Funded in part by:
Financé en partie par :
Canada

Canadian Water Network

CANADIAN NET ZERO WATER ROADMAP

Background Research

MARCH 2025

Contents

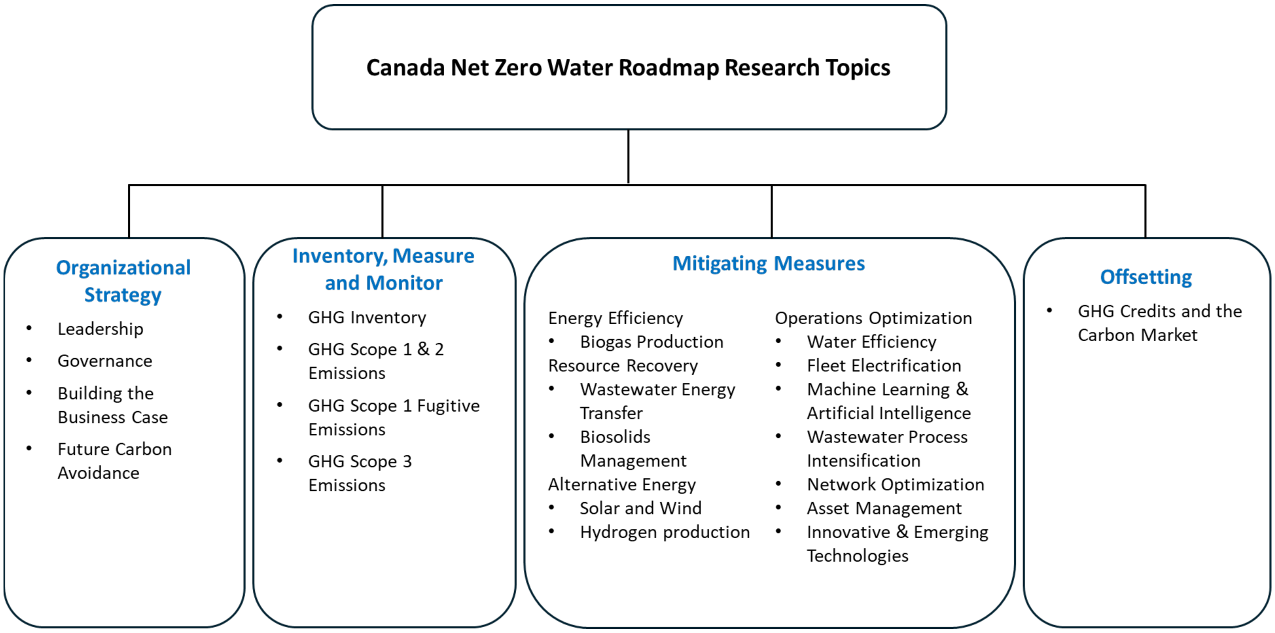

Figure 1: Net-Zero Water topics and themes included in the roadmap background research

This project is funded in part by the Government of Canada under the Implementation Readiness Fund. This grant will support CWN's project "Charting the Course to Net Zero Water: Mobilizing Canada's Municipal Water Network for Greenhouse Gas Mitigation" and will focus on developing networks and sharing knowledge. The project is active until March 2027.

Background

The objective of this background document is to identify the key themes and topics that warrant exploration by the National Advisory Committee and/or the Technical Advisory Committee. The themes and topics outlined in this roadmap are a starting point for developing the key elements of a 'roadmap" or "journey" that Canadian municipal water leaders can use as building blocks to implement Net Zero Water initiatives and programs in their municipalities. This document will capture the language and terminology our collaborative can use while building a "roadmap" for the sector and serve as background research for this project.

What is a Net Zero Roadmap?

A Net Zero roadmap is a strategic guiding document that outlines the actions and strategies for a sector to achieve Net Zero greenhouse gas (GHG) emissions by a specific time frame, in the case of the Federal Government, 2050.

Topic 1: Organizational Strategy – Leadership, Governance and Building the Business Case

Context

The governance of the net zero water journey for many utilities is dependent on setting clear goals and visions that align with the federal net zero target by 2050. Targets need to be set in conjunction with the broader municipality to ensure that all stakeholders are involved in achieving Net Zero Water. Canadian municipalities can significantly reduce GHG emissions by developing detailed programs and prioritizing pathways for GHG-reducing actions[1] through strategic leadership and governance. Underlying the governance of net zero is trust building, transparency and accountability with strategic stakeholder collaboration, and incorporating this in the municipal and federal targets.

The co-benefits of the Net Zero Water journey and energy transition can be incorporated within the circular economy and resource recovery models as climate resilience and adaptation are incorporated into long-term planning for water utilities.

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[1] Foresight Canada (2023). Municipalities: Canada's Climate Battleground. https://foresightcac.com/report/municipalities-canadas-climate-battleground

A business case for net zero in Canadian water utilities is typically a presentation or proposal to a municipal council — or in the case of a utility — their service Board, that is seeking funding, approval, or both for net zero initiatives or programs[2]. While not all net-zero actions require a business case, such as a state of good repair decision, the business case for net-zero puts a **proposed investment decision** into a **strategic** context. It provides the information necessary to make informed decisions on whether and how to proceed with business decisions whether they require investment or not, including potential cost and energy savings. For Canadian water utilities, it is important to build a strong business case with effective communication for net zero initiatives and programs in Canadian water utilities. A strong business case with tailored, pragmatic approaches for the net zero journey in any water utility or municipality is needed to gain financial support and public buy-in for programs and initiatives.

Topic 1 Objectives

- Identify key elements of strategic planning that are necessary for water utilities to attain their net zero goals.
- Explore better integration of net zero goals and targets into municipal and utility long-term master planning.
- Highlight opportunities for internal and external collaborative efforts to accelerate net zero journey in water utilities.
- Explore the elements of building a solid business case for net zero programs, strategies and initiatives in Canadian water utilities.

Topic 2: Organizational Strategy – Future Carbon Avoidance

Context

Future carbon avoidance refers to the choices that an organization can make to eliminate or reduce GHG emissions by adopting greener and more sustainable practices or low-carbon technologies. The approach of quantifying future carbon avoidance is a relatively new concept but provides an opportunity for Canadian water utilities to make better forward-facing choices on infrastructure development, acquiring new equipment, or equipment upgrades. The documentation of these emissions enables water utilities to make stronger business cases to acquire lower-carbon alternatives.

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[2] Government of Canada (n.d.) Business Case Guide. https://www.canada.ca/en/treasury-board-secretariat/services/information-technology-project-management/project-management/business-case-guide.html

Topic 2 Objectives

- Explore opportunities for future carbon avoidance within the Canadian water sector.
- Identify barriers and challenges in accounting for future carbon avoidance.

Topic 3: Inventorying, Measuring and Monitoring – Conducting a GHG Inventory

GHG inventories capture the emissions from processes and activities within water utilities and can act as a climate change balance sheet[3]. Inventories provide an understanding of the sources and amounts of GHG emissions that give a baseline for water utilities to understand what they are emitting and what they need to prioritize in GHG mitigation. A GHG inventory is a necessary step in developing climate action plans and targeted reductions of GHG emissions in water utilities[4]. The Water Research Foundation (WRF) is undertaking a project on "5188 - Establishing Industry-Wide Guidance for Water Utility Life Cycle Greenhouse Gas Emission Inventories" to develop a guidance document and spreadsheet for GHG accounting in water utilities by 2026.

Topic 3 Objectives

- Identify best practices for conducting a GHG emissions inventory through case studies in the Canadian context.
- Explore the different tools for calculating and accounting GHG inventories in wastewater, drinking water and stormwater utilities.

Topic 4: Inventorying, Measuring and Monitoring – GHG Scope 1 & 2 Emissions

Context

Drinking water and wastewater treatment plants (WWTPs) are among the most significant energy users and GHG emitters in many municipalities[5]. As outlined by the GHG Protocol[6], Scopes 1 and

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[3] ICLEI USA, (2022, March 23). *What is a Greenhouse Gas Inventory and Why is it Important?* What is a Greenhouse Gas Inventory and Why is it Important? | ICLEI USA

[4] Water Research Foundation (n.d.). Establishing Industry-Wide Guidance for Water Utility Life Cycle Greenhouse Gas Emissions Inventories. Establishing Industry-Wide Guidance for Water Utility Life Cycle Greenhouse Gas Emission Inventories | The Water Research Foundation

[5] He, Y. et al. (2023). Net-zero greenhouse gas emission from wastewater treatment: Mechanisms, opportunities and perspectives. Renewable and Sustainable Energy Reviews 184:1135-47.

https://doi.org/10.1016/j.rser.2023.113547

[6] Greenhouse Gas Protocol (n.d.). *Standards & Guidance.* https://ghgprotocol.org/standards-guidance

2 emissions are measured and monitored by water utilities as direct and indirect GHG emissions, respectively. The water sector is responsible for **1.6%** of global GHG emissions and 3% of energy consumption, and fugitive emissions from WWTPs are responsible for up to 5% of global non-CO2 GHG emissions[7]. Accurate and complete measurement of the GHG emissions from the municipal water sector is necessary for implementing and building GHG mitigation plans and deciding on reduction targets.

Scope 1 emissions in many GHG inventories include methane and nitrous oxide measurements from wastewater treatment and effluent, fossil fuel combustion, biogas consumption, flaring and incineration[8]. Non-biogenic CO_2 from wastewater and sludge treatment processes contribute to the Scope 1 emissions and include organic compounds of soap, detergent or other fossil-fueled chemicals like methanol[9,10]. Scope 2 emissions come entirely from electricity consumption and energy use. Different methods and calculators for measuring Scope 1 emissions are not standardized nationwide. One aspect of the roadmap is to work with project partners to compare these different methods and calculators for Scope 1 emissions (e.g. OWWA/WEAO calculator) and identify recommendations for best practices. Life Cycle Assessments can help water utilities understand the carbon footprint and broader sustainability impacts of their activities that bring a holistic approach to support decision-making (IWA, 2022).

Topic 4 Objectives

- Explore methods for measuring and reporting Scope 1 and 2 emissions requirements across the Canadian landscape for water utilities.
- Identify best practices and opportunities in conducting GHG inventories for the Canadian Net Zero Water sector.

Topic 5: Inventorying, Measuring and Monitoring – GHG Scope 1 Fugitive Emissions

Context

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[7] Lu et al. (2018). Wastewater treatment for carbon capture and utilization. Nature Sustainability 1: 750-758. https://doi.org/10.1038/s41893-018-0187-9

[8] International Water Association (2022). The state of knowledge on GHG emissions in the wastewater sector. https://iwa-network.org/the-state-of-knowledge-on-ghg-emissions-in-the-wastewater-sector/

[9] Maktabifard, M. et al. (2023). Net-zero carbon condition in wastewater treatment plants: A systematic review of mitigation strategies and challenges. Ren. Sus. Energy Rev. 185: 113638. https://doi.org/10.1016/j.rser.2023.113638

[10] Willis, J.L. et al. (2017). A greenhouse gas source of surprising significance: anthropogenic CO_2 emissions from use of methanol in sewage treatment. Water Sci Technol 75 (9): 1997-2012. https://doi.org/10.2166/wst.2017.033

Fugitive emissions in water and wastewater treatment and collection include nitrous oxide and methane. Nitrous oxide emissions from wastewater treatment, which are influenced by operations and processes, are estimated to be **3-7%** of global nitrous oxide emissions (Song et al., 2024) due to biological treatment processes such as sewage treatment. However, it has since been discovered that nitrous oxide emissions from water resource recovery facilities (WRRFs) can account for up to **86%** of total direct Scope 1 emissions[11]. As such, it is critical to measure and mitigate nitrous oxide. Accurate accounting of nitrous oxide emissions will assist the development of effective and practical mitigation strategies and define target baselines for water utilities.

One of the main drivers for water utilities to move from WWTPs to WRRFs is to mitigate methane emissions where value is extracted from waste output. Like nitrous oxide, methane emissions from WWTPs contribute about **5%** to global methane emissions[12]. On the other hand, methane emissions come from various sources, some of which have not been identified and can be measured with multiple tools. Methane is produced from the biological breakdown of sewage sludge and other biological processes. Still, a lot of uncertainty comes from the leaks during the anaerobic treatment processes, sewer systems and other parts of the WRRFs that may not be accounted for.

Topic 5 Objectives

- Explore methods for measuring and reporting fugitive emissions requirements across the Canadian landscape for water utilities.
- Assess current knowledge and gaps of fugitive GHG emissions in the GHG inventories of Canadian water utilities.
- Identify best practices and opportunities in conducting GHG inventories for the Canadian Net Zero Water sector.

Topic 6: Inventorying, Measuring and Monitoring – GHG Scope 3 Emissions

Context

Most water utilities use major Scope 1 and 2 emissions to set baselines and targets, as these emissions are within their control. On the other hand, Scope 3 emissions are not often included

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[11] Song, C. et al. (2024). Oversimplification and misestimation of nitrous oxide emissions from wastewater treatment plants. Nature Sustainability 7: 1348 –1358. https://doi.org/10.1038/s41893-024-01420-9

[12] Maktabifard, M. et al. (2023). Net-zero carbon condition in wastewater treatment plants: A systematic review of mitigation strategies and challenges. Renewable and Sustainable Energy Reviews 185:113638.

in the target-setting portion of GHG inventories as they are outside the control of many municipalities. However, the role of Scope 3 emissions cannot be overemphasized, as this includes embodied carbon, sources of GHGs in supply chains, off-site biosolids management and the use of chemicals, among many others. Addressing Scope 3 emissions is an opportunity for collaboration with others outside water utilities to widen their scope in mitigating GHG emissions. Measuring and monitoring Scope 3 emissions also allows the Federal Government and the Provincial and Territorial governments to support the efforts of Canadian water utilities in reducing their GHG emissions.

Topic 6 Objectives

- Explore the various options for measuring and monitoring Scope 3 emissions.
- Collate examples of Scope 3 emissions and how they are being used in GHG inventories to justify the opportunities for collective action.

Topic 7: Mitigating Measures – Energy Efficiency

Context

Water and energy are inextricably linked in the water-energy nexus, as water treatment and distribution use a lot of energy, and energy production uses a lot of water. Apart from operations optimization, there are vast opportunities for water utilities to reduce their energy use, especially through electrification. Canada's GHG emissions from power generation declined by 59% between 2005 and 2022, largely due to Ontario's phase-out of coal generation[13]. There are still opportunities for water utilities to reduce their GHG emissions through electrification in water utility operations to reduce energy costs and GHG emissions from energy use.

Topic 7a: Biogas Production and Utilization

Context

Biogas production and use is a dominant method by which WRRFs can recover energy. The efficient utilization of biogas also provides the opportunity for abatement in methane emissions from sewage sludge and wastewater treatment processes, as the Canadian Biogas Association found that municipal wastewater treatment facilities are only utilizing 20% of their biogas

[13] Canada Energy Regulator (n.d.). Provincial and Territorial Energy Profiles - Canada, CER – Provincial and Territorial Energy Profiles – Canada

potential[14]. Biogas can be converted to energy through combined heat and power (CHP), also known as co-generation, which can be a reliable, cost-effective solution for managing energy costs in WWTPs[15]. The biogas from the anaerobic digester is used as fuel to generate electricity for the facility and can be used for sewage sludge incineration. The exhaust gas is captured in a heat recovery unit where it is used for digester heat loads and space heating. Ultimately, biogas, as a renewable energy source, is advantageous to water utilities in replacing conventional energy sources.

Topic 7 Objectives

- Connect with the Canadian Biogas Association to increase the uptake of biogas production within WWTPs.
- Explore the role of biogas in reducing GHG emissions and the opportunities for mitigation when switching to biogas.
- Identify the various case studies and examples of energy efficiency through electrification for Canadian water utilities.
- Explore the available co-benefits of electrification and process optimization for Canadian wastewater, drinking water and stormwater utilities.

Topic 8: Mitigating Measures – Resource Recovery

Mitigation opportunities, in which waste from WWTPs can be repurposed to turn them into water resource recovery facilities (WWRFs) through closed-loop systems, are identified as **resource recovery** measures in this roadmap. Resource recovery presents the opportunity to utilize biosolids, products and renewable energy from waste derived from water utilities[16].

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[14] Canadian Biogas Association (2022, March). Hitting Canada's Climate Targets with Biogas & RNG. https://biogasassociation.ca/images/uploads/documents/2022/resources/Hitting_Targets_with_Biogas_RNG.pdf?v=0.677

[15] Bachman, N. (2015). Sustainable biogas production in municipal wastewater treatment plants. IEA Bioenergy. https://task37.ieabioenergy.com/wp-content/uploads/sites/32/2022/02/Wastewater_biogas_grey_web-1.pdf

[16] Water Research Foundation (n.d.) Resource Recovery. Resource Recovery

Topic 8a: Wastewater Energy Transfer

Context

Wastewater contains thermal energy that can be recovered at different scales: component, building, sewer and WWTP levels[17]. Sewer heat recovery systems pull thermal energy from wastewater instead of burning natural gas. The wastewater energy transfer (WET) system is installed at the point where wastewater exits and works by extracting and transferring heat from or to wastewater[18]. The heat recovery at the sewer pipe network level is an ideal source of heating or cooling for heat pumps because wastewater abundantly and continuously flows into the system[17]. Just like biogas production, by closing the loop, GHG emissions from burning carbon-based fuels can be reduced through the process of sewer heat recovery.

Topic 8b: Biosolids Management

Context

Biosolids management — treatment and use (in Scope 1 emissions view) — is a topic that touches on public health as we deal with contaminants of concern like PFAS in biosolids and better ways to manage to avoid climate and health risks[19]. Effective biosolids management for wastewater treatment may include thermal processes to transform biosolids to biochar through pyrolysis for energy recovery and volume reduction. However, this option is still limited by the commercial availability of technologies for this process. With emerging research, improved biosolids management is a mitigation opportunity for WWTPs as more technologies become available. The land application of biosolids benefits the economy and waste management by reducing the demand for non-renewable resources, reducing the demand for synthetic fertilizers, providing carbon sequestration and conserving landfill space[20].

Topic 8 Objectives

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[17] Nagpal, H. et al. (2021). Heat Recovery from Wastewater – A Review of Available Resource. Water 13:1274. https://doi.org/10.3390/w13091274

[18] McCormick, L. (n.d.) Wastewater Energy Transfer: The benefits and uses of wet systems.

[19] Australian and New Zealand Biosolids Partnership (n.d.). Biosolids and PFAS: Responsible management of emerging contaminants. https://www.biosolids.com.au/wp-content/uploads/ANZBP-PFAS-Biosolids-Factsheet-1.pdf

[20] Elgarahy, A.M. et al. (2024). Biosolids management and utilization: A review. Journal of Cleaner Production 451:141974. https://doi.org/10.1016/j.jclepro.2024.141974.

- Connect with the Canadian Biogas Association to increase the uptake of biogas production within WWTPs.
- Explore the role of biogas in reducing GHG emissions and the opportunities for mitigation when switching to biogas.
- Identify challenges and solutions in utilizing heat recovery from sewer systems in wastewater treatment plants (WWTPs), including innovative technologies and equipment.
- Explore the opportunities of sewer heat in reducing GHG emissions in WWTPs.
- Explore options for on-site biosolids management in wastewater treatment plants (WWTPs), including innovative technologies and equipment and regulations associated with the biosolids use in Canadian water utilities.
- Identify emerging technologies and best management practices of biosolids management in WWTPs.

Topic 9: Alternative Energy

By switching to lower-carbon sources and **alternative forms of energy**, the reliance of energy use on fossil fuel sources, and therefore GHG emissions, can be drastically reduced.

Topic 9a: Solar and Wind Energy

Context

Alternative energy like wind and solar are low-carbon energy sources that can help water utilities build resilience. Alternative energy sources have been identified as a strong mitigation measure as they directly reduce GHG emissions[21].

Topic 9b: Hydrogen Production

Context

Hydrogen production is an emerging field that explores water electrolysis, steam methane reforming during the biogas process and sewage sludge conversion into hydrogen during wastewater treatment processes to provide clean energy for use in WRRFs. With emerging technologies and research, hydrogen production may be an effective method of mitigating GHG emissions from wastewater treatment processes.

Topic 9 Objectives

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[21] Rani, A. et al. (2022). Pathways to a net-zero-carbon water sector through energy-extracting wastewater technologies. Npj: Clean Water 49.

- Explore how solar, wind and other forms of energy are offsetting energy costs and GHG emissions.
- Identify how these forms of energy are prioritized in comparison to the other forms of energy in WRRFs in terms of costs and resource availability.
- Explore emerging technologies and processes for hydrogen production within wastewater treatment processes.
- Provide the opportunity for Canadian water utilities to share their knowledge on hydrogen production and gain insights from advanced research.

Topic 10: Mitigating Measures – Operations Optimization

Context

There are numerous ways by which water utilities can optimize broader operations to reduce GHG emissions that help them attain net zero emissions targets. Water utilities upgrade equipment, use and analyze data, and optimize networks to ensure the treatment processes are more efficient by reducing leaks, using real-time data to adjust pumping and distribution networks, and responding better to emergencies. GHG emissions can be minimized by operating pumps at a consistent rate, reducing pipe velocities, energy consumption and overall costs[22]. These numerous optimization processes allow water utilities to tailor mitigation solutions to reduce their GHG emissions directly by ensuring their systems are efficient and indirectly reducing energy costs. By investing in the workforce with the appropriate technical knowledge and know-how, the workforce is a critical component of optimizing operations. The importance of operations optimization is that it easily applies to the whole water sector, not just wastewater but stormwater and drinking water utilities.

Topic 10a: Water Efficiency

The carbon impact and GHG emissions from unmanaged leakage from failed distribution systems are directly related to the energy costs of water losses[23]. Reducing water loss is a necessary measure that pertains not only to net zero but is also beneficial to saving energy and financial

[22] Luna, T. et al. (2019). Improving energy efficiency in water supply systems with pump scheduling optimization. Journal of Cleaner Production 213: 342-356.

[23] International Water Association Water Loss Working Group (2023, April 21). Leakage Emissions Initiative: Establishing a Standard Carbon Balance for Drinking Water Utilities. https://iwa-network.org/wp-content/uploads/2023/06/Water-Loss-SG-White-Paper-on-Leakage-Emissions-Initiative.pdf

costs while addressing system efficiency. Similar to the carbon balance of the GHG inventory, it is important to understand the water balance of any water utility to mitigate water losses. Carbon balance can also be calculated alongside water loss to account for the GHG emissions from water losses[23].

Topic 10b: Fleet Electrification

The transport sector is the second-largest emitter of GHG emissions, with an estimated 156.3 mega tonnes of CO_2e in 2022 (22% of Canada's GHG emissions)[24]. GHG emissions from this sector are mainly driven by the dependence of transportation on fossil fuels, and by electrifying fleet, GHG emissions can be drastically reduced. Electrifying the fleet within the water sector is an important aspect of addressing Scope 1 emissions and an opportunity for the broader municipalities to immediately reduce their GHG emissions. While there are economic benefits of transitioning to electric fleet, the successful adoption of electrifying fleet depends on supportive government policies, availability of charging infrastructure and enablement of services[25].

Topic 10c: Use of Machine Learning and Artificial Intelligence

As Artificial Intelligence (AI) and Machine Learning (ML) advancements are becoming more mainstream, there are opportunities to incorporate these technology advancements within the water sector to optimize operations. The use of AI and ML in water utilities has improved leak detection outcomes, improved water quality diagnosis, pollutant modeling, process control and analyzing customer use, among other benefits[26]. As operations are optimized, GHG emissions reduction is directly linked to energy and cost savings. The use of AI and ML are not limited to operations optimization but can be used to develop a prioritization framework in support of net-zero within the utilities and provide detailed analysis of GHG reduction measures and impacts within the system.

Topic 10d: Wastewater Process Intensification

Process intensification can contribute to operations optimization by utilizing new technologies in existing treatment processes to improve wastewater efficiency and effectiveness. Process

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[24] Government of Canada (2024). Greenhouse gas emissions. https://www.canada.ca/en/environment-climate-change/services/environmental-indicators/greenhouse-gas-emissions.html#transport

[25] PricewaterhouseCoopers (2024 March). Electrification of fleet operations. https://www.pwc.com/m1/en/publications/documents/2024/electrification-of-fleet-operations.pdf

[26] Rapp, A. H et al. (2023). Adoption of artificial intelligence in drinking water operations: A survey of progress in the United States. *Journal of Water Resources Planning and Management*. 149(7). https://doi.org/10.1061/JWRMD5.WRENG-5870

intensification can directly improve biological processes by using membrane bioreactors and other technologies, as well as best management practices like pyrolysis and other processes that maximize microbial activity and nutrient removal[27]. As fugitive emissions are linked to biological processes, one benefit of process intensification is that it may increase or decrease Scope 1 GHG emissions, but it provides the opportunity for a greater understanding of how intensification can impact fugitive emissions . An added benefit of process intensification is linked to water efficiency as the process can make it possible for water reuse in irrigation and other industrial processes[27].

Topic 10e: Network Optimization

For the purpose of this project, it is important to optimize water distribution networks for conservation of water resources and reduction of water loss[28]. In drinking water utilities, network optimization reduces operational energy use; by optimally operating water distribution and the treatment network, GHG emissions can be reduced[29]. Some studies have found that network optimization can reduce anywhere between 5 – 25% in energy cost savings, also reducing GHG emissions costs within the system[29].

Network optimization is a necessary GHG mitigation measure for drinking water utilities, as it is a large part of their Scope 1 GHG emissions.

Topic 10f: Asset Management

Asset management is a broad term that touches many of the other mitigation measures but is becoming more important as climate change impacts become more extreme and frequent. Asset maintenance is no longer about just maintaining existing assets while building new assets to respond to population growth, but also about responding to emergencies that stem from the adverse impacts on climate change as they occur. The implementation of asset management practices is dependent on the data, education, benefits, planning, regulations and funding mechanisms that are available, and should be increasingly adopted across the entire organization[30].

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[27] Wastewater Digest (2024, December 18). What is wastewater intensification? https://www.wwdmag.com/what-is-articles/article/55248805/what-is-wastewater-intensification

[28] Sangroula, U. et al. (2022). Optimization of Water Distribution Networks Using Genetic Algorithm Based SOP-WDN Program. *Water* 14 (6), 851. Doi https://doi.org/10.3390/w14060851

[29] Cardene, I. et al. (2020). Multi-objective optimization of energy and greenhouse gas emissions in water pumping and treatment. *Water Sci Technology* 82 (12): 2745-2760.

[30] CH2MHILL (n.d.) Water infrastructure asset management: Adopting best practices to enable better investments. https://www.newea.org/wp-content/uploads/2014/11/Water-Infrastructure-Asset-Management-SMR-2013.pdf

On the other hand, there is room for natural asset management within water utilities to mitigate GHG emissions. This is not limited to the wastewater sector; it includes the implementation of green infrastructure in stormwater management as well. The benefits of green infrastructure and natural assets include energy savings and nutrient load reduction, which reduce Scope 1 and 2 emissions[31].

Topic 11 Objectives

- Identify the various mitigation opportunities for Canadian water utilities in their wastewater, drinking water and stormwater management operations.
- Explore how the people, process and technology (PPT) framework can be utilized in the process of optimizing operations across the Canadian water sector.
- Identifying cross-cutting co-benefits of operations optimization within the water sector and within the broader municipal context.

Topic 11: Mitigating Measures – Innovative and Emerging Technologies

Context

The role of technologies can be woven into mitigation actions and carbon capture utilization and storage (CCUS) as an offsetting system, but this topic explores specific needs for technology advancement while addressing the barriers to technology adoption. Current and innovative technologies are **critically needed** to decarbonize rapidly, as the IPCC recognizes that innovation is a key driver of economic growth and can introduce new ways to deliver essential services[32].

A great example in which innovative technology can be used in mitigating GHG emissions is Carbon Capture Utilization and Storage (CCUS). CCUS efforts are still in development and is defined by the International Energy Agency (IEA) as the capture of CO_2 from large point sources and is gaining momentum with advanced research[33]. The challenge with CCUS as an offsetting opportunity is that it has a low carbon dioxide mitigation potential and does not address nitrous

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[31] Source Water Protection Toolkit (n.d.). Natural assets and green infrastructure. https://sourcewaterprotectiontoolkit.ca/tools/natural-assets-and-green-infrastructure/

[32] Intergovernmental Panel on Climate Change (2022). IPCC Sixth Assessment Report Working Group III: Mitigation of Climate Change. Chapter 16: Innovation, technology development and transfer from https://www.ipcc.ch/report/ar6/wg3/chapter/chapter-16/

[33] International Energy Agency (n.d.) Carbon Capture, Utilization and Storage. https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage

oxide, which is a substantial part of emissions from WWTPs. There is an opportunity to address offsetting GHG emissions with CCUS as research and technologies develop.

Topic 10 Objectives

- Assess innovative and emerging technologies with the help of the Technical Advisory Committee to address potential opportunities for adoption in water utilities.
- Gather knowledge of available technologies for water utilities across Canada for the resource library of the project.
- Identifying the roles and opportunities of CCUS in offsetting GHG emissions from municipal water services as emerging research and technologies are developed.

Topic 12: Offsetting

The rapid rise of GHG levels in the atmosphere due to anthropogenic causes has necessitated the need to begin offsetting GHG emissions. This is done by putting a dollar amount on carbon to keep organizations accountable for GHG emissions that they are responsible for.

Topic 12a: GHG Credits and the Carbon Market

Context

Canada is one of the few countries that has put a price on carbon and created a carbon market at the Federal level. At the provincial level, the GHG credit system varies and is determined by provincial and territorial governments. The GHG credit and carbon markets are an essential part of holding entities accountable to monitor, measure and compensate for their emissions if exceeded. The role of natural asset management in offsetting GHG emissions cannot be underestimated as WWTPs start to incorporate elements of circularity within their operations.

Topic 12a Objectives

- Explore the different GHG credits and carbon markets according to federal and provincial regulations across the Canadian landscape.
- Share knowledge between Canadian water utilities on how to navigate carbon markets.
- Identify the role of natural asset management in offsetting GHG emissions within the water sector.