SCALING HEAT PUMP RETROFITS

Sean Brennan
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@UrbanGreen
AGENDA

• Overview of Advancing Electrification research
• Technical challenges to electrification
• Heat pump business case and owner’s perspective
• Q&A
Electrification of light

• Turn of 20th century – Edison, Tesla and Westinghouse

Science seldom proceeds in the straight-forward logical manner imagined by outsiders.

- James Watson
Roadmap to Zero Carbon NYC

**NYC’S ELECTRIC FUTURE**

- **2019**: LL97 ENACTED
  - Office of Building Energy & Emissions Performance and Advisory Board created

- **2020**: RESEARCH
  - Carbon trading, implementation plan, utility rate cases

- **2021**: INDIAN POINT ENERGY CENTER
  - Generation stops, decommissioning begins

- **2022**: NEW TRANSMISSION ARRIVES

- **2024**: EMISSIONS LIMITS BEGIN

- **2026**: FIRST COMPLIANCE REPORT DUE
  - And every subsequent May 1st

- **2030**: EMISSIONS LIMITS BECOME MORE STRINGENT
  - Plus City government emissions must be 50% below 2006 baseline

- **2034**: GRID COEFFICIENT TARGET

*URBAN GREEN COUNCIL*
Heat pump potential

- Almost two-thirds of building emissions come from fossil fuel combustion
- Similar pattern between NYC and NYS
- Electrification can cut carbon emissions while improving air quality

Carbon emissions – 2017 (millions of tonnes CO2e)

- **NYS**:
  - District steam and electric: 31.5
  - Fossil fuel combustion: 61.8

- **NYC**:
  - District steam and electric: 12.4
  - Fossil fuel combustion: 21.0
CURRENT MARKET

Multifamily potential

- Demystifying Steam update coming October 2019
- Over 46,000 steam heated small and medium buildings
- Citywide, 1.8B SF of multifamily area uses steam heat

Predicted Small and Medium Multifamily Steam Heated Properties by Borough

<table>
<thead>
<tr>
<th>Borough</th>
<th>Small and medium properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manhattan</td>
<td>17,703 / 18,504</td>
</tr>
<tr>
<td>Brooklyn</td>
<td>16,832 / 21,020</td>
</tr>
<tr>
<td>Bronx</td>
<td>5,377 / 6,059</td>
</tr>
<tr>
<td>Queens</td>
<td>5,300 / 7,121</td>
</tr>
<tr>
<td>Staten Island</td>
<td>340 / 569</td>
</tr>
</tbody>
</table>

NOTE1: Buildings larger than 5,000 SF, smaller than 50,000 SF
Medium multifamily projects

- Harlem (The Levy Partnership, JOE NYC)
  - Construction to start in 2020

- Bronx (Bright Power, Vomar)
  - Design complete, construction start 2019 - DHW served by heat pumps

- Brooklyn (CB, RiseBoro)
  - Casa Pasiva converts 143 units in Bushwick from steam to ASHPs
CURRENT MARKET

Large Multifamily projects

Residential larger than 25,000 SF:

40% of NYC building area

30% of NYC building emissions

NOTE1: Buildings larger than 25,000 SF

URBAN GREEN COUNCIL
TECHNICAL CHALLENGES

Overview

• Technological uncertainty
• Existing electrical capacity
• Equipment placement
• Envelope improvements
• Refrigerant piping and selection
SYSTEM SELECTION

Central (VRF)
- Less roof space required
- Larger refrigerant runs and volumes
- Easier to connect additional electricity
- Difficult to meter

Unitary (mini-split)
- More space required, but smaller units
- Smaller, isolated refrigerant runs
- Some apartments will need electrical upgrade
- Tenant pays for heat through electricity
- Tendency to oversize based on product availability (2 tons is too big)
TECHNICAL CHALLENGES

Electrical capacity

- Issues for buildings and the grid
- Gathering data from utility customers with smart meters to understand demand and headroom
- Electrical upgrades could double retrofit cost
TECHNICAL CHALLENGES

Envelope Improvements

- Trade-off between investing in better envelope and HVAC equipment
- Heating load and heat pump capacity move in opposite directions
- Low-cost improvements like air-sealing should be planned and modeled
FINANCIAL CHALLENGES

Overview

• Capital costs
• Operating costs and gas cost
• Co-benefits
• Tenant relationship and rents
FINANCIAL CHALLENGES

Overview

• Heating – using gas will still be cheaper even with huge increases in efficiency

• Hot water – better business case given summer load

• Natural gas prices continue to fall, but ConEd has introduced ‘Rider Z’
Refrigerants

- Fourth Generation refrigerants
- Common assumption is 10% leakage annually and 170% over lifetime of unit.¹
- Low GWP refrigerants in more efficient equipment

NOTE1: Gallagher et al. (2014), and Intergovernmental Panel on Climate Change - IPCC (2006)
Natural gas

- US EPA estimates fugitive gas emissions at 1.4%, but 2018 study found 2.3% - 60% higher!\(^1\)

- EPA considering rolling back methane monitoring rules and exempting old well-sites

- Coal to gas carbon savings wiped out over 20 year period

\(^1\) Assessment of methane emissions from the U.S. oil and gas supply chain - Alvarez et al July 2018.
Designing VRF Retrofits for Multifamily Buildings

David Goldstein, PE
September 26, 2019
Distributed vs Central Condensing Units
Distributed Condensing Units

Advantages:

• Less disruptive piping distribution
  – No routing through corridors or risers
• Less overall piping means less refrigerant
  – Simple ASHRAE Standard 15 compliance
• Not restrained by pipe length limitations
  – Max vertical pipe run is typically 150-200 ft
• Does not occupy roof space
• Simpler power distribution
  – Existing capacity may be adequate
• No additional submetering required
• More flexibility with tenants
  – Apartment can be retrofit as they become available

Mounting Options:

• Exterior wall mounting
• Installation on balconies
• Wall opening similar to PTAC
Central Condensing Units

Advantages:
- Little or no façade impact
- Less installation work required within each apartment
  - Only refrigerant lines and wall-mounted unit
- Eliminates regular maintenance within each apartment
  - Regular filter cleaning can be done by tenant
- Easier to access the condensing units
- Easier condensate drainage from defrost

Pipe Routing Options:
- Distributed risers within the apartments
- Central riser with corridor distribution
Refrigerant Safety
ASHRAE Standard 15 & 34

• Current VRF systems use R-410A which is a safety group A1 refrigerant:
  – low toxicity and low flammability
  – Hazard is caused by displacement of oxygen

• ASHRAE Standard 34 defines refrigerant concentration limits (RCL) to ensure occupant safety
  – Also refer to local codes
Refrigerant Safety
ASHRAE Standard 15 & 34

• Example
  – 150 sq ft bedroom with 8 ft ceiling height = 1200 cubic ft
  – Refrigerant concentration limit (RCL) = 26 lbs / 1000 cubic feet
    – Maximum system refrigerant charge for this apartment is 31.2 lbs
    – Preliminary estimate of 5 lbs of refrigerant per ton
      • Verify actual charge after system design is complete
    – Maximum system capacity of 6 tons

• Strategies to comply with refrigeration volume limits:
  – Split condensing units into smaller capacities
  – Reduce piping lengths
  – Reduce the system capacity by improving envelope
  – Connect smaller rooms with door undercuts or transfer grilles
Thank you!

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Heat Pump Retrofits: the owner’s perspective

Kelly Dougherty
# What Does a Co-op/Condo Board Consider?

## Approve
- **Clarity**
  - What is VRF
  - Installation Cost
  - Utility Cost/Savings
  - Operational Costs/Savings
  - Tenant Disruption
  - Process Changes: Billing etc.
  - Timeline: When to Act
  - Benefits of Electrification
  - Success Stories
- **Incentives**
- **Connection to Local Laws**

## Disfavor
- **Conflicting Information**
  - Engineering Study vs. Contractor
  - Complicated Information
- **Disruption to Tenants**
- **Increased Cost to Operate**
- **Complicated Billing Systems/added expense**
- **Refrigerant Health Risks**
- **More Expensive Option Than “for-like” replacement**

Board members have an important responsibility to their fellow building owners. Board members must understand and agree with the benefits of converting.
## Queens Co-Op I – Feasibility Report Costs

<table>
<thead>
<tr>
<th>Option 1 – Replace Boiler</th>
<th>Option 2 – New VRF System</th>
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<tbody>
<tr>
<td>Boiler Demo</td>
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</tr>
<tr>
<td>$50,000</td>
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</tr>
<tr>
<td>New Boiler</td>
<td>VRF</td>
</tr>
<tr>
<td>$165,000</td>
<td>$1,540,000</td>
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<tr>
<td>Chimney Liner</td>
<td>New DHW</td>
</tr>
<tr>
<td>$65,000</td>
<td>$80,000</td>
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<tr>
<td>Boiler Room Code Upgrade</td>
<td>Design/Soft Cost</td>
</tr>
<tr>
<td>$35,000</td>
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<tr>
<td>Distribution</td>
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<tr>
<td>$95,000</td>
<td>$250,000</td>
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<tr>
<td>Design/Soft Cost</td>
<td>Total</td>
</tr>
<tr>
<td>$30,000</td>
<td>$2,000,000</td>
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<td>Contingency</td>
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<td><strong>Total</strong></td>
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<td><strong>$495,000</strong></td>
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Queens Co-Op I – Operating Cost

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<tr>
<td>Existing Steam Boiler</td>
<td>60,600 therms</td>
<td>$68,900</td>
<td>$9.90 (nat. gas)</td>
</tr>
<tr>
<td>VRF System</td>
<td>514,000 kWh</td>
<td>$97,700</td>
<td>$55.69 (elec)</td>
</tr>
<tr>
<td>VRF Savings</td>
<td>5,200 MMBTU</td>
<td>-$28,800</td>
<td></td>
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Queens Co-Op I: DECISION

1. VRF was too expensive for shareholders
2. Board couldn’t visit a retrofitted multifamily building in NY
3. The added cost to operate the units was difficult to explain to shareholders
4. Sponsor did not agree with VRF
5. Disruption to shareholders was too great
6. Providing/managing AC in the units is not in the buildings bylaws and was not an added responsibility the board wanted to take on.
7. Façade repairs for PTAC sleeves was not included in the budget.

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Queens Co-op II – Feasibility Report Estimates

For like replacement (w/o chiller):

$2,621,440

Vs.

VRF Replacement:

$2,565,400
Queens Co-Op II: DECISION

✗ ASHP system throughout the building
★ Decentralize cooling system w/ window PTAC

How? requiring shareholders to purchase and install window units.

Unexpected Benefit: behavioral impact, shareholders now have complete cooling control and are paying for their individual use.

A couple of things to note:

1. Will apartment values drop without central air?
2. Not every room/window can accommodate a window A/C
3. Without running the cooling plant the building is saving $119,200 annually*

*Unit owner additional spend (electric) for window A/C has not been included in this figure.
Queens Co-Op II – EUI Reduction
Considerations to Include in Full Analysis

On-Going Operational Cost Items
- **Steam Systems**: Boiler Cleaning, Tuning, Chemical Treatment, Tube Replacements, Steam Trap Replacements, etc.
- **Hydronic Systems**: Water Treatments, LL77 Compliance, Bi-Annual Unit Maintenance, Cooling Tower Maintenance/Repairs, Chiller Maintenance/Repairs, etc.
- **ASHP**: Annual Maintenance/Repairs

Other Useful Information
- Useful life comparison between systems
- Provide a reasonable increased value analysis from a realtor for decentralized heating and cooling apartments
- Include the possible LL97 GHG fines that may be avoided by converting to electric heating and cooling
Combining Measures in Feasibility Study

- Potential increase of efficacy of projects due to combining measures
  - Whole building weatherization
  - Windows
  - Facade Repairs/ Insulation
  - Low hanging fruit
    - Lighting
    - Controls
    - Pipe Insulation
    - Retro-commissioning
Non-energy related benefits

- Tenant Comfort & Control
- Behavioral Energy Reduction Leading to Higher LL133 Scores/Grades
- GHG emissions + Potential Fines
- Apartment value
- Operational costs
Conclusions

1. Consistency needed between Engineers & Contractors
2. ASHP may not be a financial fit for every type of building or system
3. Inclusion of non-energy related benefits is very important
4. Inclusion of all cost expenditures including PTAC, Fan Coil, WSHP, etc.

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