
BILTMORE
phius
PRO FORUM

DEEP ENERGY EXTERIOR RETROFITS

Sustainable Transformations: Detailing for PHIUS Retrofits

Julie Klump, POAH
Tim McDonald, Onion Flats Architecture
Jeannette Penniman, Onion Flats Architecture
Kara Haggerty Wilson, Onion Flats Architecture

RMI
ENERGY. TRANSFORMED.

façadesX
envelope solutions

BUILDING EVOLUTION CORPORATION
Achieve Performance & Durability Through a Holistic Approach™

DOER
Massachusetts Department of Energy Resources

TLH CONSULTING, Inc.
STRUCTURAL ENGINEERING SERVICES

25 YEAR ANNIVERSARY
BLW
Est. 1999

Maloney PROPERTIES

ONION FLATS
ARCHITECTURE

J M E

SEAMAN
ENGINEERING CORPORATION
HVAC · FIRE PROTECTION · PLUMBING

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Allston Brighton
COMMUNITY DEVELOPMENT CORPORATION

Mt. Weather Engineering

LSC

RESONANT ENERGY

SUSTAINABLE COMFORT

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

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JS CONSULTING ENGINEERS PLLC
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Lean Multifamily

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TIERNEY DEVELOPMENT SERVICES LLC

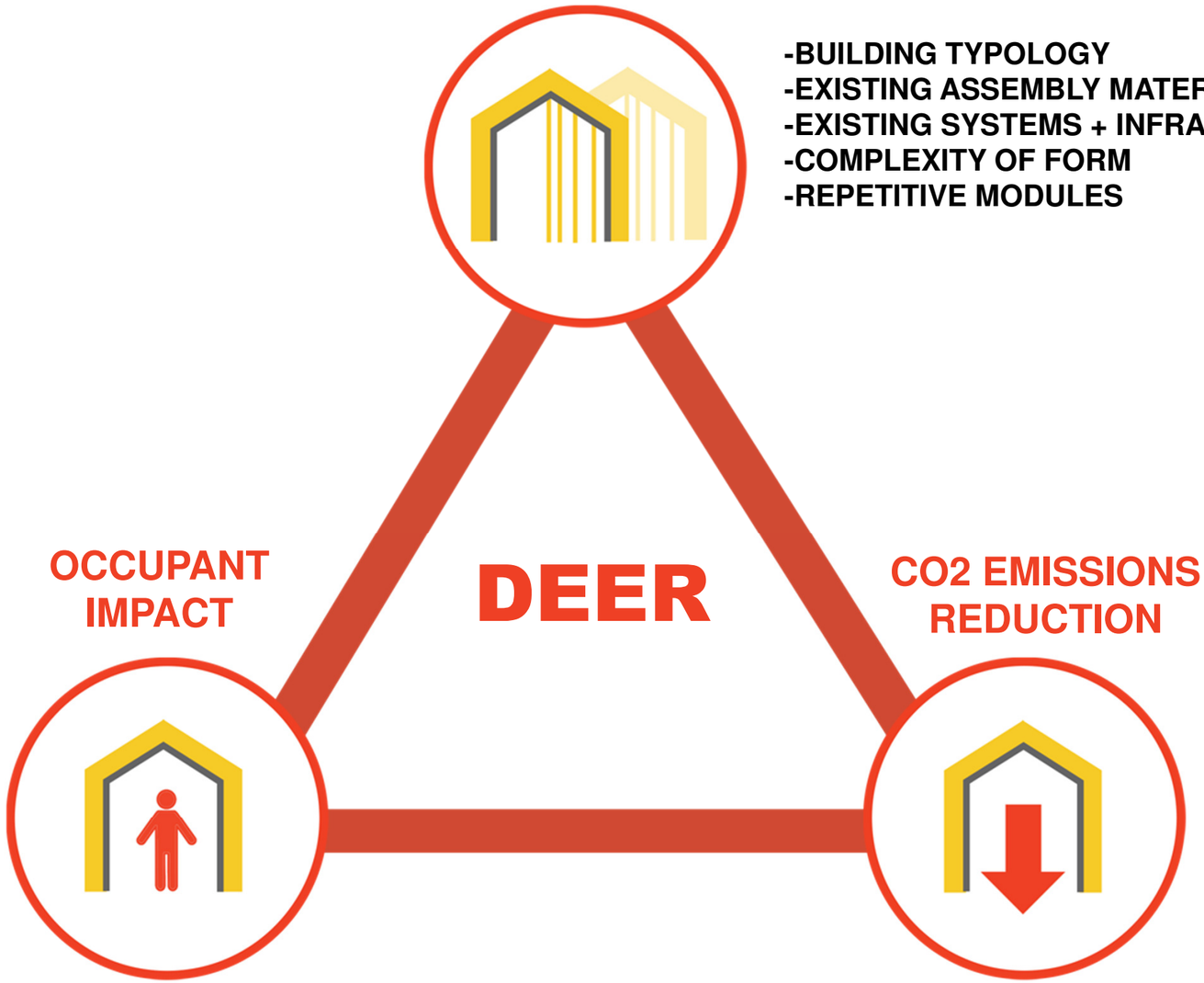
MASSACHUSETTS CLEAN ENERGY CENTER®

mass save

CITY of BOSTON
MAYOR'S OFFICE OF HOUSING

REPLICABILTY

-BUILDING TYPOLOGY
-EXISTING ASSEMBLY MATERIALS
-EXISTING SYSTEMS + INFRASTRUCTURE
-COMPLEXITY OF FORM
-REPETITIVE MODULES



OCCUPANT IMPACT

-VULNERABLE TENANT POPULATION?
-EXTENT OF IMPROVEMENTS TO UNIT?
-RELOCATION NEEDED?
-PHASED IMPROVEMENTS?

CO2 EMISSIONS REDUCTION

-ELECTRIFICATION
-ENVELOPE IMPROVEMENTS
-MATERIAL SELECTION
-SYSTEM UPGRADES
-ASSESS FOR SOLAR POTENTIAL

FUNDAMENTAL PRINCIPLES FOR DECISION MAKING

FAIRWEATHER APARTMENTS

SALEM, MA

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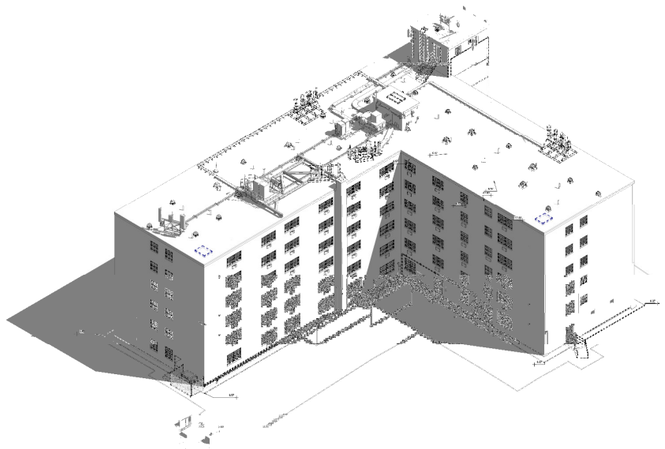
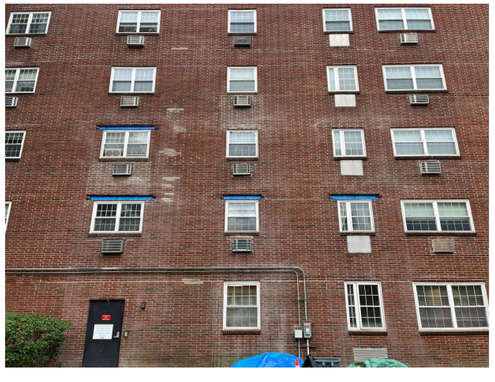
EXISTING BUILDING





BUILDING STATS:

-CONSTRUCTED IN 1967, MINOR ALTERATIONS MADE IN 2007
-STEEL STRUCTURAL FRAME, MASONRY EXTERIOR WALLS
-NON-COMBUSTIBLE CONSTRUCTION
-6 STORIES + ELEVATOR PENTHOUSE
-PARTIAL BASEMENT, MAJORITY SLAB ON GRADE
-127 UNITS, MAJORITY STUDIOS
-73,920 GSF

UNIQUE FEATURES / CHALLENGES:

-EXTENSIVE ROOFTOP TENANT EQUIPMENT
-STEEP SLOPE SITE CONDITIONS
-1 OF 4 FAIRWEATHER BUILDINGS, CONSTRUCTED FROM SAME DRAWINGS/DETAILS AND ASSEMBLIES (~600 APARTMENTS IN TOTAL)

UTILITY STRUCTURE / EXISTING SYSTEMS:

-UTILITIES PAID BY OWNER
-CO-GEN, GAS (HOT WATER AND HYDRONIC BASEBOARD HEATING)
-THRU-WALL A/C UNITS (SEASONAL)
-AIR HANDLER (FRESH AIR), NON-FUNCTIONING
-KITCHEN AND BATH DUCTED EXHAUST TO ROOF

EXISTING ENERGY PERFORMANCE:

ESTIMATED BASELINE EUI (IF AHU WAS FULLY FUNCTIONING) = 165.23 KBTU/SFYR

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SALEM FAIRWEATHER
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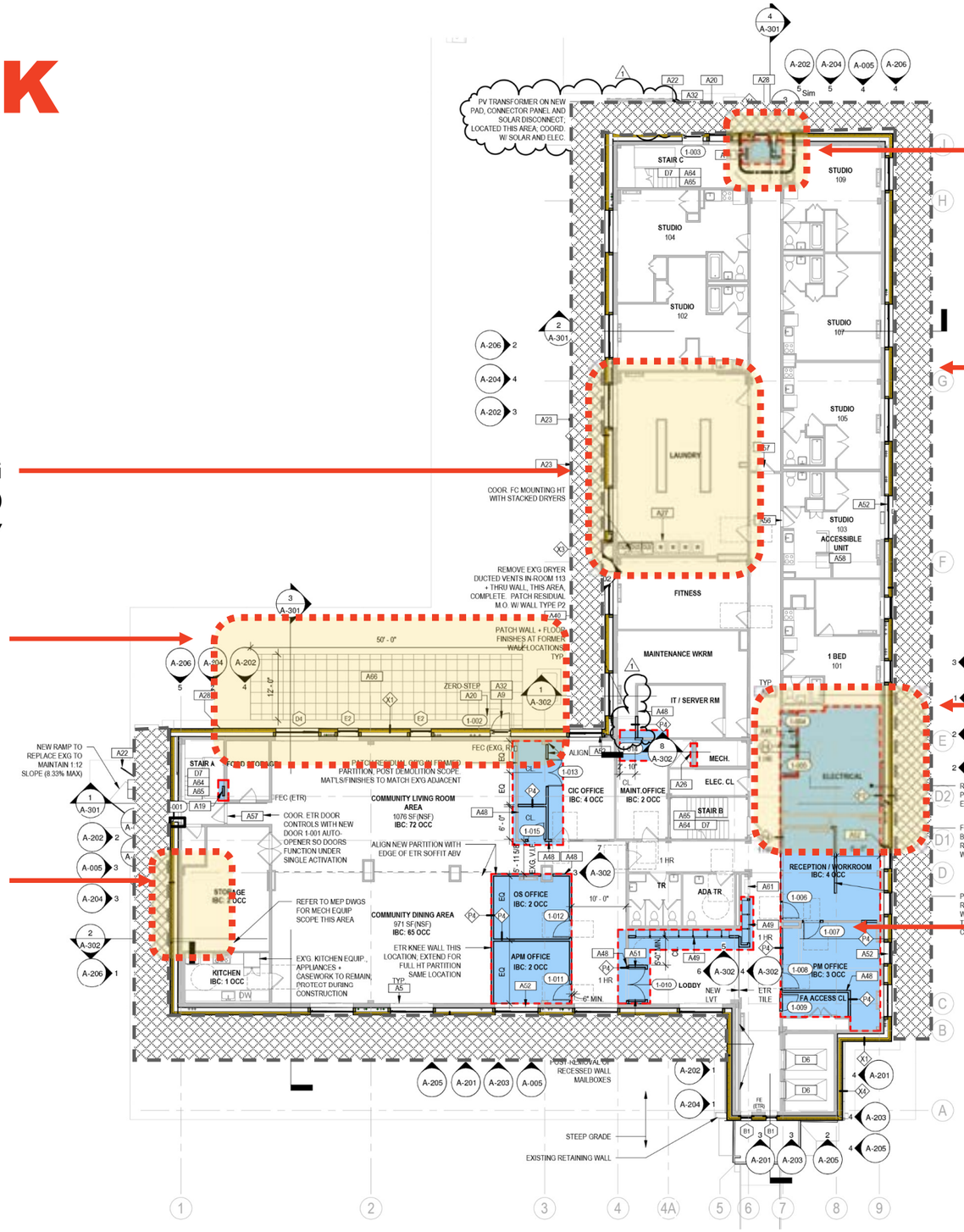
NEW WORK

GROUND FLOOR

EXISTING CENTRALIZED LAUNDRY

FUTURE TERRACE AREA

LEVEL 1 COMMUNITY ROOM ERV



CORRIDOR FRESH AIR HANDLED BY DEDICATED ERV

CROSS HATCH = ZONE FOR GROUND MOUNTED EQUIPMENT; HEATING/COOLING, DHW, SOLAR + ELECTRICAL RELATED EQUIPMENT

NEW ELECTRICAL ROOM, ADJACENT TO NEW TRANSFORMER ON SITE

BLUE HATCH = INTERIOR RECONFIGURATION / UNRELATED TO DER SCOPE

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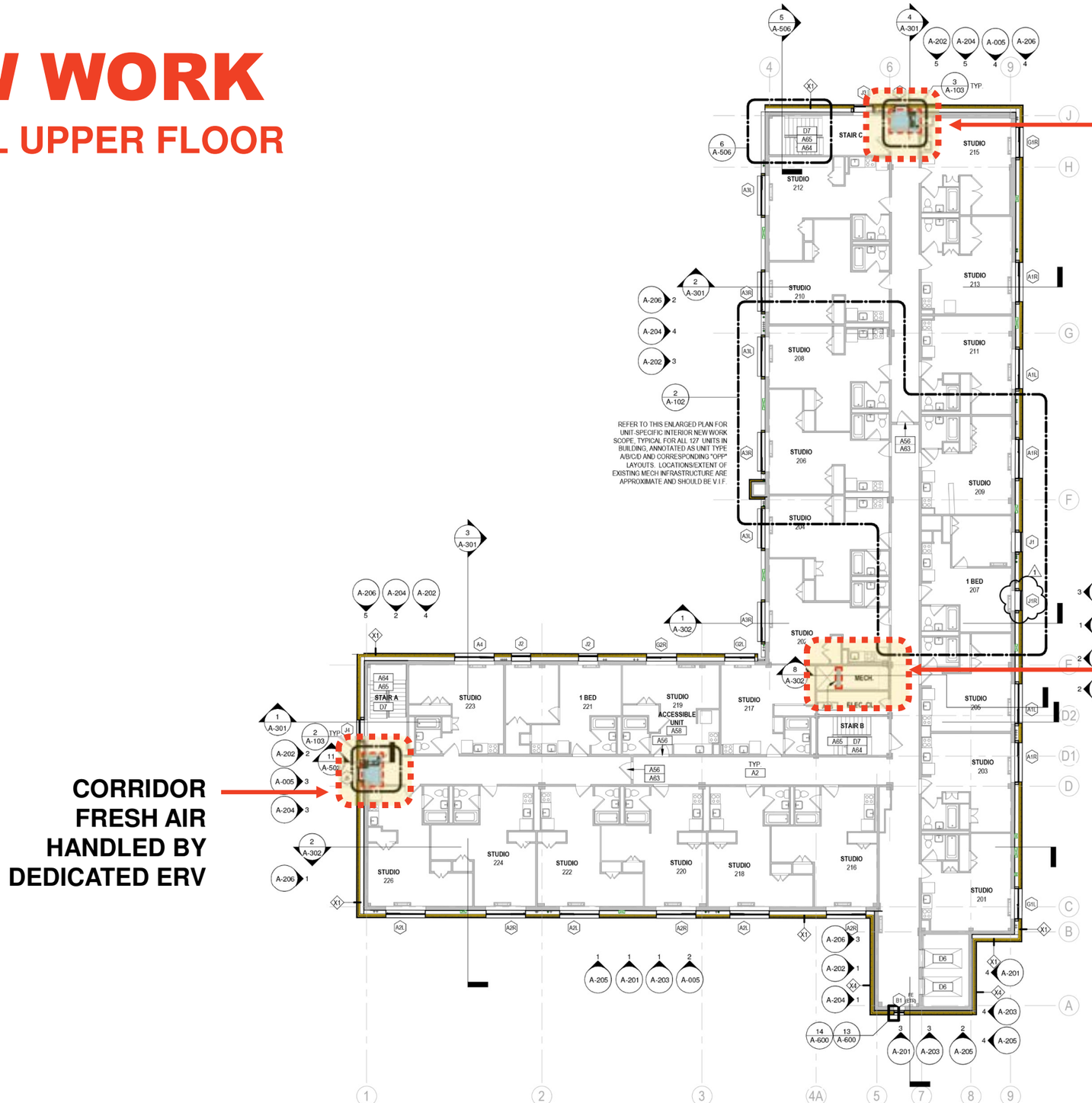
NEW WORK

TYPICAL UPPER FLOOR



CORRIDOR FRESH AIR HANDLED BY DEDICATED ERV

CORRIDOR FRESH AIR HANDLED BY DEDICATED ERV

EXISTING DEFUNCT AHU REMOVED, DUCTWORK ABANDONED IN PLACE AT CORRIDOR CEILINGS. ENTRY TO SHAFT CLOSED / SEALED

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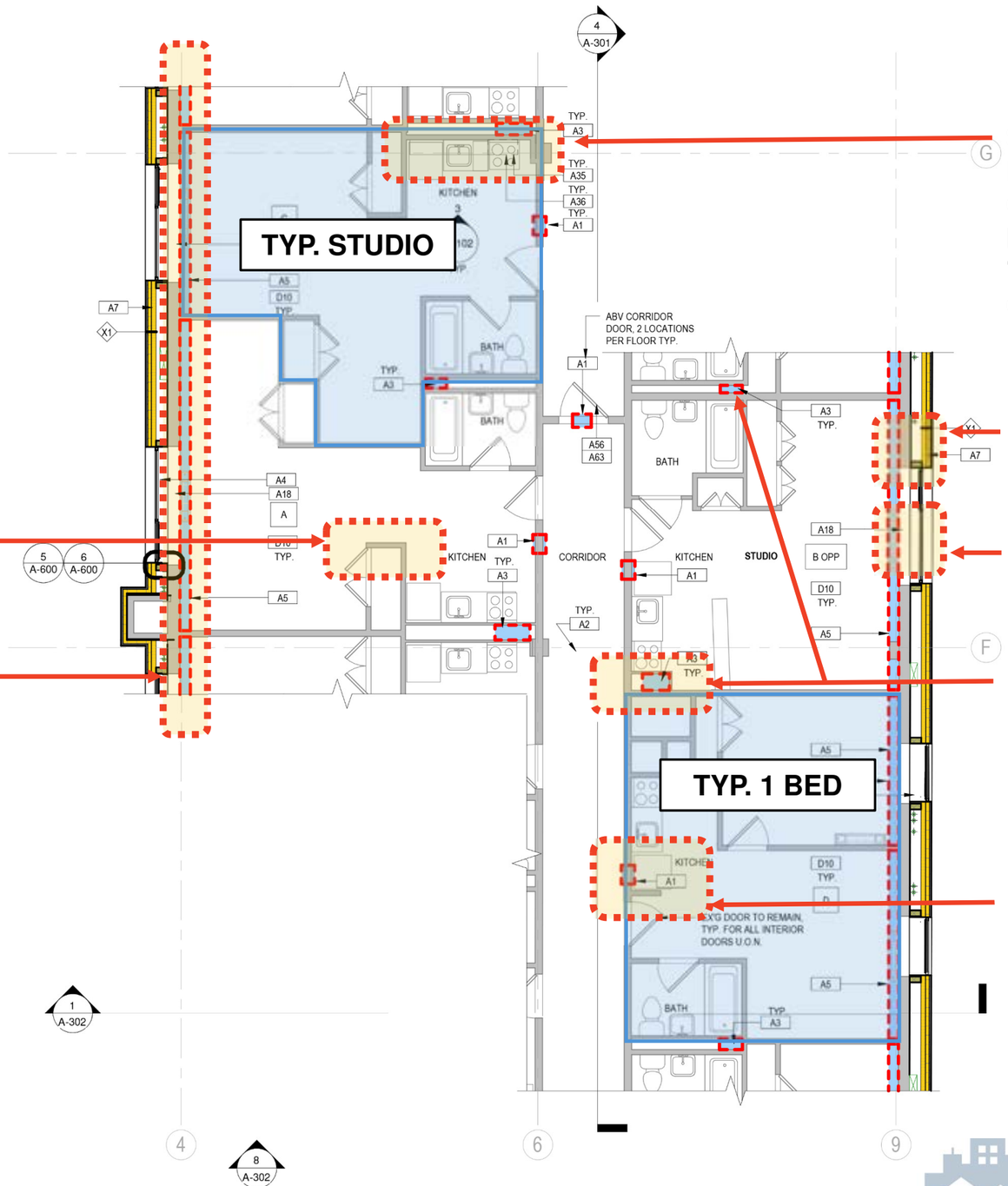
NEW WORK

TYPICAL UNIT SCOPE



REPLACE TENANT LOAD CENTERS + FEEDERS

BASEBOARD HEAT (AND GAS-FIRED BOILER) TO REMAIN FUNCTIONAL UNTIL NEW SYSTEMS INSTALLED; BASEBOARD TO BE REMOVED / CUT / CAPPED AFTERWARDS

SELECT UNITS REQUIRE KITCHEN CABINET MODIFICATIONS DUE TO EXISTING EXHAUST OBSTRUCTIONS

NEW SUPPLY AIR REGISTER IN WINDOW JAMB

NEW FAN COIL UNIT LOCATED BELOW WINDOW

KITCHEN + BATH EXHAUST LOCATIONS TO REMAIN UNCHANGED; NEW DAMPERS + GRILLES, DUCTS AEROSEALED

INFILL TRANSFER GRILLES (FORMER AHU FRESH AIR DELIVERY)

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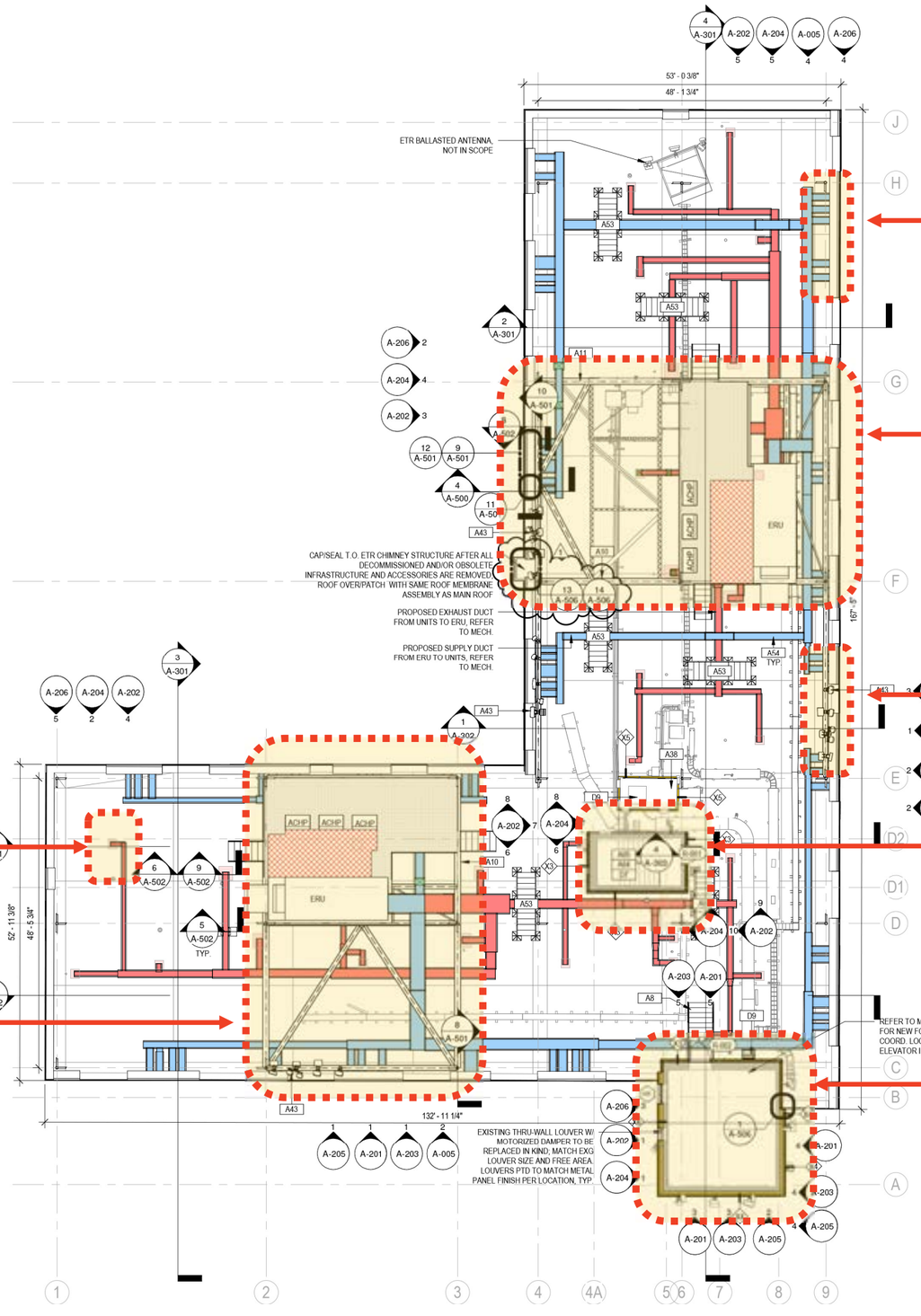
NEW WORK

ROOF



TYPICAL SUPPLY DUCT VERTICAL DROP GROUPING, ROUTED THRU NEW PARAPET

EXISTING DUNNAGE WITH EXPANDED FOOTPRINT FOR ERU + ACHPS

RELOCATED EXISTING ANTENNAS ON NEW DUNNAGE

EXISTING ROOF ACCESS STAIR

EXISTING ELEVATOR PENTHOUSE

TYPICAL NEW ERU EXHAUST DUCTWORK TIES INTO EXISTING EXHAUST THRU-ROOF LOCATIONS

NEW DUNNAGE FOR ERU + ACHPS

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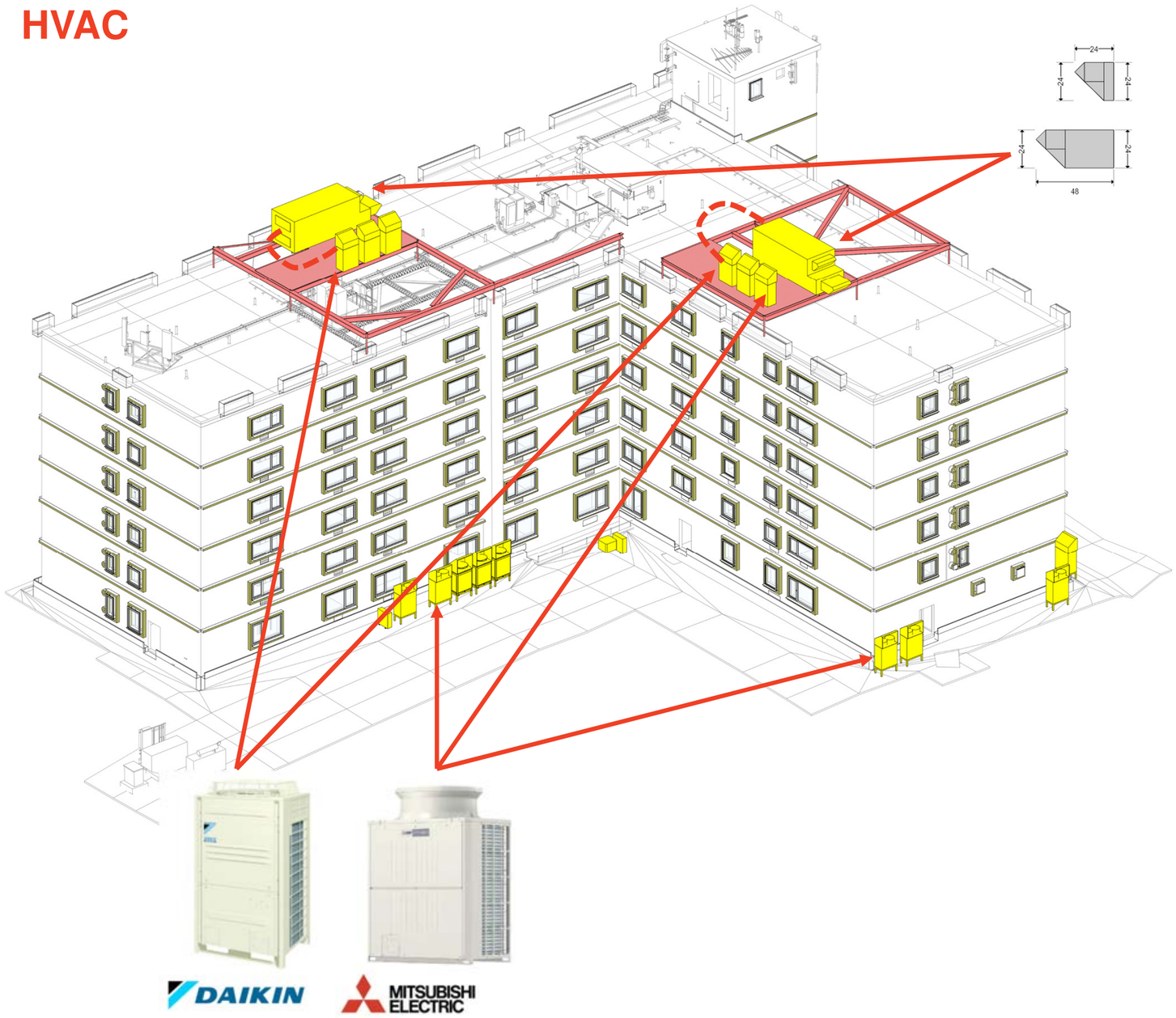
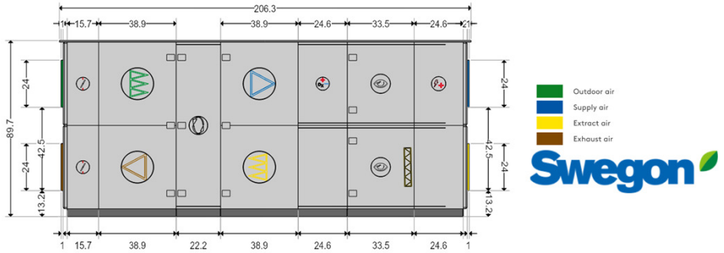
SYSTEMS

HVAC





VENTILATION:

-ROOF-MOUNTED SWEGON ERU'S W/ DAIKIN HEAT PUMPS FOR TEMPERING
-RE-USING EXISTING VERTICAL EXHAUST DUCTWORK AND SHAFT THROUGH BUILDING, UP THROUGH ROOF.
-AEROSEALING EXISTING AND INSTALLING NEW DAMPERS/GRILLES
-NEW EXTERIOR DUCTWORK LOCATED WITHIN NEW BUILDING ENVELOPE`

HEATING/COOLING:

-AIR SOURCE HEAT PUMP WITH FAN COIL TERMINAL UNITS IN EACH APARTMENT.
-GROUND AND ROOF MOUNT ACHP'S

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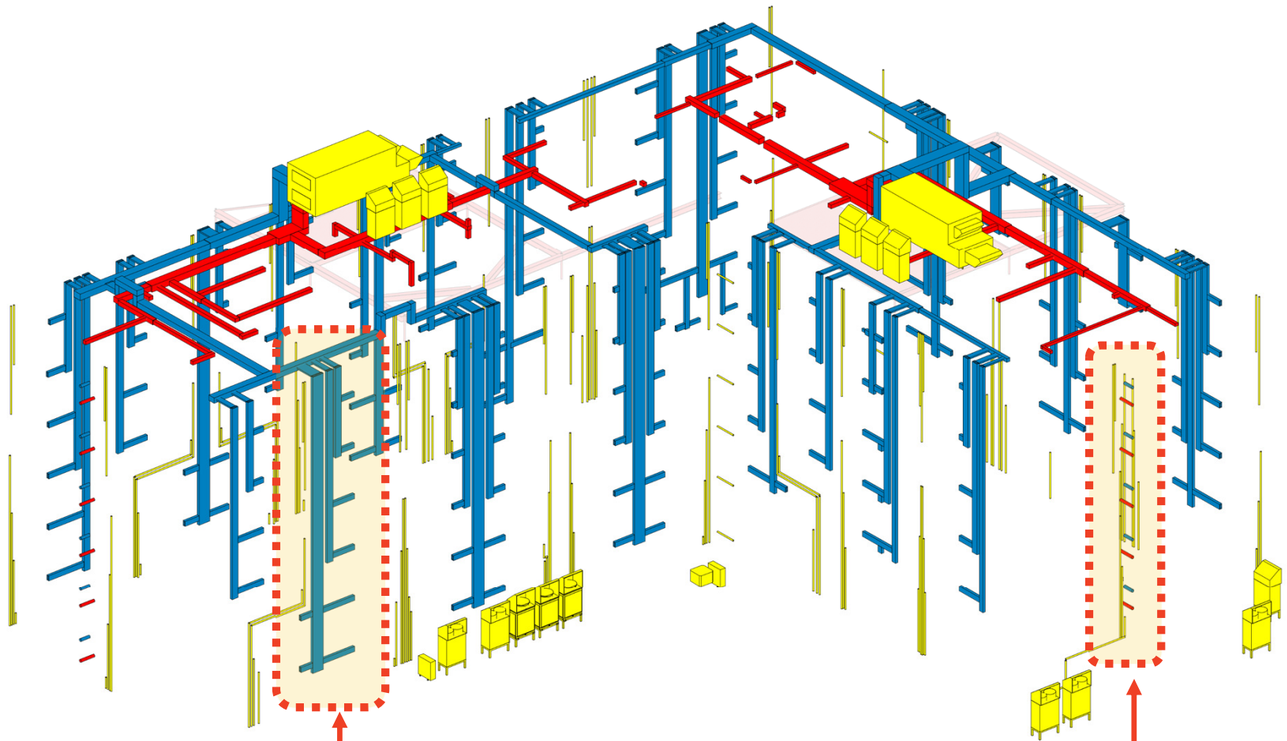
SYSTEMS

HVAC



TYPICAL UNIT SUPPLY VERTICAL DUCT RUN BRANCH LAYOUT

TYPICAL CORRIDOR ERVS WITH DIRECT EXHAUST AND SUPPLY THRU EXTERIOR WALLS

DUCT ROUTING:

-ROOFTOP DUCTS ROUTED APPROX. 2’-0” ABOVE ROOF SURFACE TO AVOID CLASHES WITH ETR INFRASTRUCTURE AND DUNNAGE
-ROOFTOP INSULATED DUCTS TRANSITION TO INTERNALLY LINED / INSULATED DUCTS AFTER ENTERING THE NEW PARAPETS
-VERTICAL DUCT DROPS ARE COORDINATED WITH PANEL ATTACHMENT LOCATIONS IN ADDITION TO LOCATIONS OF FIXED SASHES AT UNIT WINDOWS
-EACH VERTICAL DROP SERVES ONLY 2 FLOORS TO AVOID TRIGGERING NEED FOR SMOKE DAMPERS
-VOLUME DAMPERS AT TOP OF WALL, FIRE DAMPERS AT ENTRANCE INTO WINDOW JAMB

LINESET ROUTING:

-DEPENDING ON LOCATION, FAN COIL LINESETS ARE EITHER ROUTED FROM GROUND MOUNT OR ROOF MOUNTED EQUIPMENT
-LINESETS EXIT BOTTOM OF WALL SYSTEM THRU 16” TALL SECTION OF UN-SHEATHED PANELIZED WALL. SHEATHING TO BE SITE INSTALLED THIS LOCATION.

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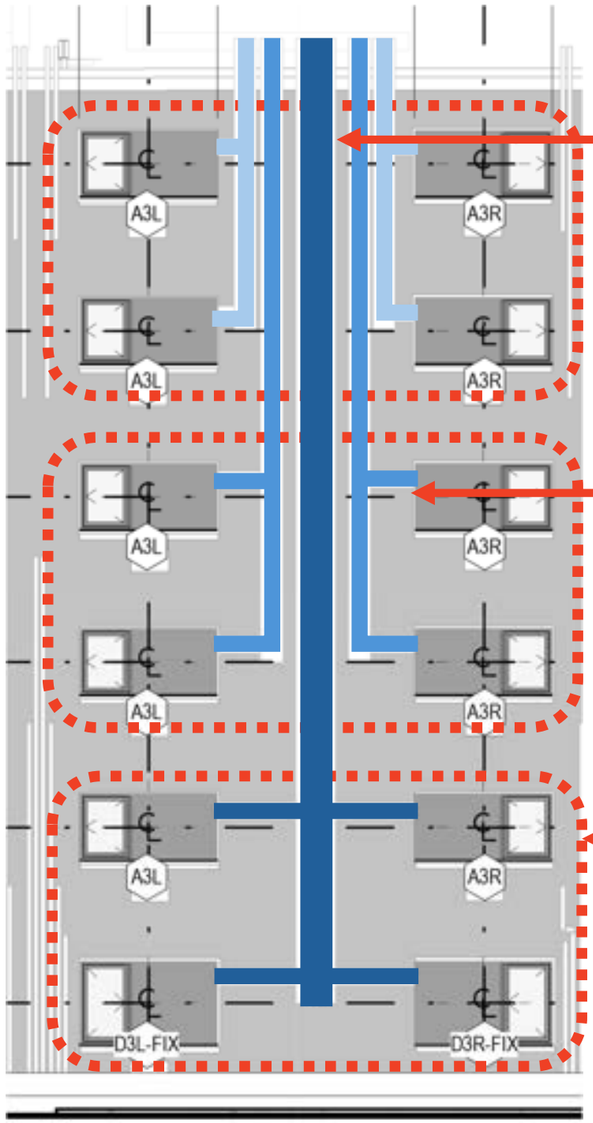
SALEM, MA

SYSTEMS

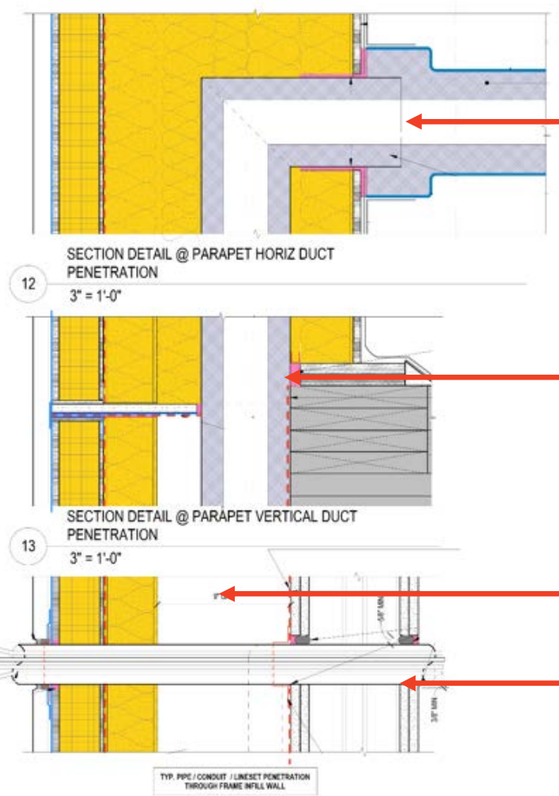
HVAC



SPECIFIC SPACING OF VERTICAL DUCT RUNS IS COORDINATED W/ REQUIRED PANEL ATTACHMENT LOCATIONS

SUPPLY DUCT ENTERS THRU FIXED WINDOW PORTION OF MULLED WINDOW

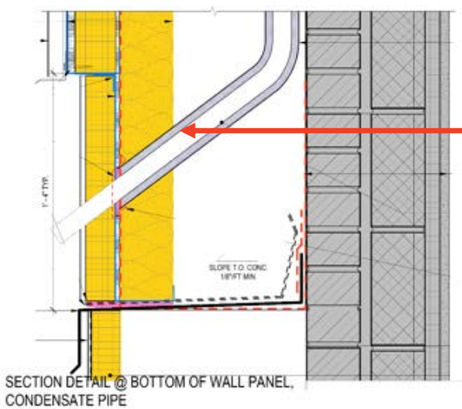
VERTICAL DUCT RUNS CONNECT ONLY 2 FLOORS AND TYPICALLY SERVE BETWEEN 2-4 APTS, DEPENDING ON LOCATION



12 SECTION DETAIL @ PARAPET HORIZ DUCT PENETRATION
3" = 1'-0"

13 SECTION DETAIL @ PARAPET VERTICAL DUCT PENETRATION
3" = 1'-0"

4 SECTION DETAIL @ TYP. PIPE/CONDUIT + WIRE PENETRATIONS
3" = 1'-0"



5 SECTION DETAIL @ BOTTOM OF WALL PANEL, CONDENSATE PIPE
3" = 1'-0"

SUPPLY DUCTS TRANSITION FROM EXTERNALLY INSULATED (R-12) TO INTERNALLY LINED (R-6) IN PARAPET

DUCTS PASS THROUGH HORIZONTAL AIR BARRIER CONNECTION AT ROOF PLANE

AIRSPACE MIN. TEMP ~50F

REFRIGERANT + CONDENSATE THRU-PENETRATIONS ARE FIRESTOPPED AS THEY EXIT 2 HOUR INFILL ASSEMBLY AT FORMER AC OPENING

CONDENSATE OR REFRIGERANT LINESET EXITS WALL CAVITY AT BOTTOM OF PANELIZED WALL

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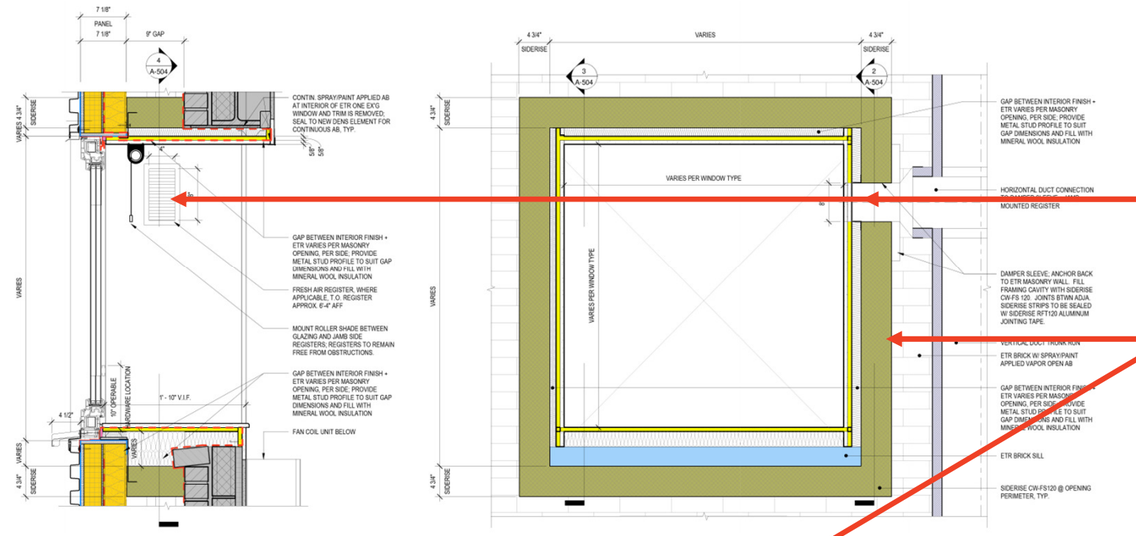
SYSTEMS

HVAC

HVAC MOCK-UPS, IN PROGRESS



SUPPLY AIR REGISTER LOCATED HIGH IN WINDOW JAMB

2 HR FIRE BARRIER AT ALL WINDOW PERIMETERS

FIRE DAMPER LOCATED IN DAMPER SLEEVE, IN PLANE WITH 2 HR FIRE BARRIER

AIR BARRIER CONNECTION @ WINDOW RETURNS

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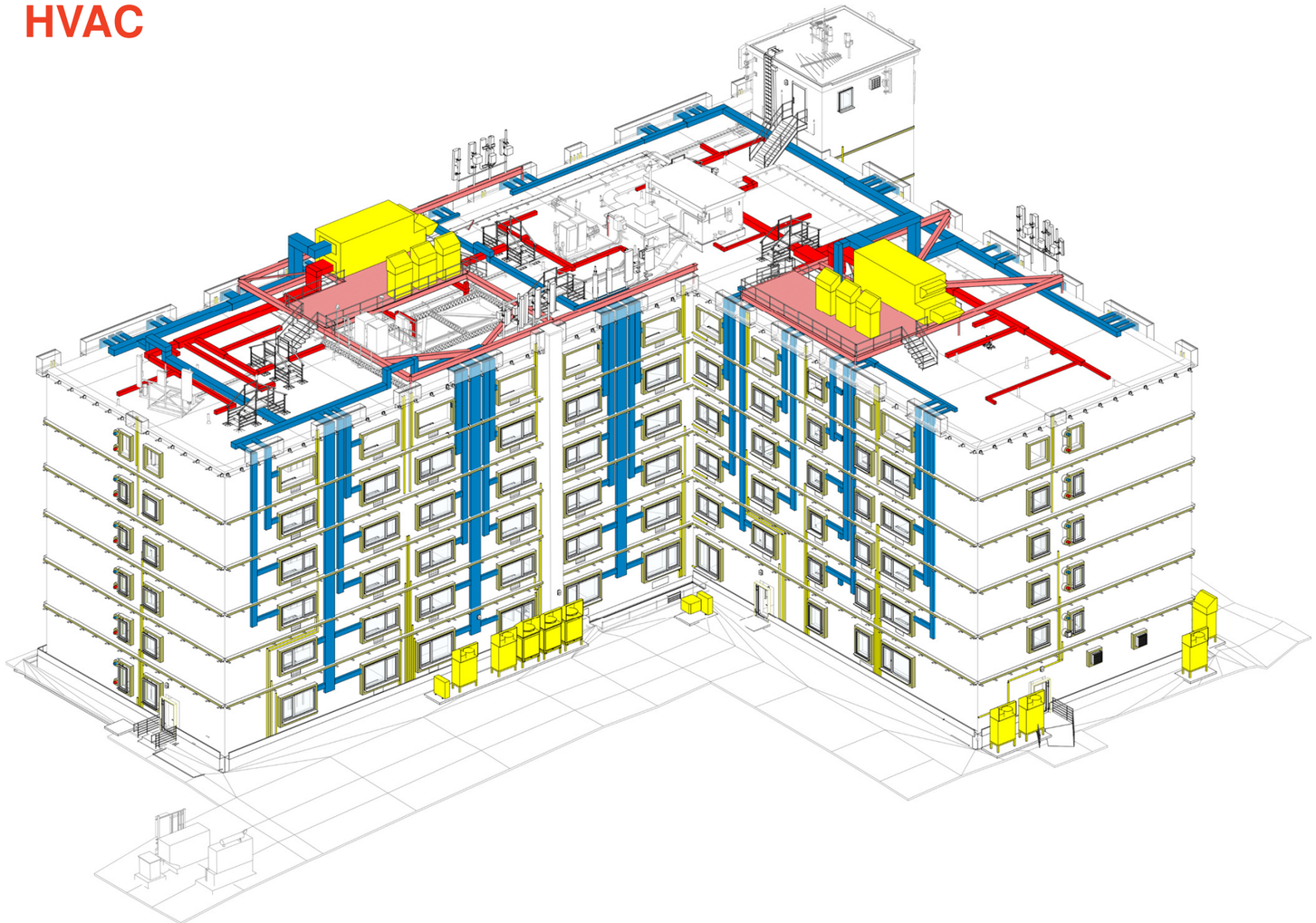
SYSTEMS

HVAC



REPLICABILITY:

-ACHP'S AND FAN COIL UNITS = STANDARD SYSTEMS AND APPROACH
-SEMI-CENTRALIZED VENTILATION

CO_2 EMISSIONS REDUCTION:

-FULL ELECTRIFICATION
-OPERATIONAL CARBON REDUCTION THRU HIGH EFFICIENCY EQUIPMENT

OCCUPANT IMPACT:

-FAN COILS REPLACE THRU-WALL AC UNITS IN SAME LOCATION
-PHASED INSTALL OF ELECTRICAL LOAD CENTER UPGRADES PRIORITIZED
-RE-USING EX'G EXHAUST DUCTS + SHAFTS
-NEW SUPPLY AIR DUCTS RUN EXTERIOR OF EX'G WALL
-NEW REFRIGERANT AND CONDENSATE LINESETS RUN EXTERIOR OF EX'G WALL
-SUPPLY REGISTER INTEGRATED INTO NEW WINDOW ASSEMBLY

ENVELOPE

EXTERIOR OVERCLAD

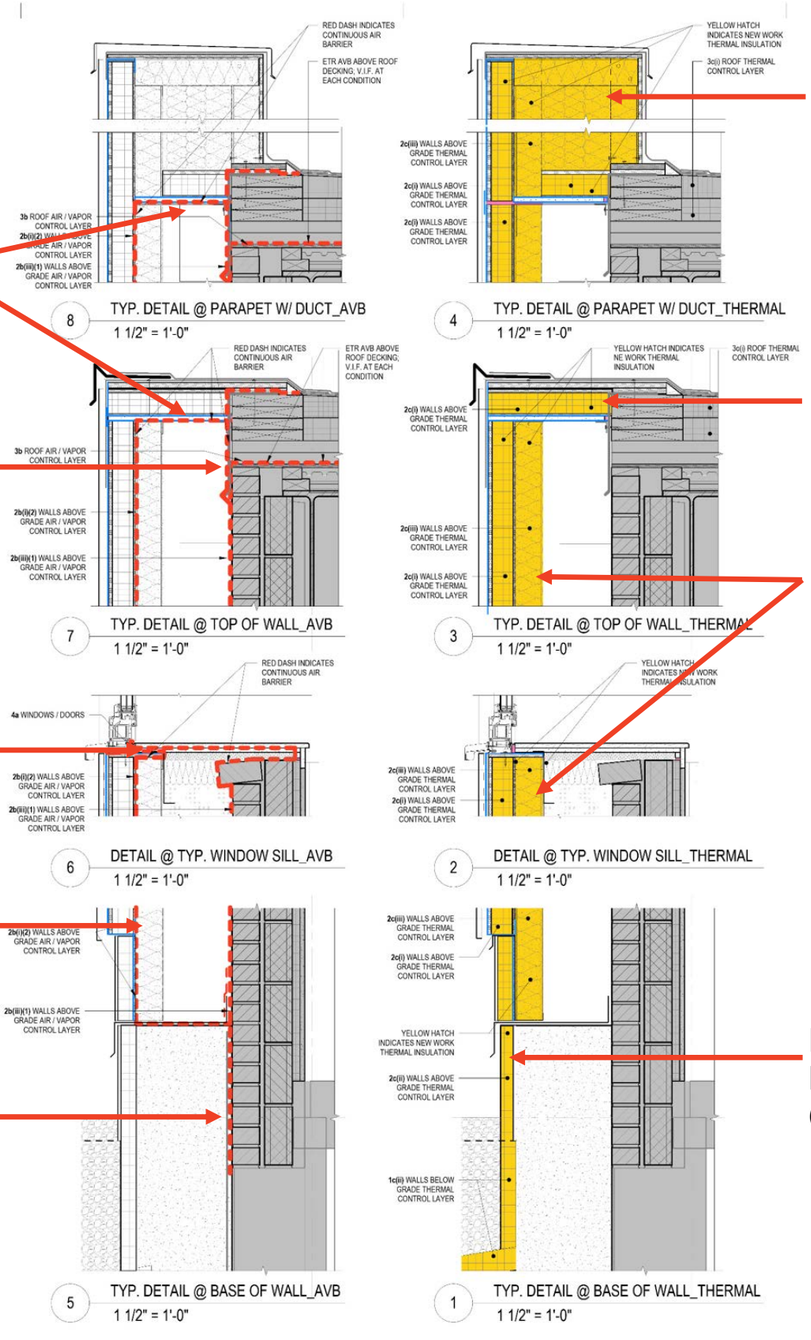
PRIMARY + SECONDARY AB'S CONNECTED @ TOP OF WALL

EX'G ROOF EDGE CAP FLASHING TO REMAIN IN PLACE; SEALED IN PLACE AND WRAPPED WITH AB MEMBRANE

PRIMARY + SECONDARY AB'S CONNECTED AT ALL SIDES OF OPENING PERIMETER

<u>SECONDARY AB:</u>
BACKSIDE OF STRUCTURAL INSULATED SHEATHING

<u>PRIMARY AB:</u>
FLUID AB COATING ON EX'G. MASONRY



AIR CONTROL LAYERS

THERMAL CONTROL LAYERS

PARAPET FILLED W/ MINERAL WOOL CAVITY INSUL.

STRUCTURAL INSULATED SHEATHING PANEL @ TOP OF WALL, ~R-21

OVERCLAD WALL PANEL ASSEMBLY INCLUDES STRUCTURAL INSULATED SHEATHING, ~R-21 AND ~R-14 MINERAL WOOL CAVITY BATT @ LGMF

RIGID INSUL. @ EXTERIOR F.O. NEW CONCRETE CURB FOUNDATION, ~R-10

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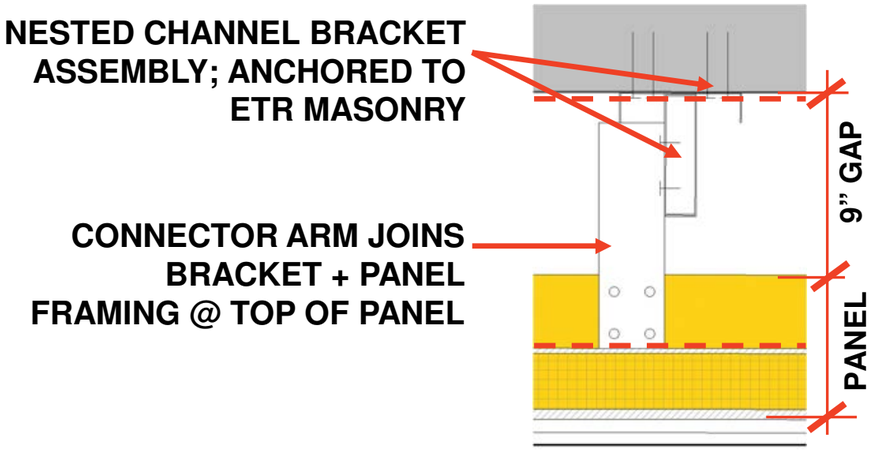
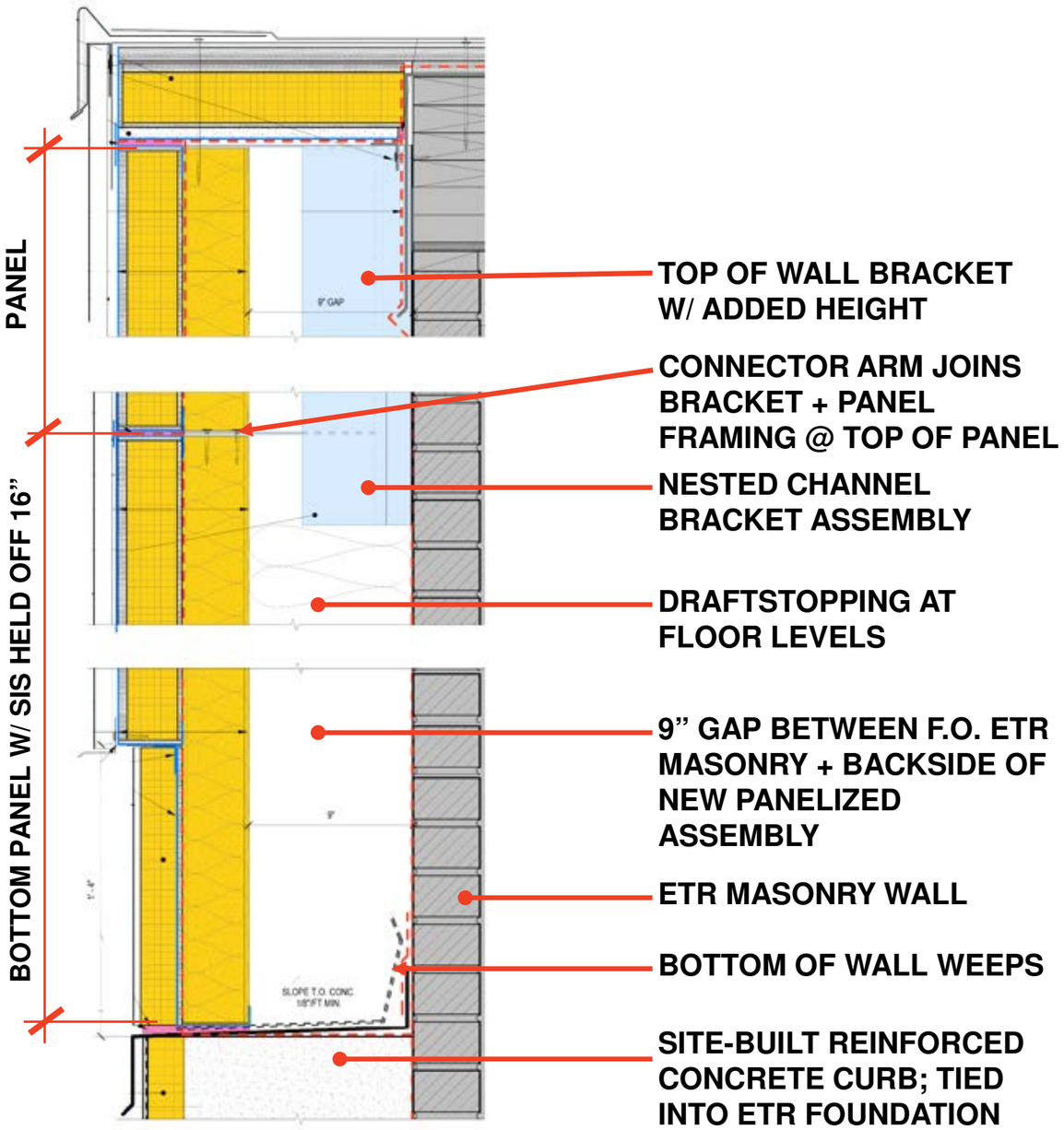
ENVELOPE

EXTERIOR OVERCLAD



PANELIZED WALL SYSTEM MOCK-UP, IN PROGRESS



SALEM FAIRWEATHER

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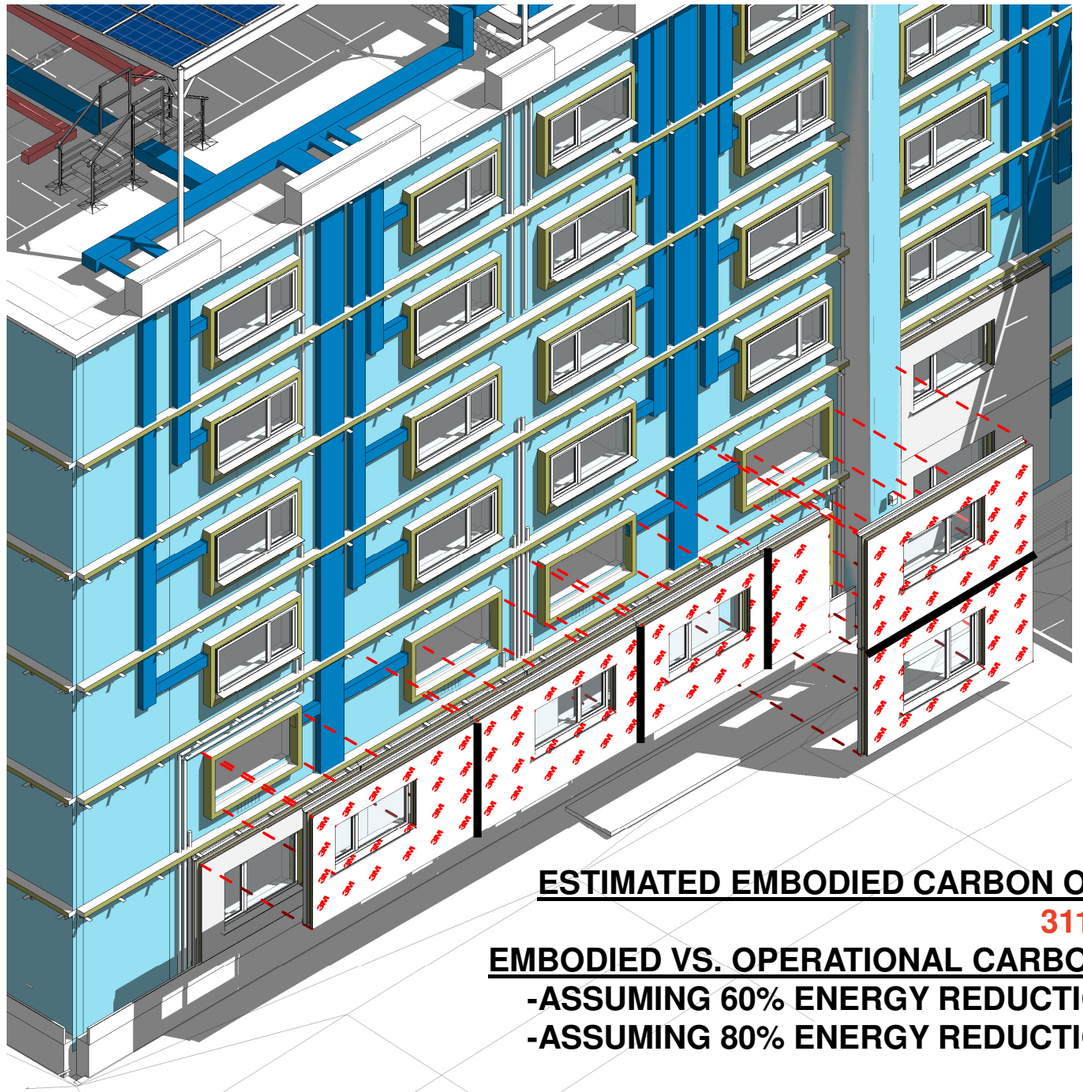
ENVELOPE

EXTERIOR OVERCLAD



ESTIMATED EMBODIED CARBON OF RETROFIT:
311.16 MT CO2e

EMBODIED VS. OPERATIONAL CARBON PAYBACK:
-ASSUMING 60% ENERGY REDUCTION: 3.40 YRS
-ASSUMING 80% ENERGY REDUCTION: 1.23 YRS

PRELIMINARY EMBODIED CARBON ANALYSIS (RMI)

PANELIZED

PANELIZED WALL		
COMPONENT / FUNCTION	MATERIAL EPD FACTOR / 100 SF	
LIQUID APPLIED VP AB	49.7	kG CO2e / 100 SF
9" AIR GAP	28	kG CO2e / 100 SF
STRUCTURAL FRAME	61.2	kG CO2e / 100 SF
CAVITY INSULATION	24	kG CO2e / 100 SF
STRUCTURAL SHEATHING	212	kG CO2e / 100 SF
AIR, VAPOR, WATER BARRIER	4.62	kG CO2e / 100 SF
MISC METAL ANGLES	12.2	kG CO2e / 100 SF
CLADDING	225	kG CO2e / 100 SF
	616.72	**kG CO2e / 100 SF**
	210.22	MT CO2e

WINDOWS		
COMPONENT / FUNCTION	MATERIAL EPD FACTOR / 100 SF	
VINYL FRAME, TRIPLE PANE	920	kG CO2e / 100 SF
	920	**kG CO2e / 100 SF**
	47.99	MT CO2e

WORK COMPLETE 2023

ROOF		
COMPONENT / FUNCTION	MATERIAL EPD FACTOR / 100 SF	
ROOF COVERBOARD OVER EXISTING	99.2	kG CO2e / 100 SF
AIR BARRIER	8.75	kG CO2e / 100 SF
INSULATION	237	kG CO2e / 100 SF
RECOVERY BOARD	39	kG CO2e / 100 SF
ROOF MEMBRANE	41	kG CO2e / 100 SF
	424.95	**kG CO2e / 100 SF**
	52.95	MT CO2e

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ENVELOPE

EXTERIOR OVERCLAD

REPLICABILITY:

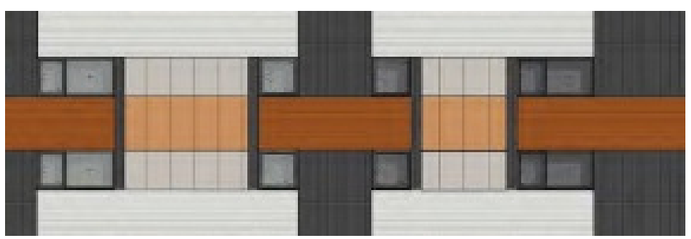
-PANELIZED SOLUTION
-FLEXIBLE ATTACHMENT DESIGN TO ADDRESS 9” GAP

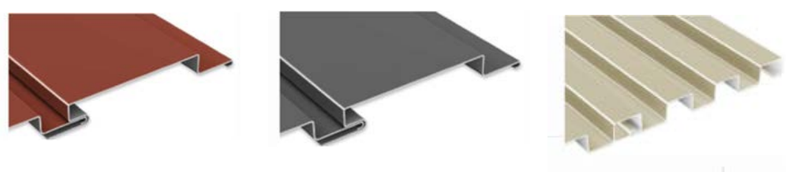
CO2 EMISSIONS REDUCTION:

-OPERATIONAL CARBON REDUCTION THRU IMPROVED AIR AND THERMAL CONTROL LAYERS

OCCUPANT IMPACT:

-WINDOWS INSTALLED IN PANEL; ONLY INTERIOR OPENING FINISHES / TIE IN BETWEEN PRIMARY + SECONDARY AB’S REQUIRE ACCESS TO APARTMENTS
-EFFICIENT PANEL INSTALL / TIME ON SITE





METAL PANEL EXTERIOR CLADDING

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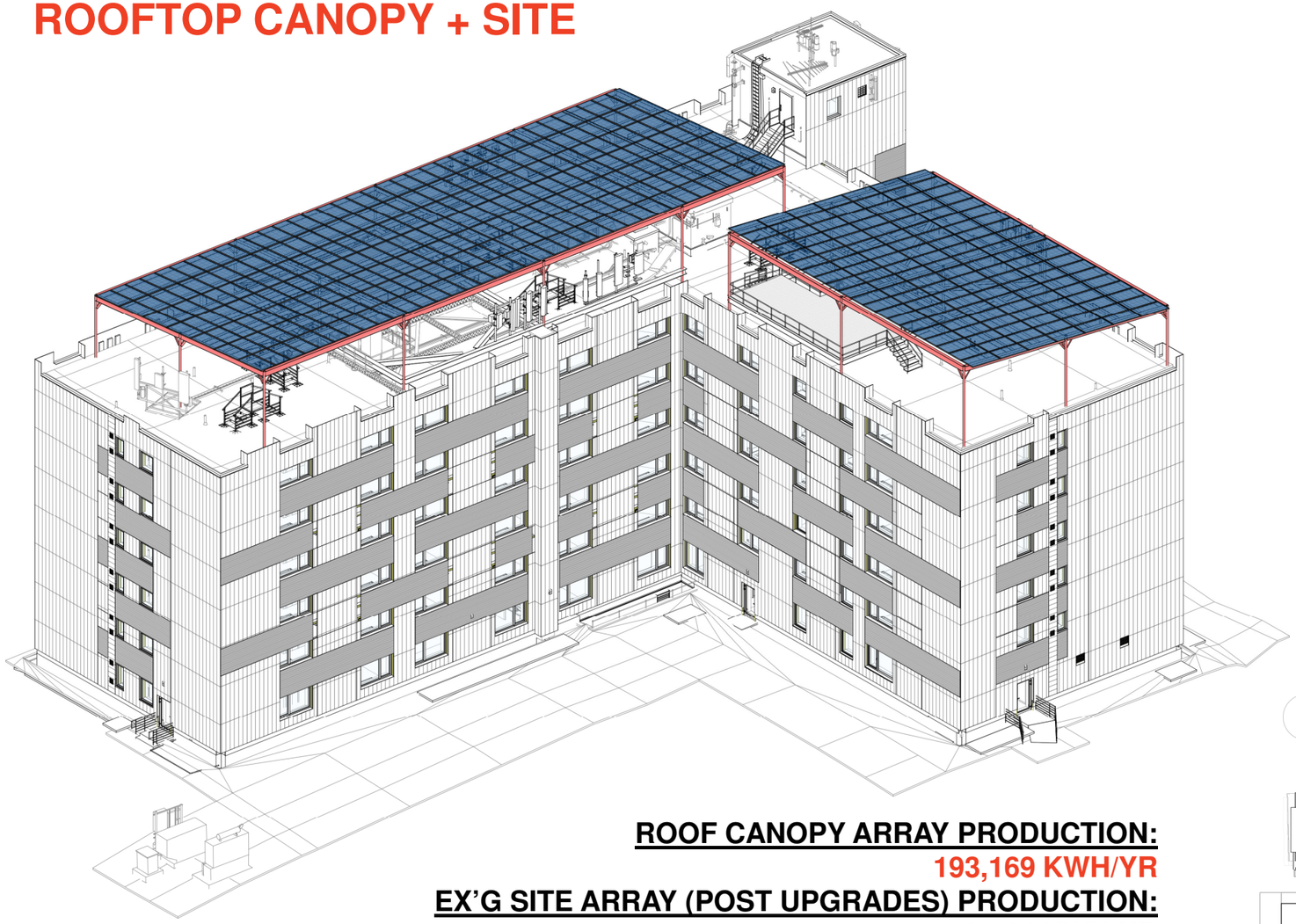
SOLAR

ROOFTOP CANOPY + SITE

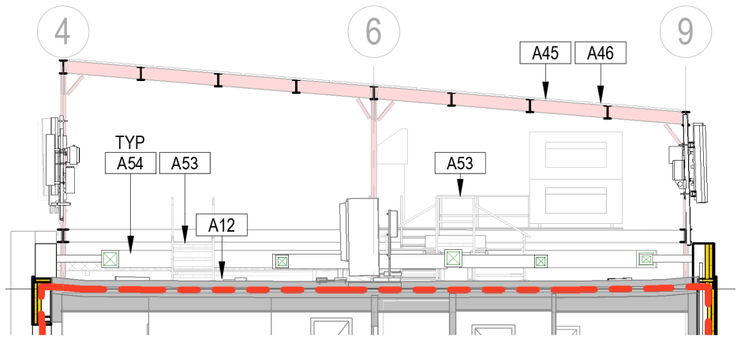


ROOF CANOPY ARRAY PRODUCTION:
193,169 KWH/YR
EX'G SITE ARRAY (POST UPGRADES) PRODUCTION:
52,503 KWH/YR
TOTAL ARRAY:
245,672 KWH/YR / 220.19 KW

REPLICABILITY:
-SIMPLE CANOPY DESIGN; INTEGRATED WITH ROOFTOP DUNNAGE REQUIRED FOR NEW EQUIPMENT

CO2 EMISSIONS REDUCTION:
-OPERATIONAL CARBON REDUCTION CONTRIBUTES TO THE OVERALL PROJECTED 92% REDUCTION IN EUI

OCCUPANT IMPACT:
-AVOIDS INTERFERENCE WITH ROOFTOP TENANT EQUIPMENT MOUNTED BELOW



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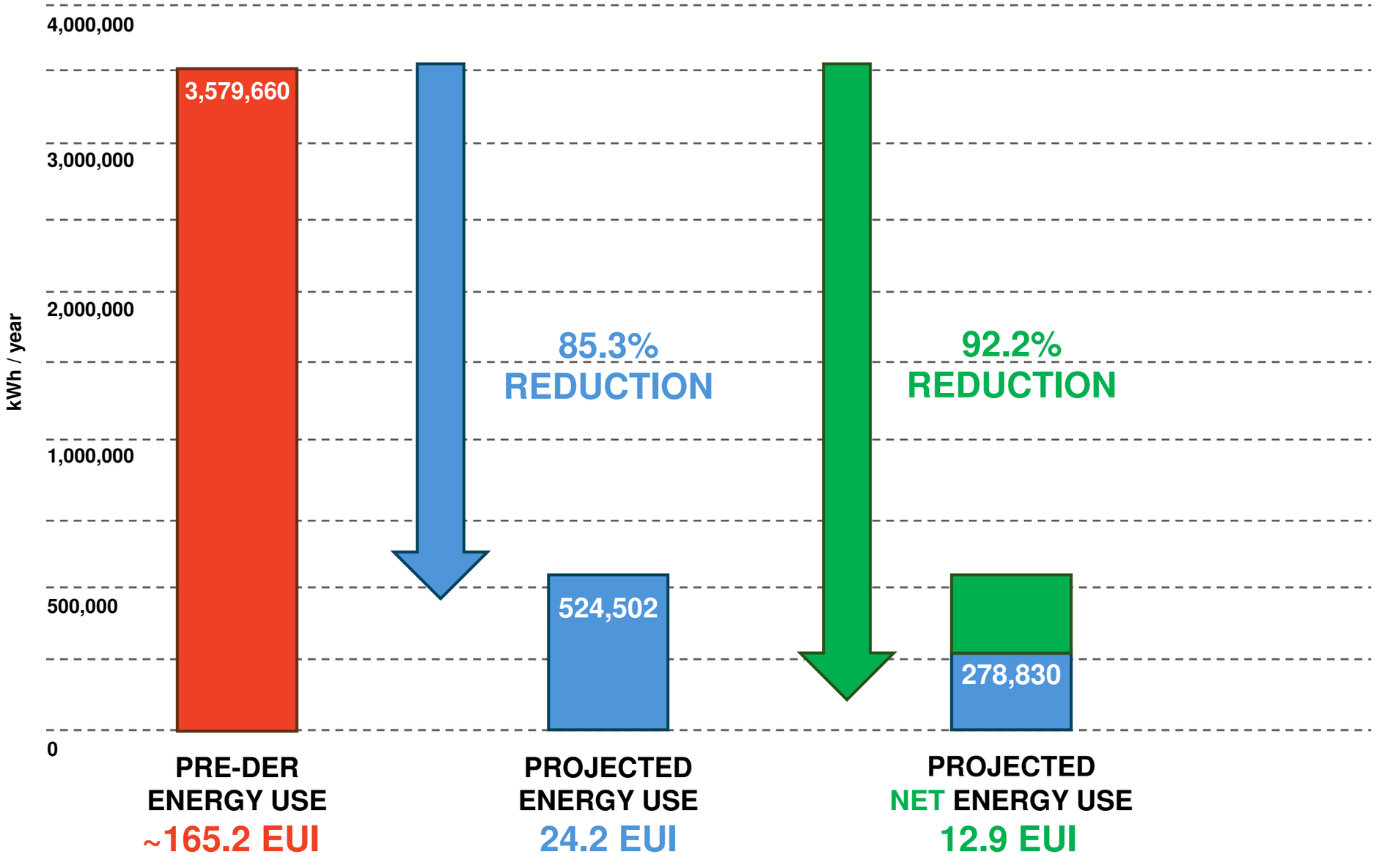
SALEM, MA

RESULTS

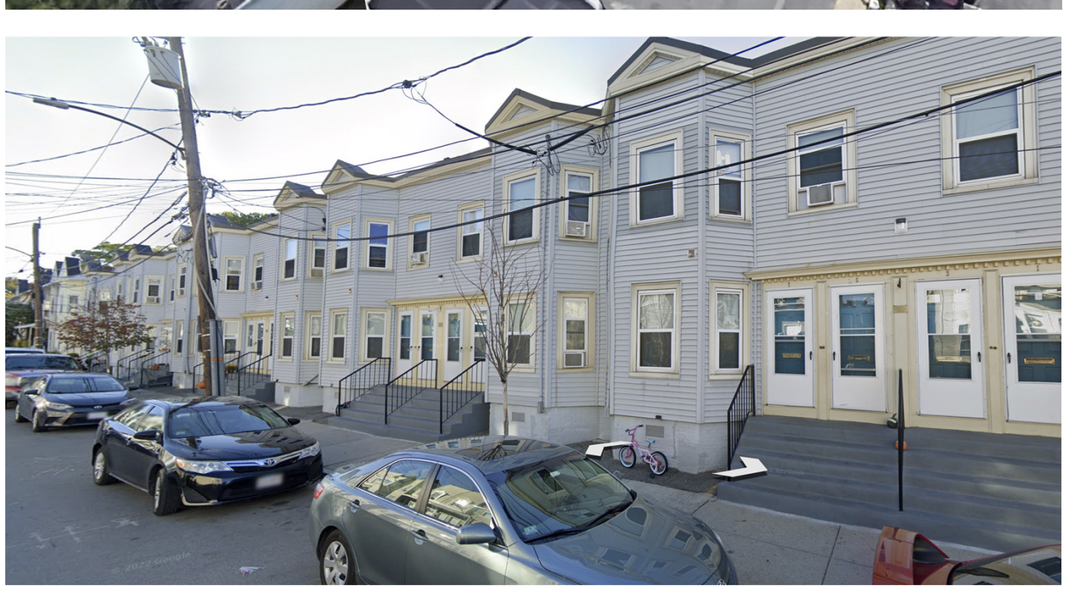

4,000,000
3,000,000
2,000,000
1,000,000
500,000
0
kWh / year
3,579,660
524,502
278,830
85.3%
REDUCTION
92.2%
REDUCTION
PRE-DER
ENERGY USE
~165.2 EUI
PROJECTED
ENERGY USE
24.2 EUI
PROJECTED
NET ENERGY USE
12.9 EUI

HANO HOMES APARTMENTS

ALLSTON BRIGHTON, MA

Allston Brighton COMMUNITY DEVELOPMENT CORPORATION

BACKGROUND



BUILDING STATS:

- 10 ATTACHED DUPLEXES
- CONSTRUCTED IN 1890s, WITH MULTIPLE INTERIOR & EXTERIOR RENOVATIONS SINCE
- WOOD-FRAMED CONSTRUCTION
- 2 STORIES + BASEMENT
- 20 UNITS – MIX OF 2- & 3-BEDROOM UNITS
- 26,018 GSF TOTAL

UNIQUE FEATURES / CHALLENGES:

- SMALL SITE WITH TIGHT CLEARANCE TO PROPERTY LINES
- BRICK PARTY WALLS BETWEEN EACH STACKED DUPLEX
- EXPLORATORY DEMO REVEALED DEGRADATION OF SHEATHING & STRUCTURAL FRAMING

UTILITY STRUCTURE / EXISTING SYSTEMS:

- DECENTRALIZED, GAS-FIRED DHW & HYDRONIC BASEBOARD HEATING (ONE SYSTEM PER UNIT)
- OWNER PAYS FOR GAS; TENANTS PAY FOR ELECTRIC
- NO EXISTING A/C, WINDOW UNITS USED BY SOME TENANTS
- NO VENTILATION, OTHER THAN KITCHEN / BATHROOM EXHAUST

EXISTING ENERGY PERFORMANCE:

- ESTIMATED BASELINE EUI = 59.2 KBTU/SFYR

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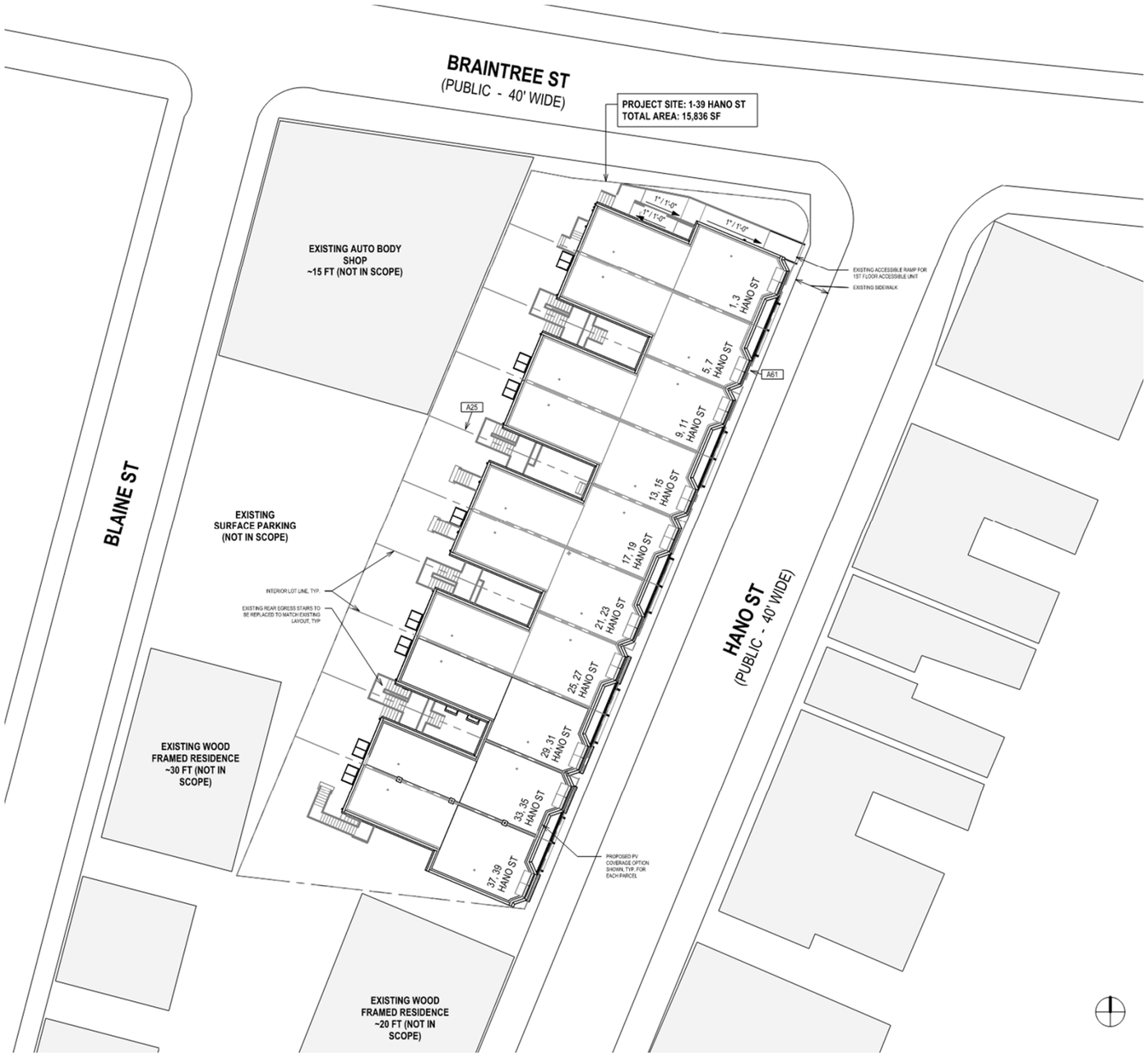
BACKGROUND



REPLICABILITY:
SMALL-SCALE PROJECT, CHALLENGING FORM

CO2 EMISSION REDUCTION:
AIMING FOR DRASTIC REDUCTION IN ENERGY LOAD

OCCUPANT IMPACT:
SOME INTERIOR WORK NECESSARY

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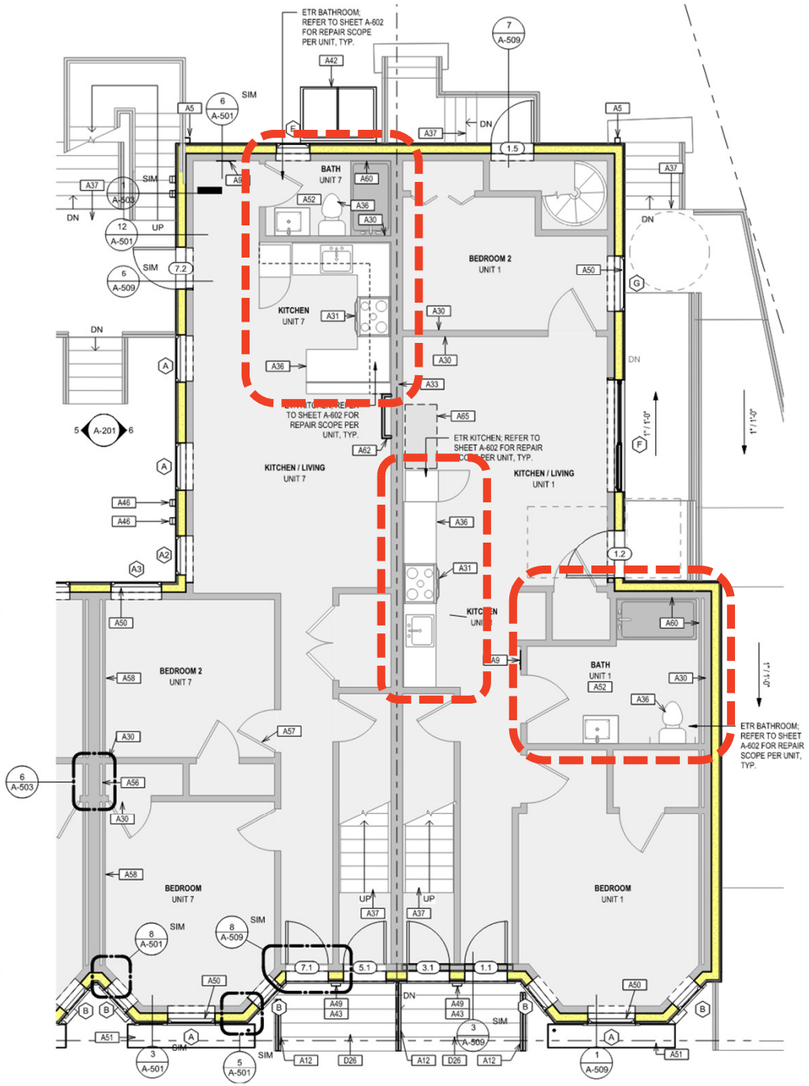
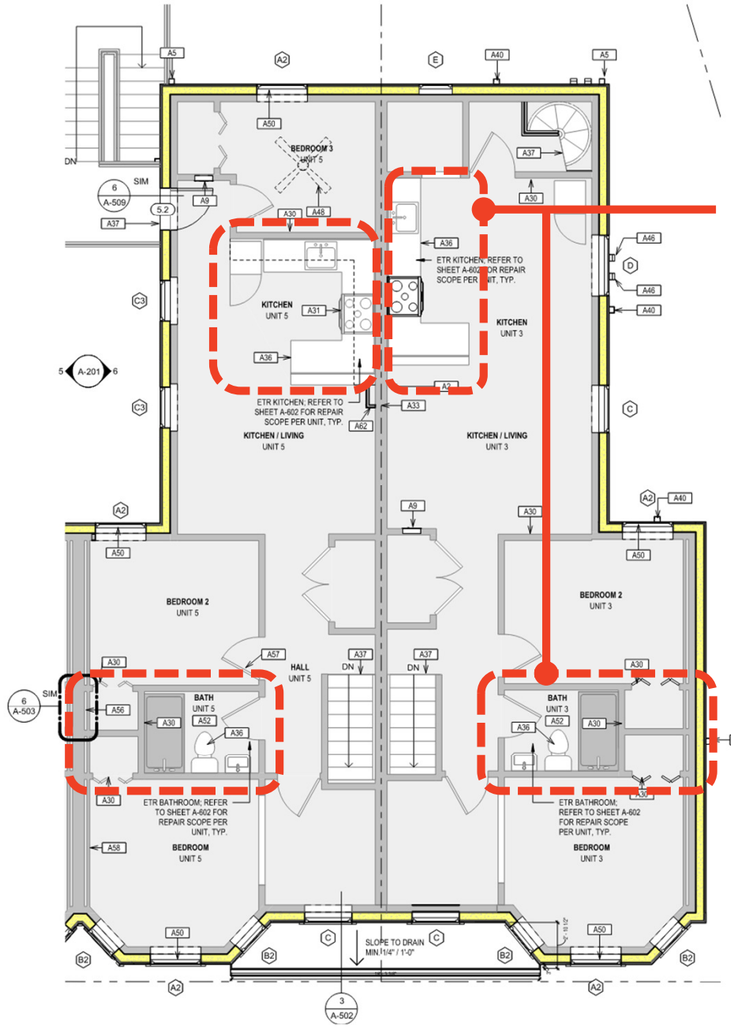
BACKGROUND



LEVEL 1



LEVEL 2

TYPICAL INTERIOR SCOPE:

- NEW APPLIANCES, FIXTURES, CASEWORK, & FINISHES WHERE IDENTIFIED OR REQUIRED FOR PHIUS PRE-REQ'S
- DISCONNECT EXISTING KITCHEN & BATHROOM EXHAUST
- NEW MECHANICAL SHAFTS & SOFFITS

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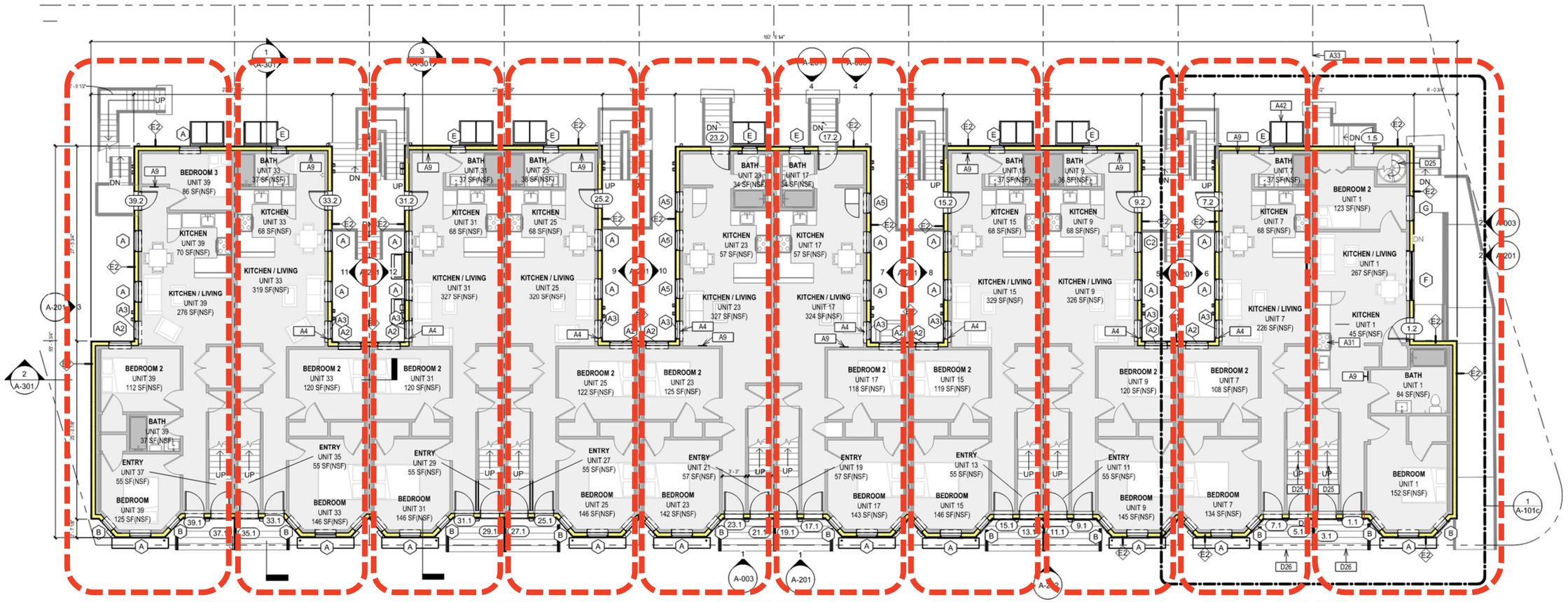
BACKGROUND

PHASING & TENANT RELOCATION



- OWNER-IDENTIFED & PHIUS PRE-REQ-RELATED INTERIOR UPGRADES
- HVAC ROUTING DESIGNED ASSUMING INTERIOR ACCESS
- 10 PHASED RELOCATIONS – 2 WEEKS EACH

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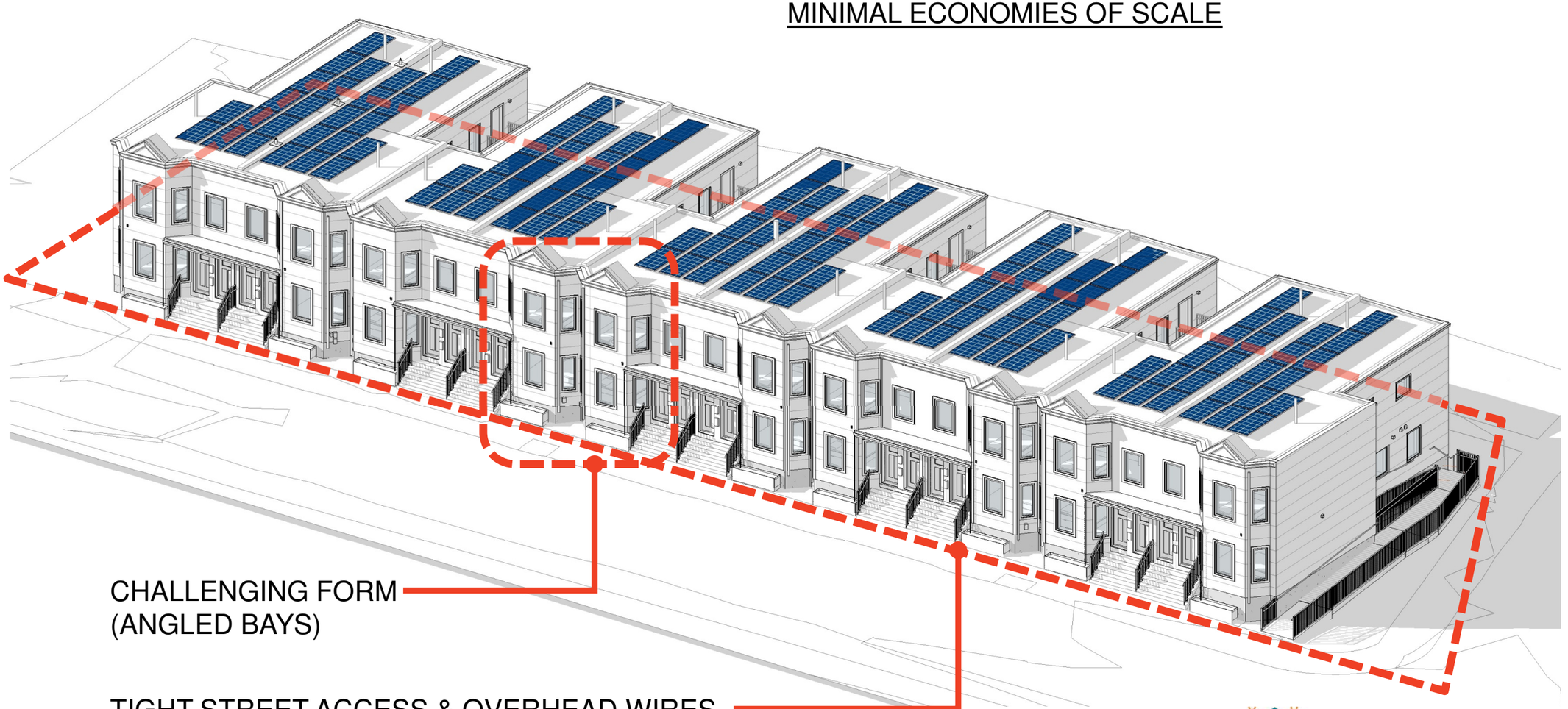
ENVELOPE

SITE-BUILT VS. PANELIZED

SMALL SCALE PROJECT +
MINIMAL ECONOMIES OF SCALE



CHALLENGING FORM
(ANGLED BAYS)

TIGHT STREET ACCESS & OVERHEAD WIRES
WITH MINIMAL CLEARANCE FOR PANELS

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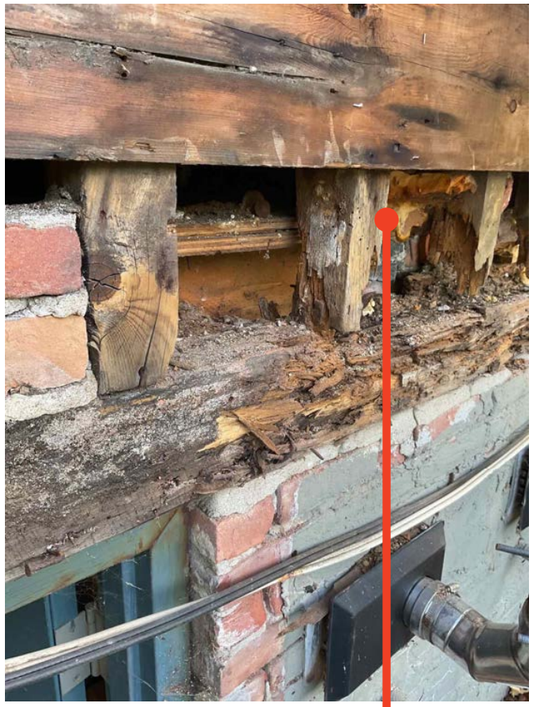
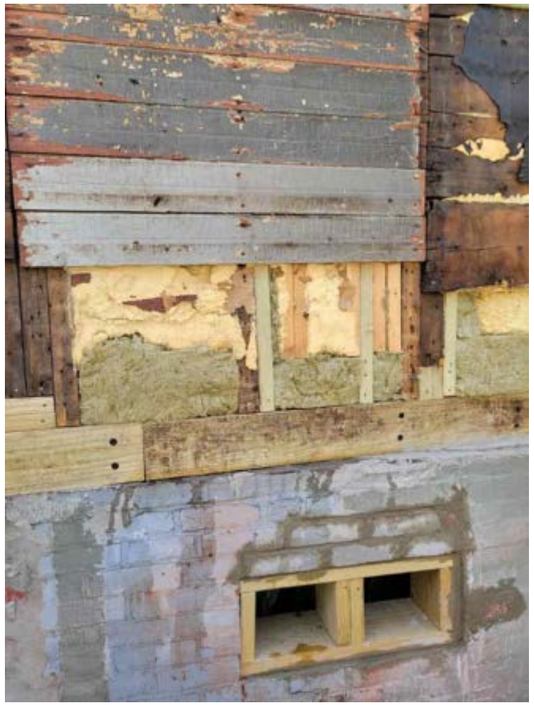
ENVELOPE

EXTENT OF DEMO





REMOVE WALL MATERIALS BACK TO EXISTING SKIPBOARD SHEATHING, LEAVE INTERIOR INSULATION UNTOUCHED

AREAS OF PARTICULAR DAMAGE: SILL PLATES, SHEATHING AROUND WINDOWS & DOORS

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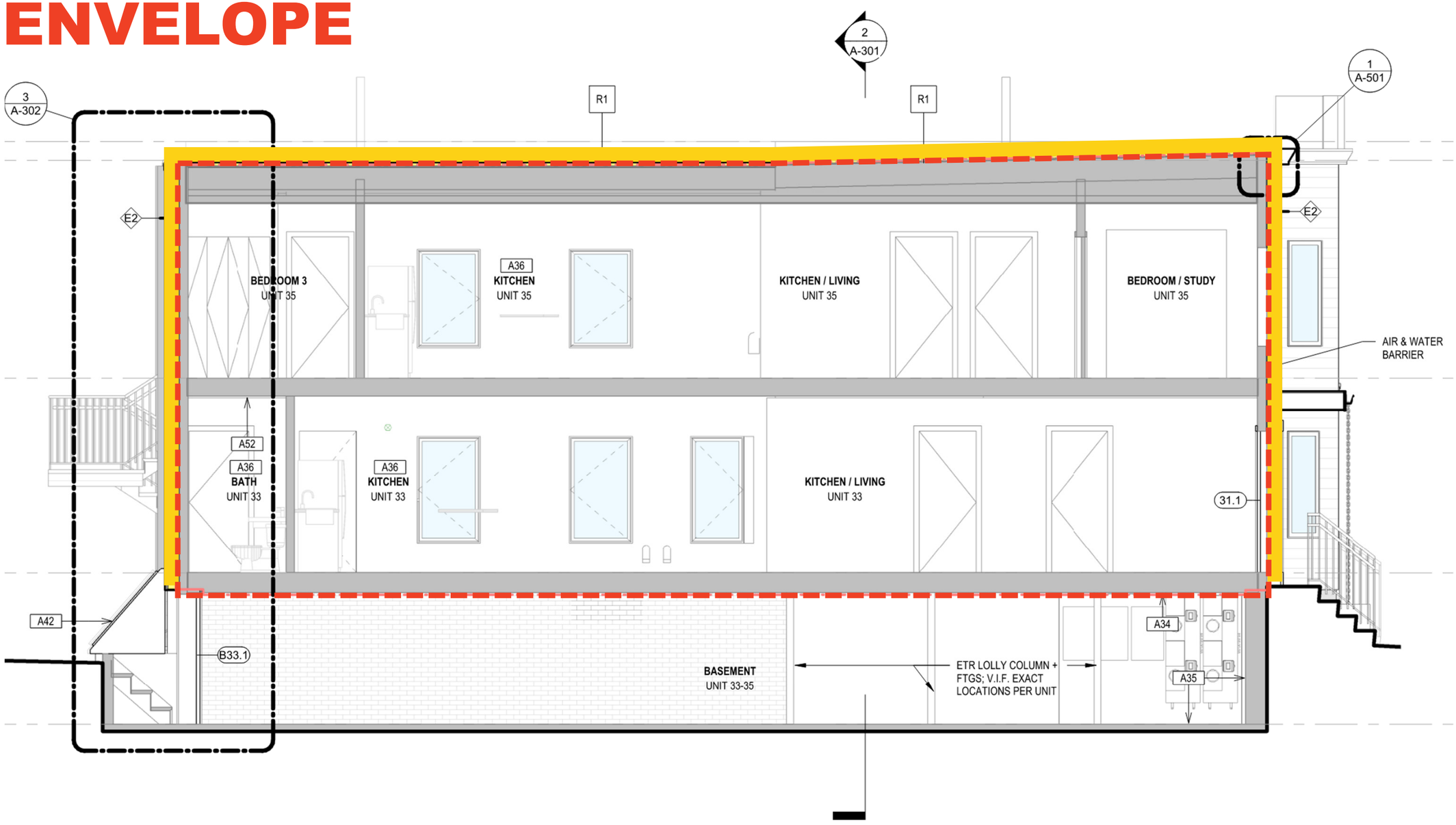
ENVELOPE



WHAT ENVELOPE IMPROVEMENTS ARE NEEDED FOR FULL BUILDING ELECTRIFICATION & PHIUS REVIVE 2021 CERTIFICATION?

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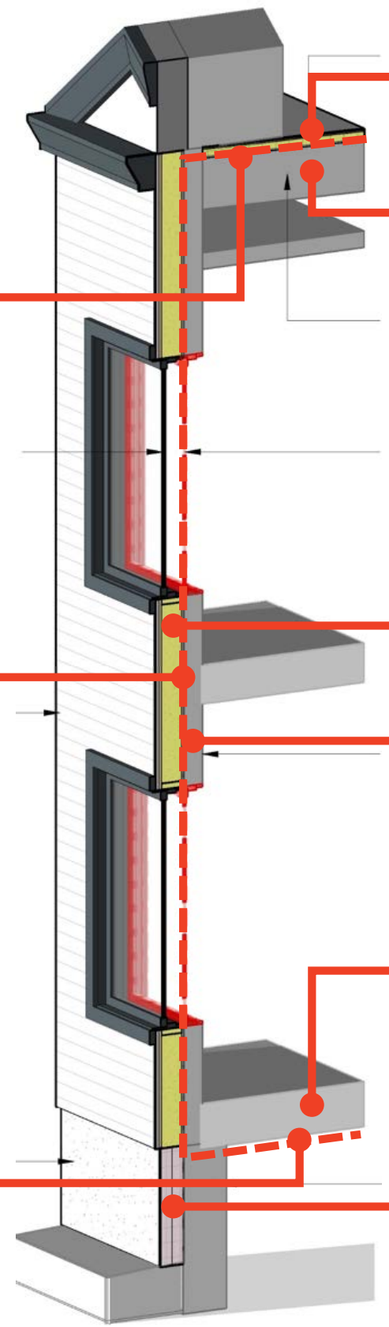
ENVELOPE

EXTERIOR ASSEMBLIES



EXISTING EPDM ROOF MEMBRANE

NEW STRUCTURAL ZIP SHEATHING WITH INTEGRAL AIR BARRIER / WRB

SPRAY-APPLIED AIR BARRIER ON CEILING

AIR CONTROL

NEW: 2” ADDED POLYISO AT ROOF (~R-14)

EXISTING: 8” CLOSED CELL SPRAY FOAM + 4” POLYISO (VAPOR-CLOSED, ~R-55)

~R-69

NEW: 5.5” WOOD FIBER BOARD OVERCLAD (~R-20)

EXISTING: 4” CLOSED CELL SPRAY FOAM (VAPOR-CLOSED, ~R-16)

~R-34

EXISTING: 3.5” CLOSED CELL SPRAY FOAM + 7.25” FIBERGLASS BATT (VAPOR-CLOSED)

~R-37

NEW: 6” EPS OVER FOUNDATION

~R-30

THERMAL CONTROL

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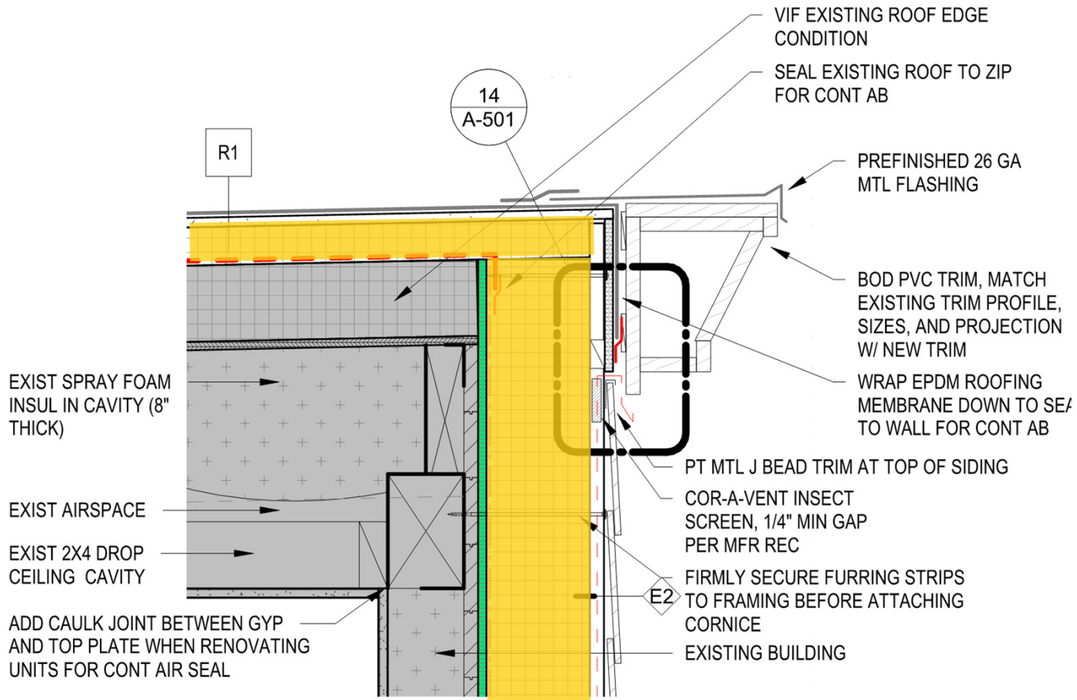
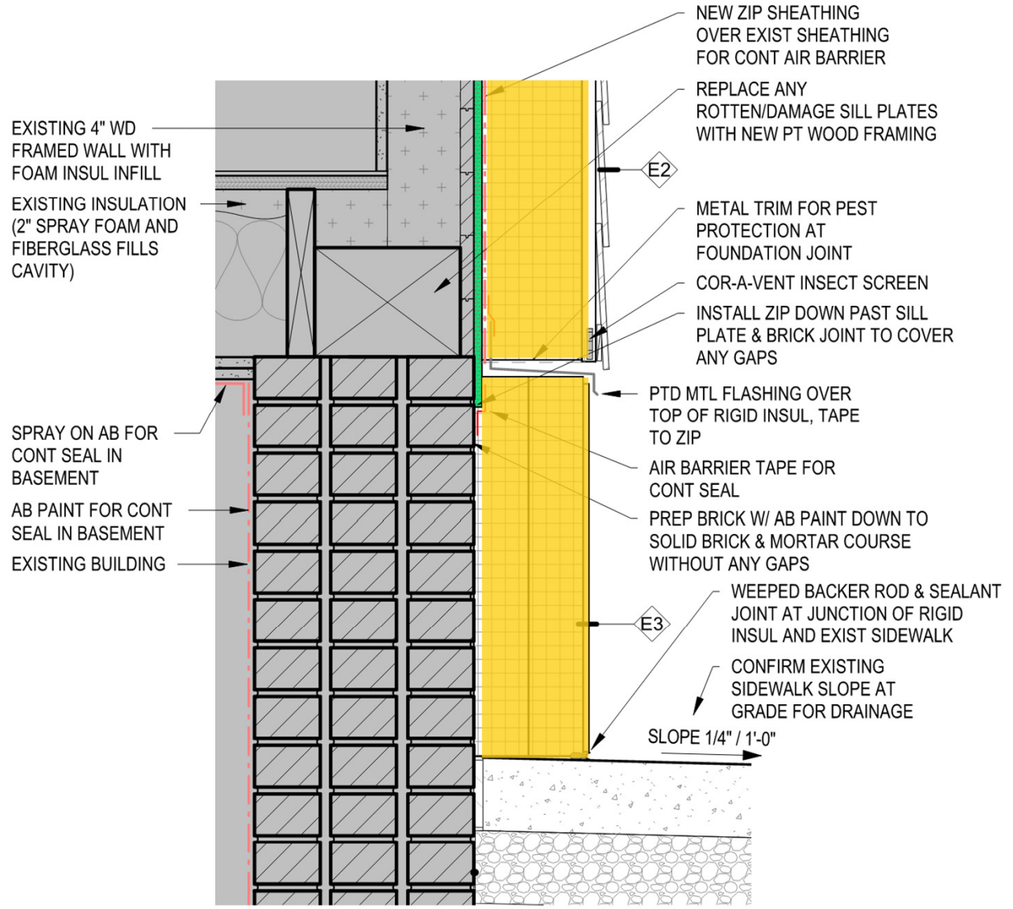
ENVELOPE

EXTERIOR ASSEMBLIES



1 FRONT CORNICE DETAIL-NEW

1 1/2" = 1'-0"



3 FOUNDATION AT FRONT WALL

1 1/2" = 1'-0"

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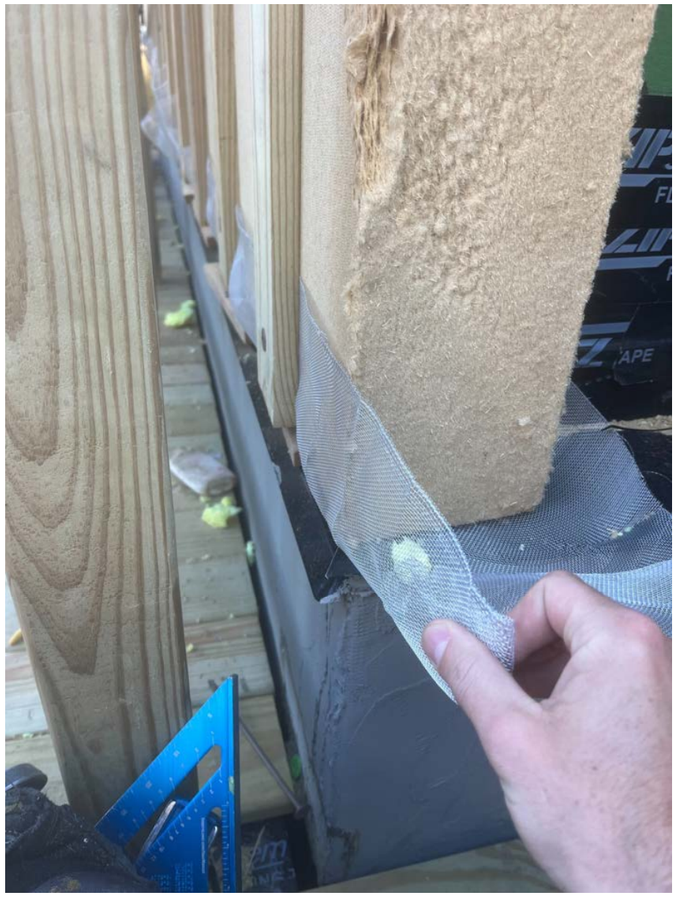
ENVELOPE

EXTERIOR ASSEMBLIES



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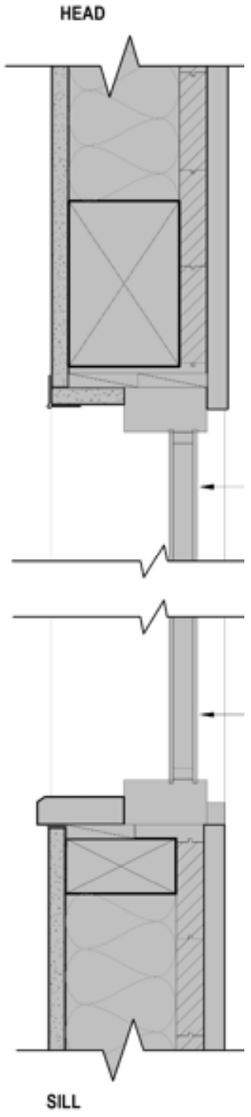
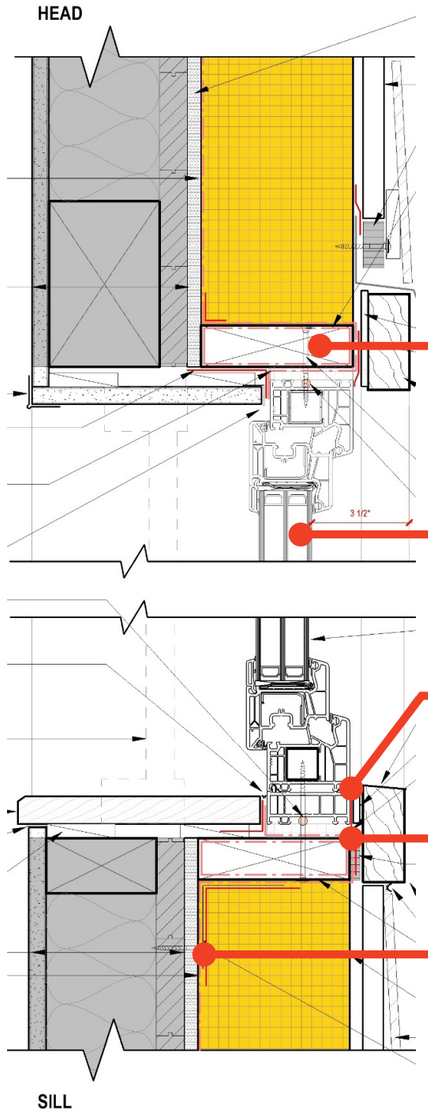
ENVELOPE

WINDOWS & DOORS



EXISTING



NEW

2X6 PREFAB BUCK WRAPPED IN SIGA FLASHING TAPE PRIOR TO INSTALLATION OF WINDOWS

TRIPLE PANE UPVC WINDOW (U-0.17)

CONTINUOUS SEALANT JOINT BETWEEN WINDOW FRAME & TRIM

CONTINUOUS AIR BARRIER TAPE AT F.O. WINDOW FRAME TO F.O. BUCK

3”x3” METAL SIMPSON CLIPS TO SUPPORT BUCK

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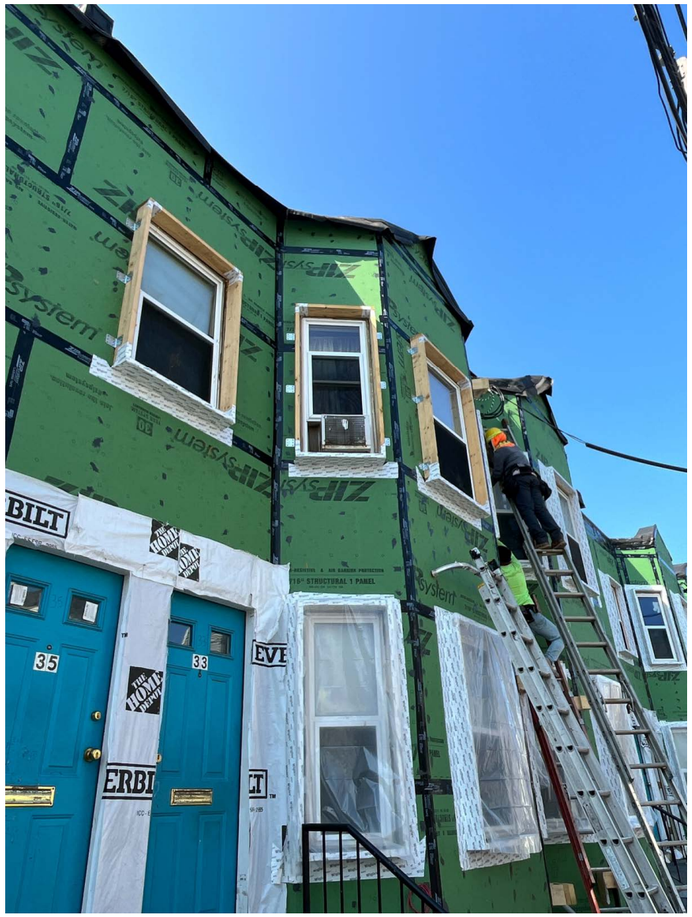
ENVELOPE

WINDOWS & DOORS



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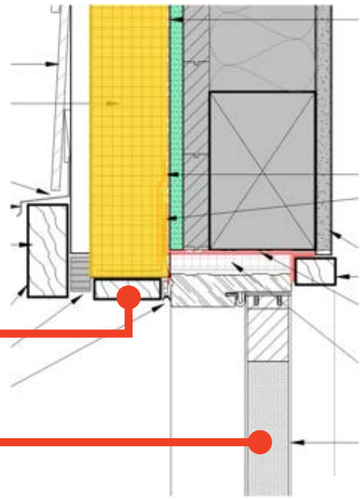
ENVELOPE

WINDOWS & DOORS



COMPOSITE TRIM WRAPPING OPENING

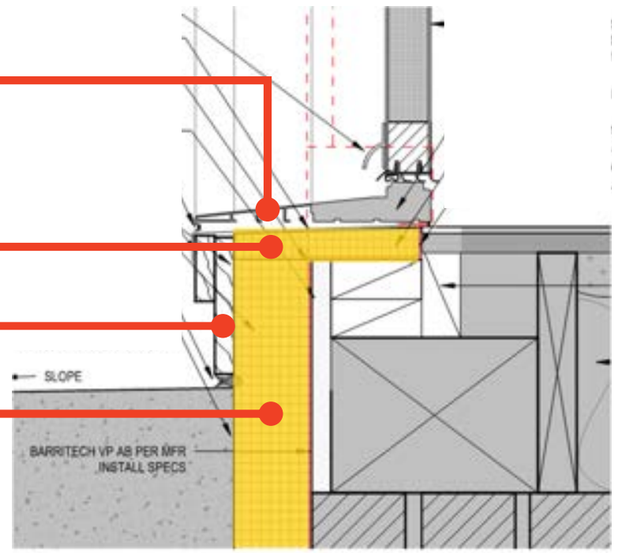
INSULATED FIBERGLASS DOOR INSTALLED WITHIN EXISTING ROUGH OPENING

SILL EXTENSION OVER EXTERIOR INSULATION AT FRONT ENTRY LANDING

STRUCTURAL FOAM SILL

COMPOSITE TRIM

3” EPS INSULATION IN NOTCH CUT IN CONCRETE LANDING



FRONT ENTRY

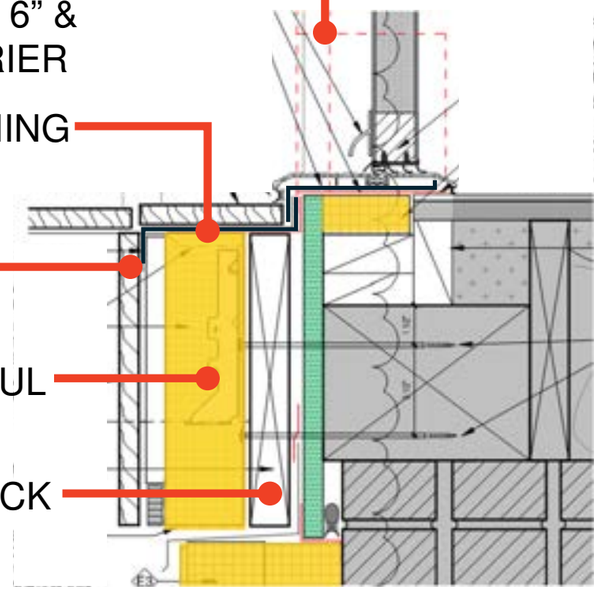
METAL SILL FLASHING WRAPPED UP JAMB 6” & TAPED TO AIR BARRIER

METAL DECK FLASHING

1X TRIM BOARD OVER INSULATION

MINERAL WOOL INSUL BETWEEN JOISTS

2X LEDGER FOR DECK FRAMING



BACK DECK

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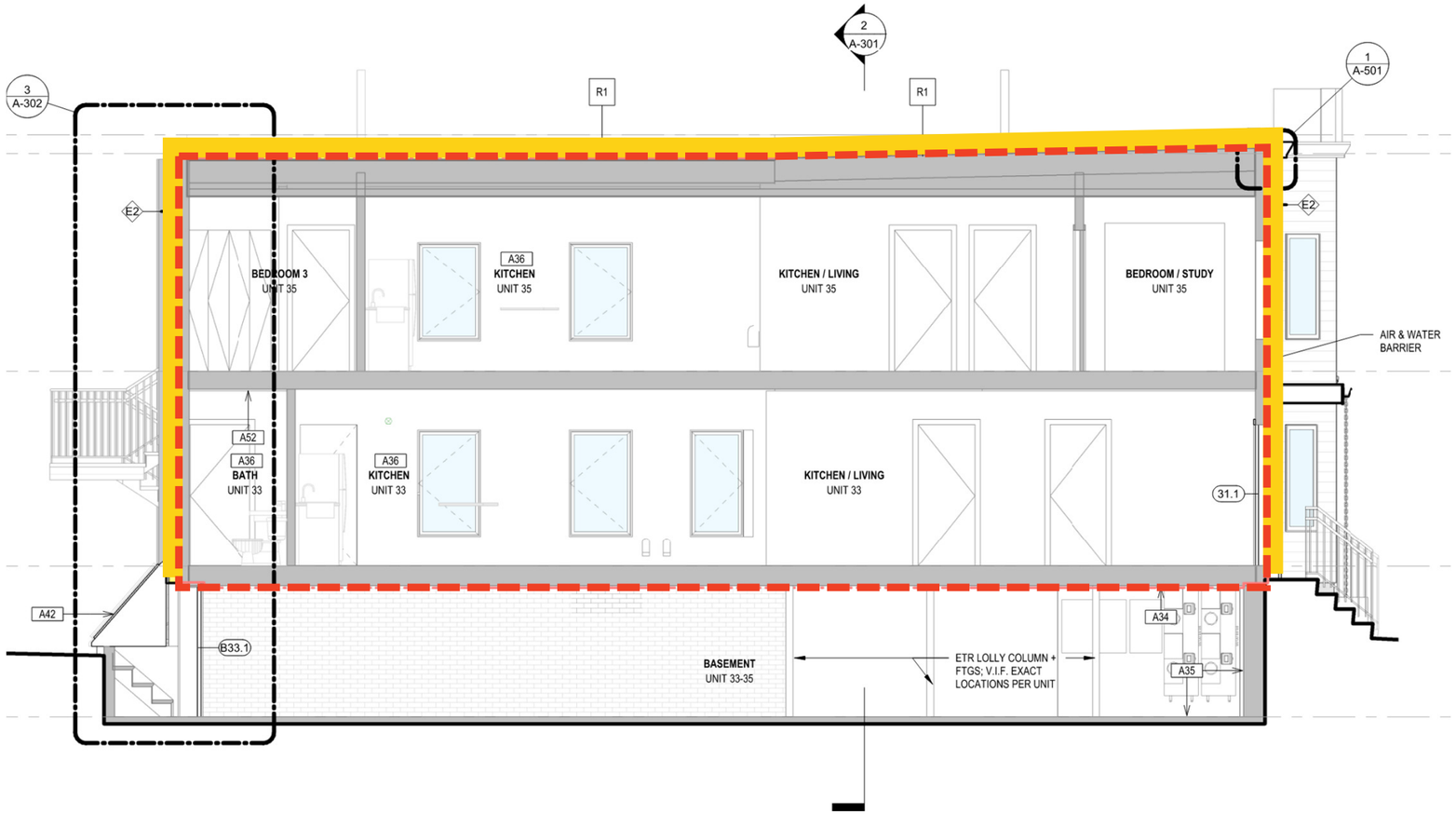
ENVELOPE



REPLICABILITY:
COMMON PRODUCTS & CONSTRUCTION METHODS

CO2 EMISSION REDUCTION:
AIRTIGHT, WELL-INSULATED ENVELOPE TO DECREASE CONDITIONING LOADS

OCCUPANT IMPACT:
LARGELY EXTERIOR INSTALLATION TO MNIMIZE TENANT DISPLACEMENT

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SYSTEMS

2-TON DAIKIN NON-DUCTED HEAT PUMP SYSTEM (ONE PER DWELLING UNIT)

100 CFM PANASONIC ERV IN BASEMENT (ONE PER DWELLING UNIT) – 70-80% EFFICIENCY

65 GALLON RHEEM HEAT PUMP WATER HEATER IN BASEMENT (ONE PER DWELLING UNIT)

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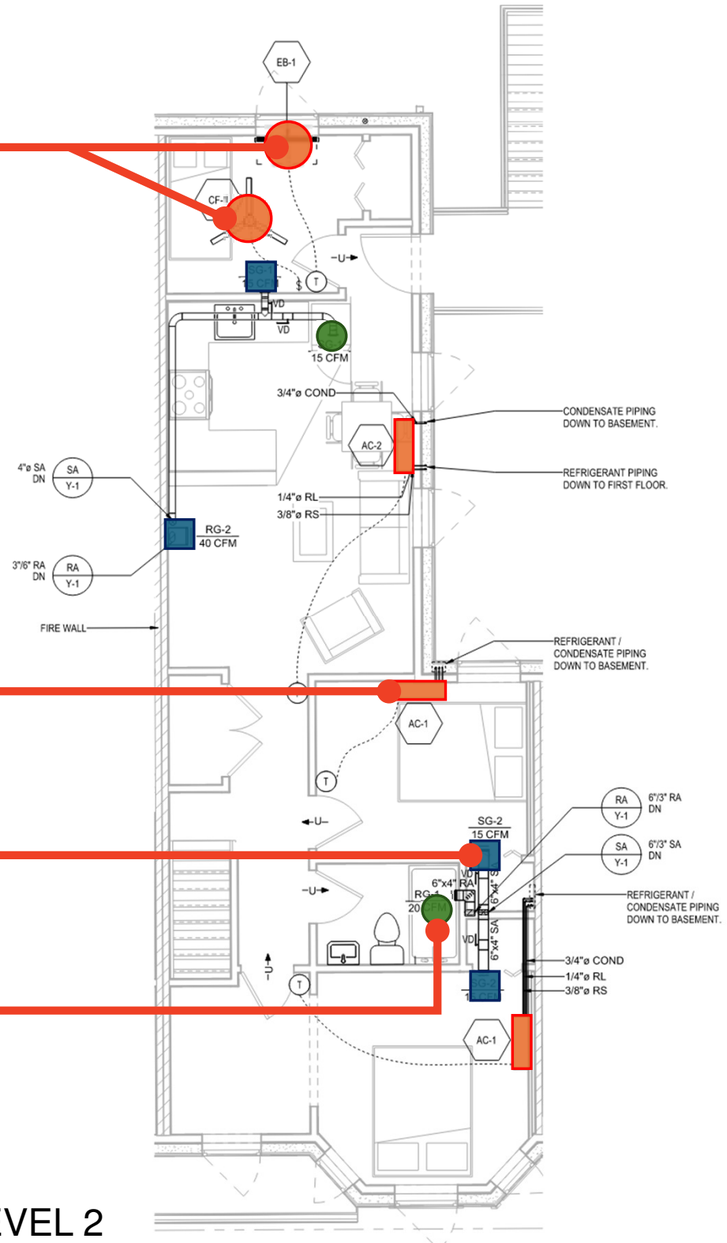
SYSTEMS

CEILING FAN & ELECTRIC RADIATOR IN THIRD BEDROOMS

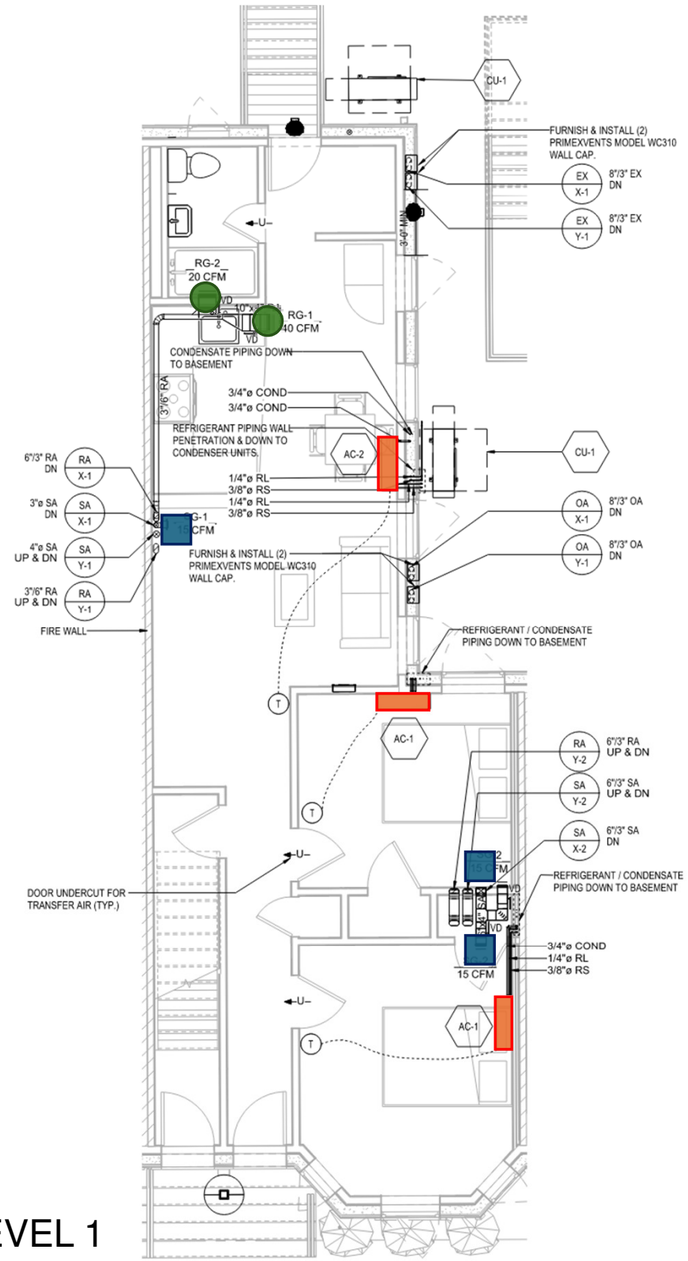
HEAT PUMP HEAD IN EACH BEDROOM & LIVING SPACE

ERV SUPPLY IN EACH BEDROOM & LIVING SPACE

ERV RETURN IN BATHROOM & KITCHEN



LEVEL 2



LEVEL 1

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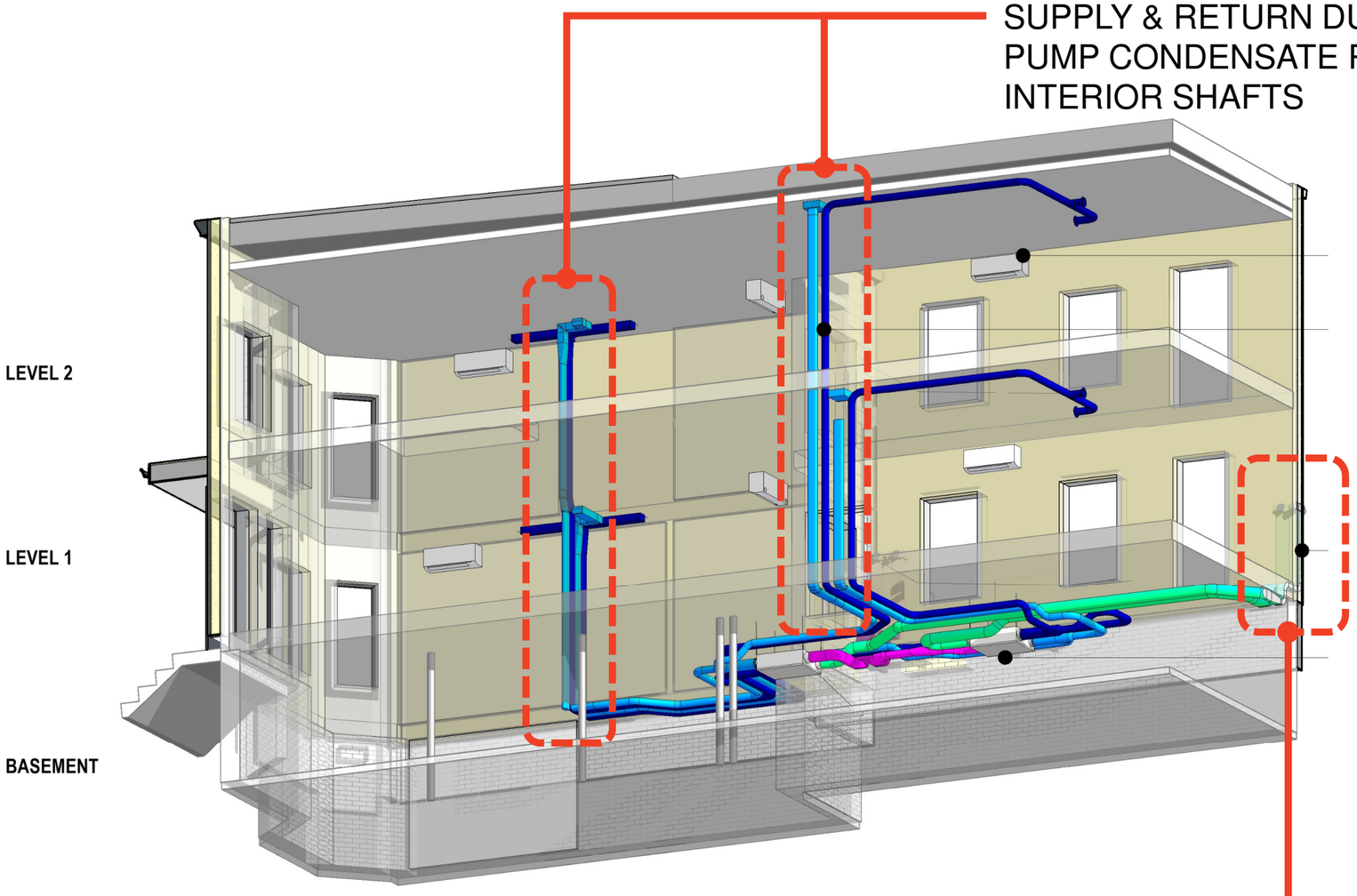
SYSTEMS

SUPPLY & RETURN DUCTWORK, HEAT PUMP CONDENSATE ROUTED THROUGH INTERIOR SHAFTS



OUTDOOR & EXHAUST AIR, REFRIGERANT LINESETS ROUTED THROUGH EXTERIOR OVERCLAD INSULATION

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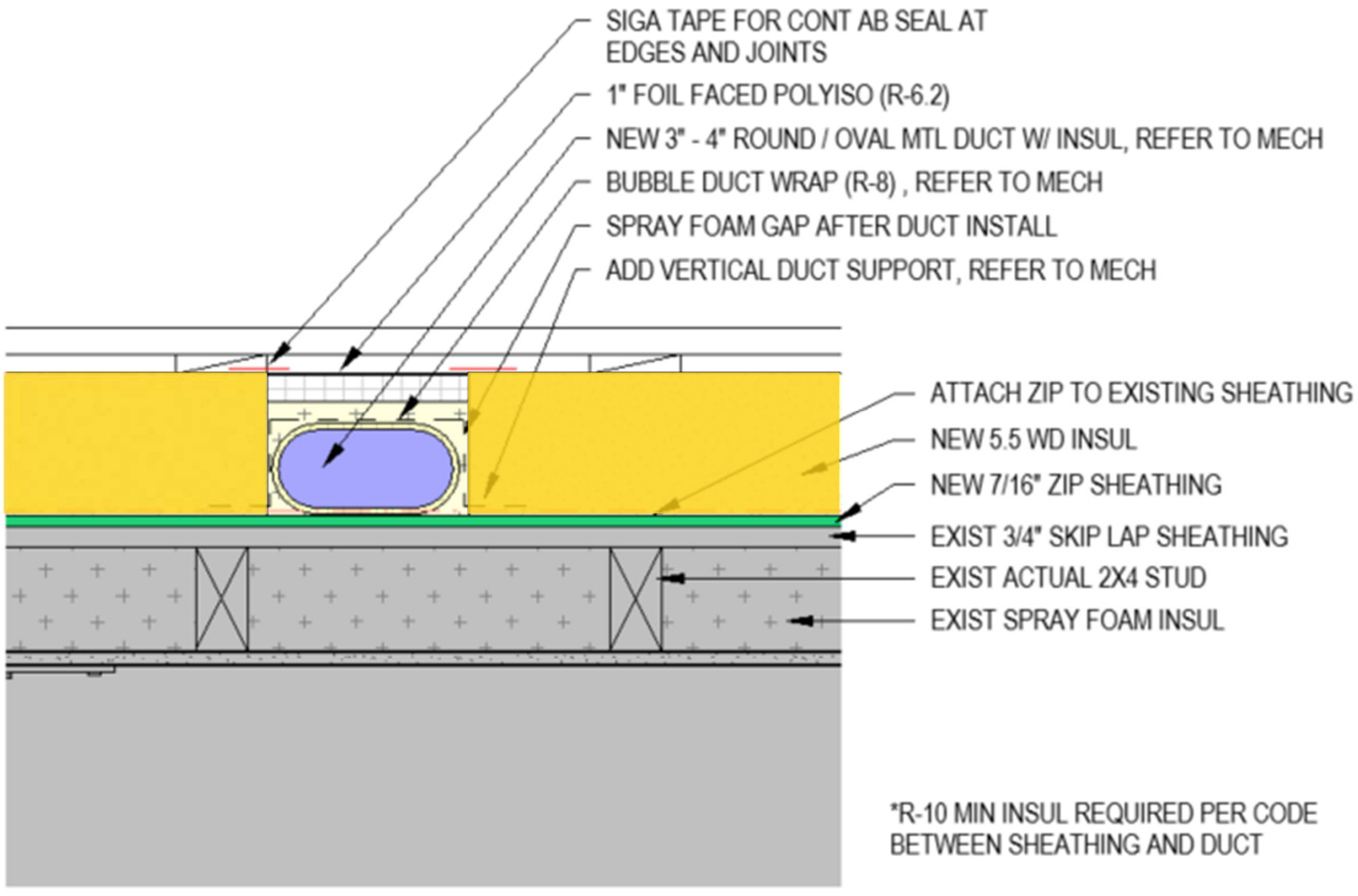
SYSTEMS



PLAN DETAIL OF DUCT IN EXTERIOR INSULATION

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SYSTEMS

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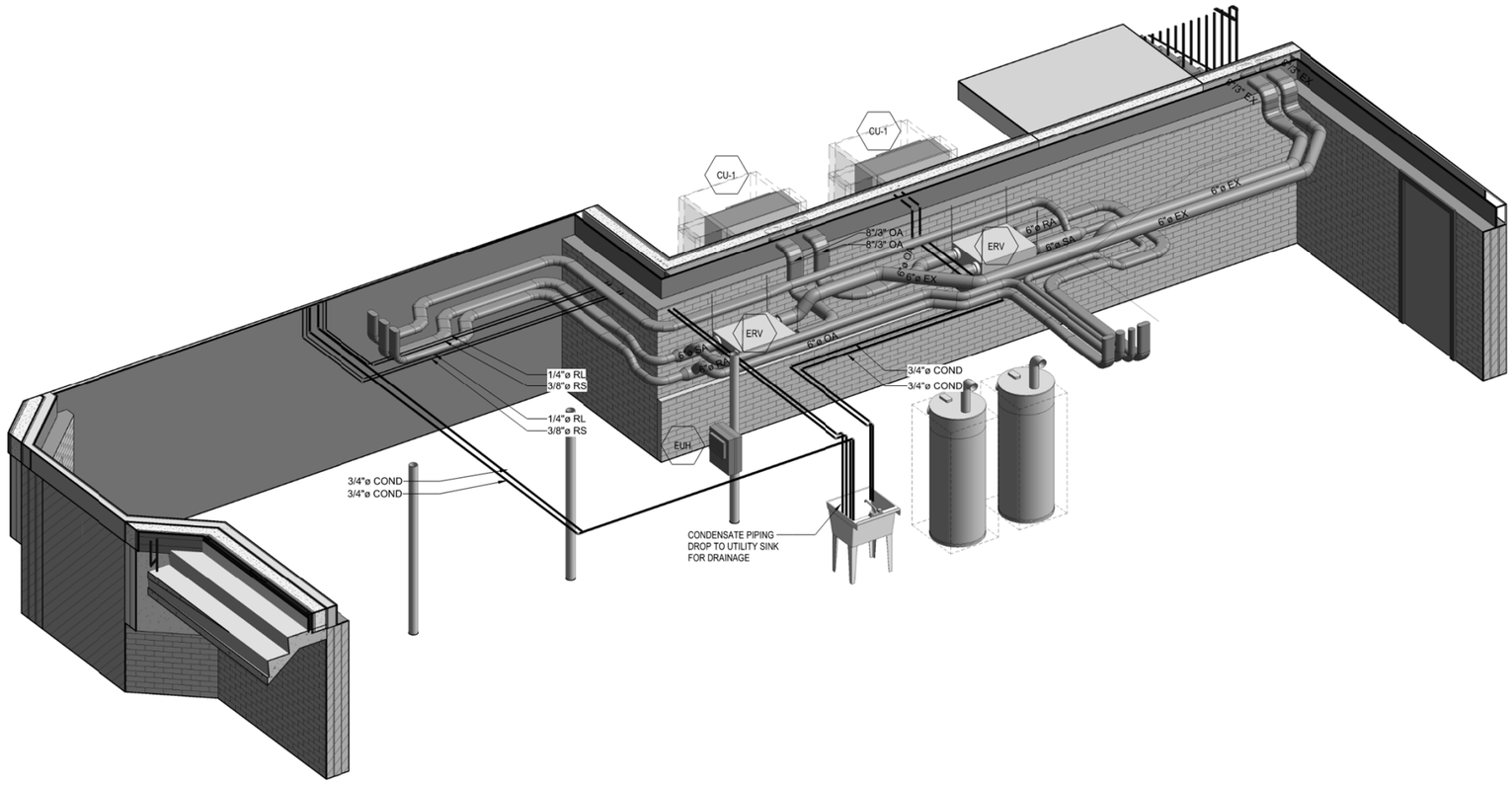
SYSTEMS



REPLICABILITY:
COMMON SYSTEMS & EQUIPMENT

CO2 EMISSION REDUCTION:
RIGHT-SIZED, ALL-ELECTRIC SYSTEMS

OCCUPANT IMPACT:
INTERIOR DUCTWORK & CONDENSATE ROUTING

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SOLAR

6.76 kW PER ROOF = 67.6 kW TOTAL

PERMITTED TO CONSIDER PAIRS OF DUPLEXES
AS SINGLE PROPERTY WITH REGARDS TO
SETBACKS FROM PARTY WALLS

CO2 EMISSION REDUCTION:
PV ARRAY GETS BUILDING ALMOST TO NET ZERO

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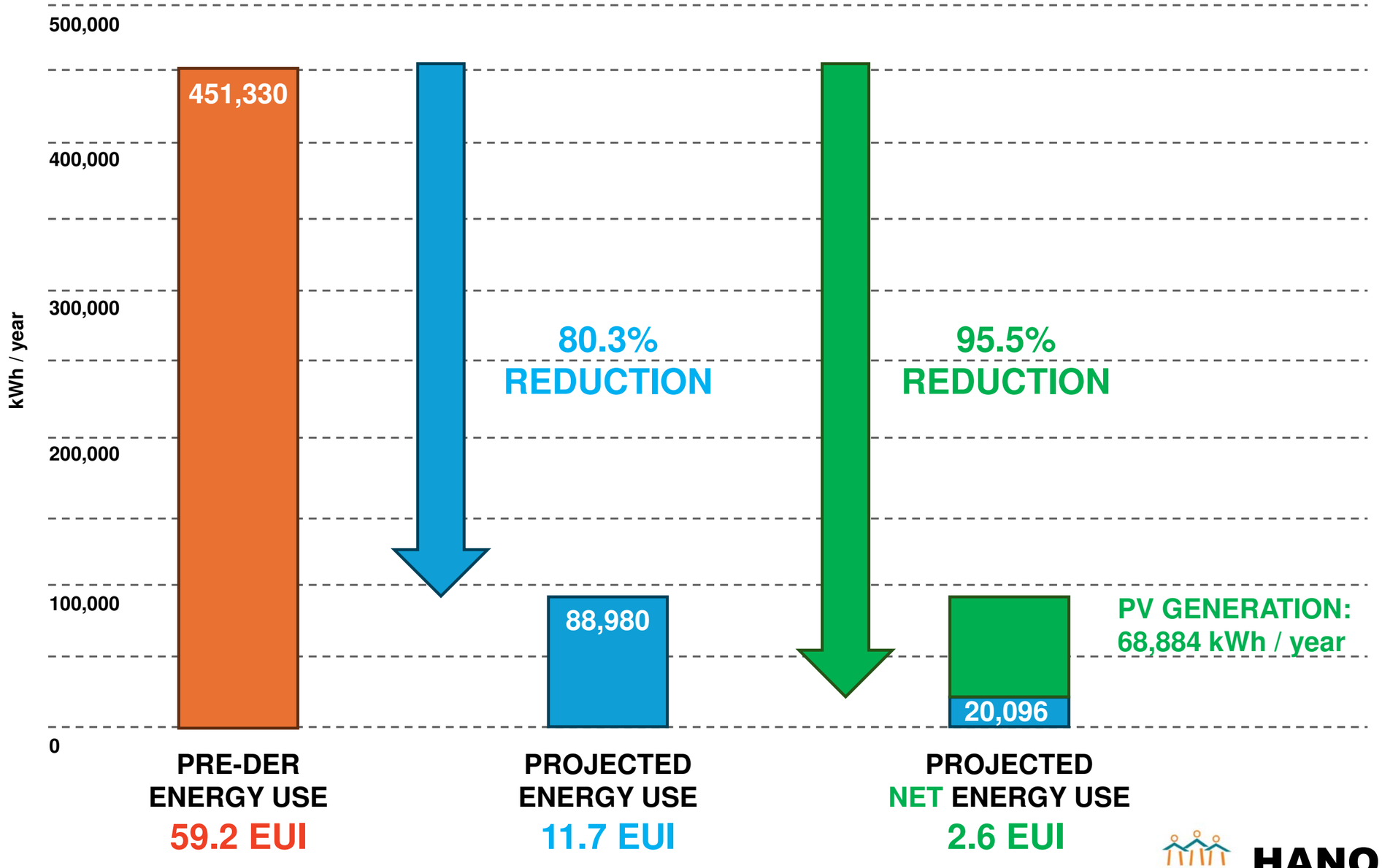
RESULTS



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RESULTS

TOTAL PROJECT COST:	**$4,212,906.00**
COST / DWELLING UNIT:	**$210,645.30**
COST / ft2 (FLOOR AREA):	**$161.92**
COST / ft2 (ENVELOPE AREA):	**$128.62**

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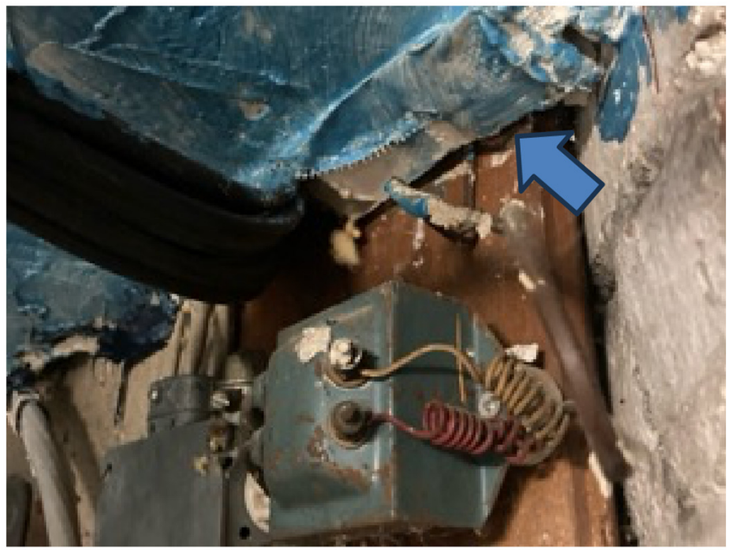
RESULTS

Equipment Set Up

Seal Penetrations In-Between Units

Seal/Cap off or Remove Old Electrical Boxes



Seal Basement Ceiling Back to the Air Barrier

BASELINE BLOWER DOOR TEST (UNITS 9 & 11):

0.834 CFM50/ft2

MIDPOINT BLOWER DOOR TEST (UNITS 1 & 3):

0.338 CFM50/ft2
(69 in2 = 8”x8” HOLE)

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BRIAN J HONAN APARTMENTS

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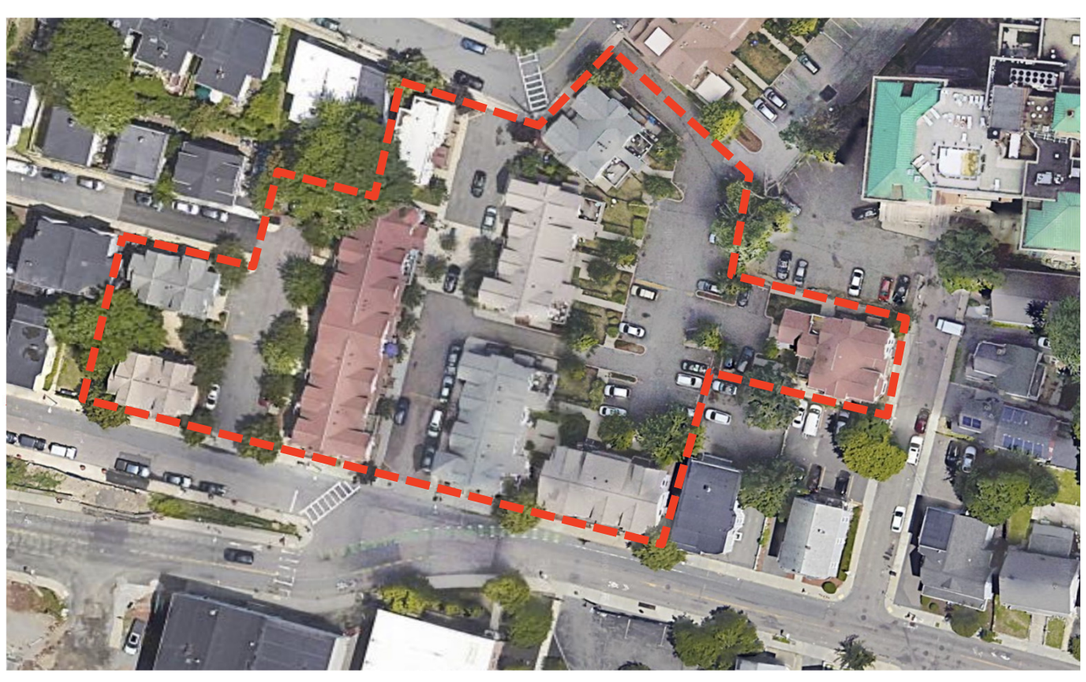
Allston Brighton
COMMUNITY DEVELOPMENT CORPORATION

BACKGROUND



BUILDING STATS:

- 9 BUILDINGS ON SINGLE SITE
- CONSTRUCTED IN 2004, EXTERIOR MATERIALS HAVE SINCE DEGRADED
- WOOD FRAMED CONSTRUCTION
- 3 STORIES + BASEMENT OR CRAWL SPACE
- 50 UNITS – MIX OF 1-, 2-, & 3-BEDROOM UNITS
- 63,203 GSF TOTAL

UNIQUE FEATURES / CHALLENGES:

- BUILDINGS SHARE ASSEMBLIES, MATERIALS, & DETAILS
- EACH BUILDING FORM / SIZE / GROUND CONDITION IS SLIGHTLY DIFFERENT
- CENTRALIZED DHW & HEATING PLANTS ARE SHARED BY TWO BUILDINGS

UTILITY STRUCTURE / EXISTING SYSTEMS:

- GAS-FIRED DHW & HYDRONIC BASEBOARD HEATING
- OWNER PAYS FOR GAS; TENANTS PAY FOR ELECTRIC
- NO EXISTING A/C, WINDOW UNITS USED BY SOME TENANTS
- NO VENTILATION, OTHER THAN KITCHEN / BATHROOM EXHAUST

EXISTING ENERGY PERFORMANCE:

- ESTIMATED BASELINE EUI = 52.3 KBTU/SFYR

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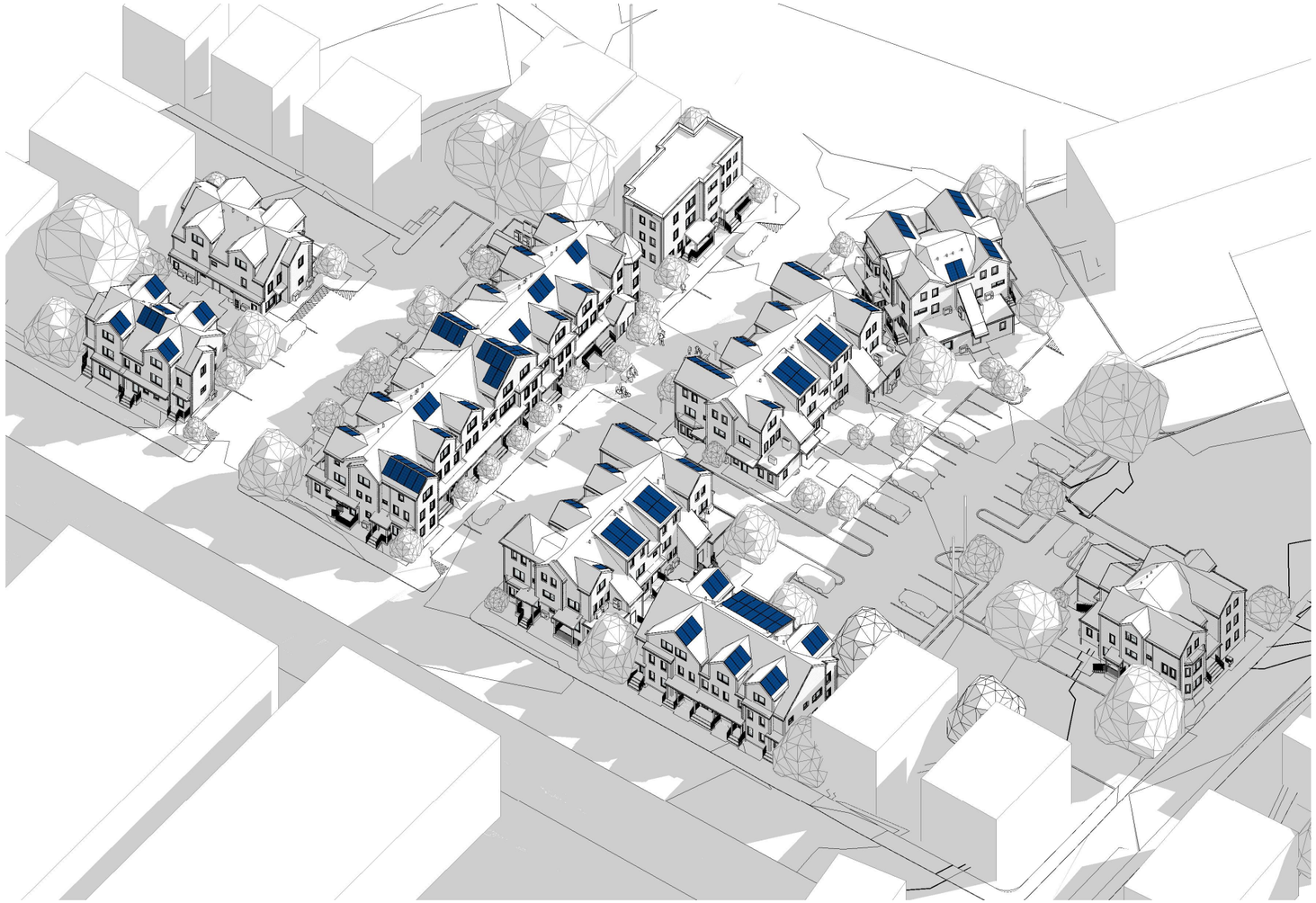
ALLSTON BRIGHTON, MA

BACKGROUND



REPLICABILITY:
SYSTEMS / STRATEGIES CAN BE REPLICATED ACROSS MULTIPLE BUILDINGS

CO2 EMISSION REDUCTION:
ELECTRIFICATION + REDUCTION IN ENERGY LOAD

OCCUPANT IMPACT:
SOME INTERIOR WORK REQUIRED

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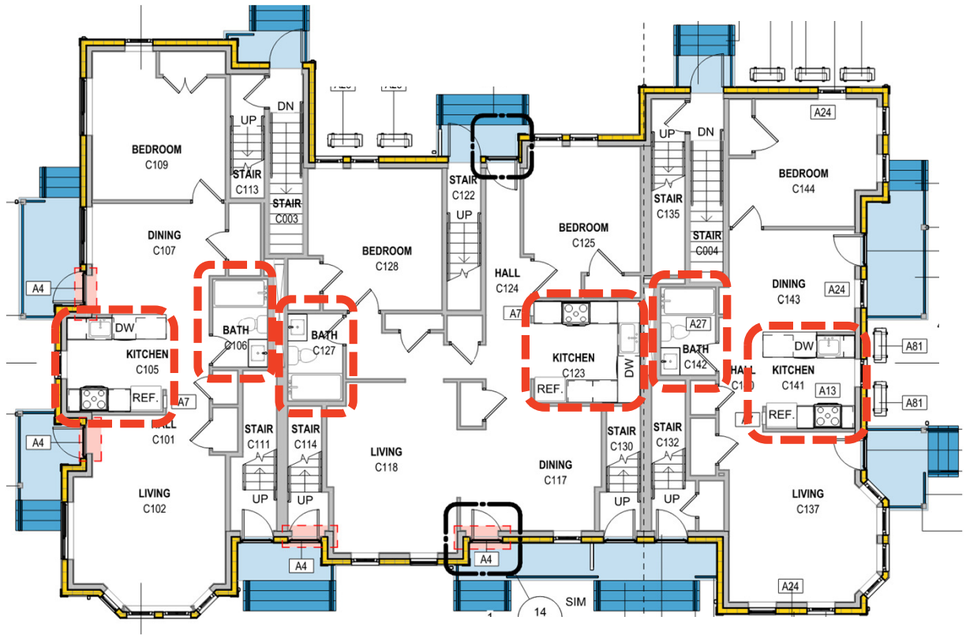
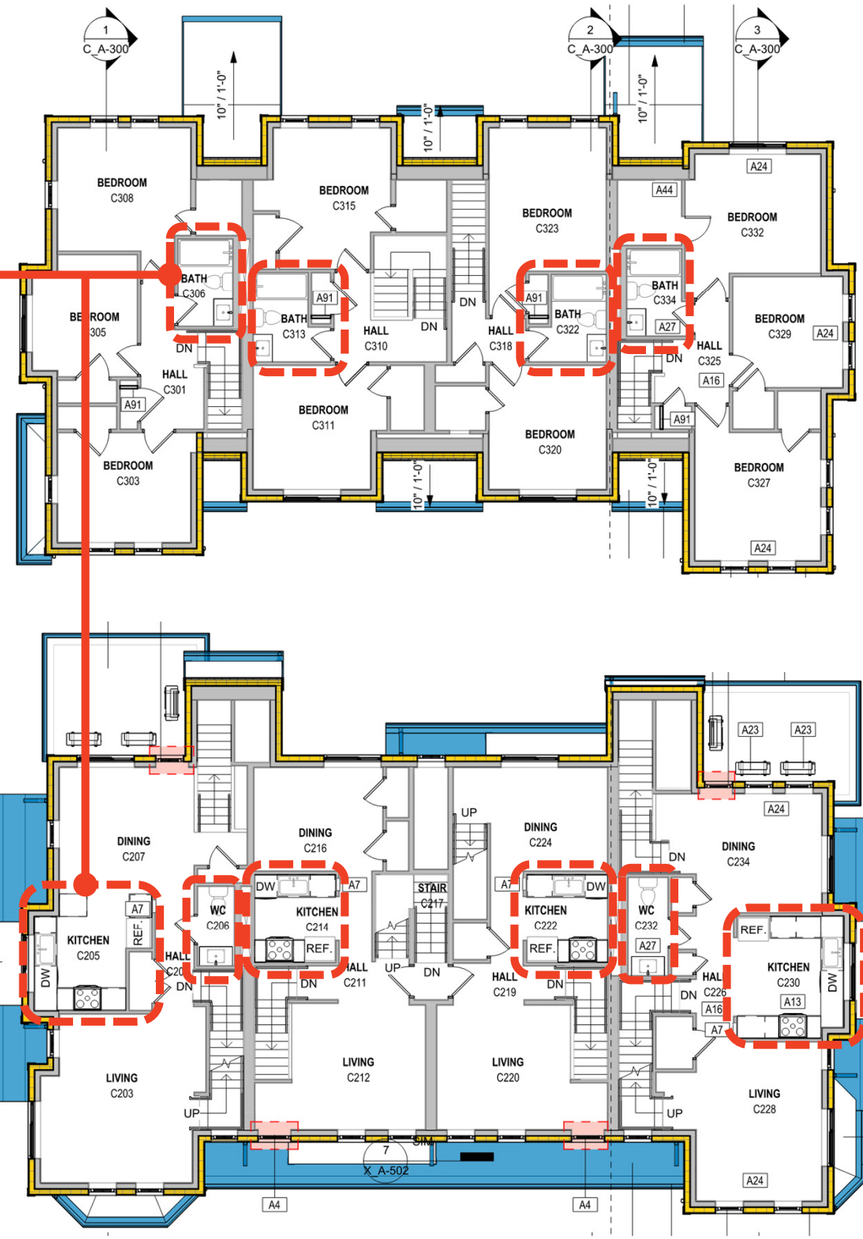
BACKGROUND

TYPICAL INTERIOR SCOPE:

- NEW APPLIANCES, FIXTURES, CASEWORK, & FINISHES WHERE IDENTIFIED
- ACCESSIBILITY UPGRADES (BUILDING J)
- DISCONNECT EXISTING KITCHEN & BATHROOM EXHAUST
- NEW MECHANICAL SHAFTS & SOFFITS



LEVEL 1 UNITS



LEVEL 2 / 3 UNITS

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BACKGROUND

PHASING & TENANT DISPLACEMENT

- PHASING PER BUILDINGS (2 FOR BUILDING B)
- TARGETING 3-4 WEEK DISPLACEMENTS

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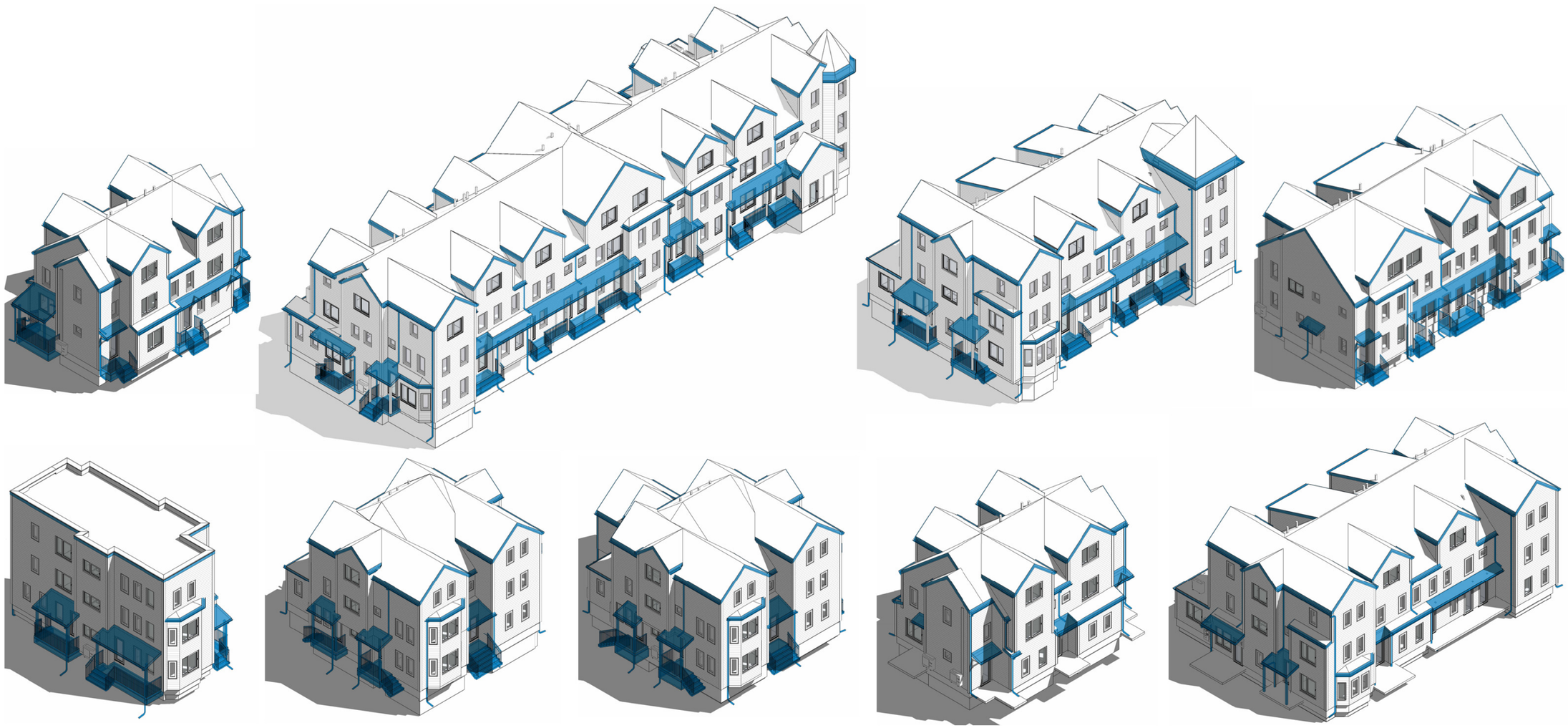
ENVELOPE

SITE-BUILT VS. PANELIZED



SLIGHT VARIATIONS IN GEOMETRY MAKE PANELIZATION DIFFICULT

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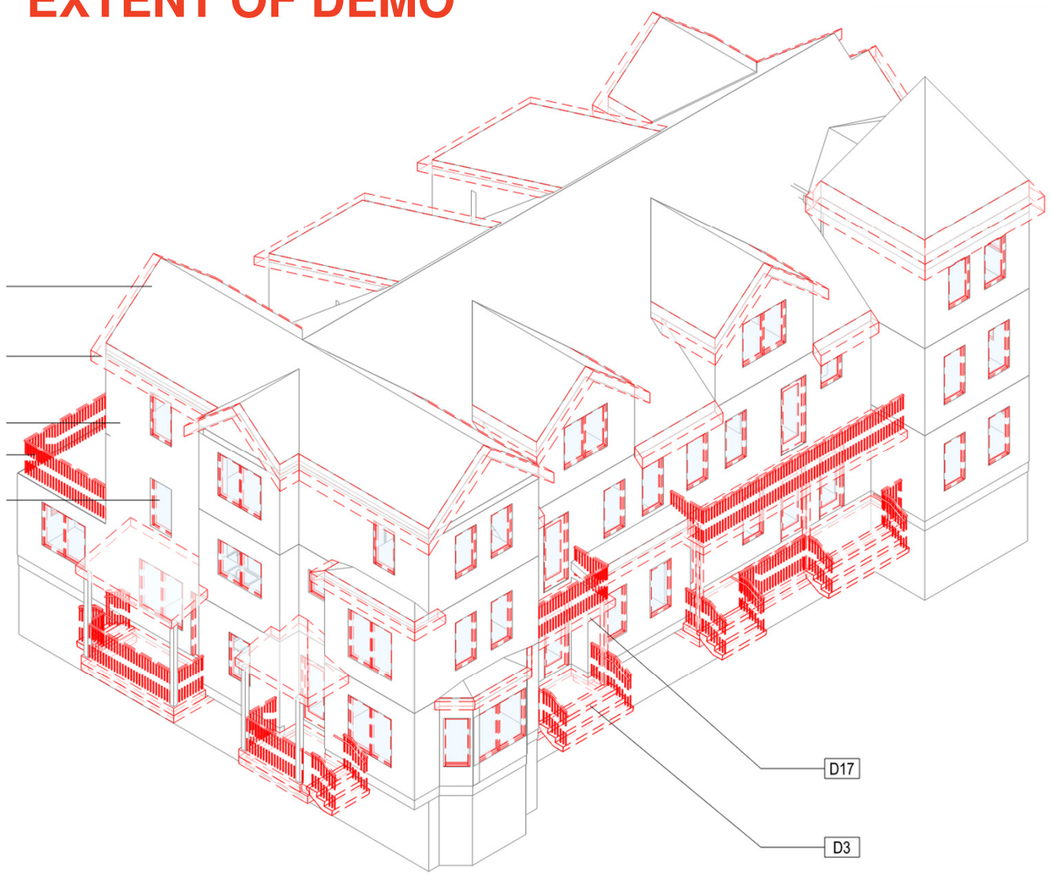
ENVELOPE

EXTENT OF DEMO



GENERAL APPROACH

- DEMO BACK TO EXISTING SHEATHING ON WALLS & ROOF
- REMOVE ALL APPENDAGES (EAVES & ROOF OVERHANGS, DECKS, PORCH ROOFS) TO ALLOW FOR CONTINUOUS AIR BARRIER
- ALL NEW EXTERIOR DETAIL TO BE OUTSIDE THE AIR BARRIER

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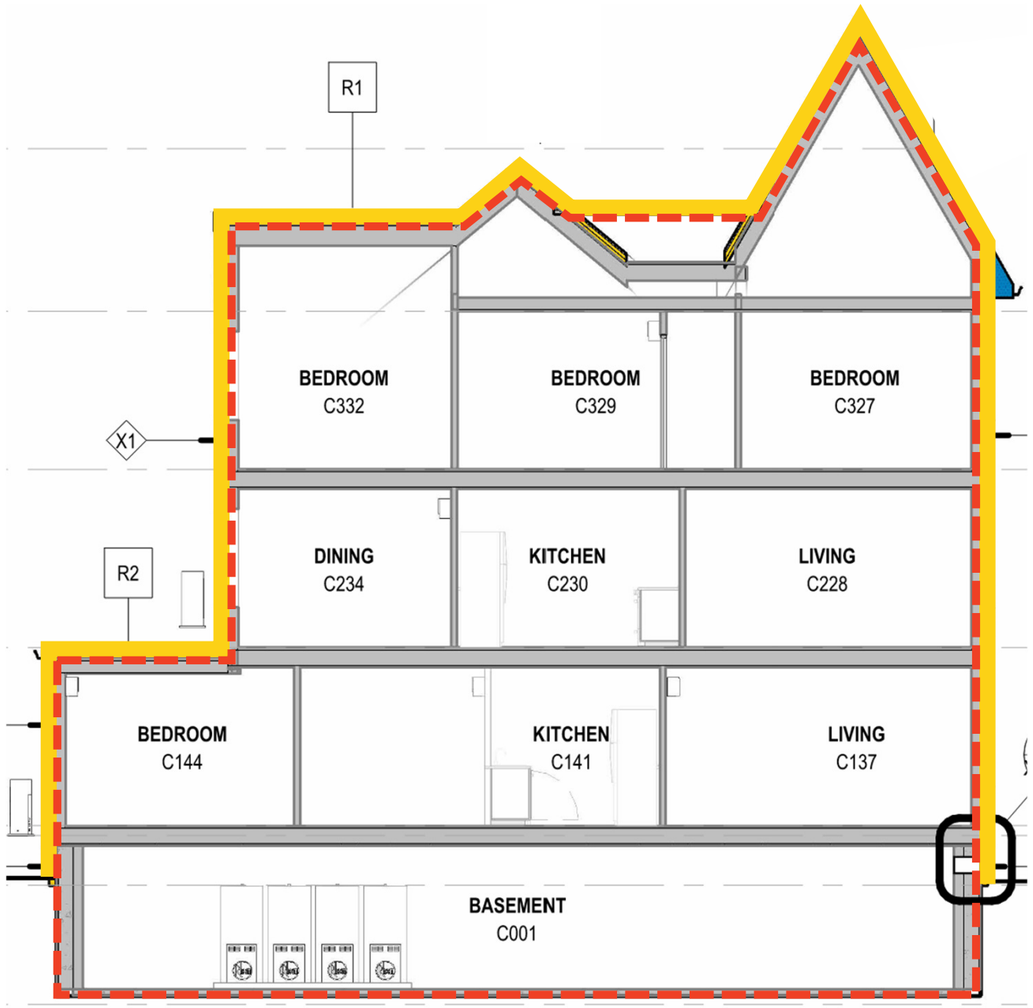
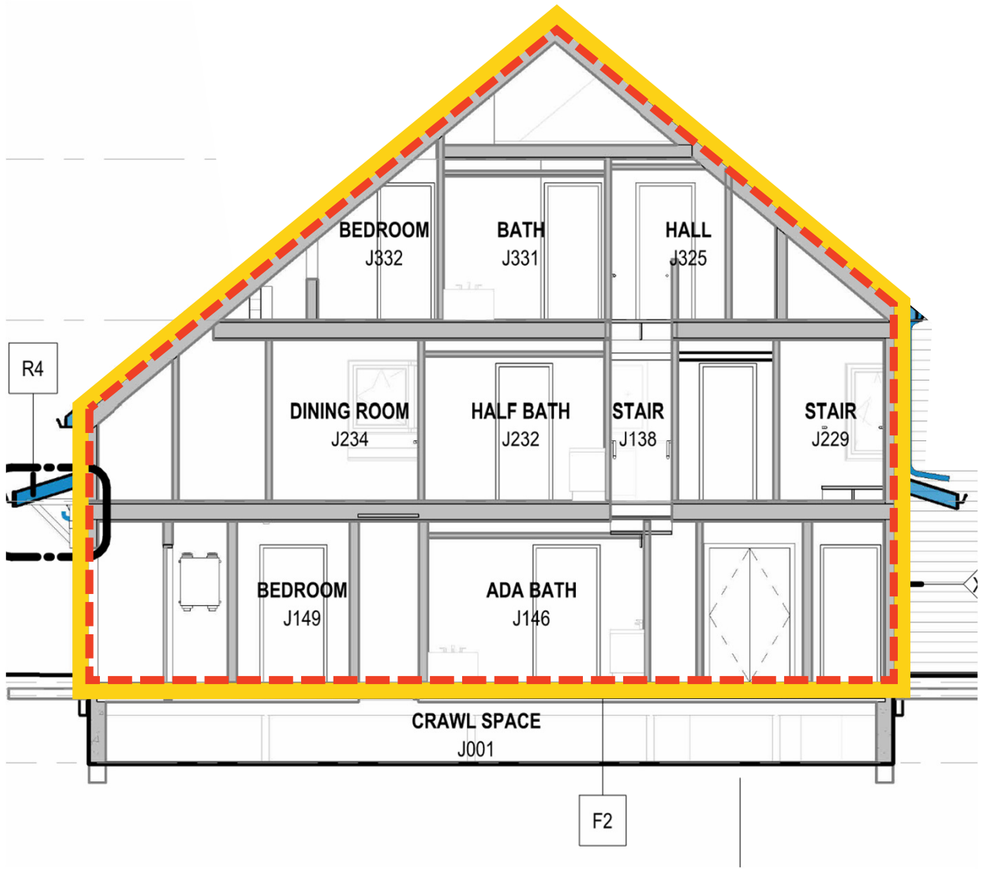
ENVELOPE



TYPICAL BUILDING WITH FULL BASEMENT



TYPICAL BUILDING WITH CRAWL SPACE

WHAT ENVELOPE IMPROVEMENTS ARE NEEDED FOR FULL BUILDING ELECTRIFICATION & PHIUS REVIVE 2021 CERTIFICATION?

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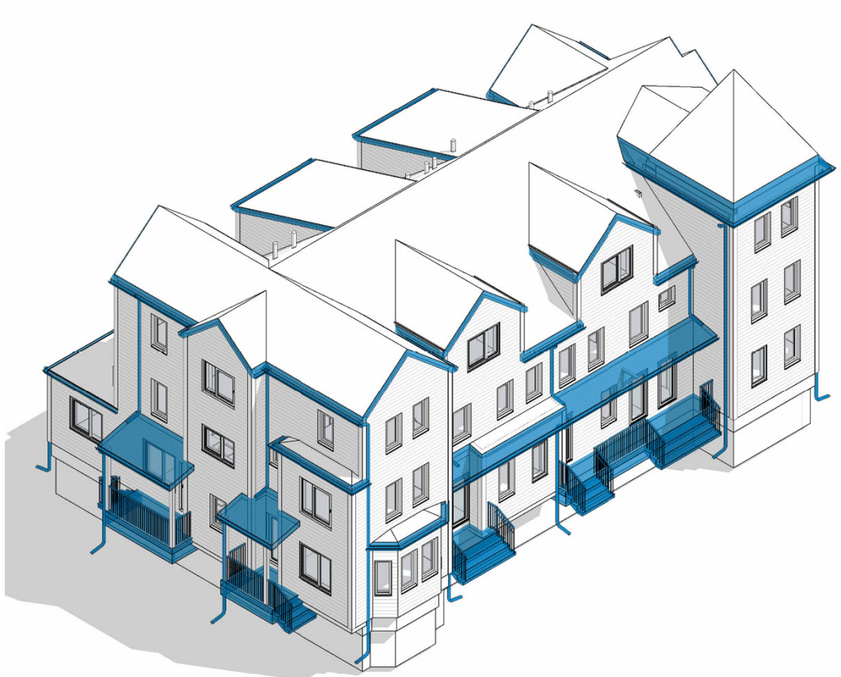
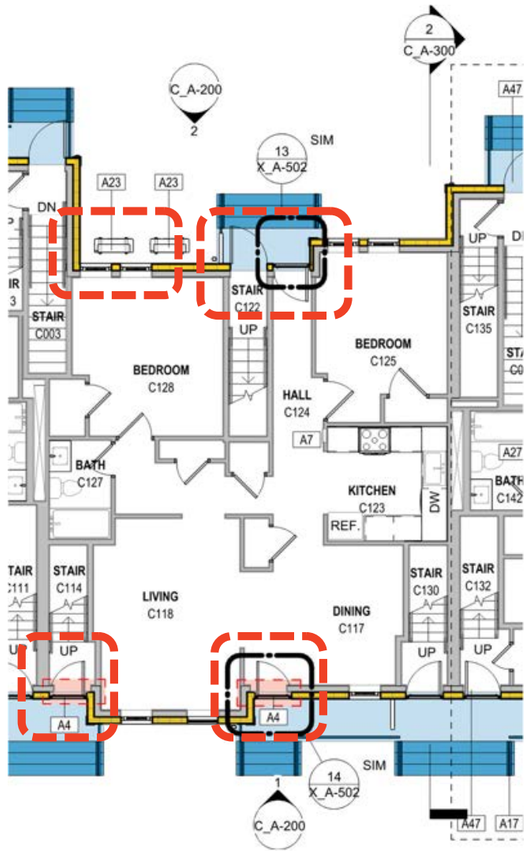
ENVELOPE

EXTERIOR ASSEMBLIES



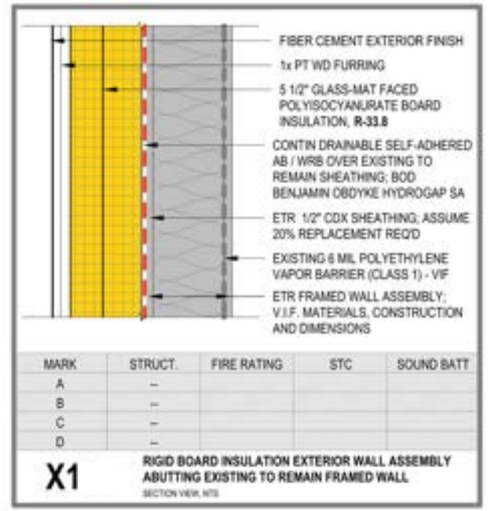
COMPLEX FORMS WITH HIGH SURFACE AREA & VOLUME TO FLOOR AREA RATIO REQUIRE HIGHER EXTERIOR R-VALUES TO HIT PHIUS TARGETS

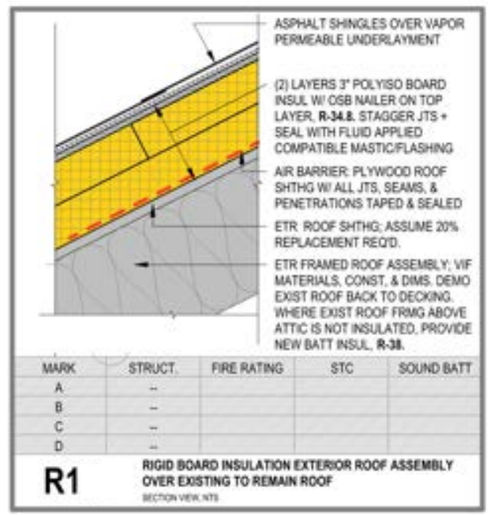
+



WINDOWS & DOORS WITH TIGHT ADJACENCIES TO RETURN WALLS REQUIRE THINNER OVERCLAD

=





POLYISOCYANURATE ON WALLS & ROOF

Allston Brighton COMMUNITY DEVELOPMENT CORPORATION

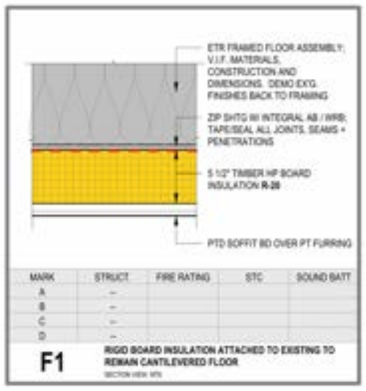
BRIAN J HONAN

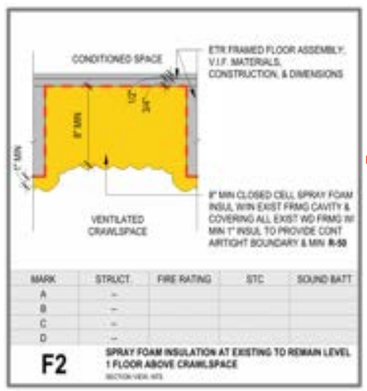
ALLSTON BRIGHTON, MA

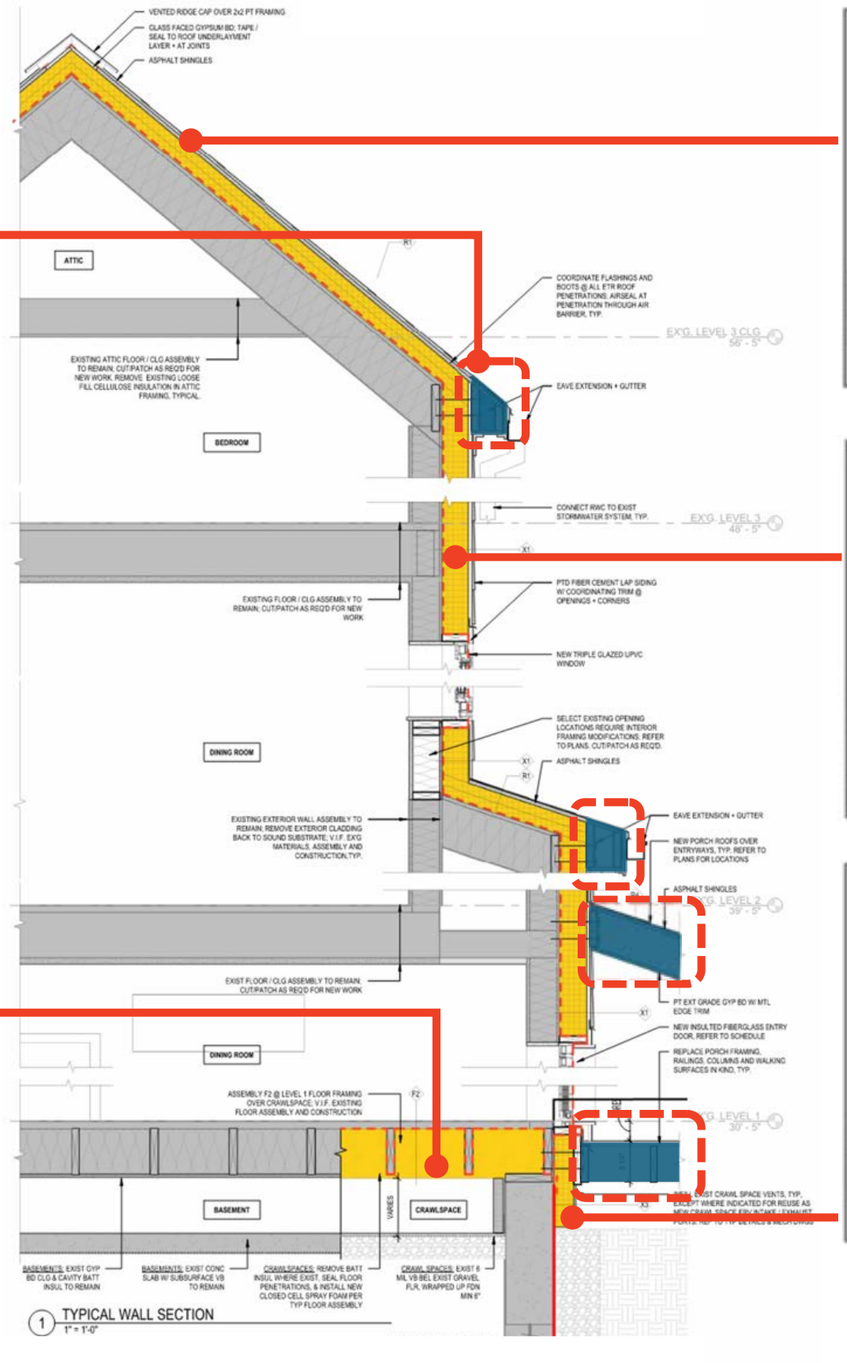
ENVELOPE

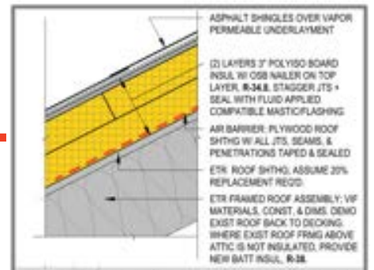
EXTERIOR ASSEMBLIES

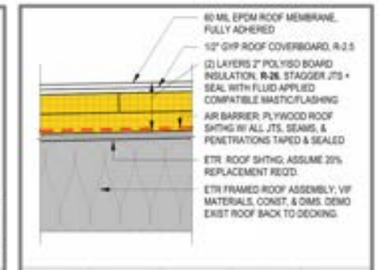
EAVES, PORCHES, PORCH ROOFS ARE EXTERIOR TO AIR & THERMAL BARRIER

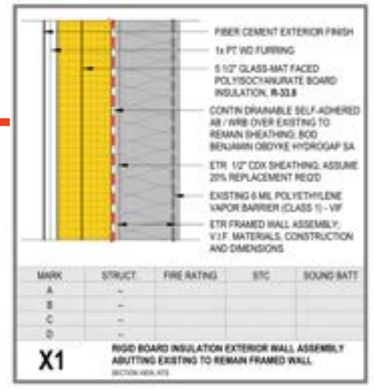


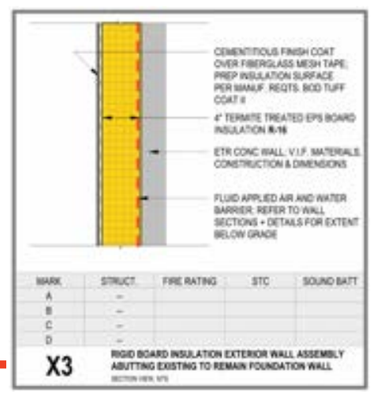












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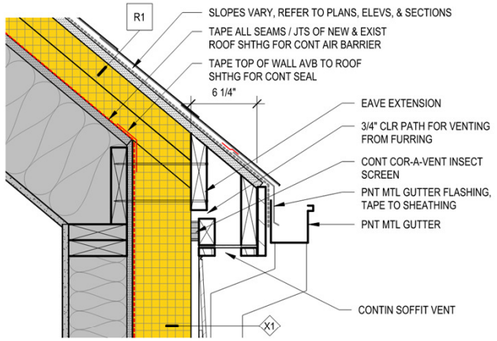
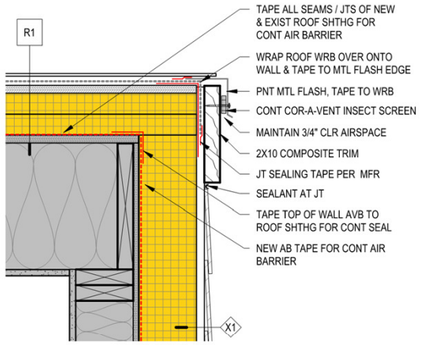
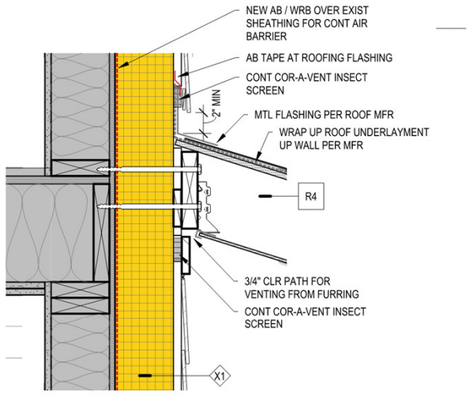
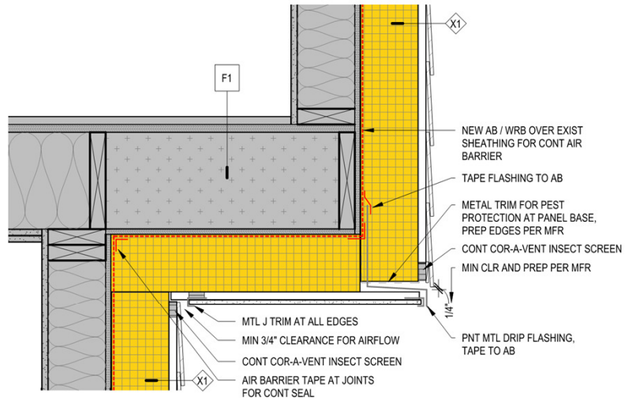
ENVELOPE

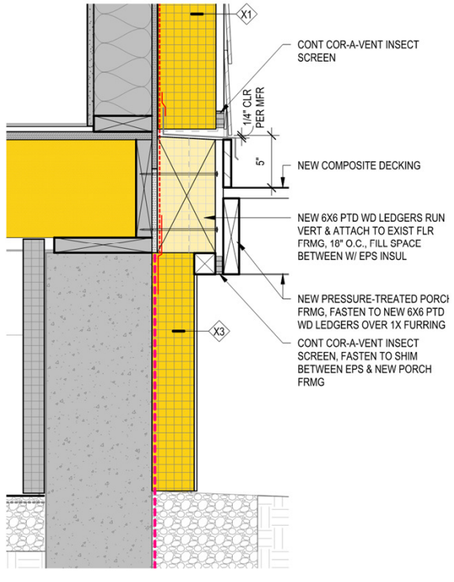
EXTERIOR ASSEMBLIES

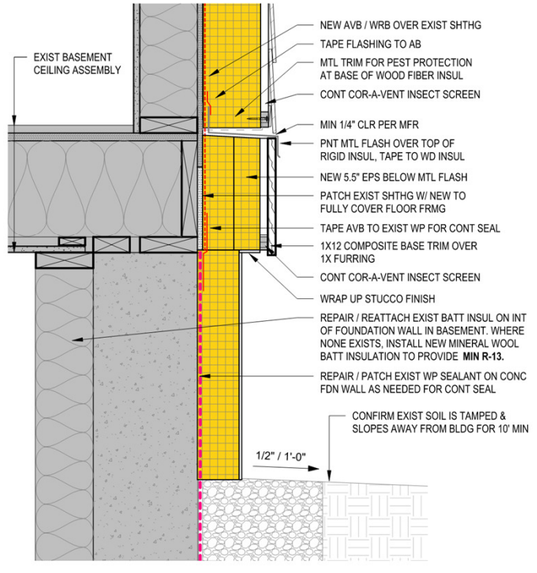












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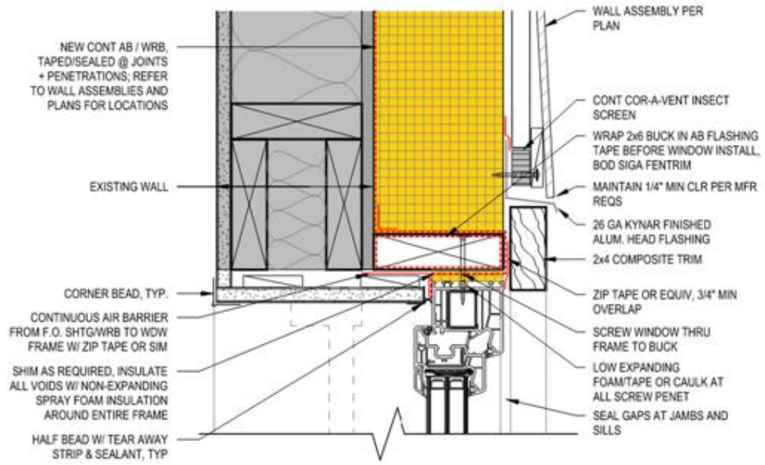
ENVELOPE

WINDOWS & DOORS

HEAD



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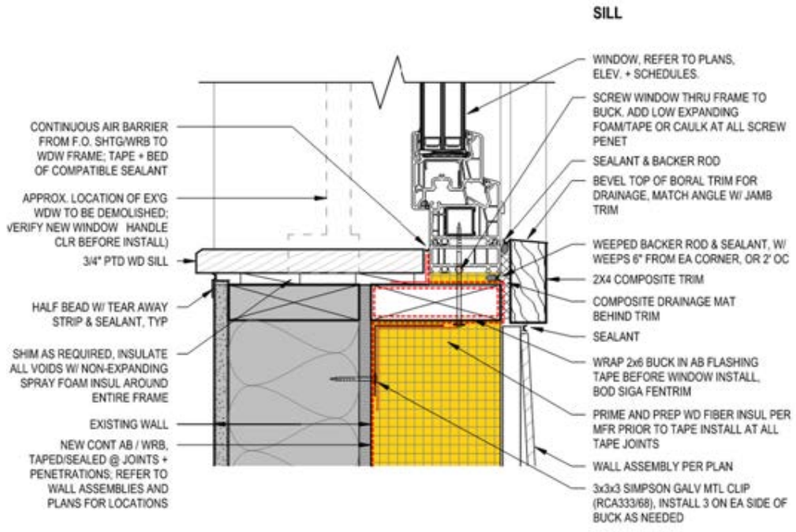
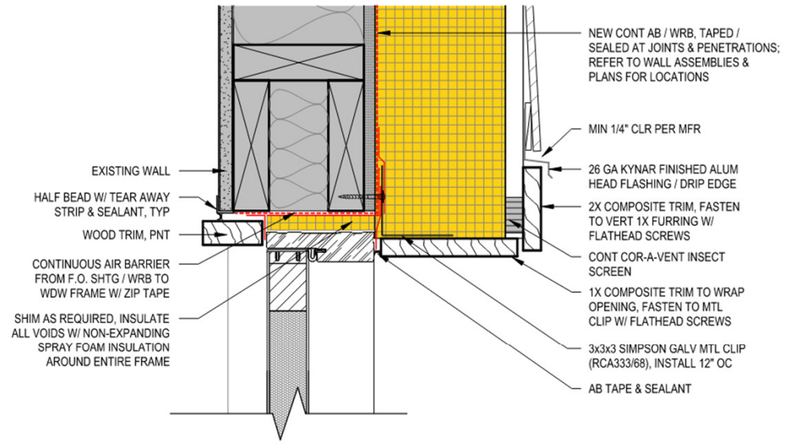
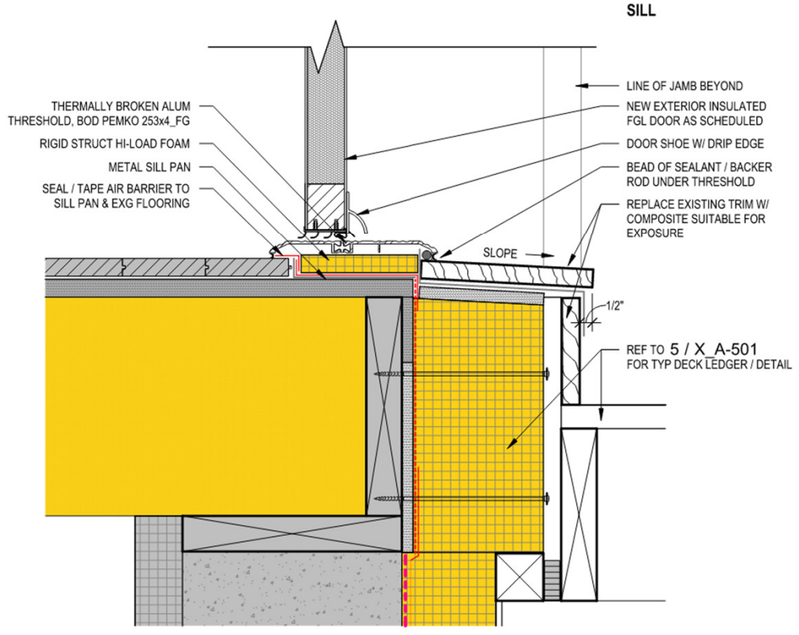


HEAD



SILL



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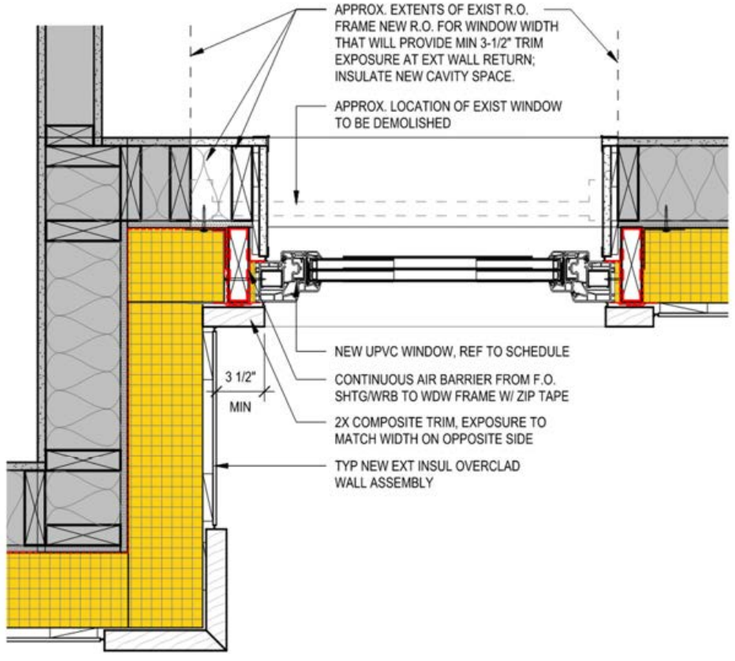
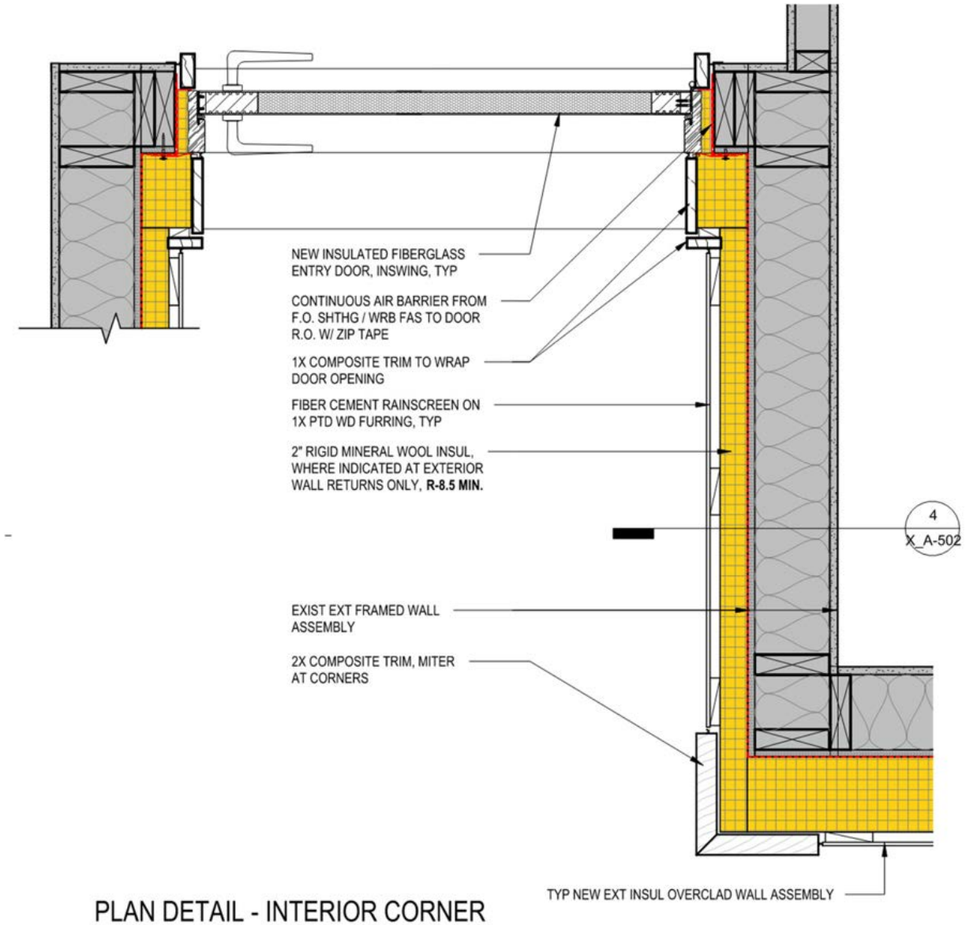
ENVELOPE

WINDOWS & DOORS



9 PLAN DETAIL - NARROWED WINDOW ROUGH OPENING
1 1/2" = 1'-0"



13 PLAN DETAIL - INTERIOR CORNER AT ALT OVERCLAD ASSEMBLY
1 1/2" = 1'-0"

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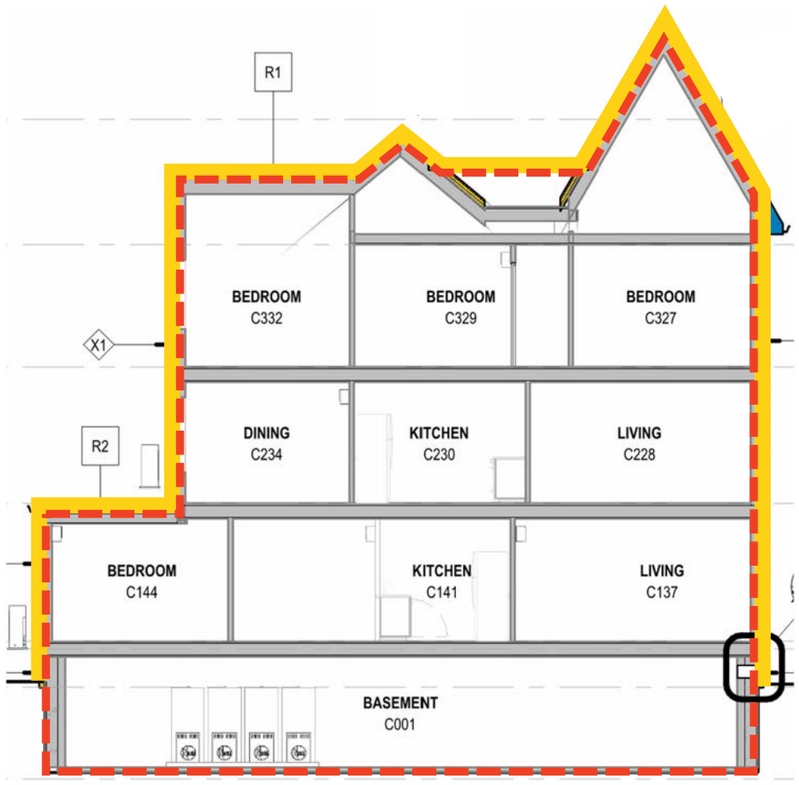
ENVELOPE



REPLICABILITY:
ASSEMBLIES & DETAILS COPIED ACROSS BUILDING TYPES

CO2 EMISSION REDUCTION:
AIRTIGHT, WELL-INSULATED ENVELOPE TO DECREASE CONDITIONING LOADS

OCCUPANT IMPACT:
LARGELY EXTERIOR INSTALLATION TO MNIMIZE TENANT DISPLACEMENT

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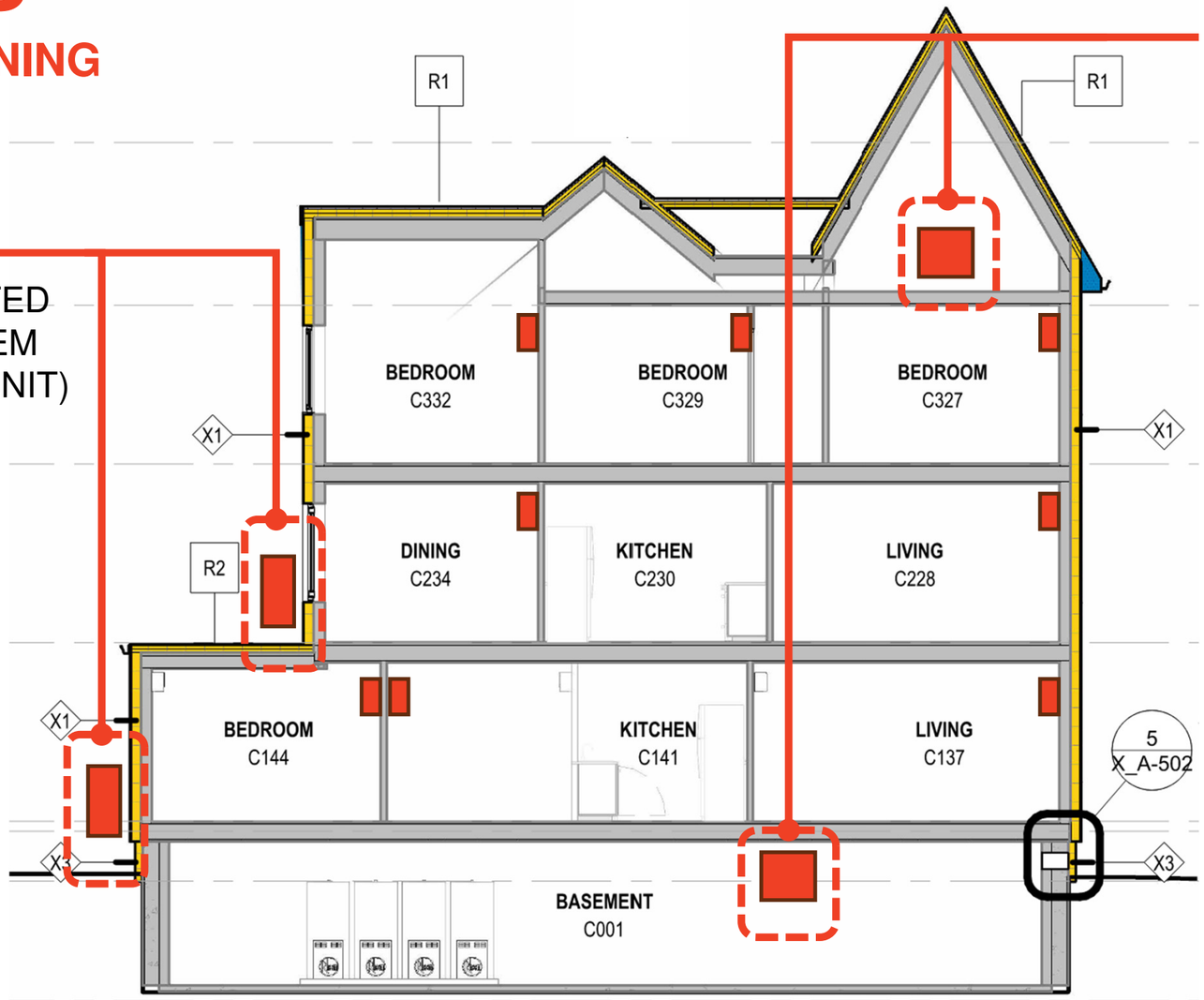
SYSTEMS

HVAC - CONDITIONING

2-TON OR 3-TON
MITSUBISHI NON-DUCTED
VRF HEAT PUMP SYSTEM
(ONE PER DWELLING UNIT)



ELECTRIC UNIT HEATERS
IN ATTICS & BASEMENTS /
CRAWL SPACES

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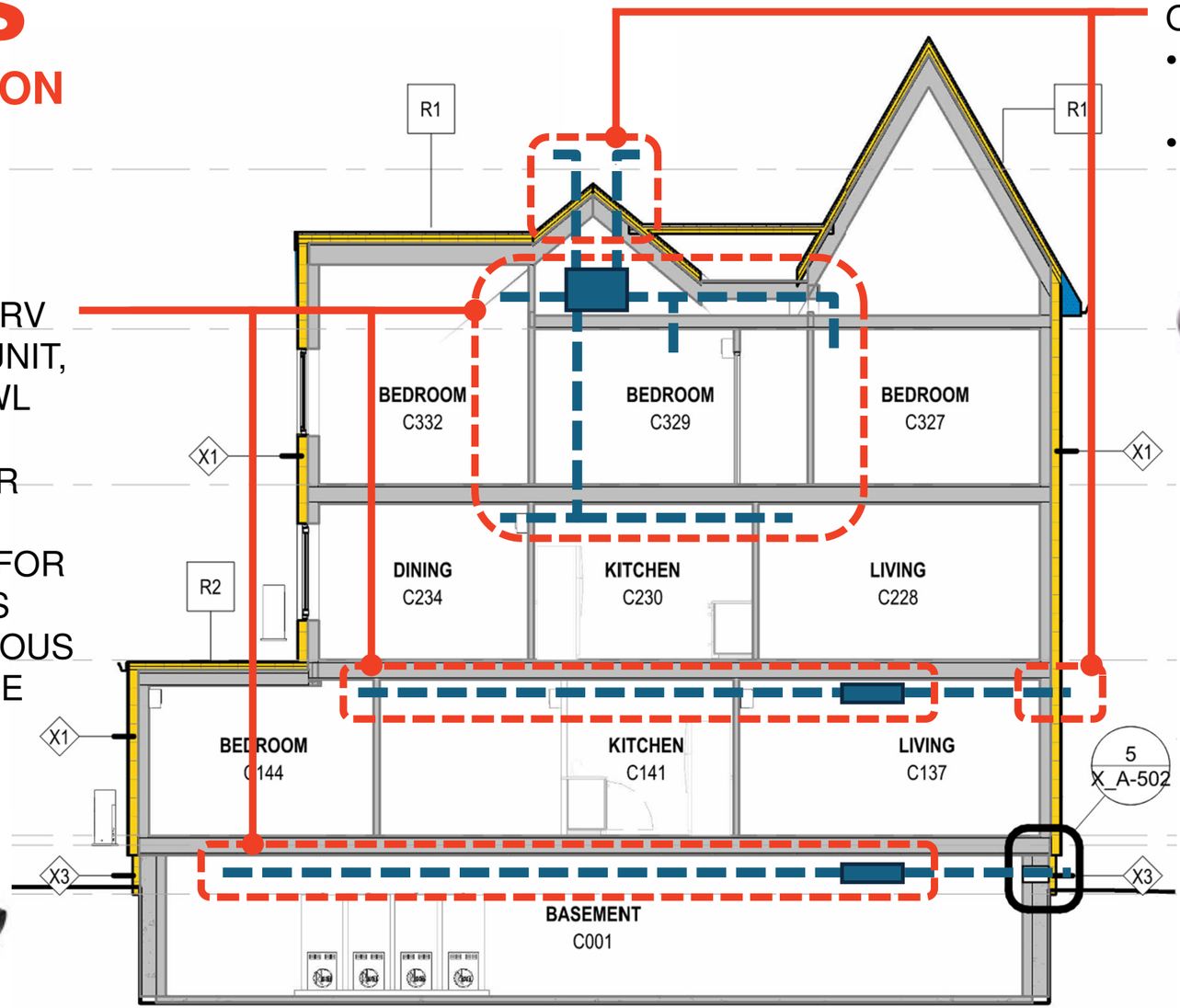
SYSTEMS

HVAC - VENTILATION

100 CFM PANASONIC ERV (ONE PER DWELLING UNIT, & BASEMENT OR CRAWL SPACE)

- IN ATTIC FOR UPPER LEVEL UNITS
- IN CEILING SOFFIT FOR FIRST FLOOR UNITS
- 50-80CFM CONTINUOUS BASED ON UNIT SIZE



OUTDOOR & EXHAUST AIR:

- ROOF VENT CAP FOR ATTIC UNIT
- COMBO INTAKE / EXHAUST PORT FOR FIRST FLOOR

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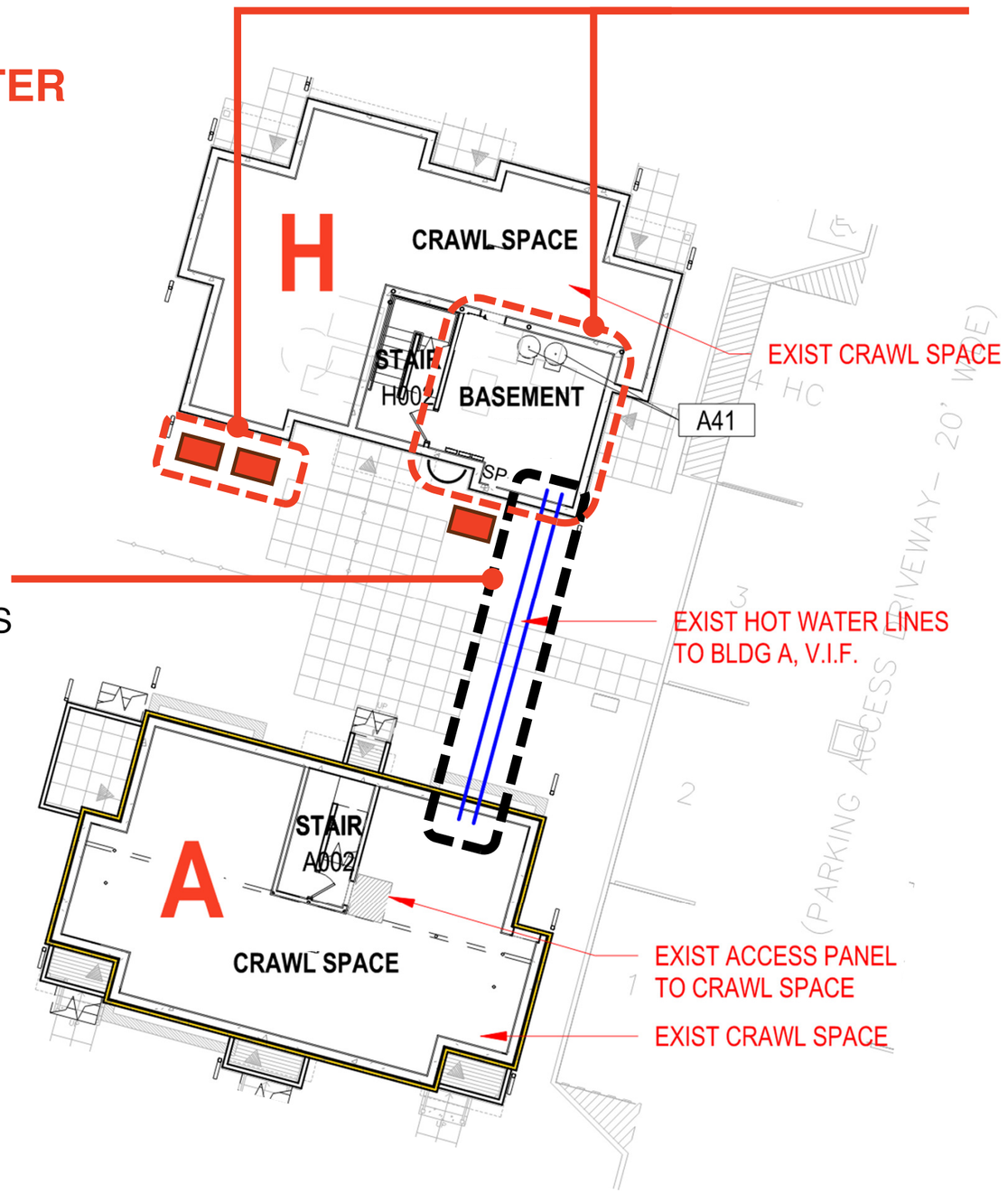
SYSTEMS

DOMESTIC HOT WATER

EXISTING CENTRALIZED GAS-FIRED DHW SYSTEMS ARE SHARED BETWEEN BUILDINGS



NEW CENTRALIZED DHW SYSTEM: SANDEN SANCO2

- HIGH EFFICIENCY AVOIDS ELECTRICAL SERVICE UPGRADES
- EXTERIOR CONDENSERS ACCOMMODATE SMALL BASEMENT VOLUMES
- CO2 SERVES AS LOW-GWP REFRIGERANT

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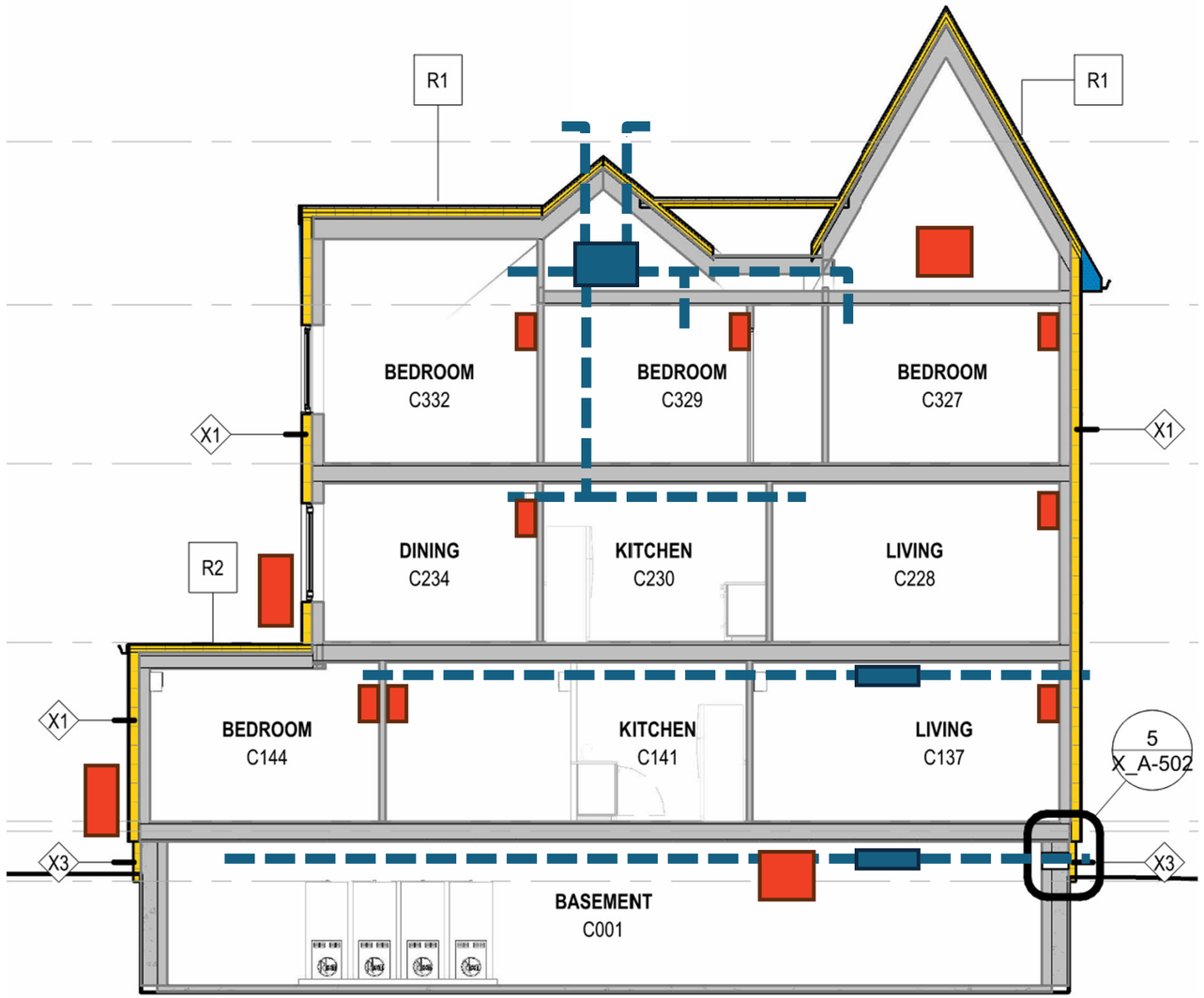
SYSTEMS



REPLICABILITY:
SYSTEMS APPLIED ACROSS DIFFERENT BUILDINGS & UNIT SIZES

CO2 EMISSION REDUCTION:
RIGHT-SIZED, ALL-ELECTRIC SYSTEMS

OCCUPANT IMPACT:
INTERIOR DUCTWORK & CONDENSATE ROUTING

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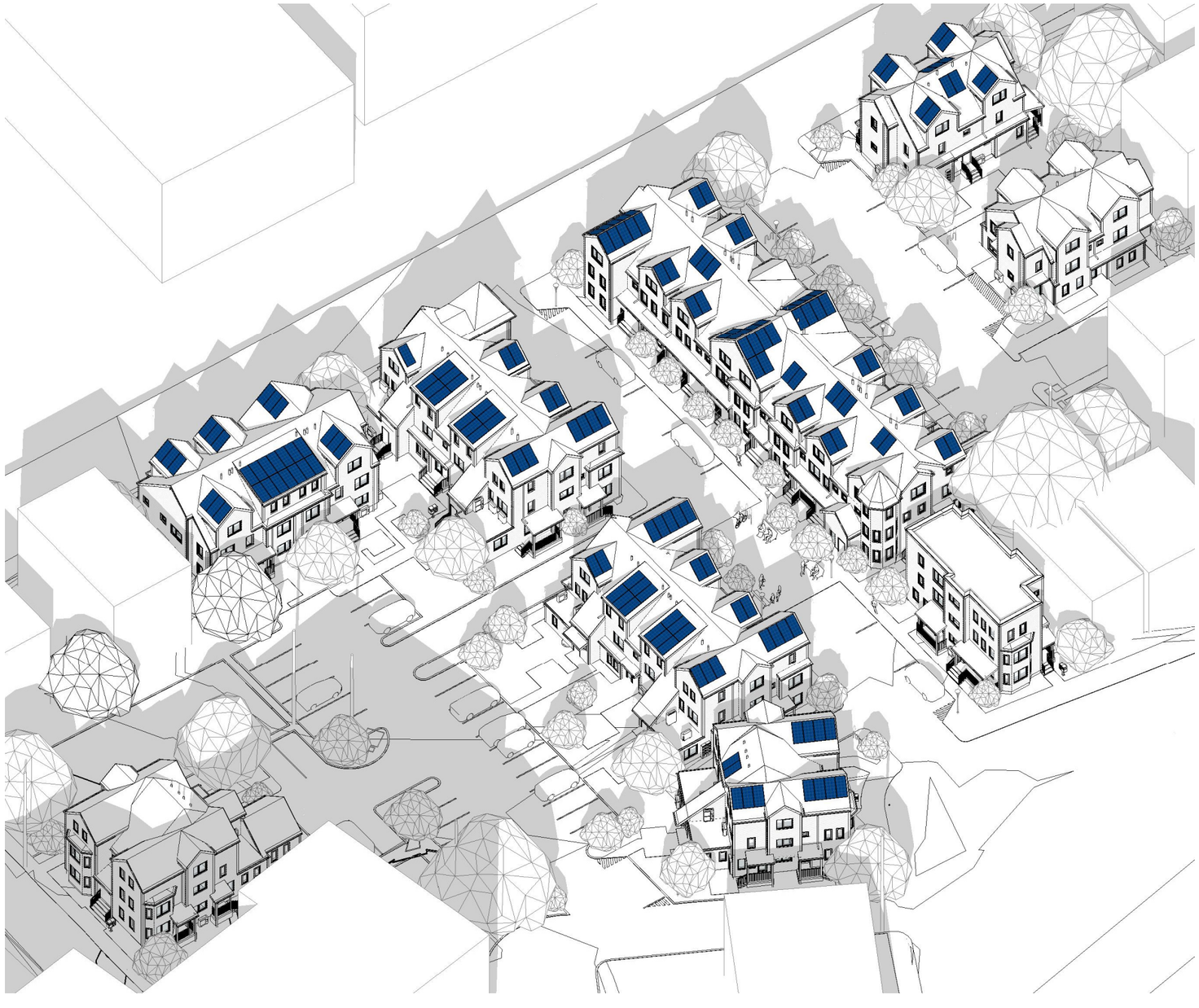
SOLAR



<u>CO2 EMISSION REDUCTION:</u>
PV ARRAY ENABLES BUILDINGS TO MEET PHIUS ENERGY TARGETS

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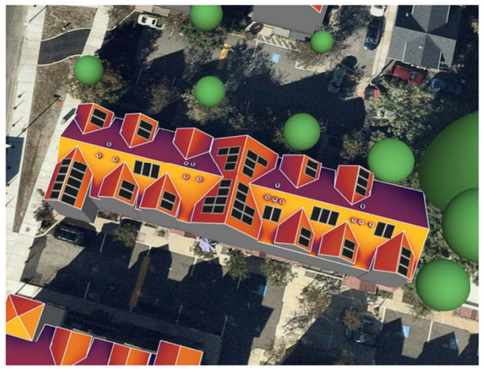
SOLAR

31-41 Everett Street - 13.1 kW

57 Everett Street - 24.6 kW



63 Hano Street - 13.5 kW

43-55 Everett Street - 11.1 kW

57-63 Everett Street - 5.3 kW

65-71 Hano Street - 5.3 kW

CHALLENGES:

- SMALL BUILDINGS
- SMALL AREAS OF UNBROKEN ROOF (MANY DORMERS)
- EXISTING PENETRATIONS
- SHADING BY CONTEXT BUILDINGS

Disqualified Sites

Site	Reason for DQ
10-16 Clevemont Ave.	Too shaded
61 Hano Street	Too small

Site Address	System Size (kW DC)
31-41 Everett Street	13.1
43-55 Everett Street	11.1
57 Everett Street	24.6
57-63 Everett Street	5.3
63 Hano Street	13.5
65-71 Hano Street	5.3
35-39 Blaine Street	3.7
	76.7

PROJECTED ANNUAL GENERATION
78,802 kWh / year

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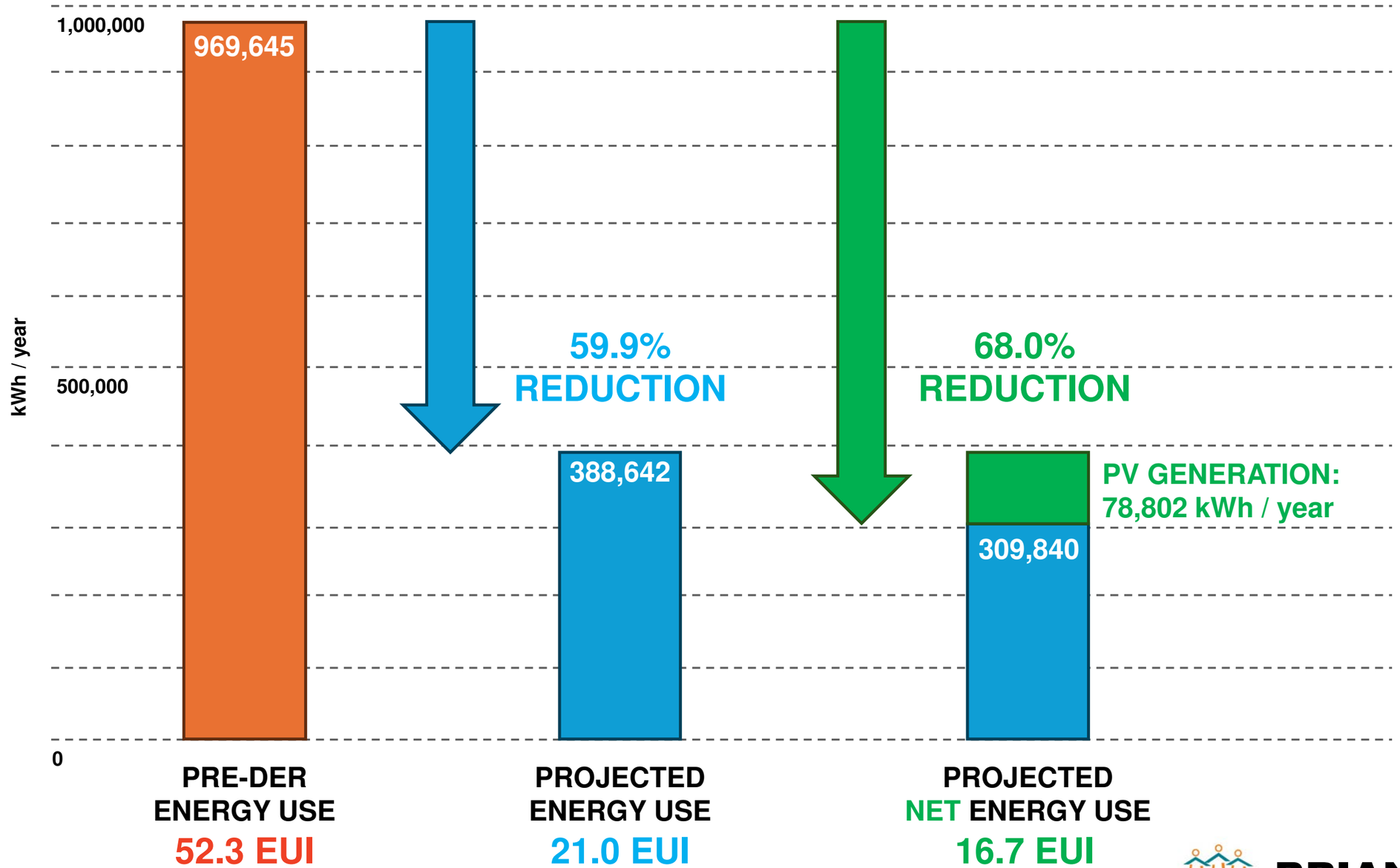
RESULTS



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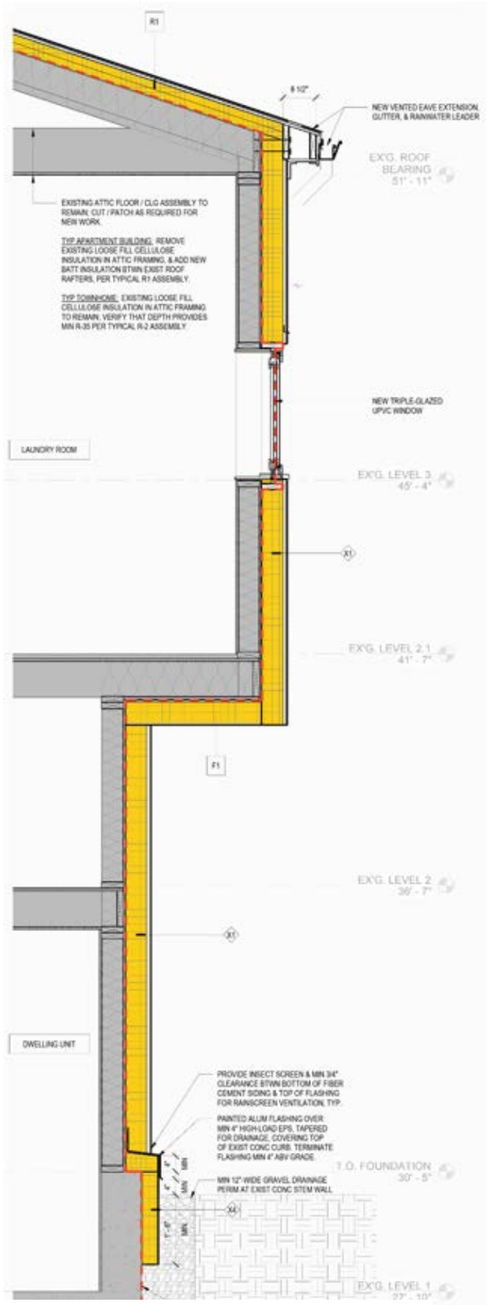
EXTERIOR PHOTOS



TYPICAL WALL SECTION

SITE PLAN

REPLICABILITY:

-29 BUILDINGS ON THE SITE, WITH 7 BUILDING TYPES. 6 OUT OF 7 UTILIZE THE SAME SET OF MODULES / COMPONENTS
-POTENTIAL FOR PANELIZED SOLUTION

CO2 EMISSIONS REDUCTION:

-OPERATIONAL CARBON REDUCTION THRU IMPROVED AIR, THERMAL CONTROL LAYERS + HIGH PERFORMANCE EQUIPMENT
-ELECTRIFICATION

OCCUPANT IMPACT:

-???
-IF PANELIZED, EFFICIENT PANEL INSTALL / TIME ON SITE
-INTERIOR UNIT KITCHEN/BATH + FINISHES IMPROVEMENTS MAY BE NECESSARY WITH FUNDING SOURCES

POAH

MEADOWBROOK APTS
FLORENCE, MA

EDIT ONLY YELLOW HI-LIGHTED CELLS

SUMMARY

NOTE: ALL COST AND ENERGY SAVINGS INFORMATION GENERATED THROUGH THIS CALCULATOR IS FOR PRELIMINARY PLANNING PURPOSES ONLY AND DOES NOT SERVE AS AN OFFICIAL COST ESTIMATE OR DETAILED SCOPE DOCUMENT AND SHALL NOT BE USED FOR CONSTRUCTION. PROJECTED ENERGY SAVINGS AND INCENTIVE VALUE / AVAILABILITY MAY VARY.

COST + ENERGY REDUCTION SUMMARY, PRE-INCENTIVES

	NON-COMBUSTIBLE CONSTRUCTION			COMBUSTIBLE CONSTRUCTION		
	TIER 1	TIER 2	TIER 3	TIER 1	TIER 2	TIER 3
PROJECTED DER TOTAL COST	$7,292,748.00	$10,658,279.23	$14,528,295.34	$7,969,037.12	$11,272,533.71	$15,355,804.73
COST/SF	$98.66	$144.19	$196.54	$107.81	$152.50	$207.74
COST / DWELLING UNIT	$57,423.21	$83,923.46	$114,396.03	$62,748.32	$88,760.11	$120,911.85
COST / ENVELOPE AREA (EXTERIOR WALLS + ROOF)	$146.91	$214.71	$292.67	$160.54	$227.09	$309.34
HVAC SCOPE COST	$3,802,485.00	$6,083,976.00	$5,069,980.00	$3,091,815.00	$4,946,904.00	$4,122,420.00
DOMESTIC HOT WATER SCOPE COST	$928,950.00	$1,486,320.00	$1,238,600.00	$1,596,032.81	$2,553,652.50	$2,128,043.75
ELECTRICIFICATION INFRASTRUCTURE SCOPE COST	$1,292,585.00	$1,292,585.00	$1,292,585.00	$2,159,000.00	$2,159,000.00	$2,159,000.00
PROJECTED EUI REDUCTION, POST DER, PRE SOLAR	15.00%	61.72%	73.86%	15.00%	61.72%	73.86%
PROJECTED ENERGY REDUCTION IN MMBTU	1262.81232	5196.040376	6538.552158	1262.81232	5196.040376	6538.552158

INCENTIVES

MASS DOER: $40,000 PER DWELLING UNIT	✓	✓	✓	✓	✓	✓
COST / DWELLING UNIT	$17,423.21	$43,923.46	$74,396.03	$22,748.32	$48,760.11	$80,911.85
PROJECTED ASSOCIATED COST SAVINGS	$5,080,000.00	$5,080,000.00	$5,080,000.00	$5,080,000.00	$5,080,000.00	$5,080,000.00
MASS SAVES LEAN: $350 / MMBTU REDUCTION IN ENERGY USE WITH 40% ENERGY SAVINGS		✓	✓		✓	✓
PROJECTED MMBTU ASSOCIATED COST SAVINGS	$0.00	$1,818,614.13	$2,288,493.26	$0.00	$1,818,614.13	$2,288,493.26
COST SAVINGS / DWELLING UNIT	$0.00	$14,319.80	$18,019.63	$0.00	$14,319.80	$18,019.63
IRA: 30% BASE CREDIT ON SOLAR INSTALLATIONS			✓			✓
PROJECTED COST SAVINGS			$96,660.00			$96,660.00
MOH ARPA FUNDING, CITY OF BOSTON: $50,000 MAX PER DWELLING UNIT WITH 50% ENERGY SAVINGS + ELECTRIFICATION						
50% ENERGY SAVINGS PROJECTED		✓	✓		✓	✓
PROJECTED COST SAVINGS						
IRA HEEHRA REBATES: MAX $14,000 PER DWELLING UNIT FOR ELECTRIFICATION	✓	✓	✓	✓	✓	✓
	$1,778,000.00	$1,778,000.00	$1,778,000.00	$1,778,000.00	$1,778,000.00	$1,778,000.00
IRA EPA/ZERH 45L: $1K / DWELLING UNIT OR $5K / DWELLING UNIT IF PREVAILING WAGE	$127,000.00	$127,000.00	$127,000.00	$127,000.00	$127,000.00	$127,000.00

COST SUMMARY, POST-INCENTIVES

PROJECTED DER TOTAL COST AFTER INCENTIVES	$307,748.00	$1,854,665.10	$5,158,142.08	$984,037.12	$2,468,919.58	$5,985,651.47
COST / SF	$4.16	$25.09	$69.78	$13.31	$33.40	$80.97
COST / DWELLING UNIT	$2,423.21	$14,603.66	$40,615.29	$7,748.32	$19,440.31	$47,131.11
COST / ENVELOPE AREA (EXTERIOR WALLS + ROOF)	$6.20	$37.36	$103.91	$19.82	$49.74	$120.58
COST % SAVINGS, POST-INCENTIVES	96%	83%	64%	88%	78%	61%

ESTIMATED UTILTY COST SAVINGS BASED ON EUI REDUCTION

EXISTING EUI (kBTU/SF YR)	113.89			113.89		
ESTIMATED EXISTING TOTAL UTILITY COST	$133,255.98			$133,255.98		
TARGETED EUI PER TIER, EXCLUDING SOLAR	96.81	43.60	29.78	96.81	43.60	29.78
TARGETED EUI CONVERTED TO KWH	2096689.389	944253.5681	644895.7665	2096689.389	944253.5681	644895.7665
ESTIMATED UTILITY COST, ALL ELECTRIC, EXCLUDING SOLAR	$440,304.77	$198,293.25	$135,428.11	$440,304.77	$198,293.25	$135,428.11
ESTIMATED YEARLY UTILITY COST DELTA, EXCLUDING SOLAR	$307,048.79	$65,037.27	$2,172.13	$307,048.79	$65,037.27	$2,172.13
UTILITY SAVINGS OR INCREASE?	INCREASE	INCREASE	INCREASE	INCREASE	INCREASE	INCREASE
SOLAR EUI (kBTU/SF YR)	0	0	4.34	0	0	4.34
SOLAR EUI CONVERTED TO KWH	0	0	93975	0	0	93975
ESTIMATED YEARLY UTILITY COST SAVINGS, SOLAR ONLY	$0.00	$0.00	$19,734.75	$0.00	$0.00	$19,734.75
TOTAL ESTIMATED UTILITY YEARLY COST, POST DER	$440,304.77	$198,293.25	$115,693.36	$440,304.77	$198,293.25	$115,693.36
TOTAL ESTIMATED UTILITY YEARLY COST DELTA, POST DER	$307,048.79	$65,037.27	-$17,562.62	$307,048.79	$65,037.27	-$17,562.62
UTILITY SAVINGS / PAYBACK PERIOD?			✓			✓
ESTIMATED PAYBACK PERIOD FOR DER IMPROVEMENTS			293.70			340.82

BERDO COMPLIANCE

APPLICABLE TO PROJECT						
COMPLIANT THROUGH YEAR	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
NON COMPLIANCE FEES + STARTING DATE						

EDIT ONLY YELLOW HI-LIGHTED CELLS

INFORMATIONAL / DIMENSIONAL INPUTS

1	**ADDRESS / LOCATION**	40R HIGHLAND AVE
	CITY	SALEM
	ZIP	01970
	STATE	MASSACHUSETTS
2	**BUILDING OUTLINE / PERIMETER (FT)**	622
3	**# OF STORIES ABOVE GRADE**	6
4	**TOTAL AREA OF BUILDING (SF) (EXCLUDING BASEMENT)**	73920
	FLOOR TO FLOOR HEIGHT (FT)	10

5	AREAS, QUANTITIES + BUILDING INFORMATION	QUANTITY	AREA PER UNIT (SF)	AREA (SF)	RENT PER UNIT ($)
	STUDIOS	127	385	48895	$0.00
	1 BEDROOMS	0	0	0	$0.00
	2 BEDROOMS	0	0	0	$0.00
	3 BEDROOMS	0	0	0	$0.00
	4 BEDROOMS	0	0	0	$0.00
	NON-RESIDENTIAL: MGMT, COMMUNITY SPACE, AMENITY			6545	
	CORE / CIRCULATION, 25% FIXED	18480			
	TOTAL QUANTITY DWELLING UNITS	127			
	TOTAL QUANTITY BEDROOMS	0			
	# OF UNITS THAT QUALIFY AS LOW - MODERATE INCOME HOUSEHOLDS	127			
		100%			
	TOTAL DWELLING UNITS RANGE	50 or more Unit			
	BUILDING CONSTRUCTION PERIOD	1960-79			
	PREVAILING WAGE REQUIRED FOR BUILDING IMPROVEMENTS?	NO			

6	**OPENINGS**			
	APPROXIMATE # OF EXTERIOR DOORS:	7		
	TYPICAL # OF WINDOWS / LIVING AREA:	2		
	TYPICAL # OF WINDOWS / BEDROOM:	0		
	ESTIMATED WINDOW SIZE (SF), SELECT ONE FROM DROP DOWN THAT IS MOST REPRESENTATIVE FOR ENTIRE PROJECT:	16	30" x 60"	12.5 SF
			48" x 48"	16 SF
			48" x 60"	20 SF
			60" x 60"	25 SF
	OPENING ADJUSTMENT FACTOR	1.25		

7	**UTILITY DATA**	
	ENERGY USE, 2 YEAR AVERAGE (kBTU)	8418057.68
	EXISTING EUI (kBTU/SF YR)	113.89
	EXISTING EUI RANGE (kBTU/SF YR)	100-120
	EXISTING EUI, WEATHER NORMALIZED (BTU/SF YR DEGREE DAY)	20.14

8	**ENVELOPE**	
	APPROXIMATE TOTAL WALL SURFACE AREA (SF):	37320
	APPROXIMATE QUANTITY OF OPENINGS (WINDOWS/DOORS), EXCLUDING ADJUSTMENT FACTOR:	254
	APPROXIMATE OPENING AREA INCLUDING ADJUSTMENT FACTOR (SF):	5080
	OPENING / WALL RATIO:	13.61%
	ROOF AREA (SF):	12320
	BASEMENT AREA (SF):	1645

9	**SOLAR + EV**	
	ROOF AREA (SF):	12320
	ROOF AREA REDUCTION FOR SETBACKS / CLEARANCES:	65.00%
	SOLAR ROOF AREA (SF):	4312
	ESTIMATED QUANTITY OF SOLAR PANELS BASED ON AVAILABLE AREA:	179
	ESTIMATED ARRAY SIZE (450 W PANELS), kW:	80.55
	ESTIMATED ARRAY KWH/YR	93975
	PROJECTED ANNUAL UTILITY SAVINGS FROM SOLAR	$19,734.75
	QUANTITY OF EXISTING / PROPOSED PARKING SPACES	69

10	**NOTABLE BUILDING CHARACTERISTICS + CAPITAL NEEDS SURVEY**	
	IRREGULAR FACADE	NO
	EXTENSIVE PORCHES AND / OR BALCONIES	NO
	KNOWN ENVIRONMENTAL ABATEMENT NEEDS	NO
	HEATING SYSTEM AT END OF SERVICE LIFE	YES
	EXISTING HEATING SYSTEM FUEL SOURCE	GAS
	EXISTING HVAC DUCTED VS NON-DUCTED	NON-DUCTED
	DOMESTIC HOT WATER SYSTEM AT END OF SERVICE LIFE	NO
	EXISTING DOMESTIC HOT WATER SYSTEM FUEL SOURCE	GAS
	ROOF AT END OF SERVICE LIFE	YES
	WINDOWS AT END OF SERVICE LIFE	NO
	KNOW FAÇADE FAILURES OR WATER INFILTRATION	NO
	HISTORICAL COMPONENTS	NO
	BUILDING TO REMAIN OCCUPIED DURING CONSTRUCTION / IMPROVEMENTS	YES

REPLICABILITY:

-CONSIDER PANELIZED NON-COMBUSTIBLE VS SITE-BUILT COMBUSTIBLE CONSTRUCTION
-CONSIDER AVAILABLE INCENTIVES

CO2 EMISSIONS REDUCTION:

-IDENTIFY POST-RETROFIT EUI GOALS
-ASSUME ELECTRIFICATION
-PROJECT ROUGH SOLAR POTENTIAL
-ASSESS AVAILABLE INCENTIVES / REQ'T.S
-REVIEW 3 SCOPE TIERS OF ENVELOPE + SYSTEMS IMPROVEMENTS

OCCUPANT IMPACT:

-CONSIDER RELOCATION COSTS AND IMPACT ON SCHEDULE

???

RMI ENERGY TRANSFORMED. ONION FLATS ARCHITECTURE

DEER COSTING TOOL
IN PROGRESS

DEEP ENERGY EXTERIOR RETROFITS

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Tim McDonald, Onion Flats Architecture
Jeannette Penniman, Onion Flats Architecture
Kara Haggerty Wilson, Onion Flats Architecture