BHB Industry Insights

DIRECT EXPANSION ROOFTOP UNITS

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Mechanical System Solutions

The Components to Keeping your Facility Running Successfully

At BHB, we understand that the least glamorous aspects of a building are often the most vital. Regardless of the type of facility you operate, it goes without saying that you want your inhabitants to be comfortable. Selecting the best HVAC system for your building and maintaining it properly is paramount to successful operations; in some facilities such as healthcare or food service you may even face legal requirements that a certain temperature be maintained for safety reasons.

From industrial warehouses to museums housing precious artifacts, every building owner will be faced with the following considerations when choosing an HVAC system:

- Initial cost to install
- Maintenance requirements
- Operating cost
- Available space for indoor or outdoor equipment
- Efficiency
- Acoustics

Our team of mechanical engineers kicks off each project by establishing a thorough understanding of your facility's intended use, space requirements, and any special prerequisites. We will also work with our in-house civil, electrical, and structural engineers to verify that city utilities are suited to the building's requirements and equipment can be safely supported. After our engineering analysis, we will design a system to meet the unique needs of your building.

There are many different options when it comes to commercial HVAC systems. In this four-part series, we dive into the following:

- Variable refrigerant flow (VRF)
- Geothermal heat pumps
- Direct expansion rooftop units (DX RTUs)
- Chilled water/heating water systems

Direct Expansion Rooftop Units (DX RTUs)

Overview

Direct Expansion Rooftop Units (DX RTUs) are a common form of air-conditioning in the industry. This type of system uses the same basic technology as a residential split system. The biggest difference is that the indoor fan and coil unit (evaporator) are coupled with the outside unit (condenser) in one piece of equipment on the roof. This type of system is widely used for its low initial cost and simplicity, and thus has gained an unfair reputation as a low-quality system. The system's flexibility and range of options allows it to be considered for various types of projects. No one system is always the right choice, but the DX RTU can be useful for any engineer, architect, or building owner.

The equipment capabilities range from simple standard options to semi-custom or custom units with variable air volume fans (VAV), variable speed compressors, and a myriad of features to treat the air before it ever enters the building.

Advantages & Disadvantages

Advantages

Initial Cost

Arguably the biggest advantage of a DX RTU is the initial cost of the equipment. While energy savings have become increasingly important, the low nominal cost of this conventional system remains attractive. Conventional HVAC systems typically have the lowest initial costs, but even among these, DX RTUs have the lowest.

Install costs are low, even compared to DX split systems because RTUs are "packaged" systems where the piping between the "indoor" and "outdoor" components are bundled together inside the unit casing. This means that the material and labor costs associated with installing and joining piping between DX split system components are avoided.

Ease of Maintenance

Because DX RTUs are so common, technicians that can service them are available in most markets; they are also relatively simple systems with understood maintenance requirements. Because of this, the cost of maintenance for DX RTUs is low. According to The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the average maintenance costs for facilities with DX RTUs is approximately $1.56 per square foot (adjusted for inflation).

DX RTUs do not require maintenance or service personnel to get on ladders to access equipment above the ceiling. They are usually installed on the roof where it is easy to access all the components.

Occupational Safety and Health Administration (OSHA) requires a six-foot parapet to avoid guardrails, safety nets, or fall arrest systems and the International Mechanical Code (IMC) requires permanent roof access if the roof is greater than 16 feet above grade.

Flexibility

DX RTUs offer great flexibility to building owners with tenants and as such are used more often than not in retail spaces where tenant spaces are combined or subdivided and their cooling/heating demands change often.

Although DX RTUs require a roof opening for ductwork, existing units can be replaced with larger or smaller units using an inexpensive curb adapter to avoid cutting in a new roof opening in a remodel. They can also be located tactically to suit the conditioned space.

Redundancy

DX RTUs are typically laid out to balance equipment costs and thermal loads which leads to several units for a building. This inherent decentralization means that if a unit fails or is taken down for repair, the rest of the units in the building can continue operation as usual and the conditioned environment for the whole building is not lost—even if the zone served by that unit is temporarily uncontrolled.

Space Requirements

Because DX RTUs are (usually) installed on the roof, this means a large mechanical room is not needed for an air handling unit (AHU), increasing the leasable floor area of a building. Units on the roof instead of above a ceiling also allows architects to design spaces with higher ceiling heights. Since the outside air intake on a DX RTU is integral to the unit, there is no outside air ductwork running the space and no louvers or additional roof penetrations. Furthermore, if an economizer is required by the local authority and code requirements, it is simple to add the functionality to the unit at the factory without the need for a full-size outside air duct and relief air duct, both of which can pose a significant coordination challenge and can preclude the aforementioned higher ceilings.

Disadvantages

Life Expectancy

Although there are plenty of anecdotes of DX RTUs out in the wild that are so old no one remembers when they were installed, the lifespan of a DX RTU is not remarkable. The ASHRAE Handbook and Jones Lang Lasalle (JLL) both estimate that the median life of a DX RTU is about 15 years with proper preventative and repair maintenance. This lifespan must be accounted for when considering the HVAC strategy for a building and an economic analysis can be performed to help plan for the long term.

Minimum Energy Efficiency

DX RTUs are typically associated with minimum energy efficiencies (and thus minimum costs), but higher efficiency tiers are available. Energy efficient options are also available such as variable speed blower fans for single-zone or multi-zone VAV operation, micro-channel compressors, variable speed compressors and condenser fans, enthalpy economizers, and energy recovery ventilators. However, despite the higher efficiencies these options allow, DX RTUs cannot achieve the same energy efficiency that more complex systems can achieve.

Structural Requirements

All the components of the refrigerant cycle are packaged in a DX RTU, this means that the unit locations, weights, and roof openings need to be coordinated with a structural engineer; however, even with structural guidance some buildings, such as pre-fabricated metal buildings, do not have adequate structural systems to support their weight. In some areas with high wind loads the structure also needs to be able to keep the units from being forcibly detached from the roof due to the force of wind on the side of an RTU.

Options, Accessories, and Upgrades

DX RTUs offer a wide variety of factory or field-installed options, accessories, and upgrades that increase energy efficiency, controllability, and comfort.

OPTION	BENEFITS	RELATIVE COST
High Efficiency Filtration	Allows for higher indoor air quality, up to MERV 14 *MERV (Minimum Efficiency Reporting Value) is measured on a scale of one to 16*	$
High Energy Efficiency Ratings	Units are available with varying levels of energy efficiency *Measured by SEER (Seasonal Energy Efficiency Ratio), EER (Energy Efficiency Ratio), IEER (Integrated Energy Efficiency Ratio), or IPLV (Integrated Part Load Value)*	$
Variable Speed/ Frequency Drive	Allows for variable air volume operation, which enable the system to meet the comfort requirements of different zones in a building without heating and cooling at the same time	$
Variable Speed Compressors	Supports variable air volume operation, higher energy efficiency, and dehumidification operation	$
Hot Gas Reheat	Allows for better humidity control and higher outside air quantities	$$$
Energy Recovery Ventilator	Provides higher energy efficiency and allows higher outside air quantities	$$$
Modulating Heat	Adjusts the amount of power or fuel used incrementally for higher energy efficiency and temperature control	$$

Summary

Despite advances in HVAC technology the DX RTU is far from obsolete. Due to space limitations, they are often the only feasible option for applications such as retail buildings and K-12 schools. In addition, they're an attractive option due to initial cost considerations, ease of maintenance, and flexibility for future modification.

Case Studies

Santa Cruz Animal Health: A Classic Fit

Santa Cruz Biotechnology in Dallas is a quintessential example of a project where DX RTUs were a good fit. This client purchased a warehouse building to grow their animal pellet production line near an existing facility; the property had DX RTUs to condition the office portion of the building, but only had ventilation and heating for the warehouse area. This is a common HVAC strategy, but the client's production process required temperature control, and the roof structure over that process area was not designed to support heavy HVAC equipment—only ventilator fans.

BHB worked closely with the client's production manager to determine the internal heat loads in the production area, then with a structural engineer to determine where DX RTUs could be located on the roof structure to avoid costly structural re-enforcement. The roof could not support a central plant for a chilled water system and there was no available space on-site for a central plant around the building.

Due to the physical constraints of the project, this was a perfect example of an application for DX RTUs.

Trinity Basin Preparatory - Panola Campus: Outside Air and User Control

K-12 schools often have DX RTUs, and for good reason—they are a good balance of first cost and user control. Schools have many classrooms and ideally each classroom would have an independently controlled HVAC unit; they also have high outside air and exhaust requirements due to classrooms, kitchens, libraries, cafeterias, auditoriums, restrooms, gyms, and locker rooms. This school was no exception.

For the classrooms BHB specified a dedicated DX RTU per classroom. The library's outside air requirements were so high that it dominated the load. To meet this load, we specified a DX RTU that was a nearly 100% outside air unit with an energy recovery wheel to help pre-treat the large amount of outside air with the air being exhausted from the restrooms.

The school also had a tornado shelter which could not have any roof penetrations, so we coordinated all the DX RTUs for both floors of the building to be located over one portion of the roof. BHB worked with the structural engineer to locate these units while maintaining access and clearances.

DX RTUs are commonly seen in K-12 educational facilities due to their flexibility to meet the various needs of the schools, and we can expect to continue seeing them in this application.