GENERAL REQUIREMENTS

ENERGY MODEL CALCULATIONS

6C.3.1 - 10

BALA

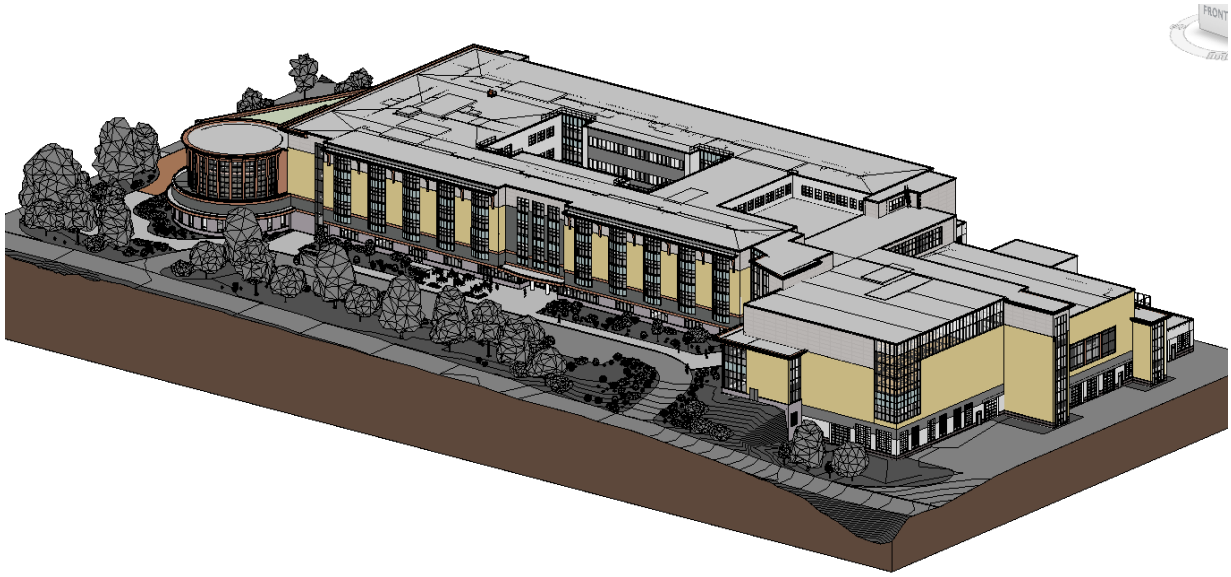
Northeast Metropolitan Vocational High School (Wakefield, MA.)

Building Energy Modeling for LEED v4 Compliance
Modeling Guidelines, Inputs, and Results

May 12, 2023

90%CD Energy model Summary:

Bala has developed the 90% CD energy model to evaluate the energy consumption and cost savings of the new Northeast Metropolitan Vocational High School against an ASHRAE 90.1-2010 Appendix G baseline building. Results from Trane Trace energy model demonstrate that the proposed new building will have more than 28% reduction in energy consumption and 35% reduction in cost compared to ASHRAE 90.1 - 2010. The purpose of this analysis is to demonstrate energy use performance in excess of the minimum requirements of LEED v4 Energy & Atmosphere Prerequisite. These results reflect the 90%CD status. Results might defer once the CD design is completed (100%), and final inputs are integrated as design values where the assumptions are used.



The energy model for the building's new 353,800 net square feet of school design includes the following space types;

- Level 0: Vocational Shops, Classrooms, Custodial Spaces
- Level 1: Admin Area (Principal, Conference, Reception), Vocational Shops, Weight Room, Locker/Shower, Nurses Suite, Auditorium, Early Childhood Education, Cafeteria, Kitchen
- Level 2: Classrooms, Vocational Classrooms, Science Labs, Media Center, Gymnasium, Offices
- Level 3: Classrooms, Vocational Classrooms, Science Labs, Offices
- Level 4: Classrooms, Vocational Classrooms, Science Labs, Offices

The energy model was conducted utilizing Trane TRACE 700 version 6.3.2.2.S. Trane TRACE is certified in compliance with ASHRAE 140-2014. The model assumptions are based on building information available at the 90% CD phase.

Hereinafter are our basic assumptions, inputs, and results.

HVAC & Energy Assumptions:

Energy Costs:

- Electricity $0.17 / kWh (MA EIA 2020 March COMM.)

Electricity and gas rates for commercial customers are published on a monthly basis for each state by the U.S. Energy Information Administration of the U.S. Department of Energy and used as the energy cost basis of both the Proposed and Baseline models in accordance with ASHRAE 90.1-2010 section G2.4.

Indoor Conditions:

School:

- Summer 75°F / 50% RH Unoccupied setback: 80F
- Winter 70°F / No humidification Unoccupied setback: 65F

Weather:

- Boston, MA TMY3
- Summer 87.6 DB / 71.7 WB (1%)
- Winter 7.7 DB (99.6%)

Schedules:

- School 10Months:
  - ASHRAE 90.1 default schedules are utilized for building occupants, lighting, and receptacles. Schedules are identical for both the Proposed and Baseline models. For 10 months school schedules, custom modifications were made and schedules were adjusted for 10 months school calendar and 2 months holiday season.
- Adult Education:
  - Sept. – June: 5 pm-9:30 pm 4 days per week
  - Sept. – June: Saturdays 8 am – 3pm
- Administration:
  - Office Staff: 260 days per year 8 am – 3 pm.
  - Maintenance Staff: 260 days per year 7 am – 11pm
- Summer Programs:
  - July: Weekdays 8 am – 12 pm

Envelope - Proposed:

All U-values listed below represent assembly values. These are given to Bala for CD analysis. For 90% CD model, we will revise the inputs as specific envelope information for all the walls and window types.

- Walls: U-0.047
- Windows: $U_{assembly}$: U-0.33 SHGC: 0.30
- Roof: R-34 / U-0.029
- Glass Area
  - 34.5%

Envelope – 90.1-2010 Baseline

- ASHRAE Standard 90.1-2010 Table 5.5-5 for climate zone 5A
- Walls – Steel-Framed, U-0.064
- Windows – Metal framing fixed, $U_{assembly}$=0.45, SHGC=0.4
- Roof – Insulation Above Deck, U-0.048
- Exposed Overhangs; U-0.038
- Glass Area – 34.5% window to wall ratio

Internal Loads:

- Proposed model Internal Loads such as Lighting power density, plug loads and occupancy for the space were defined and will be finalized in the future and Baseline model inputs were referred to ASHRAE 90.1-2010
  - Lighting Power Density, Building Area Method
    - Proposed Model 0.75 w/sf (Assumption)
    - Baseline Model : 0.99 W/SF
  - Plug Loads (Once the equipment loads are defined. Inputs for the plug loads and equipment loads might change in occupant spaces.)
    - Admin Suite: 1 W/SF
    - Auditorium: 1.5 W/SF
    - Cafeteria:0.75 W/SF
    - Classroom:0.75 W/SF
    - Conference:0.75 W/SF
    - Corridors: 0.2 W/SF
    - Gymnasium:1 W/SF
    - Lockers: 0.5 W/SF
    - Multipurpose: 0.75 W/SF
    - Office Space:1.5 W/SF
    - Storage Space: 0.2W/SF
    - Restrooms: 0.1 W/SF
    - IT/IDF: 5 W/SF
    - Electrical Rm: 5 W/SF
    - Media Center: 1.5 W/SF
    - Vocational Classrooms: 0.75 W/SF
    - Workshops: 5 W/SF
  - Occupancy
    - Interior/Furniture plans were used for occupancy inputs

Proposed System:
The proposed building HVAC systems shall be as follows (based on 90%CD Set):

- Airside/Waterside:

  Variable Refrigerant Flow (VRF) Heating/Cooling System

  1. Central Heating and Cooling System:

     - Heating and cooling shall be accomplished via multiple air cooled heat recovery, simultaneous heating and cooling, VRF systems with air-cooled condensing units

       COP Range 3.73 – 4.14

  2. Heating and Cooling for Classrooms, Locker/Shower, Offices, Media Center and Vocational Classrooms:

     - Space heating and cooling shall be accomplished via VRF fan coil units. The VRF fan coil units will be horizontal ducted type.

     - Ventilation air serving each classroom shall be provided with a variable air volume terminal unit connected to the return air duct or directly to a ceiling diffuser.

  3. Classrooms, Locker/Shower, Vocational Classrooms, and Interior Ventilation Systems:

     - Outside ventilation air for classrooms and interior spaces will be provided by roof mounted dedicated outside air systems (HRUs/ERVs).

     - The HRU will be variable air volume and will include supply and exhaust fans with variable frequency drives, and total energy recovery wheel. The units will be provided with a DX coil connected to a dedicated VRF heat pump unit capable of heating and cooling.

     - Variable supply air will be based on demand from classrooms and interior spaces. Return/exhaust air shall be controlled by air flow measurement and tracking of the supply air with variable volume control terminals in the exhaust air system.

     - Corridors will be provided with ventilation air from the HRU system.

  4. Gymnasium, Auditorium, Events Entry, Cafeteria, Culinary, Cosmetology, Vocational Shops:

     - Will be served by rooftop or indoor heating and cooling air handling units (RTU/AHU). RTU-COP: 3.73

     - The Gymnasium unit will be single zone with a variable frequency drive to modulate the supply air during periods of low demand and occupancy.

  5. Offices, Media Center, and Early Childhood Ed. Ventilation and Exhaust System:

     - The Locker Rooms and support spaces will be served by a variable volume roof mounted energy recovery ventilator (ERV).

- The unit will be multi zone with variable volume terminal units for supply and exhaust to each zone. Supply air will be based on demand from spaces. Return/exhaust air shall be constant volume in the locker/shower spaces and shall be controlled by air flow measurement and tracking of the supply air for the support spaces.

- Electric Unit Heater
  - Vestibules, Storages etc.
- AC Units
  - COP 3.73 - IDF, Electrical Rms, Network Telecom, Stairs

Baseline HVAC Equipment:

ASHRAE 90.1 Appendix G System 8 – Floor by floor chilled water AHU's supplying VAV with Parallel fan-powered boxes equipped with hot water reheat.

- PFP with electric heat on perimeter / Shut-off VAV terminal units in interior
- Airside economizers required per section G3.1.2.6.

2 Equally sized, >600 tons water cooled centrifugal chillers at 0.570 kW/ton full load (Path A) equipped with variable speed chilled water and condenser water pumps.

- Chilled water pumps (Primary and Secondary) operate at 22 W/gpm; condenser water pumps operate at 19 W/gpm.

No boilers. Electric Resistance Heating system.
Cooling only spaces will be assigned with System-4 Packed single zone HP units.
Heating only spaces will be assigned with Sytstem-10 Heating and ventilation units.

EXCLUSIONS:

- Façade lighting or site lighting
- Domestic hot water heating
- Elevators

Energy Consumption Results		
Energy Consumption (MBTU=10^6btu/yr)	ASHRAE 90.1 2010 Energy Consumption (MBTU)	Proposed Energy Consumption (MBTU)
Lighting	3,660	2,773
Space Heating (Electric)	4,911	1,516
Space Cooling	1,517	1,831
Pumps	197	0
Heat Rejection	1,543	5
Fans	2,433	2,588
Receptacles	5,682	5,682
Total Energy (MBtu)	19,943	14,395
Total Energy Reduction (%)		27.8%
EUI (kbtu/sf)	55	39
Energy Consumption / Off-set Breakdown		
Electricity (kWh)	5,499,547	3,969,582
Electricity Renewable (kWh) (+)	0	417,453
Energy Cost Summary		
Electricity	$ 934,923	$ 674,829
Electricity (Renewable) Off-set (+)	$ -	$ 70,967
Total Cost	$ 934,923	$ 603,862
Total Energy Cost Reduction (%)		35.4%