tech overview

applicable building types
hotels, large multi-family, institutional, industrial, and commercial

implementation
at equipment replacement

fast facts
- reduces GHG emissions
- extends equipment life
- reduces maintenance and utility costs
- provides high turndown and heat recovery

tech primer

Chilled Water Plant Optimization

Highly efficient centralized cooling upgrades that increase energy efficiency and savings.

Carrier Corporation

cost & benefits

GHG savings

Tenant Experience Improvements

Utility Savings

Capital Costs

Maintenance Requirements

*ratings are based on system end use, see back cover for details.

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Getting to know chilled water plants

Cooling with chilled water is a centralized air conditioning method common in large buildings. Efficiency and performance can be improved through the appropriate selection and optimization of high-performance equipment and controls.

How do chilled water plants work?

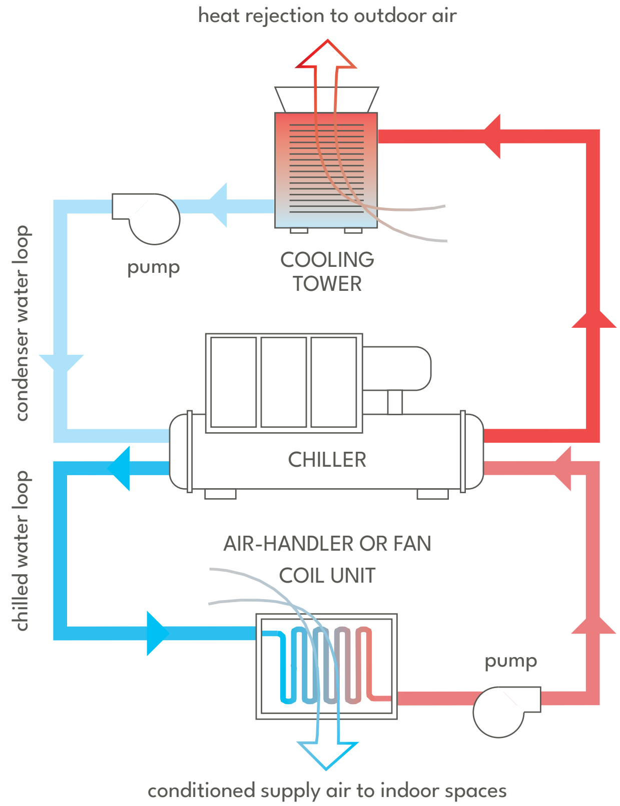
Chilled water plants use water to provide centralized cooling, and are typically found in large multifamily buildings as well as in more complex constructions such as large commercial, institutional, and industrial buildings.

Chilled water is generated by a chiller and then pumped through the building to air handlers or fan coil terminal units that cool various spaces (see Fig 1.). Warm return water is pumped back to the chiller where unwanted heat is typically rejected via a separate condenser water loop with an outdoor cooling tower. Usually located on a building's roof, a cooling tower releases heat to the outside air using evaporation.

Chilled water plants are often paired with hydronic heating systems to provide heating using the same distribution piping and terminal units.

This tech primer outlines a high performance chilled water plant retrofit and highlights opportunities to reduce greenhouse gas emissions, lower maintenance and utility costs, and maximize efficiency.

Fig 1: Chilled water is generated by a chiller and pumped to terminal units, where air passes through the unit to condition the space. Typically, unwanted heat is rejected at the cooling tower via a condenser water loop.



Assess
Always consult a qualified service provider before undertaking any building upgrades.

Coordinate Upgrades for Maximum Savings
Implementing building envelope improvements or internal heat load reductions (such as lighting upgrades) at the time of a chilled water plant retrofit will reduce the building's heat load and lower demand on the cooling system.

When future building improvements are completed, energy savings may go unrealized without optimizing the chilled water plant for newly reduced loads.

Training and Maintenance
Knowledgeable staff are fundamental to maintaining chilled water systems. Trained staff can identify and address maintenance items independently or know when to engage qualified contractors.

Energy savings can only be realized with regular maintenance of the system.

How to upgrade chilled water plants

A high-performance retrofit typically includes updating chillers and terminal units, optimizing heat rejection, correctly sizing pumps, and installing smart controls.

Retrofit solutions

Chilled water plants are comprised of a number of components that each contribute to the overall performance of the system. Completing a holistic suite of measures to address all of these components will yield the greatest results.

(A) **Upgrade Chilling Equipment –** Install either high performance, electric chillers or air-to-water heat pumps.

1. Electric Chillers – Electric chillers are significantly more efficient than fuel-fired models, however ensure that any relevant building inspection codes are followed prior to installation to maintain efficient operation.

- For maximum efficiency, a chiller must be designed for the highest supply water temperature possible, as well as the highest differential temperature possible. This will likely necessitate new terminal units that meet the same requirements (see section B).
- Select chillers with magnetic bearings and variable speed compressors, which reduce internal friction and allow for modulation; the ability to operate at variable speeds instead of simply "on" or "off." This will increase efficiency at times when the cooling system is at part load.
- Install a waterside economizer to provide "free" cooling to the building (without needing to use the chiller) during periods of mild outdoor temperatures. Selecting terminal units with a high supply temperature requirement will maximize this benefit.

2. Air-To-Water Heat Pumps – Air-to-water heat pumps are an alternative to electric chillers and have the ability to serve a building's heating and cooling needs. Implementing this new technology should be evaluated in lieu of a traditional chiller and cooling tower setup.

- Heat pumps are available with a variety of refrigerant types that each have different effects on the pump's applicability, performance, and global warming potential.

(B) **Install High Temperature-Drop Terminal Units –** Terminal units with at least 15˚F temperature difference between entering and leaving water temperatures help the whole system operate efficiently.

- Select terminal units with as high of an entering water temperature as possible.

(C) **Optimize Heat Rejection –** Cooling towers should be selected for the lowest overall size and power consumption for greatest efficiency.

- Install variable speed fans in cooling towers to save energy during mild weather.
- Install a condenser water heat recovery system for buildings with central domestic hot water (DHW) plants. Heat that would normally be rejected in the cooling tower can instead be used to heat DHW, increasing energy savings for both systems.

(D) **Properly Size Water Pumps –** Oversized pumps cannot modulate to low enough speeds, operate at poor efficiencies, and have increased maintenance issues.

- Install correctly sized pumps paired with variable frequency drives to maximize energy savings.
- Pumps must be sized based on calculated headloss (the loss of pressure due to friction) and flow rate in the system, which is highly dependent on terminal unit selection.

(E) **Install Smart Controls –** Chilled water plants typically perform best when centrally controlled through a building management system (BMS).

- The BMS should include chiller staging and speed control, cooling tower staging and fan speed control, chilled water temperature setpoint, condenser water temperature setpoint, and all control and bypass valves for economizers.

Costs and benefits of chilled water retrofits*

Greenhouse Gas (GHG) Savings

An optimized chilled water plant greatly reduces cooling related GHG emissions.

Tenant Experience Improvements

Tenants' everyday experience will remain largely unchanged, however, improving the overall function of the cooling plant will provide residents with more reliable and efficient cooling.

Utility Savings

Although energy use will be reduced, cost savings may be minimal when switching from fuel-fired to electric chillers due to the current cost of electricity. Future changes in utility costs should be considered when evaluating project feasibility.

Capital Costs

A chilled water plant retrofit requires a very large capital investment and is best implemented at the time of equipment replacement.

Maintenance Requirements

Optimized chilled water plants require a moderate level of maintenance. For larger refrigeration systems, local building code might require an on-staff engineer oversee operation. Modular chiller designs may be able to bypass this, depending on refrigerant type, individual module size, and aggregate system size. Cooling towers can have strict cleaning and maintenance protocols under local building code, however, some building owners opt for a dry cooler in order to bypass this potential need.

Take Action

This document is one of more than a dozen High Performance Technology Primers prepared by the Building Performance Partnership (BPP) to introduce decision-makers to solutions that can help them save energy and improve comfort in their buildings.

For more information, contact Built Environment Plus.

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The Building Performance Partnership (BPP), created by Building Energy Exchange (BE-Ex) and the Institute for Market Transformation (IMT), supports the creation and operation of local high-performance building hubs that accelerate measurable, equitable, and sustainable action to improve the health, comfort, and performance of buildings. With support from both BE-Ex and IMT, partner hubs serve their respective regions with customized resources that cater to the needs of their communities while benefiting from the existing resources and expertise of our network.

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*The Costs & Benefits rating system is based on a qualitative 1 to 4 scale where 1 is lowest and 4 is highest. Green correlates to savings and improvements, **dark blue** correlates to costs and requirements. Ratings are determined by industry experts and calculated relative to the system end use, not the whole building.

Note: GHG & utility savings are dependent on existing equipment and fuel type.