

SEDAC ENERGY SMART TIPS



New Construction: HVAC Systems



New Construction EST Series 3 of 4



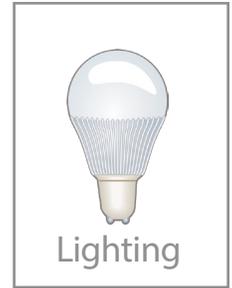
Owner's
Guide



Envelope



HVAC



Lighting

It is never too early in the design process to start thinking about heating, ventilation, and air-conditioning (HVAC).

DID YOU KNOW?

The type of HVAC system you select impacts the floor plan, floor-to-floor height, and even the design of the building façade.

Installing the right HVAC systems in your new facility contributes to a healthy indoor environment and lowers long-term maintenance and energy costs.

Heating and Cooling: There are so many great choices it is often hard to figure out the best one for your facility. Ask about the pros and cons of each system type. The best choice will depend on:

- building use type and schedules
- level of system control needed
- complexity of the system
- availability/skill level of O&M staff

Ventilation: The ventilation system should provide the right amount of fresh air to each zone based on occupancy: not too much and not too little.

Right-Sizing Equipment: Avoid the all-too-common pitfall of over-sized systems. Load calculations for equipment sizing should use the final building envelope design and take efficiency measures into account. Right-sizing equipment helps avoid occupant discomfort, and even building material damage due to poor humidity control. Right-sizing lowers first-cost and maximizes efficiency.

BE AWARE

The most efficient HVAC equipment can be operated inefficiently. Controls, commissioning, and operator training are critical.

Controls: To help to ensure efficient operation, choose system controls that match facility operations and personnel.

Commissioning: Include full building commissioning from the start of your project - it will pay off, often within a year!

Training: Provide operator training before the building opens and continuing education on equipment and controls maintenance. Be sure to budget for a controls service contract.

THINK ABOUT IT

Lowest first-cost might seem good at the time, but future occupants of the building will carry the burden of higher costs and lower air quality.

SEDAC provides personalized guidance on the selection and design of energy efficient HVAC systems for your new or existing facilities, at no cost to you or your project. We can also identify incentive funding to reduce the up-front costs of design features that will ensure future energy savings. Learn more and apply at sedac.org

The Smart Energy Design Assistance Center performs energy assessments on various building types. Each building type has different energy requirements. SEDAC's Energy Smart Tips help building operators identify energy cost reduction measures.

SMART ENERGY DESIGN ASSISTANCE CENTER
PROVIDING EFFECTIVE ENERGY STRATEGIES FOR PUBLIC AND PRIVATE BUILDINGS IN ILLINOIS

CENTRALIZED VS. DISTRIBUTED

As the plans for your new facility develop, discuss the pros and cons of various types of HVAC systems with your design professional. One of the first topics should be whether to select a single *centralized* heating/cooling plant or *distributed* heating/cooling equipment.

There is real benefit in making the right choices early in the design process. The type of system you select impacts the floor plans, ceiling heights, floor-to-floor height, façade design, ventilation and heat recovery options, controllability, as well as future space reconfiguration. First costs, maintenance, and energy costs are also affected by the type of HVAC system you select.

HEATING EQUIPMENT

We heat buildings because: 1) heat is lost through walls, roofs, and windows, 2) cold outdoor air leaks in (infiltration), and 3) cold air is brought into the building for required ventilation.

High-efficiency hot water boilers: Condensing hot water boilers achieve much higher efficiencies than conventional boilers by modulating the boiler and extracting heat that would otherwise be exhausted to the outside. Specify modulating natural gas-fired hot water condensing boilers with 94% or greater efficiency.

Modular condensing boilers: For many applications it is preferable to install a number of small boilers (modular system) rather than one large condensing boiler. Condensing boilers run most efficiently at part load. Therefore, to maximize system efficiency, multiple small boilers should fire simultaneously at the lowest firing rate possible to meet the system loads. Modular systems offer the major benefit of system redundancy when one piece of equipment fails.

High-efficiency furnaces: For smaller buildings the best solution may be distributed systems using high-efficiency natural gas furnaces. Specify 96% or better AFUE.

Energy recovery: Waste heat from the exhaust air, chiller, or other sources can be recovered and used to reduce loads on the primary heating system.

DISTRIBUTION

What is the best distribution system for your facility?

Discuss these items with your engineer and contractor:

- Should heating/cooling air be delivered with ventilation air or kept separate? (e.g. using a dedicated outdoor air system with radiant heating and cooling)?
- Which is better for your facility and why: central air handler (indoor) or distributed unit ventilators?
- Which requires the least energy to move heat around a building: Air? Water? Refrigerant? What is the required maintenance on these systems?

AN EFFICIENT SYSTEM

Integrates with the design concept

Matches planned use and zone control

Has a manageable level of complexity

Is scalable for varying demand

Is easy to maintain

Is easy to control

COOLING EQUIPMENT

We cool our buildings because: 1) there are internal heat sources like equipment, lighting, and people; and 2) heat enters from outside. Heat enters the building through windows as solar heat gain, through walls/roofs/windows from thermal transmittance, and from the ventilation system drawing in warm, humid air.

High-efficiency chillers: Choose equipment that exceeds the requirements listed as "effective 1/1/2015" in ANSI/ASHRAE/IES Standard 90.1-2013 *Energy Standard for Buildings Except Low-Rise Residential Buildings* (ASHRAE 90.1-2013), Table 6.8.1-3 *Water-Chilling Packages--Efficiency Requirements*.

Heat recovery chillers: If your building needs heat at the same time the chiller is in operation (for ventilation reheat, pool water heating, domestic hot water heating, etc), be sure to include heat recovery in your selected chiller package.

Chilled water system optimization: The overall efficiency of a chilled water system results from the optimization of all system components, including the chiller package and chilled water circulating pump(s), in combination with the cooling tower condenser water pump(s) and fans. Be sure to discuss pros and cons of different options available in the selection and sizing of the cooling tower.

High-efficiency direct expansion (DX) Cooling: For smaller buildings the logical solution may be to use distributed split DX air-conditioning. If this solution is selected, be sure your designers reference ASHRAE 90.1-2013 Table 6.8.1-1 *Electrically Operated Unitary Air Conditioners and Condensing Units--Minimum Efficiency Requirements*. Select equipment that exceeds the minimum efficiency required as of 1/1/2016.

Economizers: Air conditioning economizers make use of cool outside air in place of mechanical cooling. Economizers can be *airside* (where outside air is mixed with return air to provide the appropriate temperature of supply air directly to a conditioned space), or *waterside* (where outside air indirectly cools the space by cooling the chilled water loop).

COMBINED SYSTEMS *provide both heating and cooling.*

The first cost for combined systems is generally higher, but the long-term benefits of lower operating costs make them worth consideration, particularly when incentive funds are available to lower the initial investment.

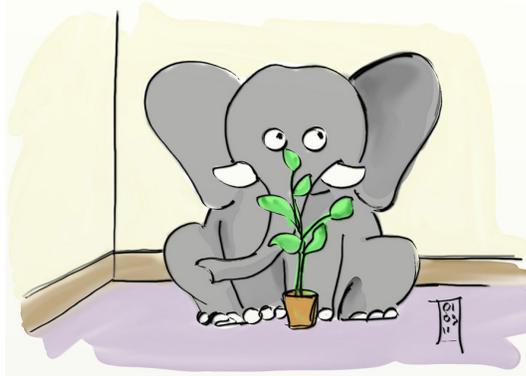
- **Ground source heat pumps (GSHP)** use the ground as a source/sink for heat.
- **Water-source heat pumps** and **variable refrigerant flow (VRF) systems** transfer heat from an overheated area of a facility into another area calling for heat.
- **Air-source heat pumps** use ambient air as a heat source and heat sink.

HVAC CONTROLS ... *the elephant in the room.*

No other system has greater potential to determine the success (or failure) of an energy-efficient building project than the selection, installation, and commissioning (or lack of commissioning) of HVAC controls. Code-required and recommended beyond-code energy-saving control strategies all rely on functional sensors and controls that operate as intended. Without this the energy consumption of the building will almost certainly be adversely affected.

Be aware that complex control systems require regular maintenance and well-trained, experienced operators to run them efficiently. Controls service contracts are critical to assure regular functional testing, software updates, and other required maintenance take place to keep systems operating as designed. Whether you choose a complex full-building automation system (BAS), or distributed controls with web-interface, make sure you have someone who has been well-trained in their operation.

Require your team to specify non-proprietary systems to avoid high component replacement costs and provide you with open-market access to controls service contractors. Avoid potential problems by limiting access to the system to trained personnel only.



VENTILATION

Indoor air quality is important!

Providing conditioned fresh air is expensive from an energy perspective, but obviously a necessity for health and productivity. There are two keys to efficient ventilation:

1. Recover energy from ventilation exhaust, using one or more of these strategies:
 - dedicated outdoor air systems with energy recovery
 - standard air handling with enthalpy (aka energy) wheels
 - energy recovery for distributed equipment (e.g. unit ventilators)
 - fixed-plate or run-around loop exchangers for applications where air-to-air exchange is prohibited
2. Control ventilation rates to provide just the right amount of fresh air for actual occupancy and activity levels. This can be done with detailed scheduling or sensor controls that rely on contaminant monitoring (e.g. CO₂ sensors).

RIGHT-SIZING EQUIPMENT

*Bigger is **not** better when it comes to sizing HVAC equipment.*

Oversized systems cost more to install and operate, provide poor dehumidification, cycle on/off too quickly (causing extra wear-and-tear), and can decrease occupant comfort.

Energy codes now require that engineers use accurate heating and cooling load calculations to size HVAC equipment. These calculations must take into account the design of the building envelope, lighting, ventilation, and occupancy loads. The loads must be adjusted to account for the inclusion of energy recovery components in the HVAC system design.

The accuracy of load calculations can be influenced by the availability of accurate project information and the interpretation of available data. Therefore, good coordination between design disciplines is critical!

Make sure your team uses accurate calculations and shares the information in order to right-size the equipment. Right-sizing saves both energy and life-cycle costs, and results in a higher level of system performance.

HVAC SYSTEM COMMISSIONING

The importance of commissioning for HVAC cannot be overstated.

Vigilant oversight during design, construction, and building startup is needed to ensure that today's sophisticated HVAC equipment (using even the simplest control systems) meets performance expectations. Equipment installers test individual components, but only a separate commissioning agent can provide whole-building systems testing. Commissioning reduces O&M costs and improves comfort. It also extends the life of equipment, construction materials, and furnishings. Third-party commissioning is best, but on smaller projects, a member of the design or contracting team can serve in this role – provided they have no other role in the project.

TRAINING *is the solution for 'I didn't know it did that!'*



Building operators have a big job that ranges from snow removal in winter, to responding to comfort complaints from tenants, to dealing with equipment failure emergencies. The last thing they need added to their responsibilities is the operation of complex HVAC equipment and controls systems for which they have had inadequate (or no) training.

The only way to achieve both energy efficiency *and* occupant comfort is to provide comprehensive initial training as well as continuing education for building operators. And don't forget the benefit of occupant education. When occupants work late, for example, they will appreciate knowing if there's an override for off-hours thermostat settings.

CHECKLIST FOR BUILDING OWNERS

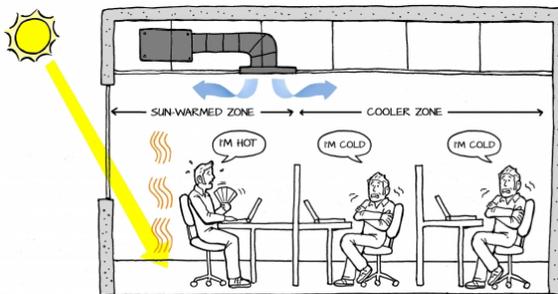
Here are some basic, but important, points to talk about with your design team and contractors. Check these items in design and ensure implementation in construction to decrease future maintenance and lower future energy costs in your building.

- ✓ **Select equipment types that meet project goals AND maximize system efficiency**
- ✓ **Require the use of accurate building load calculations - not rules of thumb**
- ✓ **Require right-sizing of equipment**
- ✓ **Discuss and incorporate equipment control strategies**
- ✓ **Commission the HVAC system**
- ✓ **Require operator training at turnover**

AVOID THESE COMMON PITFALLS

When planning for a new building, some common practices can undermine the energy efficiency of the final structure. Be aware of these pitfalls and make sure your architect, engineers, and contractors take care to avoid them.

- ⊘ **Equipment/ systems with low first-cost but high operating cost, like:**
Electric resistance heating (highest cost heating source)
Rooftop air handlers for primary heat (lowest available efficiency)
Systems that permit simultaneous heating and cooling (systems fight each other)
- ⊘ **Too little space provided for equipment in mechanical rooms**
Don't let mechanical space be an afterthought. Tight mechanical rooms can cause major maintenance headaches in the future.
- ⊘ **Equipment/ controls too complex for available staff or contractors**
The building operator must understand the nuances of the selected equipment and control systems in order to run them efficiently. Try to find a good match between the skill set of staff/contractors and the complexity of equipment.
- ⊘ **Inadequate system operation training for building operators and occupants**
Lack of training can mean that even a well-designed system doesn't get run properly, which can mean years of higher operating costs. A commissioning agent will help make sure your building operators are trained.
- ⊘ **HVAC distribution not well-integrated with envelope and lighting designs**
Remember that user comfort comes with a good envelope, efficient lighting, and HVAC appropriate to the whole building design.



SEDAC

WHO WE ARE

SEDAC is sponsored by the Illinois Department of Commerce and Economic Opportunity in partnership with investor-owned utilities to achieve energy efficiency savings in buildings throughout the State of Illinois.

SEDAC is an applied research program at the University of Illinois at Urbana-Champaign.

SEDAC works in collaboration with the 360 Energy Group.

SEDAC PROGRAMS

- Energy Assessment
- Public Sector Retro-Commissioning
- New Construction Design Assistance
- Public Sector New Construction Incentive Review
- Public Housing Efficient Living
- Training and Outreach
- Energy Incentive Guidance

"Elephant in the room" illustration courtesy of Miss Embe via Flickr.

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ENERGY SMART RESOURCES FOR NEW CONSTRUCTION

Visit the SEDAC New Construction Program website at NC.sedac.org

And for more resources and reading go to NCTips.sedac.org

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