Brown Deer Clubhouse HVAC Replacement – Options Analysis

Purpose of the Study: Review available options for the upgrade of the mechanical system at the Brown Deer Club House. The options will focus on providing HVAC cooling for the entire first floor and Pro shop along with heating system (steam boiler) replacement options.

Building Description: Building was built in the 1930's. More recent renovations include the following: Basement area was renovated in circa 2004. Kitchen has been renovated in 2016.
For the purposes of this analysis, the Building will be divided in the following Zones which are made up of the following areas:

- Zone 1 - Dining Hall with an adjacent Lobby, support space and restrooms.
- Zone 2 - Lounge area

Zone 3 -

- Golf Pro Shop with office.
- Kitchen (not part of the study).
- Basement with Lockers, Boiler room, storage spaces.

Load Calculations and Basic Assumptions.

Zone 1

- Floor area – 4,000 sq. ft.
- People load – 145 people.
- Ventilation requirements – 1,100 CFM
- Cooling load (space) – 14 tons.
- Cooling Load (ventilation) – 5 Tons.
- Heating Load (space) – 120 MBH
- Heating Load (ventilation) – 92 MBH

Zone 2

- Floor area – 3,000 sq. ft.
- People load – 50 people.
- Ventilation requirements – 370 CFM
- Cooling load (space) – 12 tons.
- Cooling Load (ventilation) – 1.5 Tons.
- Heating Load (space) – 120 MBH
- Heating Load (ventilation) – 32 MBH

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Zone 3

- Floor area – 720 sq. ft.
- People load – 7 people.
- Ventilation requirements – 60 CFM
- Cooling load (space) – 4.2 tons.
- Cooling Load (ventilation) – 0.25 Tons.
- Heating Load (space) – 43 MBH
- Heating Load (ventilation) – 5.0 MBH

Basement

- Cooling Load – existing to remain (existing locker rooms).
- Heating Load (limited space) – 40 MBH

Total load (with diversity) –

- Cooling load (space) – 24 tons.
- Cooling Load (ventilation) with 50% heat recovery – 4 Tons.
- Heating Load (space) – 280 MBH
- Heating Load (ventilation) with 70% heat recovery– 40 MBH
- Heating Load (basement)– 40 MBH

System (Option) Descriptions

Option 1A: Single condenser VRF system with Heat Recovery outside air Ventilation (ERV). System consists of the following:

- Twin 14-ton condensers assembled as a single unit located on grade, nine (9) floor mounted fan coils in Dining area, eight (8) ceiling cassette fan-coils located in adjacent areas and pro-shop and two ducted fan coils located in attic servicing Lounge area.
- Heat recovery unit HR-1: 1100 CFM exhaust from restrooms and 1200 CFM fresh air distributed directly to space of Dining area.
- Heat recovery unit HR-2 - 400 CFM exhaust from Lounge area and 400 CFM fresh air ducted to the fan-coils return plenums.
- Direct OA connections to the cassette fan-coils servicing Pro-shop.
- Integrated Control System.
- Small – (100 MBH) boiler with pumps and accessories, four (4) hydronic unit heaters.
- Electric duct heaters (1 at 20 KW and 2nd at 7.5 KW) in HR units for back up.

Option 1B: Multiple condenser VRF system with Heat Recovery outside air Ventilation (ERV). System consists of:

- AC-1: 14-ton condenser located on grade and servicing Dining area and adjacent space with nine (9) floor mounted fan coils in Dining area and 4 cassette fan coils in adjacent areas.
- AC-2: 14-ton condenser located on grade and servicing Lounge area with two ducted fan coils located in attic servicing Lounge area.
- AC-3: 8-ton condenser located on grade and servicing Pro Shop with 2 ducted fan coil located in the Pro Shop area.
- Heat recovery unit HR-1: 1100 CFM exhaust from restrooms and 1200 CFM fresh air distributed directly to space of Dining area.
- Heat recovery unit HR-2: 400 CFM exhaust from Lounge area and 400 CFM fresh air ducted to the fan-coils return plenums.
- Direct OA connections to the ducted fan-coils servicing Pro-shop.
- Integrated Control system.
- Small – (100 MBH) boiler with pumps and accessories, four (4) hydronic unit heaters.
- Electric duct heaters (1 at 20 KW and 2nd at 7.5 KW) in HR units for back up.

Option 2A: Same as Option 1B with supplemental heat via hydronic radiation. Heating system consists of:

- Single condensing Boiler 500 MBH input condensing type, with associated gas piping, venting, condensate drain, make-up water, air separator and compression tank.
- Single circulation pump with pump trim (30 GPM and 30 ft. head) and bypass control valve.
- Hot water distribution piping.
- 16 fin-tube radiators with control valves and circuit setters.
- Four unit heaters in the basement area.
- Integrated Control system.

Option 2B: 1B with supplemental heat via Heating Coils at Heat recovery units. Heating system consists of:

- Single condensing Boiler 500 MBH input condensing type, with associated gas piping, venting, condensate drain, make-up water, air separator and compression tank.
- Single circulation pump with pump trim (30 GPM and 30 ft. head) and bypass control valve.
- Hot water distribution piping.
- Heat recovery units to have hot water coil installed on discharge air with three-way control valves.
- Four unit heaters in the basement area.
- Integrated Control system.

Option 3: Boiler/Chiller: 4-pipe fan-coil system heat recovery outside air. System consists of:

- Single 40-ton air cooled chiller located on the roof.
- Single condensing boilers 500 MBH input condensing type, with associated gas piping, venting, condensate drain, make-up water, air separator and compression tank.
- Single chilled water circulation pump with pump trim (80 GPM and 40 ft. head) and bypass control valve.
- Two circulation pumps with pump trim (30 GPM and 30 ft. head) and bypass control valve.
- Insulated chilled water and hot water distribution piping.
- Nine (9) floor mounted fan coils in Dining area, eight (8) ceiling cassette fan-coils located in adjacent areas and pro-shop and two ducted fan coils located in attic servicing Lounge area.
- Four unit heaters in the basement area.
- Heat recovery unit HR-1 - 1100 CFM exhaust from restrooms and 1200 CFM fresh air distributed directly to space of Dining area.
- Heat recovery unit HR-2 - 400 CFM exhaust from Lounge area and 400 CFM fresh air ducted to the fan-coils return plenums.
- Direct OA connections to the cassette fan-coils servicing Pro-shop.
- BAS System.

Load Analysis.

A. Cooling
   - Total Cooling Connected Load – 460 MBH
   - Ventilation cooling Load (included in total load)– 80 MBH
   - Diversity factor – 80%
   - Estimated ERV cooling efficiency – 40%
   - Calculated peak cooling load = (460 – 80*40%)*80% = 324 MBH
   - Estimated cooling hours per year – 1000 hrs
   - Estimated average cooling demand – 50% of peak load.
   - Calculated cooling consumption – 324 MBH *1000 hrs *50% /12 = 13,260 ton-hrs.

B. Heating
   - Total heating connected Load – 412 MBH
   - Ventilation heating Load (included in total load)– 130 MBH
   - Diversity factor – 100%
   - Estimated ERV cooling efficiency – 70%
   - Calculated peak cooling load = (412 – 130*70%) = 321 MBH
   - Estimated heating hours per year – 6500 hrs
   - Estimated average heating demand – 40% of peak load.
   - Calculated heating consumption – 321 MBH *6500 hrs *40% = 834,600 MBTU.

C. Basement Heating
   - Basement heating connected Load – 40 MBH
   - Estimated average basement heating demand – 50% of peak load.
   - Calculated heating consumption – 40 MBH *6500 hrs *40% = 104,000 MBT**Utility Cost Assumptions**:

- Electrical rate: $0.125/KWH
- Gas Rate: $0.60/Therm

Energy Consumption Analysis:

A. <u>Options 1 A and 1B</u>
   - SEER (cooling) of VRF system: 20.0
   - Average COP (Heating) of VRF system: 4.0
   - ERV fan BHP: 1.5
   - Fan hrs of operation: 3,000 hrs per year
   - Energy consumption: Cooling = 13,260 ton-hrs *12 / 20 = 7,950 KWH
   - Energy consumption: Heating = 834,600 MBTU/ (4*3.42) = 61,000 KWH
   - Energy consumption: ERV fans = 1.5 *0.75 *3,000 = 3,375 KWH
   - Energy consumption: Basement heating = 104,000 MBTU/ 3.42 = 30,000 KWH

Total energy cost: (7,950 KWH + 61,000 KWH + 30,000 KWH + 3,375 KWH) * $0.125/KWH = $12,790

B. <u>Options 2 A and 2B</u>

- SEER (cooling) of VRF system: 20.0
- Average COP (Heating) of VRF system: 4.0
- ERV fan BHP: 1.5
- Fan hrs of operation: 3,000 hrs per year
- Energy consumption: Cooling = 13,260 ton-hrs *12 / 20 = 7,950 KWH
- Energy consumption: Heating = 834,600 MBTU/ (4*3.42) = 61,000 KWH
- Energy consumption: ERV fans = 1.5 *0.75 *3,000 = 3,375 KWH
- Energy consumption: Basement heating = 104,000 MBTU/ .9 = 116,000 MBTU

Total energy cost: (7,950 KWH + 61,000 KWH + 3,375 KWH) * $0.125/KWH + 116,000 MBTU /100 * $0.6 = $9,040 + $670 = $9,710

C. <u>Option 3</u>

- SEER (cooling) of Chiller system: 10
- ERV fan BHP: 1.5
- Fan and pump hrs of operation: 6,000 per year
- Pump and Fan-coils BHP: 5 HP
- Boiler efficiency: 90%
- Energy consumption: Cooling = 13,260 ton-hrs *12 / 10 = 15,900 KWH
- Energy consumption: Fans & Pumps = (3 +5)*0.75 *6,000 = 36,000 KWH
- Energy consumption: Heating = (834,600 + 104,000) MBTU / (90%) / 100 = 10,430 Therms

Total energy cost: (15,900 KWH + 36,000 KWH) * $0.125/KWH + 10,430 Therms * $0.60 = $6,287 + $6,258 = $12,545

Analysis Summary:

System Option	1A	1B	2A	2B	3
Estimated Construction Costs	$373,700	$405,220	$462,553	$430,030	$502,050
Estimated 1st year HVAC operation cost	$12,790	$12,790	$9,710	$9,710	$12,545
Reliability (heating)	Average	Better	Good	Good	Average
Flexibility (phasing)	Poor	Good	Good	Good	Average
Life expectancy	15 years (Note 3)	15 years (Note 3)	20 years (Note 4)	20 years (Note 4)	25 years
Familiarity	New technology	New technology	New technology	New technology	Average
Code Compliance Issues	Note 1	Note 1	Note 1	Note 1	Note 2
Annualized cost	$37,690	$39,804	$32,838	$31,211	$32,627

Notes:

1. VRF system is not available with air based economizer and may require energy model to comply with energy code.
2. Chiller/Boiler system with Fan-coils is not available with air based economizer and may require variance in order to comply with energy code.
3. Life expectancy: Electric heat used for back up only with 7,000 hrs a year compressor runtime.
4. Life expectancy: Hydronic heat could be used as a supplemental with 4,000 hrs a year compressor runtime extending the life of the VRF system.

Recommendation:

Based on the analysis, the following Options / Combination of options are recommended for implementation:

- If the facility is to operate as a seasonal occupancy, - Implement **Option 1B** as a low construction cost and good flexibility.
- If facility to operate on continuous annual basis, - implement **Option 2B** which will provide lowest annualized (depreciated) cost, greatest flexibility, lowest operation cost, and good reliability. It is also conducive to phasing of the installation based on current and future budget constraints.