VRF Case Study

Dickinson Science Center, Bennington College Case Study

GENERAL INFORMATION

Building Owner: Bennington College Corporation

Location: Bennington, Vermont

Year Built: Occupied in 1969

Square Footage: 35,000 Gross Square Feet

Building Characteristics: School building with classrooms, office, and laboratories

The VRF Units: 3 outdoor and 55 indoor Mitsubishi units (see table below for details)

PROJECT OVERVIEW

Just north of the small town of Bennington in Southern Vermont sits the sprawling 440-acre campus of Bennington College – a private university dedicated to the liberal arts. It was founded in 1932, became co-educational in 1969, and is currently a not-for-profit college that is accredited by the New England Commission of Higher Education (NESCHE). Known for its expansive beauty, distinctive architecture, and rich history, this campus is one of Bennington's most iconic landmarks.

While this region offers a beautiful depiction of life in a rustic New England town surrounded by nature, it also endures bitterly cold winters (with average low temperatures ranging from 2-12ºF) and hot, humid summers (with average high temperatures ranging from 81-90ºF). Consequently, having an adequate heating and cooling system that is able to function at very low and very high temperatures is a fundamental need for Bennington College's day-to-day operations.

In general, faculty, staff members, and students at Bennington College are committed to advancing on-campus sustainability initiatives and achieving carbon neutrality by 2030[1]. In 2008, Bennington College constructed a biomass steam plant to replace its previous fossil fuel system. At the time of installation it was projected that the system would pay for itself after 7 years; and in 2016 it was confirmed that this did in fact occur. Currently, the biomass boiler supplies the majority of the campus with heat sourced from the burning of local wood chips, drastically reducing Bennington College's overall carbon output. The college also recently introduced metering technology into 30 of its buildings, which provides real-time information on their energy use. With this technology, the campus' facility manager hopes to be better able

[1]https://www.bennington.edu/sustainability-bennington

to understand energy use, and to further inform future sustainability measures. So far, the installation of programmable thermostats in strategic locations around campus has not only paid for itself in under five months, but reduced the campus' annual emissions by over six tons of CO_2/year.

At Bennington College, one building in particular stands out for its use of efficient heating and cooling systems – The Dickinson Science Center. This building – also known as Bennington's center for the sciences and math – houses classrooms, faculty offices and laboratories for chemistry, biology, and physics. The Bennington Computer Center is also located on the second floor of the building. Since 1969, the year it was first occupied, the Dickinson Science Center building has undergone several renovations to improve energy efficiency. Despite the lack of insulation on the exterior envelope, the building utilizes variable frequency drive (VFD) pumps, variable air volume (VAV) systems, LED lights, and a heat recovery ventilator (HRV). The HRV ensures that the interior of the building is properly ventilated, which is particularly important for the functioning of laboratories. In addition to all of these measures, which improve the heating efficiency of the building and reduce overall energy use, Bennington College installed a variable refrigerant flow (VRF) multi-split system in the Dickinson Science Center building in 2014.

The VRF outdoor equipment at the Dickinson Science Center building consists of three Mitsubishi Citi Multi Units, and the indoor equipment comprises 55 ceiling mounted, floor standing and wall mounted Mitsubishi units (see table below for more information on these units). The systems were initially installed to replace the previous heating system of baseboard heat (steam from biomass) and ceiling fan coils to reduce energy costs and to add air conditioning to the entire building. Although they were sized to serve 100 percent of the building's heating needs, it was determined that it would actually be more cost effective to switch over to the steam system below 55 degrees. One feature that is particularly enjoyed by occupants of the Dickinson Science Center building is each VRF system's ability to simultaneously heat and cool. Since installation, the facility manager has noted that there have been much lower heating and cooling maintenance costs and a high level of occupant satisfaction. The decision to install VRF systems at the Dickinson Science Center is not one that the Bennington College Corporation regrets, as it anticipates much more use and comfort from these systems in years to come.

A custom rebate of $2,700 from Efficiency Vermont was applied to this VRF installation project based on the energy savings and the incremental cost. At the time of installation, the estimated incremental cost of the VRF systems over a code-compliant air-to-air heat pump system was $10,000.

The VRF Units

Model #	# of Units	Cooling Capacity (BTU/H)	Heating Capacity (MBH)	Type of Heat Pump
PLFY-P36NBMU-E	1	36,000	40 @ 47F; 25.8 @ 17F	Ceiling Mounted 4-way
PCFY-P30NGMU-E	4	30,000	34 @ 47F; 22 @ 17F	Ceiling Mounted
PFFY-P24NEMU-E	15	24,000	27 @ 47F; 17.4 @ 17F	Floor Standing
PFFY-P18NEMU-E	4	18,000	20 @ 47F; 12.9 @ 17F	Floor Standing
PCFY-P15NGMU-E	2	15,000	17 @ 47F; 11 @ 17F	Ceiling Mounted
PKFY-P12NHMU-E	12	12,000	13.5 @ 47F; 8.1 @ 17F	Wall Mounted
PFFY-P08NEMU-E	5	8,000	9 @ 47F; 5.8 @ 17F	Floor Standing
PKFY-P08NHMU-E	12	6,000	6.7 @ 40F; 4.3 @ 17F	Wall Mounted
PURY-P240TS-JMU-A	3	228,000	258 @ 47F; 182 @ 17F	Outdoor

Overall System COP

COP @ 47F = 3.4
COP @ 17F = 2.2
(These efficiencies were determined by an Efficiency Vermont analysis using bin data for Bennington)
Rebates used: Efficiency Vermont provided a custom rebate of $2,700 based on energy savings and incremental costs.
Backup heating source: Biomass central steam plant via fin tube radiation, utilizes wood chips at $50/ton, 74 percent efficiency.