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Special Report

Partners in Resilience: Constructing the Future of Sustainable Infrastructure

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INTRODUCTION

Partners in Resilience: Constructing the Future of Sustainable Infrastructure

It will cost $3.6 trillion to repair and upgrade the nation's infrastructure, but potential financial constraints are not the only obstacle to getting the job done. In the face of increasingly extreme weather, communities can no longer afford infrastructure that is simply fixed when it breaks. They need sustainable infrastructure, which offers solutions that can keep up with contemporary climate challenges. Cities worldwide are increasingly turning to private-sector partners for the long-term investment and operational expertise these new solutions demand.

Sustainable infrastructure are utilities that are designed to support a community that faces new economic, social and environmental challenges over time. In a way, they are future-proof: designed and operated to be more resilient. And if they work within a public-private partnership (P3) framework, expertise is shared and deployed at scale. According to a PwC report, the "P3 pipeline now stretches across more than 20 states, including many that have never closed a public-private partnership transaction before." With the number and size of P3s increasing each year and major infrastructure legislation anticipated on Capitol Hill, prospects for market growth in the U.S. are brighter now than at any time in recent memory.

Canada offers a model of how productive P3s can be, especially for these fundamental infrastructure projects. Over the past 30 years, more than 200 P3s have provided an average of $14 billion per year of economic activity in the country, according to a study by The Canadian Centre for Economic Analysis. Half of these infrastructure projects involve health care facilities, with CHUM, a medical complex under construction in downtown Montréal, as the biggest and one of the most environmentally innovative.

In the U.S., P3 projects in Honolulu and Philadelphia showcase what the expected boom in P3s can mean for sustainable infrastructure.

- As expanding cities and milder seasons make drinking water harder to deliver, it's important to get smarter about treating the water we do collect. In Honolulu, Hawaii, a state-of-the-art wastewater reclamation facility has reduced ocean pollution and increased the availability of drinking water, thanks to a 20-year, $140 million P3 agreement. Interest in such water reuse projects is surging across the country as a way to mitigate the effects of drought and boost water supplies in communities with limited access to freshwater. This solution allows the city to save up to $35 million over the course of the partnership.
- Green steam has provided Philadelphia with sustainable infrastructure since 2012. That's when a P3 allowed the city's regular energy operations to use the waste heat from the Schuylkill Power Station as steam power across the district. Today, the partnership supports a cogeneration project that provides electricity, "green steam" and now a new chilled water plant for the University of Pennsylvania, reducing the school's greenhouse gas emissions by 172,000 metric tons. That's the equivalent of removing 28,000 cars from the road. If the U.S. increased its use of such cogeneration from 9% to 20% (in line with several European countries), the nation could lower greenhouse emissions by 600 million metric tons, which equates to 109 million fewer cars on the road.

This special report takes a closer look at these projects, including their costs and benefits, in order to gain a better understanding of the kinds of challenges and opportunities organizations face.

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The Initiative for Global Environmental Leadership (IGEL) and Veolia have partnered with Knowledge@Wharton to create this special report.

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How a Public-private Partnership Enabled Innovation in Health Care

PUBLIC-PRIVATE PARTNERSHIPS (P3) are one of the most promising models for financing successful health care innovations. By combining public interest with private-sector research and development, P3s have injected new life into stalled projects and delivered innovative solutions to numerous industries — especially medicine.

P3s have been most successful in Canada, where they work well with the country's single-payer health system. In the U.S., the P3 market is still in its early stages, but it shows promise. That promise is reflected in Canada with a history of success built on the P3, and one recent standout in Montréal.

In the U.S., the P3 market is still in its early stages, but it shows promise.

SUCCESSFUL IN CANADA, P3S POSE NEW OPPORTUNITIES IN THE U.S.

According to the Canadian Council for Public and Private Partnerships (CCPPP), P3s offer a number of advantages over traditional financing arrangements, including the following:

- a single contract, with the scope resolved at the outset;
- confidence on budget, schedule and size of the project;
- an annual service payment based on performance, with the managing company not compensated until the project is delivered as contracted.

Commenting on the P3-supporting Royal Ottawa Hospital, for example, CCPPP sees P3s working so efficiently in British Columbia that some have been finishing hospitals early — before the allocation of operating funds. "The P3 model was able to deliver a much-needed new facility to the community on time, within budget and more efficiently and effectively than the traditional procurement approach," it concluded. "The P3 model represents a viable option for other health care infrastructure in the face of limited government and philanthropic funds."

In the U.S., initial P3 successes have been related to major infrastructure projects. A Harvard *Kennedy School Review* report counts 48 major P3 infrastructure transactions in the U.S. between 2005 and 2014 with a worth of $61 billion. Of these, 40 closed — that is more than 80% of the total, with a value of $39 billion. And with only a handful of states with offices dedicated to examining these deals, there's still plenty of room to grow. In 2016, the U.K.'s National Audit Office reported a 15-year average of $5.8 billion annually in P3 capital investment. Its economy is about one-sixth the size of the one in the U.S.

As it turns out, a promising target for future P3s in the U.S. is health care. Since 2012, spending on health care in the U.S. has risen to more than 17% of GDP, and it is expected to rise to about 20% by 2020 — reflecting an older population and an increase in requests for treatment, a rise in chronic conditions and expensive tests inspired by certain advances in technology.

CHUM: A P3 SUCCESS STORY

The brand-new $2 billion Centre Hospitalier de l'Université de Montréal (CHUM), which completed its first construction phase in 2017, merges three older hospitals (Saint-Luc, l'Hotel-Dieu and Notre-Dame) in the heart of Montréal. And, with Veolia North America as its partner, CHUM has emerged as the largest health care project in North America, as well as the largest health care project in Canadian history.

According to Martin Viau, representing the provincial agency overseeing CHUM, the three hospitals "had to rethink their facilities to globally deliver care or research in over 30 specialties, mostly in the quaternary and tertiary level of care."

Canada has an extraordinary record in P3s, especially in health care. Between 2003 and 2011, more than 50 public-private hospital projects alone, valued at more than 18 billion Canadian dollars ($12.3 billion), took place in Quebec, Ontario, British Columbia and New Brunswick. These partnerships enable a community to combine the resources and medical expertise of the public sector with the operational and environmental specialties of the private sector. Together, they can create sustainable infrastructure — introducing current customers to more efficient services that also help to future-proof Canada for the health care challenges it will face as its cities add population and natural disasters become more common.

In these projects, the government teams up with the private sector, with the latter typically responsible for design, construction, financing, maintenance and, in certain instances, operations. The managing company takes a long-term interest — 25 to 30 years — with pre-set conditions and a performance-based contract. It also takes on partners to build and operate the facility, including construction companies, architects, property managers and providers of food, janitorial services and similar essentials. Together, they bid for the contract.

To tie the hospital and its energy provider together, Veolia became a 20% partner in CHUM's development. In that way, the hospital would not just share financial risk — its energy assets would enter into a continuous collaboration. The arrangement provides benefits to the health care community that become increasingly important as the campus sees more people, patients and, most likely, extreme weather.

Viau said the P3 process presents some built-in advantages, one of them being that the private partner and the public partner are in a unique position, through a series of design workshops, to work together to get to the best understanding possible of the needs of the medical, teaching and research communities. "P3 isn't the only way to manage a hospital project," he admits. "There's no magic recipe, and CHUM would have been built without it. But this approach definitely offers better security to the public partner because of the risks that are transferred to the private sector."

Indeed, P3s aren't applicable in all situations. Quebec's formula for large projects mandates an external, independent entity that analyzes and determines the best procurement mode for each major public project. That process definitely supported a P3 for CHUM. For the next 30 years, CHUM's maintenance levels and lifecycle expenses are fixed — a major advantage to government planners. And the private partners are responsible for the maintenance and utility lifecycle operations formerly handled by the hospitals and their technical teams.

DESIGNED FOR THE ENVIRONMENT

The 22-story, 3-million-square-foot CHUM, which will be fully completed in 2021, encompasses two city blocks in the new Quartier de la Sante health care district. It has 772 patient beds, 39 operating theaters, multiple labs, 400 clinics and examination rooms, as well as ambulatory, intensive and diagnostic care. The complex is built to serve 345,000 ambulatory patients, 22,000 in-patients and 65,000 emergency-room visitors annually.

The target represents a more than 40,000-ton annual reduction in greenhouse emissions from that baseline.

Some 180 architects based around the world worked on the design, which preserves the historic St. Sauveur steeple and other architectural details from the site's earlier structure. The facility's three interconnected towers provide a showcase for large works of art and an entry garden, while rooftop gardens overlooking the city offer patients a place to relax and breathe in the healthy scent of medicinal herbs.

In its efforts to provide sustainable infrastructure, CHUM is also setting an example for environmental responsibility. The project's request for proposal (RFP) included a mandate that it use at least 40% less energy than a baseline design. The target represents a more than 40,000-ton annual reduction in greenhouse emissions from that baseline.

These environmental principles guided the plans from their inception. CHUM's power plant, provided by Sofame Technologies, is the largest among Montréal hospitals and will have best-in-class heating efficiency. Even the elevators and escalators, from supplier KONE, were chosen for their energy efficiency.

In addition, 15-foot-diameter honeycomb-design "heat wheels" capture warmth and humidity from air leaving the building and transfer it back into the fresh air entering it. The 47 SEMCO wheels in operation will be able to supply 2.8 million cubic feet of conditioned outside air per minute. According to Bruce Becker, a Connecticut-based architect who specializes in green buildings, "Energy-recovery heat wheels are one of the most effective ways to reduce energy consumption, and CHUM has broken new ground in using this technology in a high-tech, controlled hospital environment."

Under a 34-year agreement, Veolia is providing critical lifecycle and energy performance maintenance for the entire facility.

P3S AND THE FUTURE OF U.S. HEALTH CARE

Canada carries a level of public involvement that has served them well in the development of privately financed medical projects. "In the U.S., we have a different flavor, with both government and private hospitals can be either for-profit or non-profit," according to Ashley Swanson, assistant professor of health care management at Wharton.

With P3s, there's an attempt to leverage the comparative advantages of both the private and public sectors.

"Private hospitals are certainly not a failed model," she clarifies. "With P3s, there's an attempt to leverage the comparative advantages of both the private and public sectors. There's precedent for that — the vast majority of large organizations outsource some services. The University of Pennsylvania, for instance, might outsource food and maintenance services. In Canadian P3s, the government outsources management and operation of non-clinical operations to the private sector, and in some cases clinical services, too. How well that works will vary — the devil is in the details."

Nonetheless, Dr. Marc Mitchell, a professor at the Harvard School of Public Health, says public-private partnerships in health care are inevitable. "In today's world of complexity and rapid pace, it's almost impossible to do anything alone," he said. "This is especially true in health care, because constantly rising prices, changing disease patterns and increasing use of sophisticated technology for diagnosis and treatment have made it virtually impossible to imagine any single organization providing services without some type of institutional partnership."

The P3 model allows health care officials to share the risk of building new facilities with the private sector. "Under a P3 model, risks such as cost overruns and late delivery are transferred to the private sector, which is better able to mitigate and manage them," Bert Clark, president and CEO of Infrastructure Ontario, told Mediaplanet's Industry and Business.

Current U.S. concerns about government spending and health care costs also make the time ripe for P3s. "With federal budgets under increased pressure, the question of what the government can do to curb the pace of its health care spending looms large," Cognosante executive Simona Lovin wrote on LinkedIn. "Health care federal agencies have searched for creative ways to engage with the private sector outside the confines of traditional outsourcing contracts. … In doing so, these agencies have wielded a variety of market-making tools, including the creation of several P3s."

With this in mind, Moody's Investors Service said in 2014 that the future of U.S. P3s depends on political cycles (particularly gubernatorial elections); the ability of the federal government to make loans and offer other financial assistance in P3 transactions; and the rate at which other funding sources — such as gas or carbon taxes — increase available revenue. But ultimately, according to the firm, the U.S. "has the potential to become the largest P3 market in the world."

The viability of P3s in financing Canadian health care expansion has been demonstrated with the Montréal's CHUM and, to many observers, appears likely to spread in the U.S. in coming years. ●

Preventing Wastewater from Going to Waste

IT SEEMS INCONGRUOUS AT FIRST TO THINK OF HAWAII, with its lush rainforests, cascading waterfalls and palm-lined beaches, as water-stressed. But the people of Honolulu and the rest of Oahu draw most of their drinking water from volcanic-rock aquifers under the island, and as the number of people living in the area increased during the second half of the 20th century, so did the daily amount of freshwater being pumped out of those aquifers. At the same time, rapid development was impeding the flow of water down into the volcanic rock, as extensive sugar cane plantations were replaced by houses, roads and refineries. As early as the 1990s, deep-well monitors revealed increasing aquifer salinity, a sure sign that freshwater was being withdrawn faster than it could be replenished.

And yet during this period, the island was also discharging approximately 27 million gallons a day (MGD) of wastewater into the ocean. While the water was being treated at the Honouliuli Wastewater Treatment Plant about 20 miles outside Honolulu, the U.S. Environmental Protection Agency (EPA) determined that the discharged water did not meet federal standards. The City and County of Honolulu, which owned the plant, faced stiff financial penalties if it didn't upgrade its wastewater facility to provide expensive secondary treatment of the effluent leaving the plant.

In 1995, Honolulu, the state Department of Health and the EPA agreed that instead of simply renovating the existing plant, an entirely new water recycling facility would be built. The consent decree stipulated that, beginning in 2001, Honolulu would have to treat and reuse at least 10 million gallons of its wastewater daily. This approach offered several benefits: Not only would it dramatically reduce the amount of effluent flowing into the ocean and help slow the withdrawal of freshwater from the island's aquifers, but the new recycling facility would also generate new revenue through the sale of its recycled water to commercial and industrial users.

Another key attraction of reuse was its potential to grow with the population. More people meant more wastewater available for reuse, and more drinking water available for public consumption.

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THE BIRTH OF A PUBLIC-PRIVATE PARTNERSHIP

Freshwater scarcity is a daunting challenge for government officials concerned with the needs not just of today's residents, but of future generations as well. It was this sense of urgency that led the Honolulu Board of Water Supply (BWS), a semi-autonomous state agency, to focus on sustainable infrastructure.

Recognizing that building and operating a state-of-the-art water recycling plant is a major undertaking—requiring technical expertise, upfront financing and a long-term perspective that private enterprise can sometimes enhance — Honolulu entered into a $140-million, 20-year agreement with Veolia Water to design, build, operate and own the Honouliuli Water Reclamation Facility (HWRF). At the time of contract signing in 1998, Ken Sprague, former director of environmental services for Honolulu, said the public-private partnership not only saved the community tens of millions of dollars, but also allowed the project to be completed before the 2001 deadline.

Two years later, when the plant was commissioned, BWS purchased the facility from Veolia and contracted with the company to operate and maintain it for 20 years. Today, the recycling facility processes 12 MGD of wastewater, 20% more than the 1995 agreement demanded.

Ten of the 12 MGD are used to irrigate a variety of non-agricultural green spaces, including the area's numerous golf courses. This use of recycled water has a long history, stretching back to 1929, when Los Angeles became the first city in the country to reuse treated wastewater in parks and golf courses. Three years later, San Francisco opened the nation's first reclaimed water treatment facility in Golden Gate Park, and over time other regions followed suit.

"Landscape irrigation is the most widely used application of reclaimed water in urban environments and typically involves the spray irrigation of golf courses, parks, cemeteries, school grounds, freeway medians, residential lawns and similar areas, "

—National Research Council.

"Landscape irrigation is the most widely used application of reclaimed water in urban environments and typically involves the spray irrigation of golf courses, parks, cemeteries, school grounds, freeway medians, residential lawns and similar areas, " according to a 2012 study by the National Research Council.

It is easy to understand why this type of reuse is so popular. While wastewater has to be treated before it can be used for landscape irrigation, the treatment is not as extensive or expensive as that required for food-crop irrigation or human consumption. In Hawaii, the 10 MGD destined for greenspace irrigation is treated to R1 standards, which means it is safe for non-potable use but still contains nutrients such as phosphorous and nitrogen that plants crave, explains Catherine Soriano, assistant project manager for Veolia at the Honolulu Water Recycling Facility.

REFINERIES AND POWER PLANTS CAN HELP

As more golf courses placed a strain on the shallow brackish aquifers they were tapping, the amount of water withdrawn from these aquifers increased and the water left behind grew saltier. Eventually, says Barry Usagawa, program administrator for the Honolulu Board of Water Supply's (HBWS) water resources division, the water would have become unusable, leaving the irrigation customers with no choice but to start irrigating with freshwater. The reliable supply of R1 recycled water effectively ended this threat to potable water supplies. And with the expansion of HWRF now underway, that supply will keep pace with drinking demand for the foreseeable future.

Of course, if recycled R1 water ever became more expensive than potable water, golf course owners would likely switch to a cheaper option. What makes this ultra-pure supply so valuable is the recycling facility's production of this water for industrial operations as well.

HWRF produces two MGD of purified water, virtually all of it for local refineries and power plants to use for equipment cooling and, as a renewable byproduct of this process, steam power. Both industries are water intensive, although, according to the United States Geological Survey, "Production of electrical power results in one of the largest uses of water in the United States and worldwide." And both the power plants and refineries require water that is free of impurities to prevent scaling, corrosion and biological growth.

The recycling facility uses reverse osmosis (RO), the same basic technology used in desalination, to create this ultra-pure water. RO water costs more to produce than R1 water, but the industrial customer are willing to pay a premium for it because it's ultimately more cost-efficient. According to Soriano, "In the past, refineries and other industrial clients were purchasing potable water at standard rates and then paying extra to demineralize it themselves." With the new recycled RO water, they now pay a bit more upfront, but no longer have to invest their own time or money in further treatment.

The industrial part of HWRF's business is relatively small in terms of volume, but crucial to the overall performance of the facility. In fact, Usagawa calls Veolia's decision to produce both R1 and RO water "inspired," as the profits from the RO water help subsidize the R1 water. This allows the facility to keep the R1 water less expensive than potable water, thus ensuring its continued use and protecting the area's precious supply of drinking water.

In addition, the two MGD of RO water frees up 3.6 MGD of potable water. Industrial customers had needed the larger amount because of the water lost during the demineralization process they used to employ.

THE YUCK FACTOR

According to the EPA's 2012 "Guidelines for Water Reuse," only about 7% to 8% of the nation's wastewater is reused, almost none of it for drinking (although that may change as dry regions work to get past what *The New York Times* referred to as the "yuck" factor). Meanwhile, the nation's cities and towns produce 32 billion gallons of municipal wastewater every day, according to Melissa Meeker, the executive director of the WateReuse Association and Research Foundation. More than a third of it is discharged into oceans and estuaries. It's literally wasted water.

But water reuse has been growing of late, sparked by increasing concern about water supplies around the country. California and Florida are still the most active, but 15 other states are now planning reuse projects that have attracted more than $18 billion in investment. Bluefield Research, a private water advisory firm, reports that its nationwide database of reuse projects "has ballooned to 763 projects." And, says Erin Bonney Casey, a senior analyst at the firm, "the fact that project development is happening in new states shows that water reuse is no longer just a drought-mitigation strategy, but instead a viable option for utilities to boost water supplies."

Bluefield estimates that municipal wastewater reuse capacity will increase 58% from 2016 through 2026.

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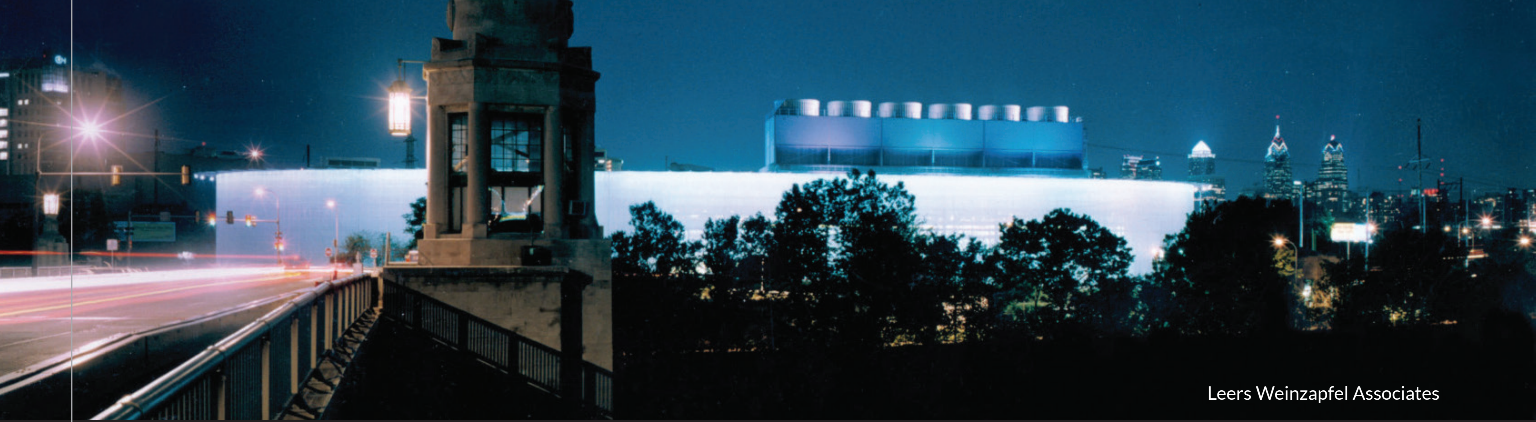
If the Bluefield estimate is correct, a decade from now the U.S. will be using about 12% to 13% of its wastewater. It's a start. But considering that water recycling leaders such as Israel are currently reusing up to 70% of their domestic wastewater, there's much greater potential for water reuse in North America. By collaborating with leaders in sustainable infrastructure across the public and private sector, America's rapidly growing coastal cities are poised to find more ways to recycle wastewater and increase their usable supplies.



Leers Weinzapfel Associates

Green Steam: Chilled Water and Clean Energy for Penn

THE UNIVERSITY OF PENNSYLVANIA SITS ON A 260-ACRE URBAN CAMPUS in the heart of Philadelphia, with 220 buildings that must be warmed in the winter and cooled in the summer, and additional thermal energy required for specialized campus equipment.

According to Ben Suplick, director of engineering and energy planning at Penn, the university has 11 miles of steam pipes (ranging from two to 12 inches in diameter) that carry both heated and chilled water around the campus. Parts of the system are more than 100 years old, dating back to 1889. Until recently, the steam was generated by Philadelphia Electric and other utilities, originally burning coal and replaced later by #6 fuel oil — what Suplick calls a "highly carbon-intensive energy source."

> Thermal energy generation is the largest single source of carbon dioxide emissions on the Penn campus, accounting for 40% of the 280,000 metric tons generated annually.

In fact, according to Dan Garofalo, the university's environmental sustainability director, thermal energy generation is the largest single source of carbon dioxide emissions on the Penn campus, accounting for 40% of the 280,000 metric tons generated annually. Going forward, as these emissions take on greater significance to the well-being of the campus, sustainable infrastructure will meet a critical need. An eco-friendly utility system, with daily operations and maintenance that can adapt to the changing needs of its campus and students, will be a huge asset.

The sustainability team knew it had to target those emissions to meet the ambitious goals of the university's Climate Action Plans (adopted in 2009 and updated in 2014). "In 2010 we studied the possibility of generating 'green steam' on the Penn campus," Suplick says. The school specifically focused on an on-campus chilled water system supported by this sustainable power source, and expanded its partnership with Veolia North America.

Through this public-private partnership (P3), Veolia operates Philadelphia's own large-scale steam and chilled water facility, and district energy system. This infrastructure is centrally located, and delivers environmental benefits across the city of Philadelphia.

THE EFFICIENCY OF COGENERATION

Prior to 2013, the Schuylkill Station plant in Philadelphia's Grays Ferry neighborhood was a mixture of innovation and tradition. It used fuel oil to produce electricity and steam through combined heat and power (CHP), also known as cogeneration, a very efficient energy solution with a proud history.

Early 20th century "power houses" often produced both electricity and steam separately for individual buildings. Thomas Edison's pioneering plants eventually combined the two for small-scale district energy by recapturing the waste heat from the generator that produces electricity. But the concept was abandoned from the 1940s to the 1970s as large, centralized utilities supplied inexpensive electricity to a broad array of customers.

In the early 1970s, following the first Earth Day, the need for energy conservation became clear, and laws such as the 1978 Public Utilities Regulatory Policies Act (PURPA) encouraged cogeneration as a way to effectively recycle heat that would otherwise be lost into the open atmosphere as carbon emissions.

In its modern form, utilities not only use the waste heat from electricity generation to produce steam for distributed heating networks, but for cooling systems that depend on chilled water as well. PURPA allowed smaller co-generators (less than 80 megawatts) to buy grid electricity at reasonable rates when their own production fell short. It also required the utilities to buy cogenerated power at rates dictated by the "avoided cost" of the utility generating the same power. It is similar to what solar and wind producers can do in states with so-called "net metering" laws.

In 2008, cogeneration provided 9% of the nation's electricity, according to the Center for Climate and Energy Solutions. That's small compared to some European countries, such as Denmark, which uses cogeneration to produce 27.5% of its electricity. But these plants are incredibly efficient, in the range of 60% to 70% compared to 20% to 25% for solar panels, says Marc Rauch, a senior specialist at the Environmental Defense Fund. An Oak Ridge National Laboratory study concluded that if that 9% grew to 20% by 2030, it would lower U.S. greenhouse emissions by 600 million metric tons. That is the equivalent of taking 109 million cars off the road.

According to GTM Research, the U.S. cogeneration market (with fuel cells included) could grow from 84 gigawatts in 2016 to 95 gigawatts by 2026.

There are also financial benefits. Boston Medical Center is now generating most of its electricity and heat from a two-megawatt CHP plant. According to CEO and President Kate Walsh, "For us, increasing efficiency and resiliency makes financial and operational sense. Cogen will save about $1.5 million in energy and heating costs, which are resources we can spend on patient care, instead of utility bills."

Also showing major improvement is the chilled water technology installed at the University of Pennsylvania. Since the 1970s, regulatory requirements have improved the needed energy efficiency of on-site chiller units by as much as 40%. And according to an Energy Design Resources (EDR) report, chiller plants in typical building cooling systems are more efficient than packaged all-air systems powered by other fuel sources 99% of the time. Under partial load conditions, on days when it is warm but not exceptionally hot, chillers become more efficient, whereas packaged units do not.

Chillers also require less space, in part because the pipes that carry cooled water through a building are much smaller than air ducts. Water is also very efficient as a medium for delivering cooled air. A pound of water can store four times the thermal energy as the same mass of air, according to the EDR report.

GREEN STEAM

In 2013, Veolia North America, which provides environmental solutions for energy, water and waste management operations, invested $60 million in its Philadelphia steam generation network, converting the system to 100% "green steam" — recycled thermal energy produced by its 163-megawatt CHP facility. The investment allowed the plant to become certified under the rigorous ISO 140001 family of environmental standards, transitioning Schuylkill Station from fuel oil to cleaner-burning natural gas.

According to Rauch, Veolia delivered a "two for one" benefit by switching an already efficient cogeneration plant to natural gas. "You can see very significant greenhouse gas emission reductions," Rauch said. The university has proven the point, reducing 172,000 metric tons of greenhouse gas emissions across campus — the equivalent of removing 28,000 cars from the road.

The new units expanded Penn's chilled water capacity by 10,000 tons, increasing energy efficiency and reducing demand on the electric grid.

More recently, the green steam installation at Penn has come to include two new steam-driven chillers, which were installed with their associated cooling towers in May 2016. The new units expanded Penn's chilled water capacity by 10,000 tons, increasing energy efficiency and reducing demand on the electric grid.

Penn needed to add chillers as new buildings were added, and old buildings were air-conditioned. "We went with steam units to give us fuel diversity," Suplick says. "We now have six electric and two steam chillers, and on peak days in the summer we can cut down on our electric demand by running only four of the electric units. Because of the way utility billing works, the ability to reduce our peak electric demand has significant financial benefits for us."

Cogeneration facilities like the one in Grays Ferry offer grid operators a number of other benefits as well:

- They are more resilient than traditional power plants. As long as chilled water and natural gas are available, cogeneration plants can continue in operation during power failures and major storms like Hurricane Sandy.
- Further, utilities can keep less efficient fuel sources in reserve for peak times when demand is high. Plants with available chilled water for cooling, in particular, avoid

that problem by eliminating their dependence on coal and fuel oil.

- Finally, cogeneration is also easy to set up (especially compared to wind farms or solar installations) in urban centers like New York and Philadelphia.

Altogether, green steam is "an important element of a good approach to reducing Penn's carbon footprint. There's been a big focus on making our buildings more efficient in their energy use. When you include the hospital, Penn's carbon emissions are on par with a city of 50,000 people, so sustainability at the university is always evolving with new approaches," according to John Keene, professor emeritus of city and regional planning at the university.

Since 2014, the Penn has cut its total campus carbon emissions by 18%.

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THE CITY'S NETWORK

Philadelphia's entire 41-mile district steam network (which became the third largest in the U.S.) supplies heating and cooling to 300 clients and 500 buildings, covering 100 million square feet in the central business district. This includes the Philadelphia Museum of Art, the Barnes Foundation, Drexel University's Integrated Sciences Building, the Liberty Bell Pavilion and Penn. The system produces 4 million pounds of steam per hour — the highest percentage of cogenerated steam in the U.S. — as well as 7,000 tons of chilled water.

Philadelphia's green steam production cuts carbon generation by 25%, with a 20% reduction in nitrogen oxides and a 93% reduction in sulfur oxides. On its own, green steam achieved 10% of the city's Greenworks Philadelphia goal (set by then-Mayor Michael Nutter in 2009) to reduce greenhouse emissions 20% by 2015.

Ultimately, "we've effectively taken 430,000 tons of greenhouse gasses out of the air. That's the equivalent of 70,000 vehicles off the road," according to Mike Smedley, vice president for Veolia in the Mid-Atlantic region.

The GTM report noted that "CHP capacity alone represents more than three times the capacity that solar provides to the U.S., and its 83 gigawatts dwarfs the 2 gigawatts of installed microgrid capacity." Cogeneration is hardly a new solution, but its proven value over more than a century is gaining the attention of property owners and developers who see new energy challenges ahead of them.

Under Philadelphia's unique P3, Penn has been setting an important example. Pennsylvania requires the state to be using 18% alternative energy resources by compliance year 2020-21. The strategic use of not just natural gas, but chiller technology, is a significant step in that direction. The University of Pennsylvania has been able to meet new regulations, limit carbon emissions, increase energy efficiency and reduce its overhead as part of its ongoing efforts to ensure a sustainable future.

Special Report

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About IGEL

The Wharton-led, Penn-wide **Initiative for Global Environmental Leadership (IGEL)** promotes knowledge for business sustainability through world-class research, transformative teaching and constructive dialogue between top alumni, academic, corporate, government, and non-government organizations. IGEL is a hub for business and sustainability, connecting and leveraging academic capital at Penn to help business leaders of today and tomorrow create more sustainable industries.

For more information, please visit https://igel.wharton.upenn.edu

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VEOLIA

About Veolia

Veolia group is a global leader in optimized resource management. With over 163,000 employees worldwide, the Group designs and provides water, waste and energy management solutions that contribute to the sustainable development of communities and industries. Through its three complementary business activities, Veolia helps to develop access to resources, preserve available resources, and to replenish them. In 2016, the Veolia group supplied 100 million people with drinking water and 61 million people with wastewater service, produced 54 million megawatt hours of energy and converted 30 million metric tons of waste into new materials and energy. Veolia Environment (listed on Paris Euronext: VIE) recorded consolidated revenue of €24.39 billion ($25.7 billion) in 2016. www.veolia.com

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