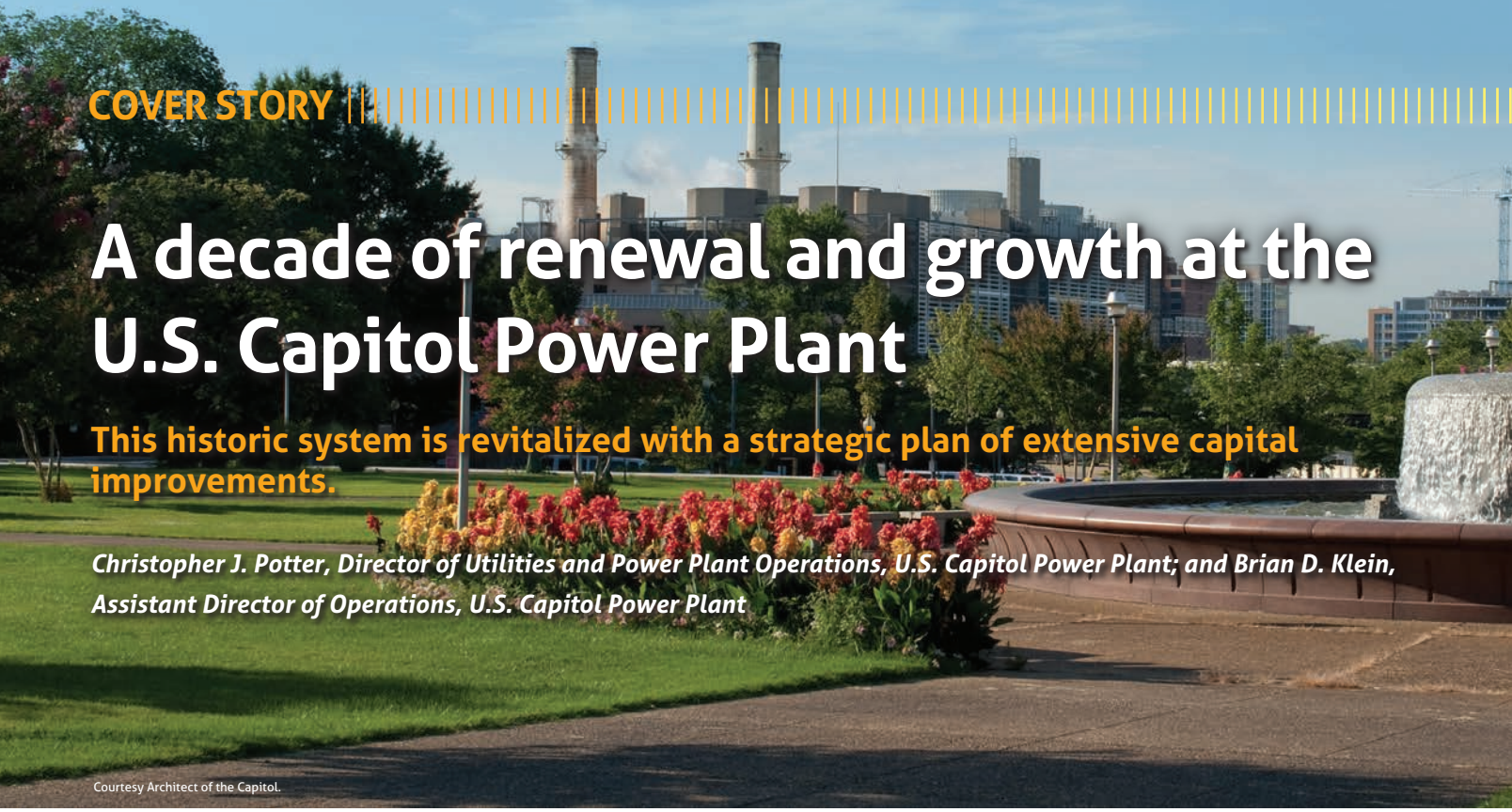
A decade of renewal and growth at the U.S. Capitol Power Plant

This historic system is revitalized with a strategic plan of extensive capital improvements.

Christopher J. Potter, Director of Utilities and Power Plant Operations, U.S. Capitol Power Plant; and Brian D. Klein, Assistant Director of Operations, U.S. Capitol Power Plant



The U.S. Capitol Power Plant.

On March 11, 1910, *The Washington Times* announced the upcoming completion of a new district energy system constructed to serve the U.S. Capitol:

"Within a week the new million and a half dollar power house, built for the purpose of furnishing light and heat to the Capitol group of buildings, will be completed. ... In addition to the Capitol, the new power house will supply light and heat to the Library [of Congress], and to the two Congressional office buildings."

Over the past century, this group of four buildings has expanded, and the district energy system now serves 24 facilities across Capitol Hill. Among them are the U.S. Capitol, the House and Senate office buildings, the U.S. Supreme Court, the Library of Congress, the U.S. Botanic Garden, Union Station, Folger Shakespeare Library and other government buildings.

The heart of the system that connects all of these vastly different facilities is located a few blocks south of the Capitol at the U.S. Capitol Power Plant (CPP), which is owned and operated by the Architect of the Capitol (AOC) – a legislative-branch federal agency that is responsible for the operation and care of more than 18.4 million sq ft of facilities and more than 570 acres of grounds (see sidebar). Included with these responsibilities are also the operation, maintenance and capital renewal of the steam, refrigeration and tunnel systems of the Capitol Power Plant.

Since its construction in 1910, the CPP has expanded and undergone several changes in its role as a district energy system. The system no longer provides power to the campus (discontinued in the 1950s), but since 1938 it has been supplying chilled-water service in addition to steam to the buildings on its Capitol Hill network.

Over the past decade, in particular, the CPP has undergone extensive capital improvement and renewal projects to ensure that it will continue to meet its congressionally mandated mission to provide heating and cooling to the Capitol campus. These projects had their origin in a long-term strategic energy plan launched in 2009.

PLANNING STRATEGICALLY

In 2007, the AOC had just completed an expansion of the West Refrigeration Plant – built 30 years prior at the CPP – to accommodate the construction of the U.S. Capitol Visitor Center. The expansion also replaced 50-year-old chillers in another area of the CPP. However, upon project completion, the AOC still relied on aging boilers and chillers to meet the steam and chilled-water loads of the campus. In fact, several of these older systems had already started to fail.

In addition to addressing aging equipment, the AOC was faced with several other drivers of change, including new federal mandates requiring a reduction of 30 percent in energy intensity by 2015, changing regulatory requirements for federal boiler emission standards and an aging tunnel system with severe safety hazards from spalling concrete. To address these challenges and ensure it would continue to meet the future energy needs of the Capitol Hill campus, the AOC initiated a comprehensive effort to develop a long-term strategic energy plan.

To achieve this task, the AOC assembled a multidisciplinary team comprising several consulting firms as well as in-house staff. It included subject matter experts specializing in distribution systems, plant infrastructure, energy markets and environmental compliance. These

THE ARCHITECT OF THE CAPITOL

This legislative-branch federal agency

- cares for more than 18.4 million sq ft of facilities, more than 570 acres of grounds and thousands of works of art;
- works behind the scenes day and night to provide Congress and the Supreme Court with facilities and infrastructure to conduct their business;
- undertakes high-visibility construction, renewal and restoration projects;
- supports numerous high-profile events like presidential inaugurations and Capitol concerts;
- employs more than 2,200 full-time employees, including craftsmen, tradesmen, gardeners, architects, engineers and service providers;
- serves 30,000 daily occupants;
- welcomes nearly 5 million visitors to the Capitol every year; and
- owns and operates the Capitol Power Plant, including responsibility for the capital renewal of plant steam, refrigeration and tunnels systems.

experts considered a wide array of different technologies, fuels and operational scenarios; explored the latest sustainability innovations; and identified and evaluated over 20 possible options to develop the new strategic energy plan.

To gain an outside perspective on the development of the plan, the AOC utilized the National Academy of Sciences to conduct an independent review. To accomplish this, the academy convened a panel of nationally recognized experts from various industries (including a few IDEA members) to review the options and strategies considered and provide input on the proposed evaluation criteria.

The evaluation criteria used for the strategic plan included

1. project costs, both construction and lifecycle costs;
2. environmental impact, of both regional greenhouse gases and hazardous air pollutants;
3. energy efficiency, both local and regional; and
4. security impacts, including availability of on-site fuel storage.

The final plan addressed recommendations for the steam plant, the chilled-water plant and the tunnel system. For the steam plant, the plan proposed the installation of a new gas-fired combined heat and power system. For the chilled-water plant, the plan called for a systematic, phased improvement and renewal project at the West Refrigeration Plant; and for the tunnels, the plan recommended a comprehensive concrete repair program and further development of requirements to replace the aging tunnels in the future.

The long-term strategic energy plan was completed in September 2009, and AOC leadership immediately began working with congressional oversight

TODAY'S U.S. CAPITOL POWER PLANT

Courtesy Architect of the Capitol.

From its beginnings as a red brick steam plant in 1910, the U.S. Capitol Power Plant has undergone numerous expansions and improvements. In 1938, the one-story East Refrigeration Plant extension was added – one of the first large refrigeration plants in the country supplying chilled water remotely. That facility now houses steam operations and the new combined heat and power unit installed in 2018. Chilled-water production is based at the West Refrigeration Plant, built in the 1970s and expanded in 2007. The CPP campus also includes an administration building added in the '70s.

committees to communicate the recommendations and develop implementation and funding strategies. The approval, funding and completion of the plan's projects were only possible through the AOC's successful master planning effort.

REFRIGERATION PLANT REVITALIZATION

Implementation of the new plan for the West Refrigeration Plant initiated with the Refrigeration Plant Revitalization (RPR) project. This project started with the development of a phased design approach to accommodate the limited availability of funding and was split into 10 separate phases.

To date, the first four phases, begun in 2012, are complete. Key accomplishments thus far include

- installation of new variable-speed chillers,
- installation of new cooling towers,
- conversion of the chilled-water pumping system from primary-secondary to variable-primary,
- conversion of the condenser water pumping system to variable-speed drives,
- installation of free-cooling and deicing systems, and
- completion of concrete repairs to the original 1970s plant structure.

The fifth phase is currently in construction: refurbishment of 1970s-era cooling towers and installation of high-performance fill along with replacement of one chiller.

Following completion of the sixth phase – which has been awarded and will be completed in fall 2021 – only one of the original 40-year-old chillers will remain in the refrigeration plant. The remaining phases of the RPR project will include

- refurbishment of the remaining 1970s-era cooling towers,
- replacement of the 4,160 V and 480 V substations,
- replacement of additional condenser water pumps with new variable-speed pumps,
- installation of additional variable-primary chilled-water pumps, and
- installation of an additional variable-speed chiller to replace the last original 40-year-old chiller.

The West Refrigeration Plant.

Energy savings, improved efficiency

The most important accomplishment of the initial phases of the RPR project was the installation of the new variable-speed chillers. These new chillers significantly improved refrigeration plant reliability and resulted in substantial energy savings.

An additional project accomplishment was the successful implementation of free cooling. CPP staff self-commissioned the free-cooling system in 2010 and have been successfully operating the system as much as possible ever since. Realizing the benefits of the system, the AOC added a heat exchanger to the RPR project to increase capacity, and the free-cooling system now provides an estimated savings of $500,000 annually.

The new chillers, free cooling and additional energy conservation measures from the RPR project have led to a 20 percent improvement in overall chilled-water plant efficiency since 2009.

THE NEW CHILLERS, FREE COOLING AND ENERGY CONSERVATION MEASURES HAVE LED TO A 20 PERCENT IMPROVEMENT IN OVERALL CHILLED-WATER PLANT EFFICIENCY.

The equipment selection process was another interesting aspect of the RPR project. Recognizing that there were only two manufacturers of the specified size of chiller and limited construction contractors with the experience to successfully complete a project of this scope, the AOC structured the government solicitation to allow each contractor to provide two bid proposals with quotes from each chiller manufacturer. In assessing the bid proposals, the AOC evaluated both initial and lifecycle costs of a system with the proposed chillers. This strategy resulted in both brands of chiller being selected for different phases of the project and has ensured the best value to the government.

CHP SYSTEM INSTALLATION

The installation of the new CHP system at the CPP took a much more winding path than the refrigeration plant project, and several challenges led to a much slower implementation.

Permitting

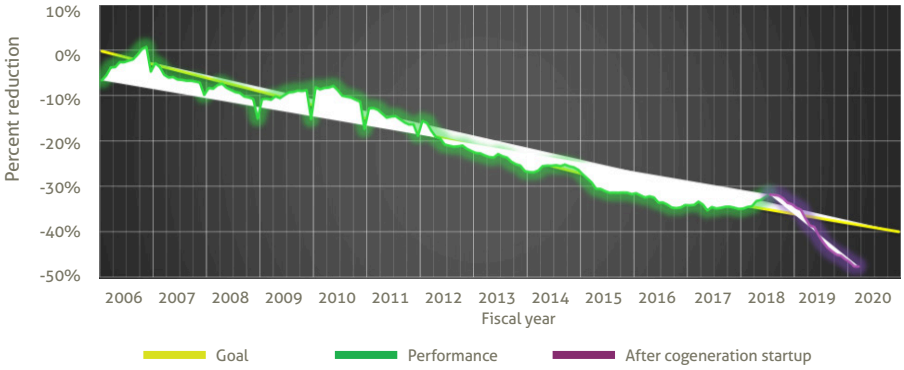
One of the most challenging exercises was to obtain the environmental air permits required to construct the CHP system. Initially, the project was structured to install two 7.5 MW combustion turbines, so the air permit applications were based on these two new units. Subsequent evaluation of project financing could not support the installation of a second combustion turbine, so the project was reduced to one. The original air permitting strategy was to add the two new CHP systems as new sources based on their maximum potential to emit. However, using this strategy would have required costly emission reduction systems on the CHP and would have resulted in an unneeded increase in overall facility allowable emissions.

To develop an alternate strategy, the AOC and an environmental consultant began discussions with the local and national environmental regulatory agencies of the District of Columbia Department of Energy and Environment (DOEE) and the U.S. Environmental Protection Agency (EPA) Region III. The AOC learned of a new permitting process utilizing plantwide applicability limit permits. These permits allow some flexibility among emitting units by limiting the emissions of the facility as a whole instead of limiting each specific unit. This new process required passage of pending regulations by both the DOEE and EPA to allow regulators to issue the permits; but the benefits would be significant, so the AOC pursued this strategy. Through effective communication and close collabora-

A heat recovery steam generator was delivered to the new CHP plant in summer 2017.

AOC engineer with the newly installed combustion turbine.

FIGURE 1. Progress in reducing campus energy use intensity, Architect of the Capitol, FY 2006-2020.



Source: Architect of the Capitol.

tion with the regulators, the AOC was able to obtain the very first plantwide applicability limit permits issued by DOEE and EPA Region III offices.

The benefits of these permits included flexibility in plant configuration, elimination of auxiliary emission controls and a guaranteed reduction in coal use. The keys to the success of this effort were having a highly skilled technical team and maintaining a good working relationship with regulators.

System construction

To construct the CHP system, the AOC partnered with Washington Gas Light through a public-private partnership called a utility energy services contract (UESC). A UESC is structured to allow a local utility to partner with a federal agency to construct energy-related projects. The utility financed and constructed the project, and the federal agency is repaying the project capital through project energy savings.

Washington Gas Light partnered with Burns & McDonnell under a design/build contract to construct the 7.5 MW CHP system. The unit was sized to essentially replace one of the two aging coal boilers at the CPP and was designed to operate on natural gas with fuel oil as backup. The system would provide steam for the district heating network as well as electricity to help power CPP chillers.

The CHP project was substantially completed in fall 2018, and the system has provided tremendous energy savings, increased steam system reliability and decreased regional emissions. Figure 1 shows the AOC's progress in reducing the electricity use intensity (total annual energy usage divided by total building square footage) of its Capitol Hill campus, including over the course of implementing the 2009 long-term strategic energy plan. As illustrated, the startup of cogeneration at the CPP resulted in a steep drop in energy use intensity that has been exceeding planned reduction goals.

Challenges met

One of the most challenging aspects of the project was working within the CPP's East Refrigeration Plant building, which would house the new CHP. The East Refrigeration Plant was constructed in 1938 as an extension to the original brick steam plant and was designed to house the first chilled-water production equipment. This facility contained numerous hazardous materials including asbestos, lead-based paint and polychlorinated biphenyls. Additionally, the work was physically constrained in a small space, required an extensive number of workers within that small area, involved multiple critical lifts of equipment and could not impact plant operations in the adjacent plant spaces.

To address this challenge, Washington Gas Light and Burns & McDonnell carefully coordinated all activities and maintained a laser focus on project safety. They utilized multiple safety managers and multiple shifts, attended daily meetings with AOC staff to coordinate construction and lockout-tagout activities and implemented an innovative task safety observation program for workers to provide feedback and support each other. The project was successfully completed with over 180,000 craft man-hours and zero recordable injuries. It was recognized in 2019 by *Engineering News-Record MidAtlantic* with an Excellence in Safety Award of Merit.

PREPARING FOR THE DECADE AHEAD

Over the past 10 years, implementation of the long-term strategic energy plan has helped the CPP keep up with the increase in heating and cooling demands. However, recognizing that much more remains to be done, the AOC recently began work on a new utility master plan to develop a strategy for the next decade. This new plan will address aging infrastructure while improving plant resiliency,

efficiency, cost-effectiveness and sustainability. The AOC is incorporating many best practices and lessons learned from other IDEA organizations and looks forward to the completion of a great utility master plan.

It was not by accident that *The Washington Times* article from 1910 mentioned above highlighted the benefits gained by connecting to district energy:

"With the completion of the power station, the heating and lighting apparatus of the four buildings will be dismantled and sold. This will eliminate the dirt and smoke nuisance. It will also provide large additional space for record storage in the basements of the group of buildings."

Reduction of environmental impacts and increased available building space are two significant benefits of district energy. But, just as Capitol Hill has expanded, the benefits of district energy have grown exponentially and now include cost savings, efficiency improvements, leverage of new technologies, and increased reliability and resiliency.

As the AOC continues to look forward and develop new plans for the future, the Capitol Power Plant will continue to provide the benefits of district energy to the nation's capital.

***Christopher J. Potter** has served since 2012 as the director of utilities and power plant operations at the Architect of the Capitol, where he is responsible for the management, operation, maintenance and capital improvement program of the U.S. Capitol Power Plant and its utility distribution system. He also oversees the utility budgeting for all facilities under AOC care. Potter began his career with the AOC in 2005 as deputy director of utilities and power plant operations. Previously he worked for the U.S. General Services Administration at its Central Heating and Refrigeration Plant. He holds a Bachelor of Science degree in mechanical engineering from the University of Maryland, a Master of Science degree in engineering management from The Catholic University of America and a Master of Public Administration degree from American University. He may be reached at cpotter@aoc.gov.*

***Brian D. Klein** is the assistant director of operations at the U.S. Capitol Power Plant with the Architect of the Capitol in Washington, D.C. In this role, he is responsible for the operations of the district energy plant serving the U. S. Capitol, the U.S. Supreme Court, the House and Senate office buildings, the Library of Congress, the U.S. Botanic Garden and several other buildings on and around Capitol Hill. With the AOC since 2003, Klein previously worked for Duke Energy at a combined-cycle power plant in Bridgeport, Conn. He graduated from Maine Maritime Academy with a Bachelor of Science degree in marine engineering technology, and he also holds a Master of Business Administration degree and a graduate certificate in public administration from the University of Phoenix. He can be contacted at bklein@aoc.gov.*

ART REPURPOSED: THE CPP CORNERSTONE

The cornerstone of the Capitol Power Plant has a unique history all of its own. Before it supported the plant, it supported the Father of Our Country – well, figuratively.

The cornerstone started out as the pedestal for the statue of George Washington by Horatio Greenough (1841). Its granite base featured the raised inscription "First in War, First in Peace, First in the Hearts of His Countrymen." In 1908, Congress passed a resolution transferring the statue from the Capitol to the Smithsonian Institution. Because a new base for the statue was authorized, the original base wasn't needed and was taken to the site for the new Capitol Power Plant.

In 1909, the pedestal was placed in the plant's foundation during construction and was used as a cornerstone. Today, the cornerstone can still be seen at ground level – proving that repurposing old items has been at the "foundation" of the Architect of the Capitol's sustainability practices for at least 100 years.

Statue of George Washington by Horatio Greenough.

The original steam plant, with cornerstone visible at lower left.