Reusing Existing HVAC Systems and Components

BY RAMEZ AFIFY, P.E., HBDP, MEMBER ASHRAE

During renovations, clients often ask if an existing oversized HVAC system or component can be reused. Budget constraints and timing are often cited. When an oversized system or components are reused, one of the following possibilities can be expected:

- Case 1: System works adequately;
- Case 2: System works adequately and may reduce energy consumption;
- Case 3: System continues to operate but increases energy consumption; and
- Case 4: System does not achieve its function.

This article reviews the impact of oversizing the most commonly used HVAC components. It also explores how new designs can be great designs if the engineered system has built-in flexibility, allowing a system to operate satisfactory under different loads and operating scenarios.

Case 1: Oversized System Works Adequately

DX Unit With Variable Speed Compressor/Variable Refrigerant Flow (VRF)

Variable speed compressors vary their speed in response to load conditions. As a result, the systems can continue to operate at part load with comparable efficiency. Designers would need to establish the minimum load permitted by the equipment manufacturer. For example, certain manufacturers limit the minimum low load to 20% of maximum load. If the anticipated minimum part load is below the manufacturer minimum load, the system operation will not be satisfactory.

Expansion Tank

An oversized expansion tank in an existing system will continue to operate satisfactorily. Although the tank will use more physical space than the system requires, the tank would continue accommodating pressure changes in a hydronic system when it is oversized.

Case 2: Oversized System Works Adequately and May Reduce Energy Consumption

Oversized Ductwork

If oversized ductwork is to be reused in an existing application, the pressure drop through the duct and duct fittings will be less than the pressure drop as the system was originally designed. This can result in energy savings only if the fan speed can be reduced, resulting in significant energy saving. Slowing a fan to 80% of its original speed will decrease the fan motor's energy consumption by approximately 50% according to fan laws.[1]

Oversized Water Pipes

Similar to oversized ductwork, oversized water pipes will also decrease the required pumping power if existing pumps are equipped with a mechanism to reduce

Ramez Afify, P.E., is the founding principal at E4P Consulting Engineering in New York. He is a member of TC 6.1, Hydronic and Steam Equipment and Systems.

pumping speed, or if the impeller diameter can be adjusted. However, oversized pipes are associated with lower water velocities which will result in air separation at velocities below 1.5 fps to 2 fps (0.46 m/s to 0.61 m/s) for pipes under 2 in. (51 mm) and air separation at velocities correspond to a head loss of 0.75 ft (0.07 kPa/m) for pipes larger than 2 in. (51 mm).[2]

If excessive air is not eliminated in the piping system, operational problems will develop including corrosion in ferrous pipes and valves due to the dissolved oxygen, noise in piping system, and inadequate flow in some areas within the system due to the formation of air pockets.

Condensing Hot Water Boilers

Condensing hot water boilers with high turndown ratio will continue to operate efficiently even in an oversized scenario. This is because condensing boiler efficiency increases at part load, especially if hot water temperature can be reset downward. Modular condensing boilers offer more flexibility with increases in the overall system turn down ratio.

Case 3: Oversized System Continues to Operate But Increases Energy Consumption

Conventional Hot Water Boiler

The energy consumption increases when a conventional hot water boiler is oversized. This is common when an existing building renovates its envelope with energy efficient fenestration for example while reusing an existing hot water boiler. The boiler will cycle on and quickly satisfies the load and then turn off. This process is associated with a pre-purge and post purge, a process that removes hot gases from the boiler but also removes significant amounts of energy. The impact on modern boiler/burner system with high turn down ration is less.

For example, if a boiler is capable of reducing its low firing rate to one tenth of its high firing rate (i.e., 10:1 turn down ratio), then a boiler can avoid wasting energy by running at low fire longer, hence avoiding frequent cycling.

This example also applies to an oversized steam boiler. The duration of firing will be shortened for an oversized steam boiler with more wasted energy during mild outdoor conditions.

TABLE 1 Oversized equipment or component impact.

COMPONENT	CASE 1	CASE 2	CASE 3	CASE 4	COMMENTS
Return Air Grille		√			Reduced noise, possible reduction in pressure drop in ducted return systems.
Supply Air Diffuser				√	Oversized diffusers cause dumping, compromising air distribution.
Ductwork		√			Energy saving if fan speed can be reduced.
Conventional DX Air Conditioning Unit				√	Excessive cycling shortens useful service life and prevents proper dehumidification.
Conventional Hot Water Boiler			√		Excessive cycling shortens equipment life and wastes energy due to pre-purge and post purge.
Water Pipes		√			Oversized water pipes may save energy, but air separation will occur at low velocities. See article for details.
Expansion Tanks	√				–
Control Valves				√	Modulation capability will be compromised.
VRF & DX Units With Variable Speed Compressors	√				New load must remain above the manufacturer's recommended minimum capacity.
Condensing Hot Water Boilers		√			The efficiency of condensing boilers increases at part load.
Constant Speed Pumps/Fan			√		Pumps/fans will operate at original speed, and valves/dampers will be partially closed to obtain reduced flow, reducing energy efficiency.
Pumps/Fans With Variable Speed Drive		√			Pumps/fans will be able to operate at lower speed, significantly reducing energy consumption.[1]
Industrial Local Exhaust				√	Particle settling occurs at lower velocity.
Commercial Kitchen Exhaust Duct		√			Must exceed minimum duct velocity of 500 fpm.[3]
Commercial Kitchen Hood			√		Higher energy consumption associated with (a) excess kitchen exhaust and (b) excess air conditioning for kitchen makeup air.

Case 1: System works adequately.
Case 2: System works adequately and may reduce energy consumption.
Case 3: System continues to operate but increases energy consumption.
Case 4: System does not achieve its function.

Commercial Kitchen Hood

Suppose a new restaurant owner would like to reuse an existing commercial kitchen hood, which is oversized for the new kitchen equipment. Since the exhaust hood airflow requirements are a function of the length of the hood,[3] both exhaust air and makeup air cannot be reduced, depriving the facility of considerable, year-round energy savings.

Case 4: Oversized System Does Not Achieve Its Function

Conventional DX Air-Conditioning Unit

The frequency of on/off cycling for an oversized DX air-conditioning unit will be excessive, shortening the useful service life of the compressor. In addition, when continuous outdoor air is provided for ventilation as required by ASHRAE Standard 62.1, that outdoor air will be introduced unconditioned to the occupied space during the frequent compressor off cycle, causing poor indoor air quality. Further, the short duration of the cooling on cycle due to system oversizing will limit the coil's ability to properly dehumidify the air, adversely impacting the humidity conditions within the occupied space. Excessive humidity levels within occupied space will be more severe in humid climates.

Control Valves

An oversized control valve will not be able to function. An oversized control valve will remain near its closed position at full load and, therefore, will not be able to modulate at part load. The valve will also hunt and will eventually fail.

Industrial Local Exhaust Duct

Reusing an existing oversized duct to transport dusts or fumes is not possible, as there are minimum velocities required to allow for transporting particles without settling.[4]

Other Systems

Table 1 (Page 79) summarizes the impact of the systems and components oversizing as well as other commonly used components.

Conclusion

Designers often need to decide if an existing system that is in a good working order can be reused. When that evaluation includes an oversized system or component, the decision is more difficult because owners would prefer reusing a system if possible. A case-by-case review is required to identify existing components that would continue to provide its function without wasting energy.

The article shows that even in scenarios where existing oversized system or components can be reused, there is often a sacrifice, which can be the inability of an oversized system to modulate at part load, a larger physical space that an oversized system occupies, etc.

Finally, designers of a new system are encouraged to consider flexibility in the design to allow the installed system to function under circumstances different from what was originally anticipated.

References

1. *2012 ASHRAE Handbook—HVAC Systems and Equipment,* Chapter 21 Fans.
2. *2013 ASHRAE Handbook—Fundamentals,* Chapter 22, Air Separation.
3. *2011 ASHRAE Handbook—HVAC Applications,* Chapter 33, Kitchen Ventilation.
4. *2011 ASHRAE Handbook—HVAC Applications,* Chapter 32, Industrial Local Exhaust Systems. ■