WaterTAP
Technology Acceleration Project

WATER

THE NEXT FRONTIER ON THE PATH TO A LOW CARBON ECONOMY

With thanks to Maas Strategies

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SECTION 1

WATER: THE NEXT FRONTIER ON THE PATH TO A LOW CARBON ECONOMY

Ontario's commitment to the transition to a low carbon economy is positioning the province as a leader in developing the technologies and talent needed to prosper in a changing climate. It is creating new jobs and growing the economy while cutting greenhouse gas emissions and ensuring a healthier environment (see Box 1). But like many jurisdictions around the world, Ontario is recognizing that readily accessible and scalable solutions to reduce greenhouse gas emissions are becoming increasingly difficult to identify.

Water is the next frontier on the path to a low carbon economy. Large amounts of energy are consumed as water is pumped, treated and heated by industry, communities and agriculture, within and outside of buildings, from private wells and public supplies, and through onsite wastewater systems and large scale municipal sewage treatment plants. When taken together, up to 19% of a jurisdiction's total demand for electricity and up to 40% of natural gas demand is related to water[1]. All of this energy use results in substantial greenhouse gas emissions.

Water technology and systems present a significant, growing and largely untapped opportunity for energy savings, greenhouse gas reductions and renewable energy generation in Ontario. The Province, recognizing the potential, is including targeted initiatives focused on the water opportunity in its plans and investments for moving toward a low carbon future.

In Ontario, water and wastewater services can consume as much as one-half of a municipality's total electricity use[2], and on average, over 30% of municipal carbon emissions are related to water services (and these numbers are to be likely conservative[A]).[3] Across Canada, emissions from wastewater treatment increased by 22% from 1990 to 2015.[4] When it comes to building-related greenhouse gas emissions, heating water remains second only to space heating for residential, commercial and institutional sectors in Ontario.[5]

Data from the United States indicate that over one third of the total energy consumed in the manufacturing sector is used to supply boilers and generate steam in five industries: pulp and paper, food processing, chemicals, petroleum and steel.[6] These industries parallel Canada's top industrial water users and greenhouse gas emitters;[7] unfortunately, data on energy consumption for water services in Ontario's industrial sector are reported in aggregate only, making the true potential for water-related greenhouse gas reductions difficult to quantify. Indeed, data deficiencies and information gaps pose problems for assessing the potential for water-related greenhouse gas reductions across many sectors.

A growing economy, a population projected to increase by 30% by 2040, and the need to protect water supplies and aquatic ecosystems are increasing pressure on existing water infrastructure and driving demand to build new systems (see Box 2).[8] Together, these forces have the potential to substantially increase energy demands and greenhouse gas emissions associated with water and wastewater services across sectors in the coming years. Getting ahead of these trends will be critical to ensuring that Ontario is positioned to seize on the opportunities and address the challenges the future will bring.

BOX 1

ONTARIO'S COMMITMENT TO CLEANTECH AND A LOW CARBON ECONOMY

Through a combination of policies and investments designed to cultivate an environment for innovation, Ontario is emerging as a global clean technology powerhouse and front-runner in the transition to a low carbon economy. Indeed, the province is home to Canada's fastest growing cleantech sector with $8 billion in annual revenue generated by 3,000 companies that employ over 65,000 people.[9]

Anchored by a target to reduce greenhouse gas emissions by 80% below 1990 levels by 2050, Ontario's five-year Climate Change Action Plan is a central pillar of the province's shift to a low carbon future. And smart investments and revenue generating mechanisms are providing the fuel to move the transition forward. The Climate Change Action Plan regulates carbon through a cap-and-trade system that will generate almost $2 billion in revenue annually to be reinvested in efforts to cut greenhouse gas emissions. The five-year, $650-million Business Growth Initiative and the Ontario Green Investment Fund support companies and projects to reduce greenhouse gas emissions, increase energy efficiency, support cleantech innovation and drive job creation and economic development."[10,11]

As part of Ontario's recently announced Cleantech Strategy, which includes initiatives funded by proceeds from the province's carbon market, cleantech accelerators including WaterTAP will receive renewed funding to help companies grow and meet global demand for innovative new technologies.[12]

BOX 2

ILLUSTRATING THE ENERGY IMPLICATIONS OF PROTECTING ONTARIO'S WATER

To meet new regulatory requirements to control phosphorus pollution in the Lake Simcoe watershed, York Region's newest wastewater treatment plant will require more than 3,000 kWh of energy per million litres treated – six (6) times the energy used at its existing Duffin Creek facility where more stringent phosphorus limits have yet to come into effect.[13]

A Excludes process emissions generated by large wastewater treatment plants, fuel consumption associated with trucking solids to disposal sites and with construction vehicles/machinery for new infrastructure.

SECTION 2

BUILDING ON THE ONTARIO ADVANTAGE

Ontario is home to a critical mass of clean water technology and services. In addition to academic research excellence, the sector is benefiting from entrepreneurs and startups that are identifying solutions to solve the world's water challenges. This growing sector benefits from business growth services, including targeted support from three key organizations: the Water Technology Acceleration Project (WaterTAP), the Southern Ontario Water Consortium (SOWC) and the Ontario Clean Water Agency (OCWA). Together, these organizations collaborate with companies, end users, governments and other partners to help Ontario clean water innovators navigate the complex path from idea generation through product development to market leadership.

Ontario's water innovation ecosystem encompasses a vast network that includes 22,000 people employed in the water industry, 8,200 post-secondary graduates with water-related degrees, 42 Canada Research Chairs and nearly 50 universities and colleges hosting water-related research programs. Mobilizing this capacity will become increasingly important – across Ontario and around the world – as the pressure to dramatically reduce greenhouse gas emissions intensifies, and as water and energy resources become increasingly stressed. By investing in a targeted initiative to tap into water-related energy savings and greenhouse gas reductions, Ontario is mobilizing its water innovation ecosystem and building on its cleantech advantage to further advance the province along the path to a prosperous, low carbon economy.

SECTION 3

UNPACKING AND TAPPING INTO THE WATER OPPORTUNITY

Water-related opportunities to advance Ontario's transition to a low carbon economy are diverse and many. Solutions are at different stages of development – from concept to commercialization to market diffusion. They include everything from nature-based approaches such as constructed wetlands to radically efficient treatment technologies to high-tech tools that use artificial intelligence to optimize water systems. These solutions cut across the full spectrum of water services – from water provision to wastewater treatment to stormwater management.

This section focuses on three key areas of opportunity where Ontario's leading water technology companies, service providers and knowledge generators can have the greatest impact on reducing carbon emissions:

1. Maximizing energy efficiency
2. Generating renewable energy from wastewater
3. Recovering valuable resources from waste streams

This section provides a snapshot of solutions to demonstrate what Ontario's clean water innovators are capable of delivering. But these examples only scratch the surface of what is possible. Ontario has the experience and expertise needed to dive deep into the water opportunity – to fully understand and assess the potential for energy savings and greenhouse gas reductions across sectors, and to develop new and novel solutions to translate that potential into significant impact.

In some cases, tapping into the opportunities is about scaling up the deployment of existing solutions. In many others, it will depend on future innovations – on leveraging the capabilities of Ontario's water innovation ecosystem to generate and implement *new* technologies and approaches that cut greenhouse gas emissions while delivering high quality water services.

3.1

MAXIMIZING ENERGY EFFICIENCY IN WATER SYSTEMS

Energy freed up through efficiency initiatives is typically the cleanest and most cost-effective source of "new" supply.[14] A recent report by Ontario's Environmental Commissioner points to the untapped potential of water-related energy efficiency, noting that the water and wastewater sector "has only realized one-tenth of the proportional electricity savings from conservation programs that the average Ontario customer has."[15] Water-related energy savings are also likely to be significant among the province's large industrial and institutional water users and greenhouse gas emitters. However, critical information, currently missing, is needed to identify and assess these opportunities.

This is where Ontario's clean water technology sector comes into play. A new cluster of companies focused on monitoring and analyzing water and energy use, an established pipe inspection and rehabilitation cluster, and a full range of energy efficient treatment and distribution equipment providers are at the ready to assess the potential, identify actions, and implement solutions to maximize energy efficiency and reduce greenhouse gas emissions across entire water systems.

Two key categories of technologies for tapping into water-related energy savings are:

1. Optimization and automation
2. Treatment and conveyance solutions

Optimization and automation

Water and energy data generated from innovative sensor, monitoring and decision support technologies is making it easier to locate and prioritize actions to improve the energy efficiency in water systems. This high-quality data is, in turn, spawning innovations in water and wastewater treatment optimization, including software solutions that allow plant managers to investigate the impact of proposed changes to operations and equipment on treatment performance, costs, energy use and greenhouse gas emissions before they are implemented (see Box 3).

The smart water systems of the future will feed real-time data to systems that employ artificial intelligence to automatically adjust the many elements of a water system that impact energy use. The wide variety of sensors, automation and control equipment and software packages being developed and envisioned by Ontario companies provide the tools that, ultimately, will allow both human operators and machines to make better informed decisions aimed at constantly maximizing energy efficiency.

BOX 3

SMART WATER INNOVATIONS SAVE ENERGY

MANTECH's game-changing technology offers the pulp and paper, food and beverage and industrial wastewater markets with fast robust water quality analysis to enable energy savings through process optimization.

HydraTek has developed proprietary software, TransAM, to analyze pumping efficiency and assess the potential for equipment upgrades aimed at saving energy for water providers.

Hydromantis & Alert Labs partnered on a groundbreaking project to use dynamic sensors to feed information to novel wastewater and energy models capable of providing operators with real-time feedback for optimizing equipment and operating strategies that generate energy savings.[16]

Treatment and conveyance solutions

Ontario's world renowned membrane, disinfection and pipe rehabilitation companies are poised to scale up a suite of radically efficient water technologies and solutions that deliver superior performance to municipalities, industry and other end users. Energy saving innovations are also emerging in the areas of nutrient removal and solids handling. Indeed, Ontario's innovators are working to constantly find new opportunities to tap into energy efficiency at all stages of the water and wastewater treatment and conveyance cycle (Box 4).

BOX 4

ONTARIO'S RADICALLY EFFICIENT WATER SOLUTIONS

Drinking Water Disinfection: The TrojanUVTorrent™ developed by Trojan Technologies produces one-third the carbon emissions of comparable ultraviolet drinking water treatment systems.

Pipe Rehabilitation: Ontario firm FER-PAL's innovative technique for repairing water mains uses liners and robotics within existing pipes. Trenchless technology results in 78-100% fewer greenhouse gas emissions than traditional open-cut technology.[17]

Forward Osmosis Membranes: Forward Technologies has developed a forward osmosis membrane process that uses as little as one-tenth of typical thermal energy processes and serves the industrial, agriculture, and oil and gas sectors.

Solids Dewatering: A solids management solution offered by Bishop Water Technologies use industrial fabrics and the emission-free power of gravity to reduce the volume of wastewater solids by 90%. Mining, pulp and paper industries and municipalities use this innovation.

Nutrient Removal: A novel ammonia removal process using annamox bacteria was tested in Guelph, Ontario by CH2M. The process is estimated to reduce energy use by roughly 60% and produce 90% less sludge compared to conventional treatment.[18,19]

3.2

GENERATING RENEWABLE ENERGY FROM WASTEWATER

Long viewed as an unavoidable and costly by-product of urbanization, the vast volume of wastewater produced by cities and towns is increasingly recognized as valuable feedstock for generating low carbon, renewable energy. Anaerobic digestion technologies that process wastewater into biogas are key to realizing the promise of net zero energy – or even energy positive – wastewater treatment facilities.

Ontario is home to approximately 485 municipal wastewater treatment plants (WWTPs).[20] Transforming these facilities into renewable energy centres would provide communities with a steady stream of low cost and low-carbon energy to replace the fossil fuels typically used for everything from heating and electricity generation to powering buses, trucks and other vehicles. In fact, generating biogas at WWTPs across Canada has the potential to offset 2.8 million tonnes of carbon dioxide equivalents per year, which is the equivalent of taking 600,000 cars off the road, while also creating 1000 year-long construction jobs and 250 ongoing positions.[21]

The City of Hamilton's Woodward Avenue WWTP clearly illustrates the potential for generating renewable energy and revenue from wastewater. The Woodward plant has been converting biogas to heat and electricity since 2006. In 2011 it became the first in Canada to inject clean, renewable natural gas into the Union Gas distribution pipeline, generating an estimated $2 million in annual revenue from 17,000 m^3 of biogas.[22]

Ontario innovators are building on the basics of biogas generation with new technologies aimed at squeezing the maximum amount of energy possible out of every drop of wastewater. The City of Stratford is leveraging funding from the TargetGHG program to explore the potential for increasing biogas generation at its WWTP by combining wastewater sludge with other sources of organics like food waste and compost.[23] New techniques are under development to increase biogas production by breaking open the cell wall of organisms in wastewater solids to liberate significantly more energy; these techniques may also reduce the solids that need to be trucked to disposal sites.[24] Canada's FedDev Ontario program recently awarded funding to researchers at the University of Guelph to advance the development of one such technology.[25]

While 30% of Ontario's WWTPs are already equipped with anaerobic digestion technology, only a fraction use the resulting gas for heating or generating electricity and only a handful are employing new technologies and techniques to maximize biogas production. Ontario companies working around the world to transform wastewater into renewable energy supply are ready to apply their solutions here at home (See Box 5). This is an area that is ripe for growth in Ontario. By targeting regulations, cleantech incentives programs and infrastructure funding initiatives to support innovation, governments can create the conditions to make net zero (or net positive) energy wastewater treatment facilities a reality across the province.[26]

BOX 5

INNOVATIVE ONTARIO CLEANTECH GENERATES RENEWABLE ENERGY

Anaergia offers anaerobic digester technology for municipal and food wastes along with the OMNIVORE™ technology to double biogas production.

Biorem offers a proven, cost effective line of biogas conditioning systems designed to protect equipment from the damaging effects caused by H_2S, siloxanes and volatile organic compounds (VOCs) typically found in sewage, digesters or landfill gas.

Suez Water Technologies & Solutions is piloting an enhancement to a new biological hydrolysis process in Guelph and Stratford that promises to yield 25% more biogas from wastewater.[27]

3.3

HARVESTING VALUABLE RESOURCES FROM WASTE STREAMS

Wastewater produced by municipalities, manufacturing facilities and buildings is feedstock for more than renewable energy. According to the Water Research Foundation, "most, if not all, materials in wastewater can be commoditized."[28] Fertilizer, recycled water and energy, and even heat are all valuable resources that can be recovered from wastewater. Three categories of solutions for harvesting resources from waste streams and reducing greenhouse gas emissions are:

1. Reusing and recycling heated water
2. Producing biologically based fertilizers
3. Heat recovery and exchange

With a thriving resource recovery and reuse cluster of companies, Ontario is well-positioned both to scale up existing solutions, and to lead the way with future innovations that fully put into practice the principles of a low carbon, circular economy and realize its potential. New construction and greenfield developments – for industry, buildings and public infrastructure – present unique opportunities to fully reimagine waste as a resource and create the regenerative, closed-loop energy and water systems of the future.

Reusing and recycling heated water

Most of Ontario's large industries, including steel production, paper manufacturing, chemical plants and food and beverage processing rely on high volumes of warm water and steam to create their product and wash equipment. Heating water and generating steam is known to have a high-energy intensity and often relies on fossil fuels. Reporting required by Natural Resources Canada indicates that heating water is the second highest source of greenhouse gas emissions in residential, commercial

and institutional sectors, yet the agency does not require any reporting on the energy used for water in the industrial sector.[29] Such gaps in information make it difficult to identify the potential for reusing and recycling heated water to contribute to energy and greenhouse gas reductions.

Companies that offer plant level water-energy audits are critical to revealing opportunities to recycle water and the associated heat. Countless water process experts that specialize in water recycling membrane technologies, steam system optimization, monitoring and computer simulation also have key roles to play in tapping into hot water reuse and recycling opportunities.

BOX 6

RECYCLING WATER REDUCES FOSSIL FUEL USE

Pulp & Paper Manufacturing: An analysis of energy and water systems in the Weyerhaeuser mill in Longview, Washington identified plant-wide opportunities for reusing white-water that amounted to natural gas savings of 100 billion Btu per year, and annual cost savings of $220,000.[30]

Food Processing: Suez Water Technologies and Solutions in Ancaster, Ontario uncovered an opportunity to use their membrane technology to recycle hot water at a Unilever margarine and vegetable oil plant in Rexdale, Ontario. Natural gas usage was reduced by 8% resulting in annual savings of $299,000 and 1,600 metric tonnes of carbon dioxide.[31]

Chemical Production: The chemical industry identified water as a potential source of energy savings in facilities. A study of energy savings across the sector suggested that water conservation, reuse, and recycling could reduce and reuse the low-grade heat and reduce carbon dioxide emissions equivalent to taking 1.5 million cars off the road annually in the United States.[32]

Producing biologically based fertilizers

The 2.5 million wet tonnes of biosolids and sludge[33] generated annually at wastewater treatment plants across Canada is increasingly valued for nutrients it contains. Cleantech companies are applying scientific advances to harvest nitrogen and phosphorus from wastewater solids to produce biologically based slow-release commercial fertilizer products (see Box 7). These solutions not only produce a valuable product that can generate revenue for municipalities, they can also divert solids from landfills or incinerators where their disposal produces deleterious greenhouse gases.[34] Many of these same technologies reduce the volume of solids that must be trucked offsite by 30% or more, reducing the fossil fuel use associated with freight.[35]

New technologies can extract phosphorus from liquid wastewater streams and convert it to fertilizer – a potentially significant breakthrough when compared to more energy intensive biological and membrane processes often used to remove phosphorus. Recovering nutrients to produce biofertilizer (a type of fertilizer that can reduce the need for chemicals and pesticides) can offset carbon emissions resulting from the production of chemical-based fertilizers, and at the same time reduce the amount of nutrients discharged to the environment where they can cause serious water quality problems in river, lakes and streams.[36]

Recovering nutrients is just the tip of the iceberg when it comes to extracting valuable resources from wastewater. Emerging technologies are promising to expand the number of compounds recoverable to include metals, thermoplastics, methanol and others.[37]

BOX 7

FROM WASTEWATER TO COMMERCIAL FERTILIZER

Ontario company **Lystek** produces a commercial-grade liquid biofertilizer called LysteGro, which is being used in a growing number of applications across the province.[38] Another innovative technology installed at a WWTP in Edmonton, AB that extracts phosphorus from wastewater and converts it to a commercial fertilizer was found to reduce 12,400 metric tonnes per year of carbon dioxide equivalent emissions compared to conventional fertilizer production.[39]

Heat recovery and exchange

Capturing energy from, or transferring energy to, water is a low carbon alternative to fossil fuels for heating and cooling water and spaces at a range of scales. Any instance where a difference between water or air temperature exists is an opportunity to move heat; this is the principle behind the household drain water heat recovery systems that are now a mandatory energy-saving solution required in all new homes in Ontario.

There are plenty of opportunities to apply this principle in other contexts. Technologies and strategies are surfacing to make heat recovery from water viable in larger scale applications like apartments, condominiums and office buildings. At an even larger scale, deep lake cooling technology that relies on heat exchange has proven to be an effective district energy solution for cooling buildings in cities like Toronto. Each of these technologies radically reduces the use of fossil fuels, and associated carbon emissions, required for space and heating and cooling (see Box 8).

BOX 8

SPACE HEATING FUELED BY INNOVATIVE WATER SOLUTIONS

Stantec: Ontario's Stantec Consulting has built the first LEED certified WWTP in North America, in Dryden, Ontario. Waste heat from the treatment plant is repurposed to provide clean, green heating of the onsite office building.[40]

Enwave: The Enwave Deep Lake Water Cooling technology uses water from Lake Ontario to provide a reliable, efficient and sustainable source of cooling for offices in downtown Toronto, reducing electricity use by 75 per cent compared to traditional air conditioning solutions.[41]

SHARC System: A Vancouver company has developed a new technology for multi-tenant buildings that extracts heat energy from wastewater using a heat pump, providing clean energy to heat both water and the building space via radiant floor heating.[42]

SECTION 4

CONCLUSION

With readily available and scalable carbon cutting solutions increasingly difficult to identify, Ontario will need to look for new and novel opportunities to achieve its target of reducing greenhouse gas emissions to 80% below 1990 levels by 2050.

Water presents a significant and growing opportunity for tackling carbon emissions.

The potential for water-related energy savings, renewable energy generation and resource recovery that reduce greenhouse gas emissions is woven through the entire Ontario economy – and it is largely untapped.

Ontario's vibrant water innovation ecosystem is well positioned to seize this opportunity. A wide range of water technologies and solutions that reduce greenhouse gas emissions are available or under development, and the province's water innovators are poised to discover many more in the years to come. Mobilizing the province's water innovators to accelerate implementation of existing technologies and approaches and continue to lead the way on developing new and novel solutions will require leadership, direction and dedicated support.

By investing in established accelerator organizations with the expertise and experience to make it a success, Ontario is building on its position as a clean technology leader to accelerate the transition to a prosperous, low carbon economy.

SECTION 4

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