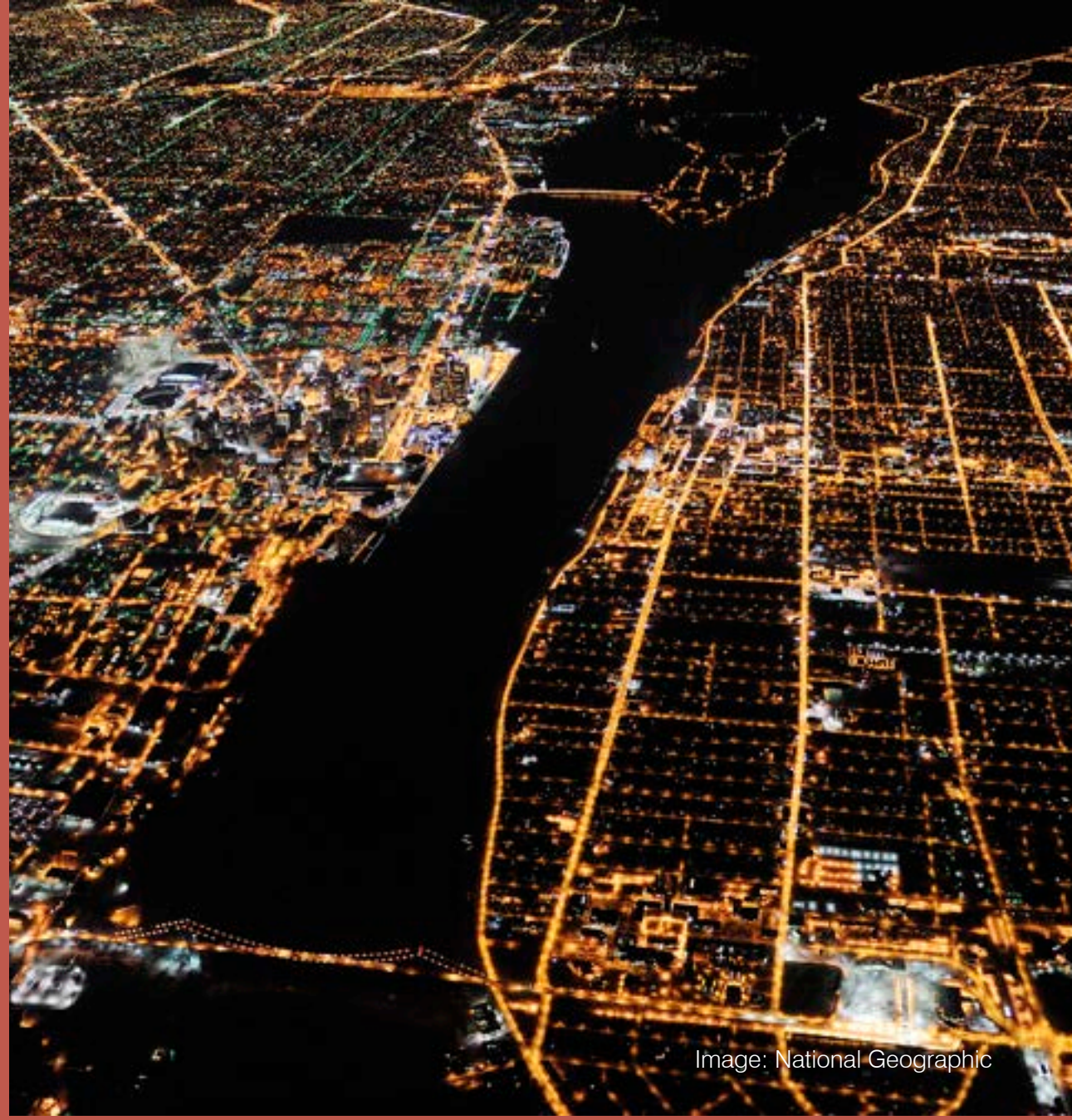


Image: National Geographic

How We Judged Every Option

Energy Efficiency

Refrigerant Reduction / Global Warming Potential (GWP)

First Cost

Operational Cost

Regulatory Compliance

Fire Safety

Client

Maintenance & Operational Complexity, Metering

Architectural Integration

Refrigerant Reduction: How We Arrived at the Options

Collaborate
Client, Engineer, Cost Estimator, Architect, Construction Manager / General Contractor

Research
Site conditions, project criteria, past experience, WUFI Passive energy modeling, Equest and additional consultant modeling

Analyze
Evaluate all options against our core criteria

Decide
Determine the most appropriate system for this specific project

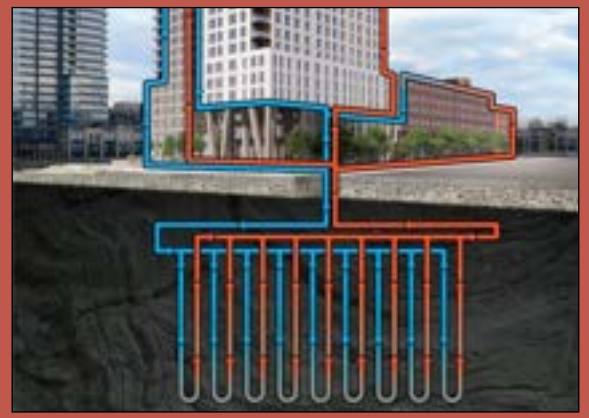
The Four System Options Considered

Standard centralized VRF

Centralized, conventional
✓ Well-understood
✗ High GWP, fire-rated shafts

Air-to-water system

✓ Reduced refrigerant, efficient
✗ Requires rooftop space
✗ High upfront cost



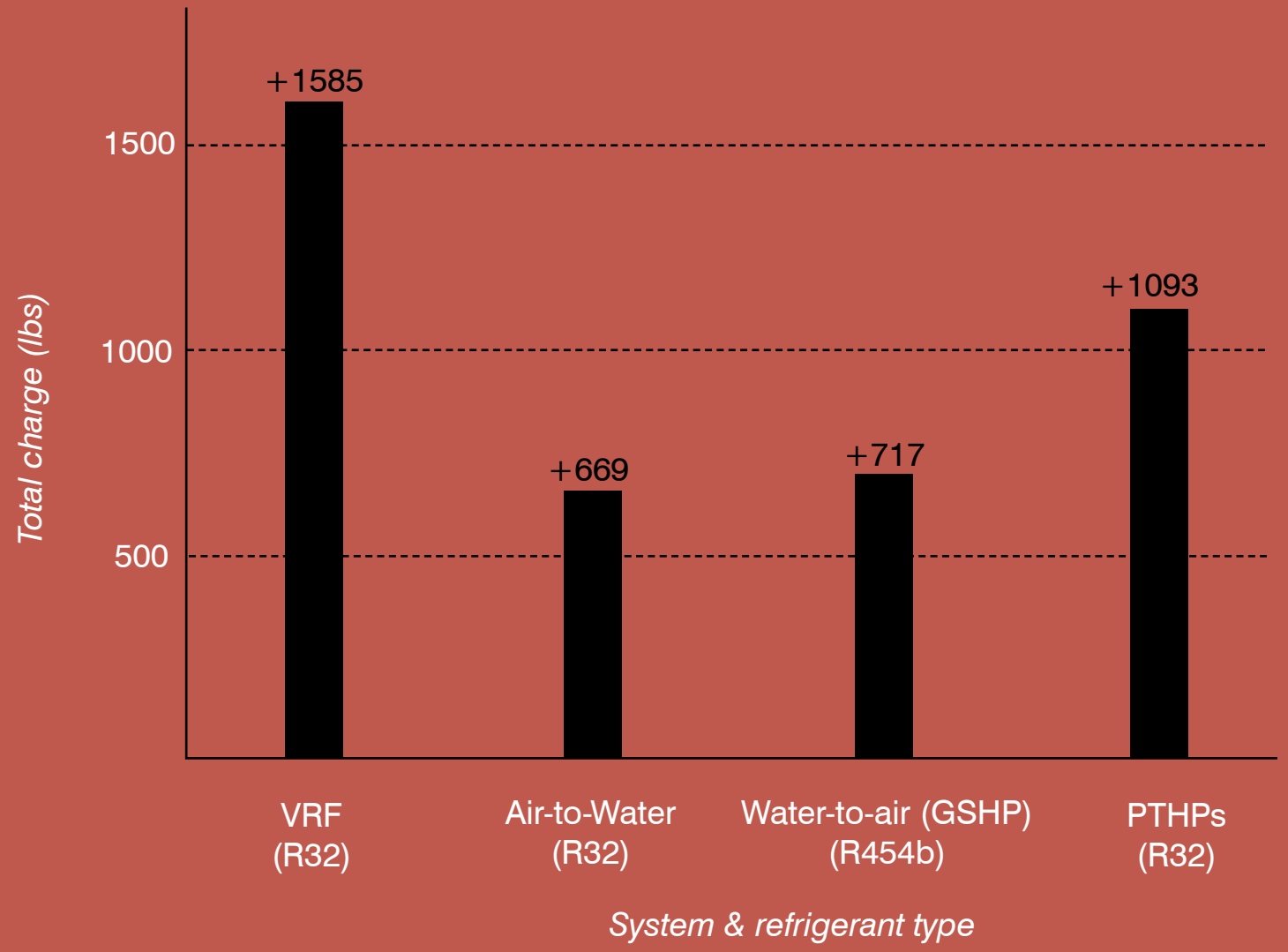
Water-to-air GSHP (Geothermal)

Geothermal field
✓ Reduced refrigerant, efficient
✓ Grants available
✗ Very high upfront cost

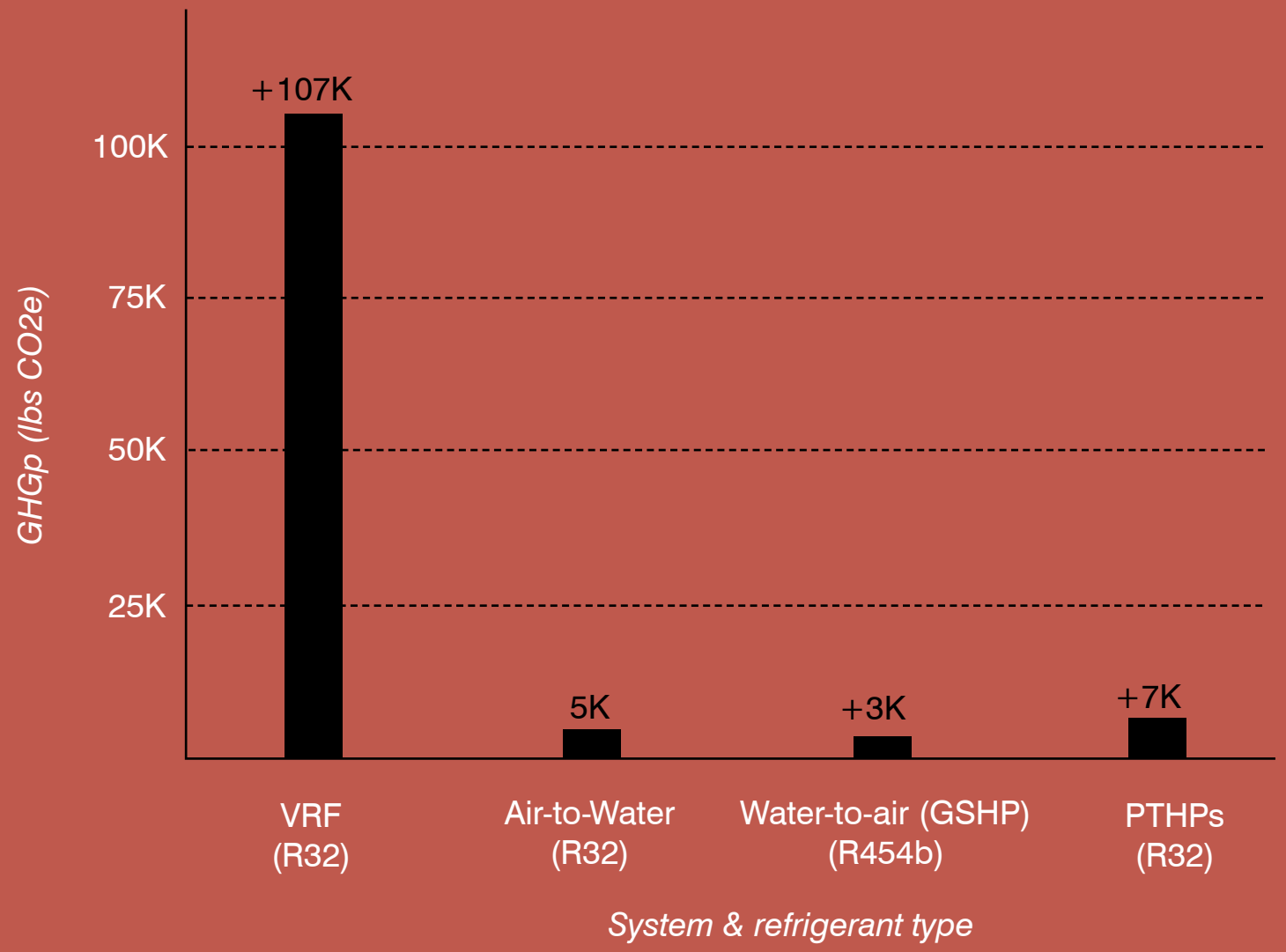
Packaged termal heat pump units (PTHPs)

Decentralized / unitized
✓ Reduced refrigerant
✓ Low GWP, simple, affordable
✗ Slightly lower efficiency

The Four System Options Considered - Refrigerant Charge



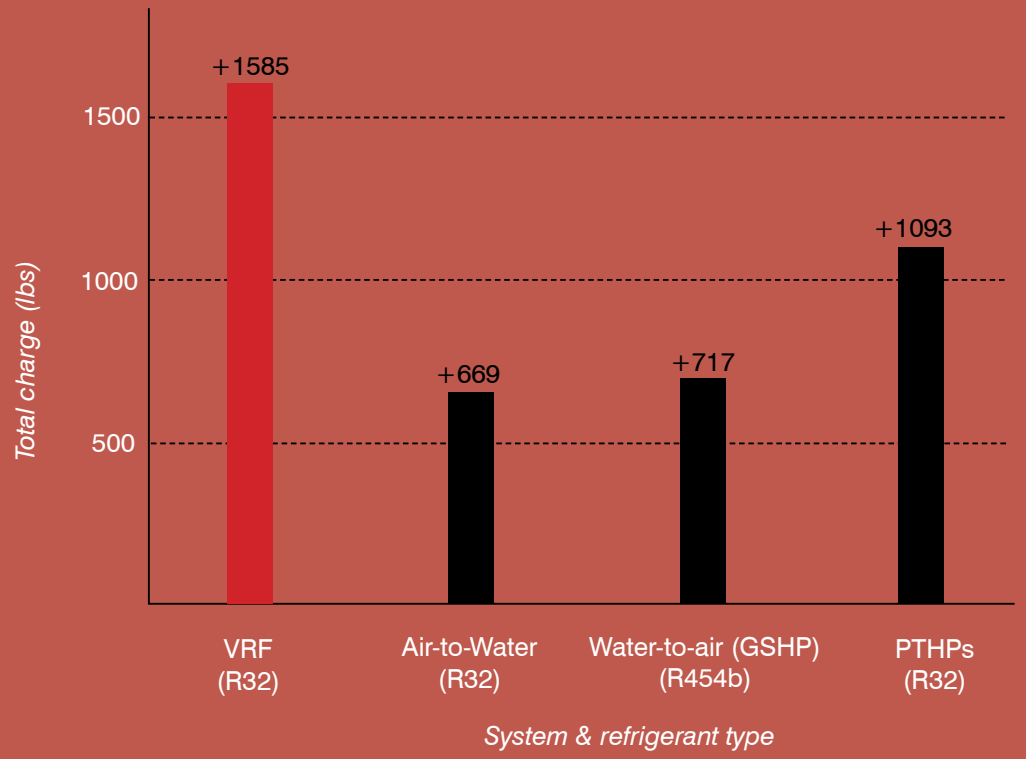
The Four System Options Considered - GHGp (with system leakage)

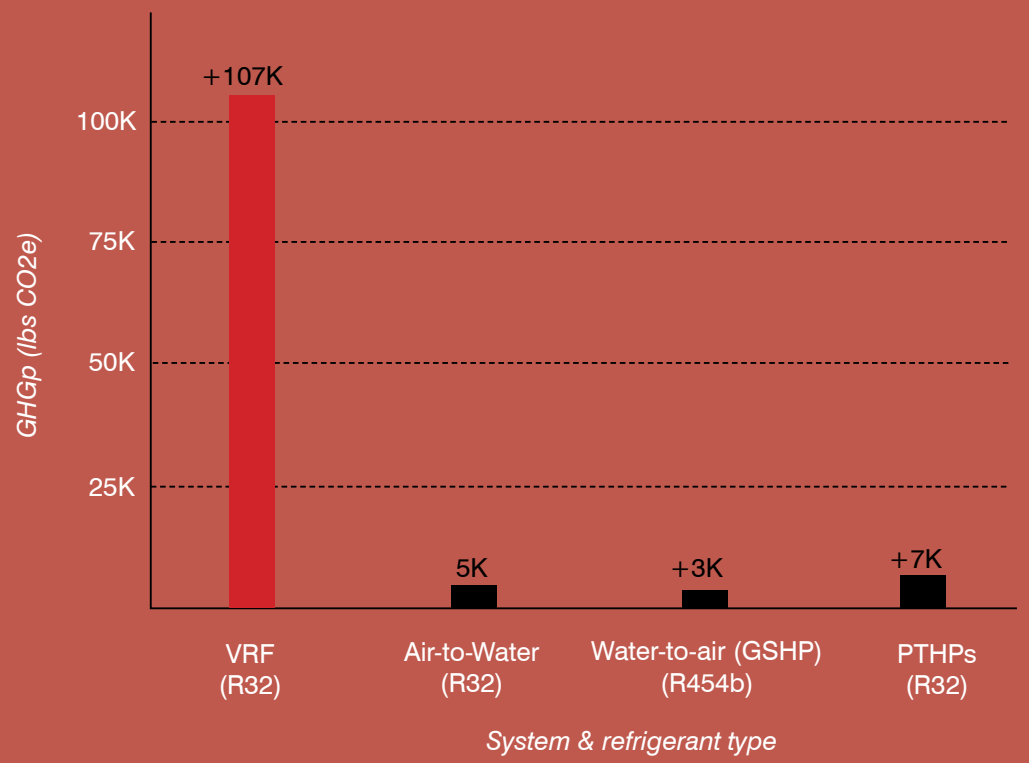


Annual Leakage Rate of Refrigerant mass charge	
VRF air conditioner	10%
Hermetic units with no field installed refrigerant piping	1%

As tabulated in ASHRAE Standard 228

The Four System Options Considered - Narrowing the Field

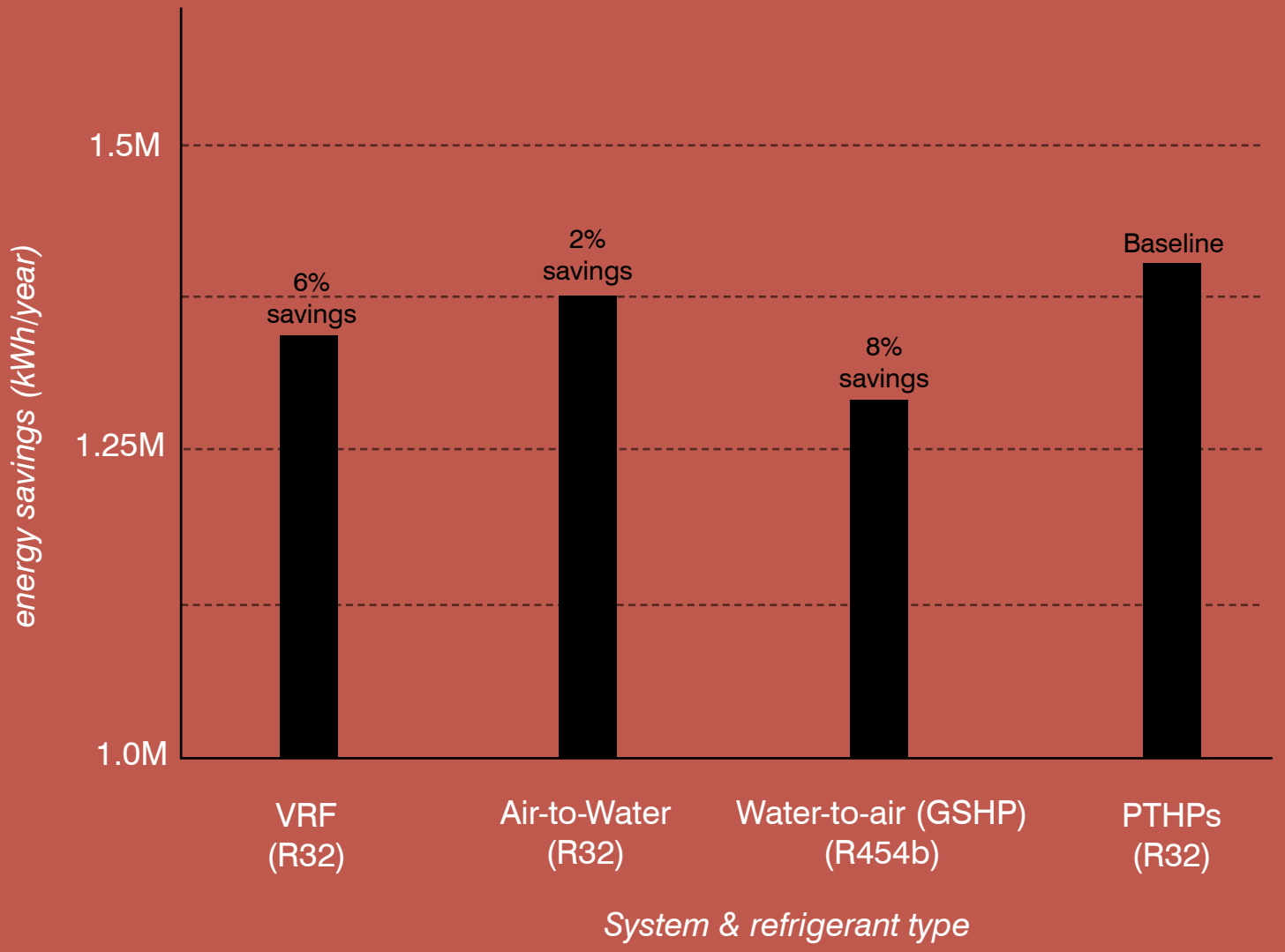




Eliminated Standard VRF due to:

- Prohibitive fire safety requirements (costly rated enclosures)
- Unsustainable high-GWP refrigerant load

The Four System Options Considered - Operating Energy Savings



Option 1: Air-to-water System

How It Works:
Rooftop mounted air-source heat pumps feed hydronic system, with fan coil units in apartments

Energy Efficiency ●●●

Refrigerant Reduction / Global Warming Potential (GWP) ●●●●

First Cost ●●●

Operational Cost ●●●

Architectural Integration ●●●

Fire Safety ●●●●

Client ●●

Regulatory Compliance ●●●●

Maintenance & Operational Complexity ●●●

Pros

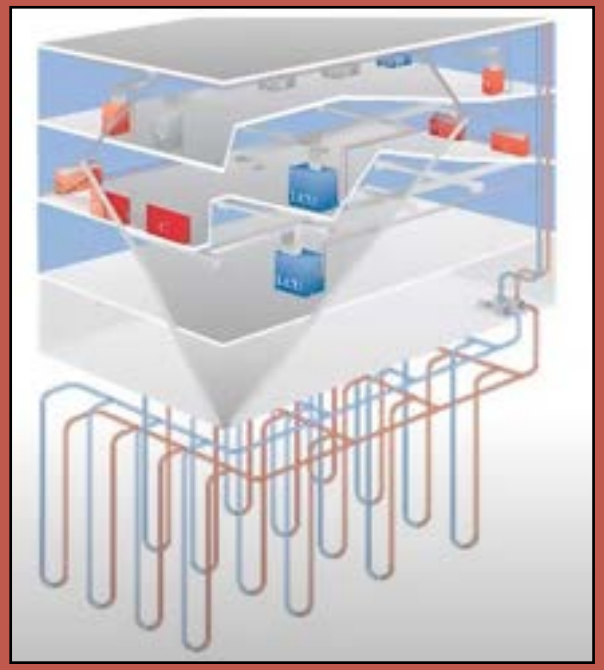
- **Sustainability:** significant reduction of refrigerant; increased efficiency compared to baseline
- **Safety/health:** factory-sealed refrigerant systems
- **Energy:** reduced energy load and utility reduction

Cons

- **Architectural integration:** requires large rooftop area (already being utilized for DHW)

Option 2: Water-to-air GSHP (Geothermal)

How It Works:
Ground Loop Heat Exchanger (GLHE) plus building system (HVAC): water-source heat pumps, interior piping, pumps, etc



Energy Efficiency ●●●●

Fire Safety ●●●●

Refrigerant Reduction / Global Warming Potential (GWP) ●●●●

Client ●

First Cost ●

Regulatory Compliance ●●●●

Operational Cost ●●●●

Maintenance & Operational Complexity ●●

Architectural Integration ●●●

Pros

- **Sustainability:** significant reduction of refrigerant; highly efficient
- **Safety/health:** factory sealed refrigerant systems
- **Energy:** reduced energy load and ~8% utility reduction compared to non-geothermal systems
- **Carbon**: emissions (tCO2e) reduction

Cons

- **Cost:** High upfront investment difficult to justify on savings alone; requires grants.
- **Implementation:** critical to properly size ground loops; requires specialized installers.
- **Perception:** Some client hesitancy based on past industry experiences, lack of familiarity
- **Integration**: early design integration is critical

Option 3: Unitized Packaged Terminal Heat Pumps (PTHPs)

How It Works:
Decentralized, self-contained units in each apartment. Decouples heating/cooling from ventilation (even though some units have this capability)

Energy Efficiency ●●

Refrigerant Reduction / Global Warming Potential (GWP) ●●●

First Cost ●●●●

Operational Cost ●●●

Architectural Integration ●

Fire Safety ●●●●

Client ●●●

Regulatory Compliance ●●●●

Maintenance & Operational Complexity ●●●

Pros

- **Sustainability:** significant reduction in refrigerant
- **Safety/health:** no long refrigerant lines; eliminates fire-rated shaft requirements (except if provided in common areas)
- **Cost:** affordable first cost, low maintenance/leaks
- **Operations:** clear utility cost-split (landlord vs tenant)
- **Aesthetics:** one unified opening built into window
- **Control:** individual heat/cooling control in units

Cons

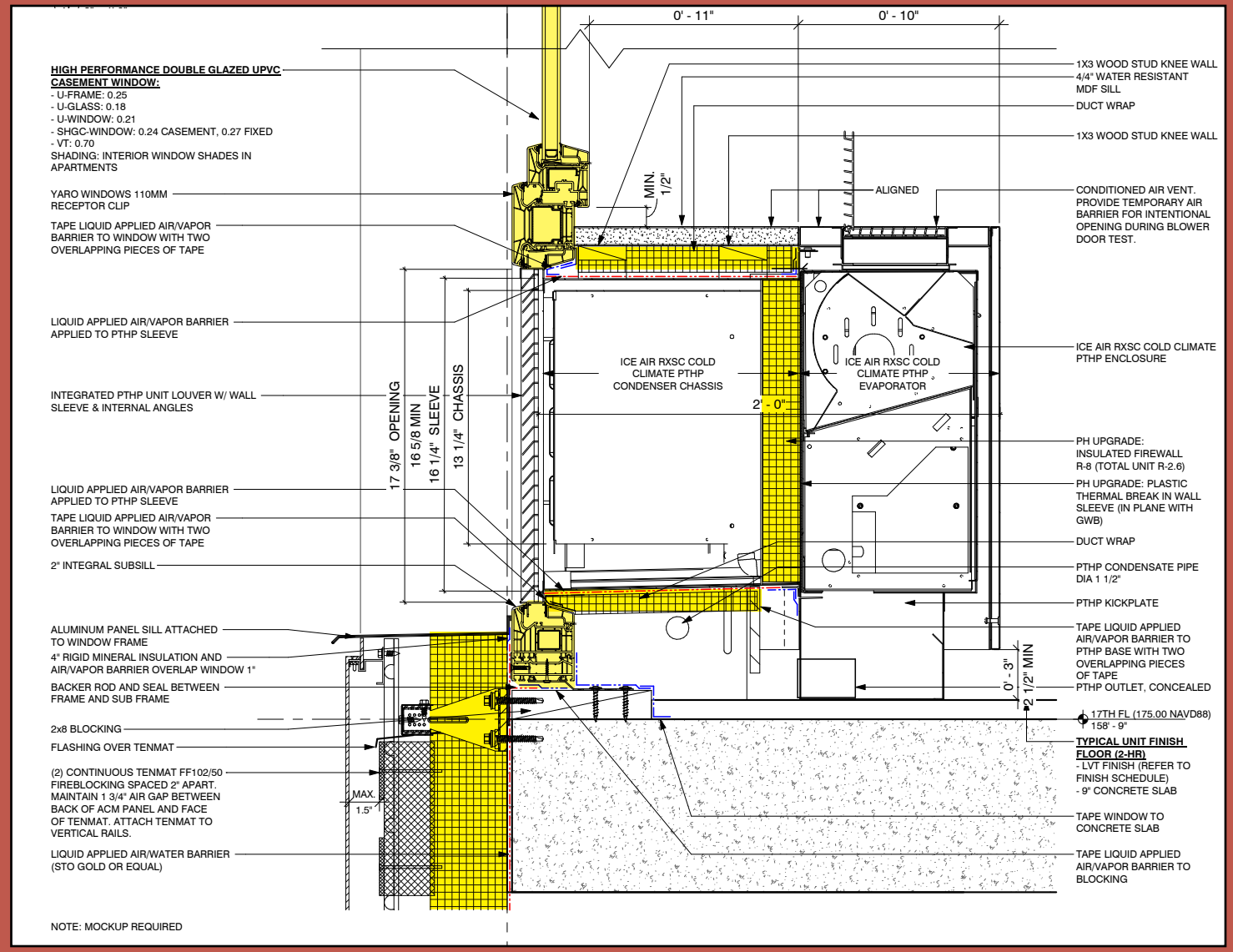
- **Efficiency:** Slightly lower COP than ideal centralized systems
- **Install:** air-sealing at additional 700+ openings
- **Maintenance:** Managing 700+ individual units

Evaluation Summary

	Air-to-water	Water-to-air GSHP	PTHPs
Energy Efficiency	●●●	●●●●	●●
Refrigerant Reduction / Global Warming Potential (GWP)	●●●●	●●●●	●●●
First Cost	●●●	●●	●●●●
Operational Cost	●●●	●●●●	●●●
Regulatory Compliance	●●●●	●●●●	●●●●
Architectural Integration	●●●	●●●	●
Fire Safety	●●●●	●●●●	●●●●
Client	●●	●	●●●
Maintenance & Operational Complexity, Metering	●●●	●●	●●●

Implementation & Integration

- Coordination with manufacturer, GC and envelope/Passive House consultant to arrive at adequate solution for window unit integration
- Facade studies to develop acceptable aesthetic integration
- Mock-up and testing required



Reflections & Lessons Learnt

- Importance of holistic, interdiscipinary decision-making for a project specific solution
- Review all possible options based on code, manufacturers etc at outset of project - then narrow the field
- Connect specialists (engineer, owners, tax experts etc) to advocate for and explore new technologies
- Consider best practices for collaborating with engineers on compliant designs
- Timing is critical - early consideration and resaerch (including financing systems) is critical to ensure time to integration

Looking Ahead

- **Regulations:** Preparing for further refrigerant phase-outs.
- **Technology:** Assessing emerging alternatives (water-based heat recovery, low-GWP refrigerants).
- **Strategy:** “Future-proof” designs by prioritizing flexibility and low-GWP principles from the start.

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Questions?

Thank you!

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