General HVAC Recommendations

DESIGN GUIDELINES FOR ENERGY EFFICIENT HVAC SYSTEMS

Thank you for your interest in energy efficiency! Energy efficient heating, ventilation, and air conditioning (HVAC) equipment reduces operational costs and environmental impacts. Our recommended guidelines for HVAC equipment, intended for use in both retrofit and new construction applications, are based on those from the Consortium for Energy Efficiency's (CEE) and International Energy Conservation Code (IECC) 2015. CEE is a nonprofit public-benefits corporation that develops initiatives to promote the manufacture and purchase of energy-efficient products and services. IECC 2015 is one of the most progressive energy codes published to date.

Through your electric utility's energy efficiency programs, CLEAResult helps building owners, architects and engineers evaluate the benefits of energy efficiency. Building owners are encouraged to assess and address their energy use through a variety of program-related services, including energy performance benchmarking, energy master planning, technical assistance and even public relations support. This document offers objective, third-party recommendations on best practices in the areas of energy usage and energy efficiency. These services are provided free of charge through your electric utility and are not intended to substitute for the services of paid professionals.

HVAC Equipment Efficiencies

HVAC equipment consumes 40-60 percent of a building's energy use, according to the Department of Energy, meaning that significant savings can be realized through implementing energy-efficient measures. The following air conditioner and heat pump minimum recommendations from CEE are the most efficient yet cost effective recommendations published by a third-party non-profit group to date. Your bottom-line savings is important, so higher efficiency equipment should be evaluated on a life cycle cost basis to see if the first cost is justified by the energy savings over the expected life of the equipment.

Keep in mind that if you're looking to upgrade, you should consider HVAC equipment that meets or exceeds the minimum efficiencies outlined below. To compare efficiency upgrade costs, we recommend soliciting add-alternate bids for the different efficiency options.

RECOMMENDED AIR CONDITIONER AND HEAT PUMP EFFICIENCIES

Equipment Type	Size Category	Full Load Efficiency	Part Load/Seasonal
Air Conditioner (air cooled)	≤ 5.42 tons	12.5 EER	15.0 SEER
	> 5.42 tons and ≤ 11.25 tons	12.2 EER	14.0 IEER
	> 11.25 tons and ≤ 20 tons	12.0 EER	13.2 IEER
	> 20 tons	10.8 EER	12.3 IEER
Heat Pump (air cooled)	≤ 5.42 tons	12.5 EER	15.0 SEER
	> 5.42 tons and ≤ 11.25 tons	11.3 EER	12.1 IEER
	> 11.25 tons and ≤ 20 tons	10.9 EER	11.7 IEER
	> 20 tons	10.3 EER	10.7 IEER

Source: Consortium for Energy Efficiency Tier II Recommendations

"PATH A" AND "PATH B" CHILLERS

In large chiller plants, some chillers may be designed to operate primarily at part-load. These chillers have high part-load efficiencies and follow compliance "Path B" in an energy code. Typical chillers are designed for full load efficiency and follow code compliance "Path A". Please note that a chiller must satisfy minimum requirements for both full load efficiency and Integrated Part Load Efficiency (IPLV) for either Path A or Path B in order to conform to a particular building code.

In the following tables, we recommend the chiller efficiencies championed by International Energy Conservation Code (IECC) 2015, which is one of the most progressive energy codes published to date. Please reference IECC 2015 for minimum efficiency recommendations for other types of HVAC equipment.

RECOMMENDED MINIMUM AIR-COOLED CHILLER EFFICIENCIES

Equipment Type	Size Category	Path A		Path B	
		Full Load Efficiency (EER)	IPLV (EER)	Full Load Efficiency (EER)	IPLV (EER)
Air Cooled with Condenser	< 150 tons	10.1	12.7	9.7	15.8
	≥ 150 tons	10.1	14.0	9.7	16.1

Source: International Energy Conservation Code 2015

RECOMMENDED MINIMUM WATER-COOLED CHILLER EFFICIENCIES

Equipment Type	Size Category	Path A		Path B	
		Full Load Efficiency (kW/ton)	IPLV (kW/ton)	Full Load Efficiency (kW/ton)	IPLV (kW/ton)
Water Cooled, Centrifugal	< 150 tons	0.610	0.550	0.695	0.440
	≥ 150 tons and < 300 tons	0.610	0.550	0.635	0.440
	≥ 300 tons and < 400 tons	0.560	0.520	0.595	0.390
	≥ 400 tons and < 600 tons	0.560	0.500	0.585	0.380
	≥ 600 tons	0.560	0.500	0.585	0.380
Water Cooled, Non-Centrifugal	< 75 tons	0.75	0.60	0.78	0.50
	≥ 75 tons and < 50 tons	0.72	0.56	0.75	0.49
	≥ 150 tons and < 300 tons	0.66	0.54	0.68	0.44
	≥ 300 tons and < 600 tons	0.61	0.52	0.625	0.41
	≥ 600 tons	0.56	0.5	0.59	0.38

Source: International Energy Conservation Code 2015

Recommended System Features

The following system features are proven to enhance energy efficiency in most HVAC systems. We recommend that these features be incorporated into the mechanical system design. Please note that while chillers and air-cooled air conditioners and heat pumps qualify for simple deemed savings in most energy efficiency program jurisdictions, many of the following features only qualify for incentives in a retrofit scenario where measurement and verification has been performed to quantify energy savings.

PROGRAMMABLE THERMOSTATS/SETBACK CONTROLS

Setback controls adjust space setpoint temperature and reduce or eliminate ventilation during unoccupied periods. Controls should consist of *optimum start controls* that will allow for conditioning to begin prior to scheduled occupancy time, such that the setpoint temperature will be met at the time of occupancy.

DEMAND CONTROL VENTILATION

Demand control ventilation (DCV) allows for accurate building ventilation through feedback from carbon dioxide (CO2) sensors. Outside air is expensive to condition, especially in hot, humid climates. DCV offers a potential to save significant energy in areas where occupancy is highly variable or irregular such as meeting rooms, studios, theaters, and educational facilities. CO2 controls should allow for both a reduction of outside air flow when occupancy is low and an increase in outside air flow beyond minimum set points when occupancy is high.

ECONOMIZER CONTROLS

All units supplying fresh outdoor air should be equipped with enthalpy-based economizing for “free” cooling. Such controls monitor both indoor and outdoor air temperature and humidity, and switch the system into “economizer” mode when two conditions are met: 1) outdoor air enthalpy falls below indoor air enthalpy and 2) the zone is in cooling mode. In economizer mode, the system draws sufficient outdoor air to offset the cooling load.

ENERGY RECOVERY SYSTEMS

Energy recovery systems transfer heat between conditioned air exiting the building and incoming outdoor air. Energy recovery systems include heat pipes, air-to-air heat exchangers, and heat wheels. Heat wheels are sometimes treated with desiccants, which transfer humidity and are especially useful in hot, humid climates when attempting to condition latent air. Depending on climate, Energy Recovery Ventilators (ERV) are recommended in ventilation systems with a high percentage of outside air. ERV should only be considered on ventilation systems with more than 70 percent of their designed supply air consisting of outside air.

UNDERFLOOR VENTILATION

Ventilation systems that deliver conditioned air from overhead require much mixing of air within a space before occupants can reap the comfort benefits. Underfloor ventilation can save energy by delivering conditioned air where it is needed. Consider employing underfloor ventilation in large rooms and spaces with high ceilings.

VARIABLE FREQUENCY DRIVES

Variable frequency drives (VFDs or VSDs) modulate the speed of motor rotation. Install VFDs on any motor larger than 1 horsepower in the following situations:

- Supply fans in variable-air-volume air handling units.
- Pumps that operate under variable load in the primary loop of a chiller system.
- Cooling tower fans—control VFDs on cooling tower fans such that all coupled cooling towers ramp up and down as one large cooling tower.

PART-LOAD CHILLERS

In very large chiller plants, some chillers may be designed to operate primarily at part-load in order to increase the efficiency of the entire chiller plant at less-than-peak times. Such high-efficiency part-load chillers may decrease the overall annual energy use of the building. Such chillers often utilize multiple stage compressors, variable frequency drives, and/or magnetic frictionless bearings to attain superior part-load efficiency.

DUCTLESS MINI-SPLIT

“Mini-Splits” consist of small condensers and ductless fan coil units. These are particularly popular in small areas with unusual or constant loads that do not need fresh outdoor “make-up” air. Many data server closets and large electrical rooms in new buildings are equipped with these low-tonnage systems.

Unusual System Types

WATER-SOURCE HEAT PUMPS

Water is generally a more efficient heat sink than air. Because of this property, HVAC condensers may be water-cooled instead of air-cooled. Water-cooled air conditioners and heat pumps use a building water-loop. This loop has its own set of pumps. In a typical water-source heat pump system, the water loop goes through a cooling tower. In a geothermal heat pump system, the water loop goes through ground wells or submerged heat exchangers to reject system heat. Because of the thermal properties of water, these systems can be highly efficient. These systems require a custom measurement and verification approach to energy savings within most energy efficiency incentive programs.

VARIABLE REFRIGERANT SYSTEMS (VRF, VRV, MULTISPLIT)

HVAC systems with variable-flow refrigerant compressors are relatively new to the US market compared to other technologies, but have been gaining popularity domestically and abroad. These systems may be called “Multi-Splits”, Variable Refrigerant Volume, or Variable Refrigerant Flow systems, and are a close cousin to the ductless “Mini-Splits” mentioned in the previous section. Unlike a typical air conditioner or heat pump system, one condenser connects by refrigerant lines to multiple indoor fan coil units. These systems are capable of providing simultaneous heating and cooling to different zones within a building. Keep in mind that Variable Refrigerant systems typically need supplemental conventional HVAC units to provide fresh “make-up” air. These systems require a custom measurement and verification approach to energy savings within most energy efficiency incentive programs.

Example HVAC Specifications

NEW CONSTRUCTION AND RETROFITS

A. The HVAC system shall be commissioned after construction has completed. The commissioning agent shall ensure all equipment is operating as designed in a properly functioning system.
B. All cooling equipment shall meet any applicable building and energy codes and shall comply with the efficiencies recommended in this document.

C. Retrofit designs shall be based on new load calculations for the entire facility as it currently functions.

CONTROLS

A. HVAC controls will incorporate setback temperatures during unoccupied periods. The controls must determine occupancy through either occupancy sensors or time clocks.
   a. Occupied Mode: the cooling setpoint shall be 74^{0}F (adjustable), and the heating setpoint shall be 68^{0}F (adjustable).
   b. Unoccupied Mode: the cooling setpoint shall be 79^{0}F (adjustable), and the heating setpoint shall be 63^{0}F (adjustable).

B. When the outside air temperature drops below 74^{0}F (adjustable) and the HVAC system is in cooling mode, the HVAC system shall go into economizer mode—the outside air dampers will open 100%, and the cooling coils will be set to off.

C. Large rooms with highly varying occupancy shall employ demand control ventilation (DCV) system to monitor CO2 concentration within the space and outside.
   a. CO2 setpoint shall be 500parts per million (PPM, adjustable) higher than outdoor CO2 levels.
   b. CO2 levels shall not be allowed to exceed 1,000 PPM.