weftec
the water quality event™

HORIZON SCAN

The outlook and momentum on the technology trends that will shape the future of water sector innovation

INTRODUCTION

The Water Environment Federation's members are on a quest to catalyze innovation in the water sector. To aid in that quest, WEF constantly looks ahead to find topics, technologies, and ideas to help ensure progress. When seeking to chart the course forward for the water sector, we realized that traditional surveys act like a compass for a sailor. A compass or a traditional survey provides valuable information on direction. Effective navigation, however, requires a complete picture that combines direction with maps identifying safe ports, dangerous shoals, and weather forecasts to properly chart a course.

The WEFTEC Horizon Scan presents this complete picture by combining forward-looking expert statements with attendance data.

For more than 90 years, WEFTEC® has been the water quality show where topics first emerge, new technologies debut, and experts come together to discuss what's needed and what's next. For these reasons, we engaged the dedicated professionals who choose the WEFTEC program, the experts who present technical sessions, and the attendees who choose what's most important to them. The result is the WEFTEC Horizon Scan, which is developed in conjunction with WEF Innovation Partner, BlueTech Research, the leading market intelligence firm in the water sector.

A focus group of more than 40 WEF technical committee and task force chairs assembled for a forward-looking discussion at the 2018 Midyear Meeting. The discussion focused on a set of topics conceived by BlueTech Research based on a scan of abstracts submitted for WEFTEC. Following several hours of discussion seven technology trends and two water sector drivers emerged. These trends capture the thinking of those engaged in creating the future of the water sector.

These trends are presented alongside an analysis of the 15 most attended technical sessions at WEFTEC 2018. This portion of the analysis provides the input of WEFTEC attendees who "voted with their feet" by choosing to attend technical education sessions at WEFTEC. This traffic data shows which sessions drew enough interest to motivate water professionals to seek them out. These thousands of data points helped to ground-truth the insights of the hundreds of technical experts who selected the content for the WEFTEC program and the dozens of WEF leaders who identified key trends during the focus group.

Also included here is the list of the top 20 technical papers chosen by BlueTech Research from the abstracts accepted for WEFTEC 2018. Merely having a paper accepted at WEFTEC is a marker of the quality of the technical content; fewer than half of all submissions are chosen for the program. More than 200 technical experts on the WEFTEC Program Committee evaluate submissions via a rigorous process. The additional review provided by BlueTech Research analysts and technical advisory group members strengthened the impact of already selective set of technical content. See the full list of the Top 20 BlueTech Research papers beginning on p. 12.

Putting all these sources together yields a holistic view of the trends, research, and interest emerging within the water sector. While the perspectives shared here do not rise to the level of predictions or endorsements, they do provide a summary of current impressions and a starting point for further discussion.

THE WATER INNOVATION CYCLE

To help provide participants with a consistent basis to begin these discussions, BlueTech Research shared its innovation theory and analysis approach. This includes how disruption happens, the innovation cycle, and the value in listening to many voices while forecasting which trends will grow and thrive and which will fade.

Disruption refers to a new product or service providing a marked improvement such that the net increase in productivity over established practices is at least 30%. Moderately disruptive innovations provide between 30% and 50% improvement, while highly disruptive solutions bring greater than 50% improvement. Disruptive innovations can drastically change the landscape of a sector by displacing established market leading firms, products, and alliances.

These percentages come from the assumption that established mainstream processes will be refined and gain efficiency at a rate of about 5% per year. This means that the clock is ticking on new inventions; they must make it to market quickly enough to avoid having established technologies gradually improve until the benefit offered by the new technology is swallowed by continuous improvement.

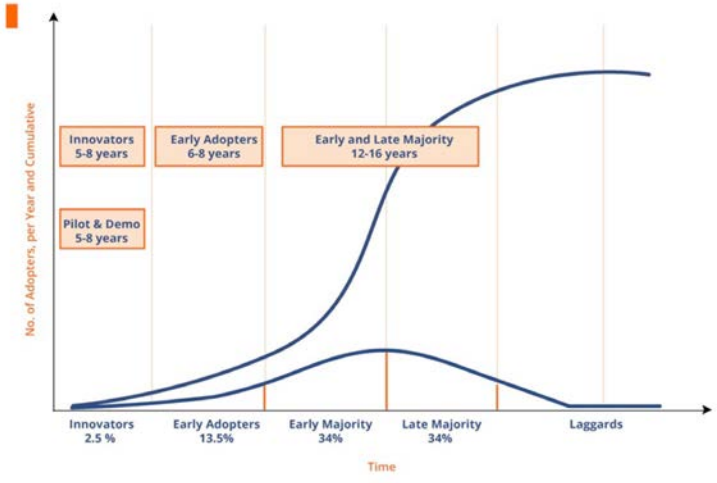
The water sector sees innovation emerge on its own timeline. While the water sector pace is slower than the information technology cycle, for example, it includes the same phases. These phases are described by the type of people and organizations that choose to implement the technology.

They include innovators, early adopters, early majority, late majority, and laggards. The figure below shows what this cycle looks like graphically and indicates how long these periods take in the water sector.

Predicting which innovations will match this curve and become successful relies on many factors, but BlueTech Research has learned that the water sector "self-hypnotizes" to change through dialogue and data. Put another way: Listen to the chatter, it paves the way for adoption.

Listening to the sector is what led WEF and BlueTech to assemble these discussion sessions. Individuals' opinions and perspectives are valuable but also can blind one to all of the possibilities; convening a larger group harnesses the wisdom of crowds to provide the best chance to accurately predict what the future of the water sector holds.

Water Technology Adoption Model



WATER SECTOR DRIVERS

Technology alone is not enough to drive innovation. The conditions need to be such that a technology can offer the right benefits at the right moment to gain its footing in the water sector. To this end, one discussion area provided participants the opportunity to offer their views on what forces are driving change. The participants were asked to use two ideas to help categorize and define these drivers. They were asked to think about:

- how utilities can prepare for future systems level changes and
- if these drivers are crisis-based or regulatory.

Systems-level changes

Point-of-use and point-of-entry (POU/POE) water treatment technologies were forecast to be a major concern in this area. Widespread adoption of the devices that embody these modes of use may cause significant changes to waters received by WRRFs. Secondly, utilities must be prepared to handle the repercussions of unmaintained POU/POE devices.

Gravity-fed collections systems also were identified as a place where systems-level changes may be underway in the short term. Even though gravity-fed systems use minimal energy and have centuries of successful operation, failing infrastructure and efficiency losses can open the door to different and/or better methods for collections systems using technology from today.

Crisis versus regulation

In some cases, a new public concern or crisis may require that utilities and state/local governments respond faster than the regulatory process allows. In these cases, the need for prompt action to maintain public confidence can be both a driver and an inspiration to innovative.

Antibiotic-resistant bacteria have the potential to disrupt the disinfection market. The topic has moved from mostly academic circles many years ago to public discussion now. As a crisis-driver, this situation may necessitate stricter disinfection practices and new tools to understand pathogens better. (The participants noted that metagenomics may be a useful tool for this purpose.)

Microconstituents were identified as another potential crisis-driver. Microconstituents have grown steadily in number as more and more compounds are tested for ecological and human health risks. However, the process for creating regulations for emerging contaminants lags significantly behind the identification of potentially hazardous components. As it stands, actions taken regarding micropollutants are primarily in response to crisis rather than regulatory pressures.

TECHNOLOGY TRENDS

CIRCULAR ECONOMY: BIO-BASED MATERIALS FROM WASTEWATER

TECHNOLOGY TREND 1

OUTLOOK

The benefits of creating bio-based materials from wastewater fall under the tenets of sustainability. Products typically will be energy neutral, focus on reuse potential, and may be biodegradable alternatives to conventional products. Harvested cellulose from wastewater displaces virgin wood fiber in some applications, and bioplastics from wastewater displace both the use of petroleum products in conventional plastics and the use of food stocks for bioplastics.

Since the technologies to isolate and create products from wastewater are established, the question of future adoption is economy-based rather than technology-based. The future is unclear whether products from wastewater will be produced in adequate quantities and be sufficiently valued in the economy to sustain value from waste undertakings.

Many participants didn't see a way forward for a focus on value-added materials from water resource recovery facilities. Some questioned the market potential of such items, asking 1) can they be sold and 2) in what quantities. While the products fit into a circular economy, that economy will need to exist for facilities to undertake capital improvement projects to produce such goods.

While it is possible that sustainability bottom lines, as opposed to economic bottom lines, could serve as an initial driver for a circular economy, participants thought it was unlikely. Sustainability issues such as carbon neutrality would only serve as a driver if established as regulation or in the case of extreme crisis. In the current environmental climate, participants thought that utilities might be willing to pay slightly more for green alternatives, but not significantly more.

MOMENTUM

The technical papers identified by BlueTech Research related to Circular Economy ranged from zero liquid discharge (ZLD) in Singapore to thermal hydrolysis to enhance carbon utilization for energy generation (Ng 2018, Barber 2018). Better treatment and recovery of wastes from pharmaceuticals to LEGOs also were identified (Sela 2018, Nielsen 2018).

Because Circular Economy issues are, by definition, interdisciplinary, the topics associated with these technical papers vary; they include resource recovery, industrial reuse, sludge treatment, and micropollutants. Presentations on Circular Economy drew huge crowds. For example, Technical Session No. 100, The Emerging Circular Economy – Can We Make a Relevant Contribution?, was the second highest attended session at WEFTEC 2018. It was joined on the Top 15 attendance list by Technical Session No. 104, The Value of Water and the UN Sustainable Development Goals.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
100	Master Lecturer: The Emerging Circular Economy -- Can We Make a Relevant Contribution?
104	The Value of Water and the UN Sustainable Development Goals

DECENTRALIZED INFRASTRUCTURE TECHNOLOGY TREND 2

OUTLOOK

Pre-fabricated units typically only have application in temporary situations, such as work camps or disaster sites. Current decentralized infrastructure, which is characterized by pre-fabricated, self-contained, and modular technology solutions, is targeted at small-scale wastewater producers with few treatment options. These users, for example, could include remote food and beverage processors.

For decentralized treatment to make an effect on mainstream municipal sectors, regulations and permitting will need to change to accommodate localized and, potentially, densely packed systems. Young professionals' opinions on this type of change suggested a model similar to cable service or home warranty where a system-operation fee could include remote monitoring by systems experts and routine on-site maintenance.

Overall, during the next decade decentralized infrastructure is unlikely to emerge as an immediate solution to American infrastructure problems. However, decentralized practices do have niche applications, including some municipal cases, such as in-building reuse and small-scale industrial treatment. In these cases, homes and buildings can save on water usage and disposal costs by performing limited onsite greywater treatment for internal reuse. The participants noted that if this form of building-scale reuse gains traction, it may have real effects on operations at centralized WRRFs. These niche uses form the current core of the American decentralized market.

MOMENTUM

The trend of Decentralized Infrastructure was well-represented in both the Top 20 BTR technical papers list and attendee interest.

Technical papers included those on industrial on-site treatment at refineries and petrochemical wastewater facilities (Cunningham 2018) as well as the beverage industry. Coca Cola, PepsiCo, and brewery papers were in the Top 20 BTR (Nof 2018, Valladares 2018, Gluck 2018).

On the municipal front, four of the top attended sessions — sessions 103, 211, 312, 414 — were related to advances in collection systems. This included presentations of "sewer scalping," a decentralized water reuse technique in Technical Session No. 333, the Interactive Knowledge Exchange: Technical and Innovation. Focus on the interplay between collection systems and treatment is critical as the sector moves to be more flexible to implement distributed solutions.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
103	Tracking Down the Roots of Our Sanitary Sewers
211	Collection Systems Sewer Condition Assessment, Rehabilitation, and Construction
312	Under Pressure: Reducing the Stress of Working With Collection System Forcemains
414	Infiltration and Inflow in the Collection System: How To Fight the Good Fight

ONE WATER: CLOSING THE LOOP

TECHNOLOGY TREND 3

OUTLOOK

The concept of one water is that all water has the potential to be source water for human activities, whether for non-potable reuse, such as for landscaping irrigation, or for potable reuse. The topic of water reuse is not new but has been a slow-growing market. History has shown utilities and water suppliers preferentially seek out water management methods other than reuse to ensure supplies. These range from conservation practices all the way to seawater desalination. The challenge to water reuse adoption comes from both regulatory and public-pressure angles.

However, recently consumer engagement with and interest in water has begun to grow. A prime example is the interest in designer water — in-home treatment to purify and then re- mineralize water to consumer tastes for such purposes as brewing better coffee or tea. Likewise, in-home sensors that relate to water quality from point-of-use systems affect consumer interactions with water. The direction that having access to these devices and data will push reuse is highly variable; the path it follows will depend on how well the public can be educated on water safety. Data and data systems will need to provide assurance to consumers to bolster support for water reuse programs.

From a technology standpoint, many treatment techniques can play a role in a closed-loop lifecycle of water. Current systems rely on reverse osmosis and advanced oxidation for the highest level of treatment to remove micropollutants and pathogens. However, concern around pathogens remains high, and confidence in reuse treatment technologies is one of the main hurdles to adoption.

MOMENTUM

One Water is a concept integrating the management of drinking water, wastewater, and stormwater in a holistic sense. This theme is highly related to the theme of Circular Economy. In what seems like a conundrum, One Water management requires the identification of different types of water to ensure "fit for purpose" where the right water quality and source is used for the appropriate use.

In one of the Top 20 BTR papers, "One Water LA 2040 Plan Integrating Major Stormwater Efforts Creates Opportunities," the author discusses the opportunities for stormwater to play a role in Los Angeles's water supply (Whitman 2018). In terms of session attendance, well over 200 professionals participated in Technical Session No. 200, the Water Policy Update, which was joined on the top 15 list by Technical Session No. 215, The Big Picture: Integrated Watershed Planning.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
200	Water Policy Update
215	The Big Picture: Integrated Watershed Planning

THE ROLE OF CUSTOMER: POINT-OF-USE TECHNOLOGY TREND 4

OUTLOOK

Increased connectivity and information sharing are enabling customers to make decisions about their water management and treatment. Discussion participants believe that the primary driver toward point-of-use technologies is awareness of emerging contaminants of concern. Customers may seek more information on water quality and find it from third-party services, such as at-home measuring kits and smartphone interfaces, rather than their utility. The lack of easy information access from utilities then becomes a driver toward personal control and home-based technologies.

However, customer understanding of technology operation may also be limited, which leads to assumptions about technology performance and a lack of ownership or misunderstanding of maintenance needs. Similar patterns have occurred with green infrastructure installations; long-term functionality is difficult to achieve due to lack of ownership and routine maintenance.

Utilities already are concerned with point-of-use technologies because these point-of-use systems come with disposability and sustainability issues. For example, some technologies that use salt hardening produce waste that can cause issues in collection systems. To avoid these problems, some utilities have opted to create buyback programs. This raises the question: who bears responsibility for managing the downstream effects of these point-of-use systems? Should the burden fall on the customer, the technology provider, or the utility?

MOMENTUM

The focus group was asked about trends in the entire water sector. Therefore, some of the themes may be outside the traditional audience of WEFTEC. The fourth tech theme, Point-of-Use, is typically a residential or small commercial drinking water concept. However, Point-of-Use treatment and Data-Driven Decision Making (upcoming in Theme 7) were on display in the WEFTEC Innovation Pavilion during Technical Session No. 342, DC Water's Smart Water Fountain Initiative. These new tech-fountains have multimedia point-of-use filters and sensors that use real-time data and analytics to monitor both water quality and flow levels. The fountains send information to the cloud and back, alerting when water quality measurements begin to deteriorate. Alerts are sent by text or email to a water manager who can order replacement filters and schedule maintenance, everything large utility treatment distribution and collection teams do, but on a smaller scale.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
342	DC Water's Smart Water Fountain Initiative (Innovation Pavilion)

BIOLOGICAL PARADIGM SHIFT TECHNOLOGY TREND 5

OUTLOOK

Conventionally, biological processes are viewed as simple and cheap option for wastewater treatment where growth and performance of microbial communities happen by means not understood truely, but governed by aeration. Reductions in cost of DNA sequencing have paved the way for metagenomics — the analysis of DNA to identify genetic families — as a practical tool for analyzing biological processes, and shining a light on the microbial processes much like the microscope shed light in bacterial communities. Like data systems in other parts of utilities, metagenomics brings predictability to biological processes. Biological phosphorus removal started as an accident; now, this new tool has identified the strains of bacteria responsible for phosphorus removal, enabling operators to optimize treatment processes.

However, the discussion participants expressed that there is reluctance for utilities to push too boldly into metagenomics and other next-gen biological technologies. Until the technologies are proven to be sound methods, there will continue to be hurdles to adoption. However, opinions on the future of the technology are positive. Participants believe that metagenomics will be a staple tool in utility labs within 10 years.

Another innovation in biological treatment is the ability to harness enzymes for degradation. In living organisms, enzymes work to catalyze reactions without being consumed and without growing. Enzymes selected to breakdown wastewater components can do so while creating much fewer solids, but discussion participants were guarded and skeptical. Enzymes were regarded as an artificial approach to treatment; participants stated that adding a special formula to solve so many problems felt like a "snake oil" solution. They also cited concerns of enzyme effects downstream as well as using genetically modified organisms. Opinions on the technology are not reassuring; most believe that the technology will flat-line.

MOMENTUM

Next-gen biological technologies using metagenomics are expected to rapidly gain prominence. Evaluation of the microbiomes in nutrient removal through deammonification was the theme of one of the papers to look for by BlueTech (Caligaris 2018). In addition to that paper, several WEFTEC technical sessions — 306, 605, and 519 — discussed metagenomics to solve problems ranging from foaming to annamox to antibiotic resistance genes in water reuse.

In terms of attendance, Technical Session No. 206, Unlocking the Mysteries of Microbial Ecology of Enhanced Biological Phosphorus Removal (EBPR), was one of the top 15 attended sessions. Beyond WEFTEC, the sold-out James Barnard Research Conference on Emerging Themes in Biological Phosphorus Removal and Recovery held in January 2019 further demonstrated the interest in advancing this trend.

Notably, not all activity surrounding the Biological Paradigm Shift was at the research level. Microbe Detectives (now named ThinkR3 LLC) exhibited in the Innovation Pavilion for the second time at WEFTEC 2018 after their debut in 2013. This company uses DNA analysis to identify nearly all microorganisms in a sample with a single analysis. Looking at the relative proportions of microorganisms present and their functions in wastewater treatment can help optimize the treatment process for such objectives as increasing biogas production, reducing foaming, and facilitating nutrient removal.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
206	Unlocking the Mysteries of Microbial Ecology of Enhanced Biological Phosphorus Removal (EBPR)
407	Tools and Case Studies for Optimizing Phosphorus Removal

WATER RESOURCE RECOVERY FACILITIES AS BIOREFINERIES TECHNOLOGY TREND 6

OUTLOOK

Water resource recovery facilities (WRRFs) are a huge source of energy, if properly harnessed. Originally, biogas produced by anaerobic treatment was flared off to prevent a dangerous build-up of gas. Then, co-generation technologies utilized the biogas to generate heat and electricity for on-site use. The next stage in energy utilization from wastewater is to be able to convey the energy off-site for use in other applications and industries. The methods of transporting energy include upgrading biogas to biomethane and perhaps even to liquid biofuels, smart connection to the grid for electricity buyback, and isolation of energy from alternative sources such as fats, oils, and greases.

Discussion participants hailed algae as a brilliant solution for both treating water and creating a valuable byproduct in the form of biolipids. However, technology — both algae cultivation and algae–water separation — will need to advance more before algae can compete with existing technologies. Currently, it is difficult to grow enough algae to make harvesting the lipids worth the effort for the energy potential.

Young professionals were more optimistic about the future of energy products from wastewater than more tenured participants. But as the future of bio-energy products is economy driven, campaigns to promote wastewater as a carbon-neutral energy source may be needed for widespread success. The shift of vehicles away from fossil fuels, for example, may yield a demand for biogas and biofuels that can drive the need for upgraded bio-energy from wastewater.

MOMENTUM

Wastewater treatment has always been a biological process; now the trend is to view WRRFs as biorefineries. Various aspects of biogas production from anaerobic digestion appear in dozens of technical papers at WEFTEC each year. However, some take the next step. Biofuels represent this next step beyond biogas and biological carbon recovery for biofuels (Kim 2018) was one of the BlueTech targeted papers. Another pathway for WRRFs to become biorefineries include algae for both products (dyes, pharmaceuticals, animal feed, etc.) or as biofuels, such as that discussed in the technical paper, "Growth of Algae for Biofuel Production in Highly Saline Oilfield Fracking Produced Water" from Technical Session No. 602. One of the top attended technical sessions also was related directly to this trend; Technical Session No. 324, The Resource Recovery Playing Field: Product and Energy Recovery from Wastewater Solids.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
101	Exploring the Tensions Within the Water-Energy-Food Nexus
207	Evaluating Energy Use and Management Alternatives for Operational Efficiency at WRRFs
324	The Resource Recovery Playing Field: Product and Energy Recovery From Wastewater Solids

DATA-DRIVEN DECISION MAKING

TECHNOLOGY TREND 7

OUTLOOK

Sensors and controls integrated into pumps, valves, motors and connected together — also known as the Internet of Things (IoT) — allow for remote and automated control of facility functions. Collection of data and analysis using machine learning or artificial intelligence tools provides operators with information on how to best run facilities. This discipline often is called predictive analytics. It changes the human role in systems from data manipulation and trend identification to putting these results into context and action within the greater scale of the overall facility. It moves the users from struggling to reach computational proficiency to thriving in a decision-making environment.

Discussion participant opinions on data-driven operations were positive to the point of incorporating data into decision-making but began to falter as they approached the point of full automation. Sensor accuracy poses the biggest hurdle to automation. Sensors capable of being installed on-line to transfer information remotely often are not accurate enough. Facilities still must rely on laboratory testing as a backup measurement. Sensors play just one role in earning trust and acceptance for data-enabled facilities. At its heart, skepticism of automation lies in the fear that errors will lead to significant human health risk.

Larger organizations were predicted to be less hesitant to adopt data-enabled systems as they have more diverse technical personnel on staff. In fact, the discussion participant suggested that shifting from conventional operation to data-driven operation may not actually reduce the number of jobs available as operator positions are replaced by hardware and software engineers. The difficulty for facilities then shifts to knowing how to hire the right person for a position that is still growing and changing.

MOMENTUM

Terms such as smart water, intelligent water systems, data analytics, or Internet of Things (IoT), all refer to data-driven decision making. Smart water accounted for three of the Top 20 BTR papers (Porro 2018, Pahlevan 2018, Graf 2018) and two of the most-attended sessions. Technical Session No. 102, The LIFT Intelligent Water Systems Data Challenge was standing room only to see the challenge winner, Great Lakes Water Authority (Detroit), and finalists. In the Metropolitan Water Reclamation District of Greater Chicago and Clean Water Services (Portland, Ore.), battle it out for the $25,000 top prize.

The evolution of SCADA and how it fits in the rapidly changing smart-water world was the focus of Technical Session No. 409, Automation and SCADA: Where Have We Been and Where Are We Going?, which was another Top 15 attended session.

Many traditional WEFTEC exhibitors feature Data-Driven Decision Making components in their product lines. Along these lines, the WEFTEC Innovation Pavilion serves a bellwether for future trends and the number of smart water-related, early-stage companies has steadily climbed with zero in 2012 to 19 in 2018.

TOP RELATED WEFTEC 2018 SESSIONS

Technical Session	Title
102	Intelligent Water Systems Data Challenge
409	Automation and SCADA: Where Have We Been and Where Are We Going?

TOP 20 PAPERS

BlueTech's yearly analysis of the papers presented at WEFTEC takes in over 600 abstracts. From these, we select what we believe to the most impactful and interesting sessions which also map to the key technology themes we monitor. Sometimes individual papers can be striking or interesting, unveiling a breakthrough new technology, or a key advance in a specific area. One example this year would be the paper on the first direct potable reuse (DPR) plant in California, presented by Elisa Garvey of **Carollo Engineers.**

Another way to look at the papers is in aggregate, to reveal underlying trends and patterns. Technologies attract interest and then fall out of favor, and certain key themes move gradually from fringe issues to generally accepted ways of thinking. A key example is the Circular Economy. Particularly within the context of climate change, this is an area which is becoming firmly established in almost every conference, most notably with an ever- increasing focus on reuse, but interest in resource recovery is also growing from year to year.

One example which we found particularly interesting was "Treatment of Industrial Reverse Osmosis Brine using Nanofiltration for ZLD Application" from How Yong Ng at the **National University of Singapore.** This is another example of enabling the use of a waste product as a resource, as well as how nanofiltration is gathering interest for niche applications.

On the reuse side, Chris Weiss of the **H2M Group** presented a significant advance – the first full-scale reuse facility in New York State. We have categorised industrial reuse separately this year, as there is growing corporate interest in this issue, with multinational businesses bringing their own perspective. Edgar Valladares of **PepsiCo** will share their experiences with using RO and MBR at various COD-heavy food manufacturing sites, while William Cunningham from **Siemens Energy** will provide an interesting update on the company's PACT MBR technology and how it is addressing the challenges of treating refinery and petrochemical wastewater for reuse.

Last year BlueTech published a blueprint on the increasing interest in the use of peracetic acid (PAA) as an alternative to chlorine in disinfection, and the momentum appears to be continuing with a paper from the **City of Cincinatti** on the promise of combining UV treatment with PAAs. UV disinfection specialist **Trojan Technologies** presented a comparison of PAAs with sodium hypochlorite, peracetic acid, and performic acid.

There are a couple of topics representing areas which BlueTech has identified as attracting increasing interest: the use of micro-bubbles in various applications beyond flotation treatment, and UVC-LED disinfection technology. If some papers offer a glimpse into what may be focus areas in the future, then the presentations by Gary Hunter from **Black & Veatch** and Jy Hu of the **National University of Singapore** will be worth a look.

However, one of the most keenly-debated topics of all, and well-represented topics overall at WEFTEC is the area of digital water – the use of intelligent control and monitoring systems, automation and big data, grouped generally here as "Smart Water." "Building an integrated AI and mathmatical modeling framework for online supervision and control of water resource recovery facilities," presented by Jose Porro of **Cobalt Water,** is an excellent example of where this area is heading.

Finally, **Nima Pahlevan** of **NASA** is presenting what promises to be a fascinating paper on achieving (near) real-time monitoring of water quality using satellites. The concept of monitoring the condition of water networks from orbit is already being developed and sucessfully trialled by **Utilis,** so this would perhaps represent the next logical step.

THE TOP 20 WEFTEC 2018 PAPERS

Presentation title	Lead Presenter, Organization	Key Technology Theme
A solution for onsite treatment of low flow, high BOD brewery wastewater	Steven Gluck, Steven J. Gluck LLC	Biological Treatment
Design, Construction Challenges and Performance of Package Plant at a Coca Cola Bottling Plant in a Remote Location Using the Biofilm Technology	Keren Nof, Aqwise	Biological Treatment
Wastewater disinfectant showdown: A techno-economic and life cycle assessment of sodium hypochlorite, peracetic acid, and performic acid.	Roberta Maffettone, Western University - Trojan Technologies	Disinfection
Combined PAA and UV Treatment For Wastewater Disinfection: A Plant-Scale Pilot Study	Achal Garg, MSD City of Cincinnati	Disinfection
PACT MBR Delivers New Design and Operating Criteria for Reuse of Refinery and Petrochemical Wastewater	William Cunningham, Siemens Energy	Industrial Reuse
Full scale wastewater recovery and reuse projects in several of PepsiCo food manufacturing facilities in Mexico, utilizing state of the art technologies that include Membrane Bioreactor and Reverse Osmosis.	Edgar Valladares, Pepsico	Industrial Reuse
No LEGO in my Effluent Please - Danish Perspective on Microplastics	Per Nielsen, VCS Denmark	Micropollutants
A case study of challenging pharmaceutical wastewater treatment with MBBR	Debora Sela	Micropollutants
Achieving sustainable and long term NOB repression for shortcut nitrogen removal and mainstream deammonification	Marc Caligaris, SUEZ International	Nutrient Removal
Biological Carbon Recovery from the Advanced Biofuel Process Wastewater using Anaerobic MBR	Gyu Dong Kim, RTI International	Resource Recovery
Treatment of Industrial Reverse Osmosis Brine using Nanofiltration for ZLD Application	How Yong Ng, National University of Singapore	Resource Recovery
Combined microbubble ozonation-BAC system for reverse osmosis concentrate treatment	Jy Hu, National University of Singapore	Resource Recovery
Trailblazing: Ventura's Path to Become the First DPR System in California	Elisa Garvey, Carollo Engineers	Reuse
Planning and implementation of the first full-scale reuse plant in New York State.	Chris Weiss, H2M Group	Reuse
Using thermal hydrolysis to significantly reduce or eliminate downstream drying and incineration of sewage sludge	William Barber, Cambi Inc.	Sludge Treatment
Building an integrated AI and mathematical modeling framework for online supervision and control of water resource recovery facilities	Jose Porro, Cobalt Water LLC	Smart Water
Towards a satellite-based near real-time monitoring system for water quality	Nima Pahlevan, NASA	Smart Water
Intelligent Water Systems: Who, What, Where?	Walter Graf, WERF	Smart Water
One Water LA 2040 Plan Integrating Major Stormwater Efforts Creates Opportunities	Eliza Whitman, EW Consulting Inc	Stormwater
UV-C LED and When Will it Be Primetime in Wastewater	Gary Hunter, Black & Veatch	UV-LED

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