INTEGRAL GROUP

DATE: September 29, 2020
TO: John Settles and Andrew Aurbach; Owners, Kaizen Community Strategies
FROM: Sam Brooks; Principal, Integral | Allison Naganuma; Energy Analyst, Integral
RE: 1364 Bryant Street, NE: Path to Net Zero Energy (NZE)

1364 Bryant Street NE — Net Zero Strategies

SUMMARY

Highlights. The potential annual renewable power generation at 1364 Bryant Street, NE ("Bryant Street"), via rooftop solar, could cover the building's total annual electricity consumption. The building currently uses roughly 17k kWh annually; Integral estimates Solar PV on the Bryant Street rooftop could generate over 18k kWh annually.

With respect to achieving NZE for total energy use, Bryant Street would need to transition from natural gas heating and cooking to all-electric systems and: (i) generate all electricity from onsite solar; and/or (ii) virtually purchase renewable electricity offsite (e.g. community solar). In order to achieve NZE onsite, Bryant Street would need a deep energy efficiency retrofit to achieve ~63% energy savings (with EUI ~62% below average EUI for multifamily buildings) and install a ~14.4kW solar system on the roof.

Key Challenge. Converting the building to total 100% Net Zero Energy (NZE), inclusive of its thermal needs, will be challenging. The building uses considerable energy for heating and modest amounts for cooking; electrification of these systems will be expensive. It is possible that payback periods for electrification could be reduced to within 20-30 years — for either air source heat pumps (ASHP) or ground-source heat pumps (GSHP) with geo-exchange — but further detailed engineering evaluation is required.

Given current price estimates, an assumed carbon fee is required to create a positive Net Present Value (NPV) for the electrification of building systems. With an assumed carbon price of $150/ton, building electrification would have an NPV of $6,754.

Note: Because two of the building's units have recently replaced their boilers (to highly efficient boilers), this project's economics were uniquely challenging. If those boilers had not been replaced in the last several years, the lifecycle cost of all-electric heat pumps would have been more attractive relative to boiler replacement; in this instance, the "business as usual" case was such that the boilers do not need to be replaced for several decades.

Efficiency Measures. Integral recommends a range of efficiency measures including lighting upgrades; envelope improvements; HVAC controls; and behavioral change through robust energy monitoring.

Bottom-line: Integral Group recommends an iterative strategy to work towards net zero energy, with at least three phases:

PHASE I

- Insulation and air sealing (attic, walls, etc.)
- LED lighting retrofit
- Solar PV
  - Third-party financed system would include replacement to electric infrastructure, including replacement of fuses with traditional electric panels
- Energy monitoring at the current transformer (CT) level (when fuses replaced with panel)
  - Monitoring will provide two benefits: (i) tenants will have more visibility and control to reduce their utility costs; (ii) KCS will be able to better understand and target Phase II and Phase II NZE measures

PHASE II

- 6-month review — with focus on insulation and air-sealing impact on heating loads

PHASE III

- Electrification
  - Likely air source heat pumps (ASHP) for heating and domestic hot water, though secondary review of ground-source (i.e. geothermal) heat pumps
  - Induction/electric cooktop
- Fans
  - Low-profile fans (to improve thermal comfort)

CURRENT CONDITIONS

Utility data was available for two of the four units (Apt 3 and Apt 4): 24 months of natural gas bills; 24 months of electric bills; and 24 months of hourly interval electricity data.

Unit	Date	Natural Gas (kWh)	Natural Gas ($)	Electricity (kWh)	Electricity ($)
Apt 3	Aug '18 – July '19	11,840	$555	4,939	$724
	Aug -19 – July 20	11,322	N/A	5,459	$663
Apt 4	Aug '18 – July '19	18,113	$771	3,023	$476
	Aug -19 – July 20	18,459	$817	3,234	$526
TOTAL (Simplifying approx: Apt 1 & Apt 2 use energy equal to average of Apt 3 & Apt 4)		59,734		16,655	

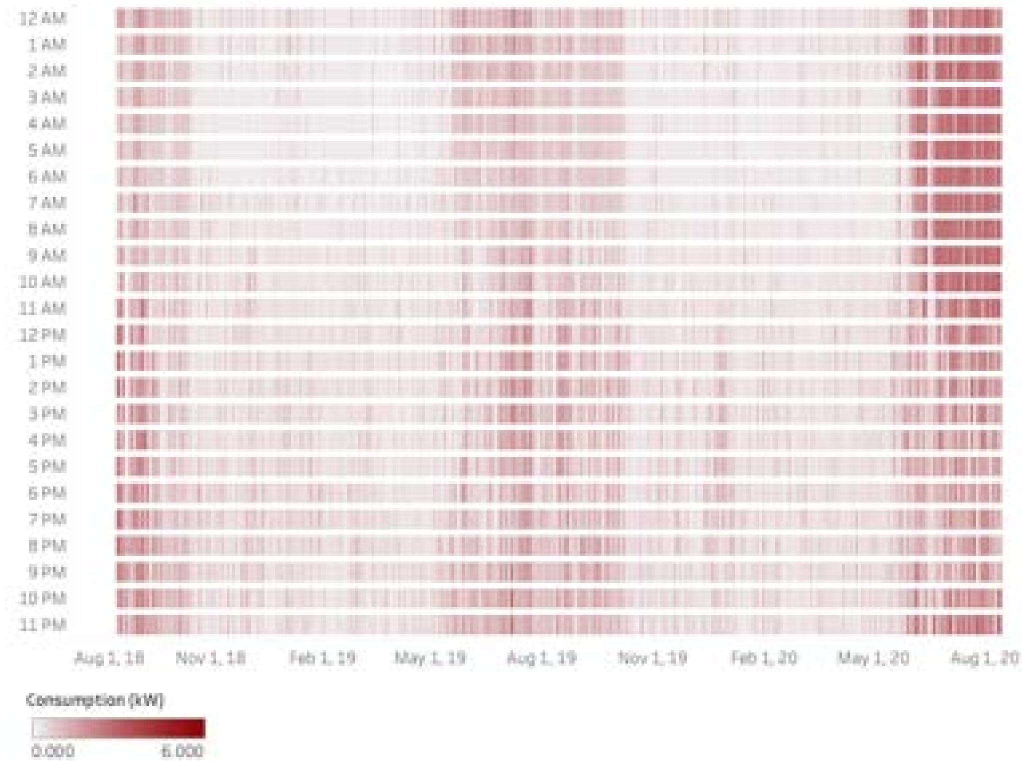
Estimated Annual Total Energy Consumption: 59,734 kWh (converted from therms to kWh)[1]

Energy Use Intensity: 93 (kBTU/sqft). Bryant Street's energy use intensity is above that of an average multifamily home (EPA average for multifamily of all sizes is 60), though this is expected, given the age of the building.

Electricity Interval Data. Interval data from Pepco was obtained for two of the four units. As seen in the graphic below, most electricity use is in the summer, for cooling.

[1] Simplifying approximations: Apt 1 and Apt 2 use the average energy between Apt 3 and Apt 4

1364 Bryant St - Apt 3/4 - Electric Heatmap



NET ZERO ENERGY – PROJECT REVIEW

VIRTUAL SITE VISIT

COVID-19 precluded the project team from a traditional site visit. KCS' John Settles performed a 'virtual' site visit by walking through two of the units, showing key building systems and characteristics to the Integral Project team via FaceTime.

CHARRETTE

While COVID-19 also prevented the anticipated charrette from taking place in person, the project team met with the various stakeholders for the project six times via videoconference. During these meetings, the building owners, engineering team, consultants, contractor, and tenants were able to communicate about various components of the project, including:

- Project goals
- Logistic concerns
- Thermal comfort
- Electric reliability
- Impact of COVID-19 on energy consumption patterns
- Possible schedule for NZE implementation

PATH TO NET ZERO — POTENTIAL MEASURES

SOLAR FEASIBILITY

Integral performed an in-depth analysis of the solar potential at 1364 Bryant Street, resulting in a schematic design of possible installation.

Estimated system size:
14.4kW

Estimated annual generation: of 18,685.

This level of generation would be sufficient to cover the building's existing electricity consumption; with significant improvements to energy efficiency, this generation could cover the building's new electric load if all-electric thermal systems were deployed.

AIR SOURCE HEAT PUMP (ASHP) & GROUND SOURCE HEAT PUMP (GSHP) (referred to as Geo-Exchange (GHX) herein)

An ASHP is a piece of mechanical equipment that transfers heat from outside air to inside a building (for heating); it can also operate in reverse, transferring heat from inside a building to outside (for cooling).

A geo-exchange (GHX) system uses the natural ambient temperature of the ground, which retains substantial amounts of low-grade heat from absorbing solar radiation. This provides effectively "free" low-grade thermal exchange. The ground can be used as a heat sink, for heat rejection; and a heat source, for heat extraction.

For Bryant Street, the project team looked at both options — with a particular focus on GHX, given the technology is relatively rarely used in this setting (vs the more common ASHP). After meetings with three separate vendors, the initial GHX review indicated that GHX may be cost prohibitively expensive. However, Integral believes that costs may come down if the market matured in this market — a mid-market in between residential and large-scale commercial — in which case GHX could be worth further investigation.

Ultimately, electrification via ASHP may be advisable for Bryant Street. Indicative pricing from a local contractor suggests replacing the existing boilers with ASHP would cost $4,500.

ENERGY MODELING FOR ASH, GSHP, DEEP EE RETROFIT

Detailed energy modeling can be found in the Appendix to this document, an Excel spreadsheet titled, "1364 Bryant Street NE - Path to Net Zero - Modeling & LCCA 20200920."

Key figures:

Electric Use (kWh)	
BAU	16,655
ASHP	50,338
GSHP	46,778
ASHP w/ Deep EE Retrofit	18,685
Nat Gas Use (kWh)	
BAU	59,734
ASHP	-
GSHP	-
EUI - baseline	93.09
EUI - ASHP	61.34
EUI for Onsite NZE	22.77
% EE Improvement = NZE	63%
Onsite NZE - % Below Avg. EUI	62%
Avg EUI - Multifamily (via DOE)	60

PROPOSAL: PHASED APPROACH

Integral recommends a phased approach as outlined on p.1 of this document. This three-part initiative could offer at least three key benefits:

- Low-cost, high-impact retrofits
- Energy monitoring for robust understanding of initial EE retrofits — and the most cost-effective path to necessary deep EE retrofit (to achieve NZE)
- Time for market to mature — for more cost-effective all-electric HVAC systems

ADDITIONAL CONSIDERATIONS

Preemption of future risk. In recent years, some jurisdictions have used regulatory approaches like natural gas bans (or phase-out plans), net-zero ready building codes, and incentive programs to discourage fossil fuel use and drive electrification. By electrifying buildings before such regulatory changes could take place in DC, Bryant St. could be "future-proofed" — potentially avoiding investments in traditional fossil fuel-powered systems that could become obsolete or illegal. Electrification can also reduce price-risk to future volatility in fossil fuel commodity markets.

Opportunities at traditional systems' end-of-life. This project faced somewhat significant challenges, from a lifecycle cost perspective, because two of the building's boilers were recently replaced. The most advantageous time to electrify a building is when traditional systems reach their end of life; in this instance, the "business as usual" case indicated no need for boilers replacement for several decades.

Cost impacts on tenants. More efficient energy systems can reduce energy bills, giving tenants more money to spend on essential items like medicine and food. While this is a benefit for all households, this is particularly important for residents that experience 'energy insecurity' or the "inability to adequately meet basic household energy needs."[2]

Health impacts on tenants. By eliminating natural gas combustion, electric systems remove a dangerous source of indoor air pollution from the home. Even cooking with gas appliances can result in acute exposure to nitrogen dioxide (NO_2) levels;[3] burning natural gas with boilers (for space heating) also creates harmful air pollutants. The elimination of combustion would increase indoor air quality for tenants, and generally create healthier and safer communities.

Sector-wide importance of electrification. The movement towards electrification of the building sector is increasingly acknowledged to be vital to mitigate catastrophic global warming.

[2] One in three U.S. households faces a challenge in meeting energy needs. https://www.eia.gov/todayinenergy/detail.php?id=37072
[3] UCLA Fielding School of Public Health, Department of Environmental Health Sciences. Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California. April 2020.

The Intergovernmental Panel on Climate Change (IPCC) reports that the replacement of fossil fuel-dependent heating and cooking systems with those that run entirely on electricity is a key pathway towards decarbonizing the buildings sector and reducing emissions.[4] The end-goal of this transition is to create all-electric buildings powered entirely by zero-carbon energy sources (i.e. wind and solar).

For heating and domestic hot water (DHW) systems, heat pumps are the main technology that enables building electrification. Like a refrigerator, heat pumps use electricity to transfer heat from one place to another to achieve optimal indoor temperatures. In the winter, heat pumps extract heat from the surrounding air or ground and transfer it into the building using a compressor and refrigerant; in the summer, the same system can run in reverse to reject heat to the outside environment and provide cooling. Heat pumps are significantly more efficient and can produce fewer GHG emissions than the systems they replace. In a recent study, Rocky Mountain Institute found that heat pumps can be 2.2 to 4.5 times more efficient than an Energy Star gas furnace annually.[5]

Potential policy support. Integral hopes that the exploration of energy savings, financial feasibility, and barriers associated with electrification in small residential units — such as 1364 Bryant Street — can help inform DC's Department of Energy and Environment (DOEE) of key factors to consider when making policy decisions pertaining to decarbonization and electrification.

[4] Intergovernmental Panel on Climate Change (IPCC). Mitigation Pathways Compatible with 1.5. 2019.
[5] McKenna, Shaw, and Mark Silberg. It's Time to Incentivize Residential Heat Pumps. Rocky Mountain Institute. June 2020.