

Investing in our water future

Collaborative partnerships with private sector companies, nonprofit organizations, government, research institutes, and other entities are helping to develop low-energy, sustainable technologies that help secure clean and reliable water supply. Xylem's Senior Vice President and Chief Innovation & Technology Officer, **Jay Iyengar**, reports the results of several R&D partnerships.

Collaboration between a variety of research partners and the water industry is a crucial factor in helping to advance the sustainability and efficiency of the water sector. Investment in research and development (R&D) is necessary in order to find workable, sustainable solutions to global water challenges and ensure the preservation of water, a precious and finite resource.

Partnerships with research institutes, nonprofit organizations, technologists, government entities, start-up companies, suppliers, and customers are an important aspect of how Xylem approaches the challenge of solving water problems. Xylem is investing more than ever before in R&D and innovation to drive new technologies in smart devices, innovative business models, systems intelligence, automation, and advanced treatment and industrial services. By 2020, the company forecasts that US\$1 billion of its revenue will be coming from products, technologies, and services that will be launched over the next 5 years.

Water scarcity and reuse

Research partnerships have supported the development of smart, efficient solutions and furthered the dialogue about fostering greater sustainability across the water and wastewater sector. Water scarcity is a pervasive challenge facing many global communities, with rapid population growth, urbanization, and persistent drought placing a serious strain on the ability to deliver fresh, safe, and clean water where it is needed. Water reuse is a proven approach that can help meet growing water demands while safeguarding existing water supplies.

Xylem is working with universities, research institutes, and government agencies around the world to accelerate vital research and development efforts in water

recycling and reuse. In Stockholm, Sweden, for example, Xylem has established a water reuse research partnership with the Swedish Environmental Institute (IVL) and the Royal Institute of Technology (KTH) to develop a pilot plant and test bed for advanced process technologies that enable water reuse. The pilot plant, Stockholm's Hammarby Sjöstadsværk, is a wastewater plant with a unique history. The site opened in October 2003 as a research facility and opened its doors in 2008 to partners to facilitate long-term cooperation between researchers, municipal water treatment plants, and industry. In 2011, Xylem and IVL announced a significant long-term partnership in research and development in water reuse. A key element of this investment was the design, installation, and commissioning of the reuse pilot plant, which became operational in July 2012.

The partnership enables pioneering research and development with partners who understand the need to develop efficient and scalable solutions while also understanding the enormous global need for sustainable and cost-effective solutions. At Sjöstadsværk, Xylem is demonstrating a number of different technologies that can contribute to the world's growing need for improved water treatment and reuse. Primary, secondary, and tertiary disinfection and advanced oxidation processes (AOP) are combined to create treatment systems that can be adapted to local and regional requirements and conditions.

The primary research goals involve optimizing treatment processes and systems for non-potable (non-drinking) water reuse applications worldwide in order to achieve the best possible reduction of micropollutants, such as

pharmaceuticals and endocrine disruptors, and to optimize treatment processes to minimize life-cycle costs. The Sjöstadsværk facility is acting as a test bed to fine tune and validate innovations in each of these areas and is driving significant technological advances with regard to optimized reuse treatment. This water reuse pilot and test facility enables Xylem to demonstrate different processes and technologies, both individually and as part of an integrated process, and to bring solutions to customers more quickly.

The research has also sought to understand the costs associated with the construction of water reuse plants, their operating

expenses over 20 years, and how to deliver the most environmentally efficient solution. An important decision-making tool when building or retro-fitting a sustainable water reuse plant is the plant's life cycle cost (LCC), which includes both capital expenditures (CAPEX) and operational expenditures (OPEX). The research began with a pilot study at Hammarby Sjöstadsværk that analyzed eight different treatment lines followed by a full-scale modeling of four different effluents in plants of three sizes: 20,000 person equivalent (PE), 100,000 PE, and 500,000 PE. The modeling, based on market conditions in Spain, showed that for plants larger than 100,000 PE,



OPEX is the largest fraction of the overall life cycle cost, not CAPEX. This finding dispels a common misconception and demonstrates that the initial capital investment is not an adequate indicator of the most economical solution for water reuse.

In the United States, Xylem has funded several pilot studies related to water reuse. Since 2009, Xylem has been a member of the Water Environmental and Technology (WET) Center located at Temple University (Pennsylvania), Arizona State University and the University of Arizona in the United States. Xylem has invested in several pilot assets donated to the WET Center at Temple University and in the new facilities of the Water & Energy Sustainable Technology (WEST) Center in Tucson, Arizona. These pilots allow researchers to evaluate the principles and applicability of various ozone, UV, and AOP treatment applications for wastewater and simultaneously develop new online monitoring and control systems.

Smart water management

Around the world, research partnerships are underway that help to advance the smarter use and reuse of water. In Australia, for example, the Smart Water Fund was established by the state of Victoria in 2002. The fund receives US\$760,000 (AU\$1 million) from

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each of Melbourne's four major water utilities and has supported more than 230 industry-orientated research initiatives over the past decade. One such initiative involves an experiment at a wastewater treatment plant on the outskirts of Melbourne where scientists from Flinders University are closely monitoring algal ponds at the treatment facility in the hope of eventually generating liquid biofuel.

In Singapore, smart water management is a national priority. Xylem and Public Utilities Board (PUB), Singapore's national water agency, are engaged in a long-standing collaborative public-private partnership designed to develop new technologies and

engineering solutions essential for the growth of Singapore. Singapore, for example, has aggressively targeted leak detection and remediation since unresolved leaks waste significant amounts of precious water and energy each year in municipal water systems around the world. Xylem partnered with PUB and Visenti, a small local technology company, to implement an end-to-end, real-time monitoring solution to help Singapore optimize energy consumption, water quality, and leakage detection.

A more recent initiative has focused on reducing water loss, or non-revenue water, in Singapore, where non-revenue rates run at a mere 4.6 percent, one of the lowest levels in the world. Helping the water-scarce city-state reduce losses even further is a new smart monitoring system developed by Xylem, which uses multi-functional water sensors known as data sondes. The sensors feed data about pressure irregularities and other key factors into analytics software provided by Visenti, and this information is then sent to a central command center by text message and apps. Xylem and Visenti are currently co-developing a cloud-based service that will enable alerts to be sent via the Internet to any device, even in remote areas. PUB uses the updates to adjust water flow and pressure in the water network, which cuts water losses

due to leaks and clogged pipes.

The Xylem-PUB partnership has also included an AOP pilot study, which demonstrates that ozone-based AOP can remove taste and odor compounds in addition to trace contaminants in water supply – a process which may be key to the large-scale implementation of this technology, both for drinking-water production and water reclamation.

Pioneering original research

In addition to research partnerships, Xylem also conducts original research, recently publishing a report titled "Powering the Wastewater Renaissance." This report concludes that wastewater utilities could cut electricity-related carbon emissions by nearly half by adopting readily available energy-efficient wastewater technologies. Furthermore, the research shows that since a revamped wastewater sector would consume less energy, 95 percent of these emission reductions would either pay for themselves or result in savings that could be channeled into additional sustainable upgrades.

Most recently, in an effort to better understand how those living in the US state of California currently perceive recycled water, Xylem commissioned an independent poll earlier this year. The US Drought Monitor shows

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Left: Xylem and IVL are conducting R&D at the Hammarby Sjöstadsværk water reuse pilot plant, which was commissioned in July 2012.

Above: Xylem launched the Flygt Concertor, the world's first wastewater pumping system with integrated intelligence. This interconnected wastewater pumping system senses the operating conditions of its environment, adapts its performance in real time, and provides feedback to pumping station operators -- reducing energy costs 70 percent. Photos by Xylem



Rex Plaizier, CEO of WesTech Engineering

properties of these compounds increase the commercial potential of bile pigments for many areas of application. Current production of desirable bile pigments is very expensive, as they are often sourced from animal materials.

Production of phycocyanin from cyanobacteria is a potentially cost-effective and sustainable way to obtain large quantities of this chemical feedstock for conversion into desirable bile pigments. Their extremely large genetic diversity also leaves open the possibility of the production of many other useful bioproducts.

Wet Lipid Extraction: The production of biodiesel from algal biomass requires the extraction of the lipids or oil from the harvested algae biomass. However, typical methods of extracting oil from algae have several drawbacks, including significant energy investment, costly solvents, and contamination.

SWBEC developed a wet lipid extraction procedure to help address these issues associated with algal lipid extraction and biodiesel production. The procedure is capable of extracting up to 79 percent of the algal lipids from wet biomass by acid and base hydrolysis of the algal biomass, followed by phased separation steps. Of the lipids extracted from the wet algal biomass, up to 77 percent of those lipids can be collected for the production of biodiesel.

In addition to the isolated algal lipids processing, algal biomass using this wet lipid extraction procedure generates four streams, three of which have been used for the production of additional

bioproducts and biofuels. These streams are:

- Acid and base hydrolyzed algal biomass for fermentation processes such as Acetone, Butanol, and Ethanol (ABE) fermentation, or anaerobic digestion for biogas production
- An aqueous phase containing soluble carbon and inorganic nutrients that can be used as a growth medium for recombinant *E. coli* to generate bioplastics (polyhydroxybutyrate PHB), or recycled so that the nutrients derived from the algal biomass can be used to supplement a medium to generate additional algal biomass
- The isolated algal lipids can be converted to biodiesel by esterification of the collected free fatty acids.

The Sustainable Waste-to-Bioproducts Engineering Center has demonstrated considerable success in the development of new, bio-based sustainable engineering technologies that convert municipal wastes into high-value bioproducts. “The Utah State University-WesTech Engineering partnership provides a model for how together we can accelerate the process of going from knowledge discovery to application and implementation of critical engineering solutions to improve the quality of life,” says Plaizier. “It is a corporate-academic partnership unique to algal research.”

Author's Note

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that more than 60 percent of California is suffering “extreme to exceptional drought” conditions as the state suffers the worst drought in more than 150 years. Xylem believes that water reuse can, and must, play a crucial role as part of a multi-pronged approach to securing a resilient, viable water supply. The survey results are encouraging, with 76 percent of respondents reporting the belief that recycled water should be used as a long-term solution for managing water resources. Additionally, 89 percent of California residents stated that they would be more willing to use recycled water after learning about the advanced treatment processes used to make it clean and safe. Furthermore, 88 percent agree that seeing a demonstration of the water purification process would make them more comfortable using and drinking recycled water.

Collaborative R&D advances water industry

In January 2016, Xylem and the Masdar Institute of Science and Technology (Masdar), located in Abu Dhabi, United Arab Emirates, announced a research collaboration to establish sustainability indicators such as energy and cost performance of processes and equipment for water, wastewater and water transport, and treatment facilities in Abu Dhabi. Masdar is an independent, research-driven graduate-level university focused on advanced energy and sustainable technologies. The key performance indicators (KPIs) will be developed through a one-year study that aims to help policy-makers, regulators, and those responsible for specifying and purchasing equipment and processes in the region make more informed decisions. This process will serve to improve the country's water and wastewater sector, in particular its energy efficiency, ultimately supporting the deployment of highly efficient technologies and processes to help solve pressing water issues

with sustainable solutions.

Additionally, a partnership formed with Massachusetts Institute of Technology (MIT) under the Institute's Industrial Liaison Program (ILP) enables Xylem to harness MIT resources to address current challenges and anticipate future needs in the area of water management. Company executives monitor MIT research developments, identify relevant MIT resources, and have face-to-face access to expert faculty.

Customer feedback

As well as collaboration with partners, working closely with customers is crucial to enlightening the development of technology required to solve current and future water challenges. This collaboration and research is aimed at advancing the sustainability of the wastewater sector. For example, Xylem launched the Flygt Concertor – the world's first wastewater pumping system with integrated intelligence that delivers 70 percent energy reduction, unprecedented flexibility, and reduced cost of ownership – based on ongoing R&D and customer research.

The challenges facing the water sector are complex and will not be overcome easily. It is crucial to invest in research and work with the best and brightest to continue to advance the sustainability of the water sector in order to ensure protection of this vital resource.

Author's Note

Senior Vice President and Chief Innovation & Technology Officer, Jay Iyengar leads Xylem's global R&D, technology, and innovation activities. Reporting to Xylem President and Chief Executive Officer, Patrick Decker, she works closely with the senior leadership team to evaluate the technological landscape and accelerate the company's customer-driven innovation agenda to drive growth. Iyengar is based at Xylem's global headquarters in Rye Brook, New York, USA.



Hammarby Sjöstadsværk pilot plant. Photo by Xylem