ONTARIO RIVERS ALLIANCE

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14 May 2023

Ministry of Energy
P2D Consultation
Energy Supply Policy Division
7th Floor, 77 Grenville Street
Toronto, ON
M7A 2C1
By email: P2D.Consultation@ontario.ca

Re: ERO-019-6647 – IESO Pathways to Decarbonization Study

Dear Sirs:

The Ontario Rivers Alliance (ORA) is a not-for-profit grassroots organization with a mission to protect, conserve and restore riverine ecosystems across the province. The ORA advocates for effective policy and legislation to ensure that development affecting Ontario rivers is environmentally and socially sustainable.

The ORA is presenting feedback on our review of the Independent Electricity System Operator (IESO) P2D study, "Pathways to Decarbonization". ORA also made a submission on 8 May 2023, to The Honourable Tod Smith, Minister of Energy, Ken Hartwick, President and CEO of Ontario Power Generation, and Julia McNally, Director of Planning Projects & Sustainability, IESO; entitled 'Hydroelectric and its Pathway to Decarbonization' which also responds to this ERO posting and is located here.

ORA is strongly in favour of the 'Moratorium' scenario over the 'Pathway to Decarbonization' scenario, which will be explained and supported in our comments that follow.

1. Regulatory Streamlining:

The ORA will never be in favour of streamlining the regulatory, approvals and permitting processes as they were put in place to protect our natural environment and communities, and have already been significantly undermined.

Instead, we need strong and rigorous environmental assessment and public, Indigenous and robust stakeholder consultation if we are to build climate resilience into our air, land and freshwater resources.

I will briefly address my rationale and the dangers of streamlining the regulatory regime of hydroelectric facilities in particular, as it is commonly claimed by governments and industry to be 'clean', 'green' and 'non-emitting. However, this is misleading the public at a pivotal time when we should be following the science.

Hydroelectric is not “clean”, “green” or “non-emitting” of greenhouse gas emissions (GHG) as is commonly asserted by the waterpower industry and governments. Indeed, waterpower makes a significant daily contribution to the earth’s accumulation of GHGs into the atmosphere[1] and has resulted in significant and ongoing negative effects on water quality, water quantity, ecological processes, fish and wildlife populations and habitat, as well as indigenous communities. More on this later in this submission.

A very high environmental and socio-economic price has been paid in the past in terms of losses to valued natural resources due to the installation of dams and waterpower facilities. The socio-economic costs of these losses are generally ignored[2,3] and rarely revealed to the public.

The collateral environmental damage caused by dams and hydropower facilities has been well documented for decades, including the loss or serious decline in migratory fish species (waterpower facilities are key factors in the listing of some iconic fish species as species at risk in Ontario and elsewhere)[4,5], declining biodiversity[6], impaired water quality (including elevation of mercury concentrations in fish tissue)[7],[8], and are critical threats to imperilled aquatic species.[9]

Significant ecological damage from waterpower has been ongoing for many decades in Ontario and other locations worldwide.[10] In fact, in Ontario dams are considered to be a major factor in the extirpation of Ontario’s Atlantic Salmon stock[11], one of the most important causes of significant anthropogenic mortalities and decline of Ontario’s American Eel[12], and a key threat to Ontario’s declining Lake Sturgeon populations.[13,14,15]

In addition, the hydroelectric industry has been extremely negligent in protecting fish species, as there are a total of 224 hydroelectric facilities in Ontario, including 66 owned by Ontario Power Generation, and <u>only 3 are fitted with operating fishways</u>.

Hydroelectric projects have significant and ongoing negative environmental impacts and must be rigorously studied, planned and constructed with robust stakeholder and Indigenous consultation.

It is crucial to consider that future environmental and socio-economic costs and uses of hydropower will rely on water availability and must be accurately understood to inform decision-makers in this time of uncertainty.

These considerations were never adequately considered in the legislation before this government came into power; however, we cannot afford any further streamlining of the meagre environmental protection that we have left.

2. Planning and Citing of New Electricity Generation Projects:

For the reasons set out in this submission, the ORA does not support any new hydroelectric power generation. However, the pumped storage projects currently in the planning and approvals phase look to involve large electricity storage and output capacity with minimal effects on Ontario's freshwater ecosystems. The ORA strongly objects to any new hydroelectric development in Ontario.

3. Natural Gas-Fired Generation:

In general, ORA supports non-renewable sources of electricity temporarily, as long as they are on a trajectory of closing down as quickly as possible. As expanded on below (Page 5), the

Intergovernmental Panel on Climate Change (IPCC) National Inventory Guidelines, clearly reports that hydroelectric reservoirs are a significant and ongoing source of GHG emissions, including methane, which persists for the entire life cycle of the facility. This is a major issue as hydroelectric facilities are touted by proponents to remain in operation for 100 years or more.

Several hydroelectric facilities over or around 100 years of operation are currently going through the upgrade and retrofitting phase. Even if the facility shuts down, the sediment accumulating behind the dam means that it will continue to spew out methane.

A natural gas facility can be turned off when it is no longer required; however, a hydroelectric dam only stops emitting methane once it is removed and the riverine ecosystem is restored. There have never been any up-front decommissioning fees required to remove the dam at the end of its useful life. When a hydropower operator decides to stop generating and retire the facility it's doubtful the proponent will remove the dam. The century-old Howson Dam on the North Maitland River generated electricity at one time; however, it failed during the June 2017 flood. The municipality is seeking funding to have it decommissioned.

In addition, as stated earlier, hydropower also inflicts a multitude of other significant and ongoing negative impacts on the environment and stakeholders. Consequently, hydropower is the wrong choice for offsetting other GHG polluters.

The ORA supports a moderate increase in costs to the electricity system and ratepayers for wind and solar, but not the scenario laid out in the Pathways scenario. The debt that was carried over from the first green energy rush has just been pushed down the road and never dealt with properly. That debt needs to be paid off before another is incurred.

4. Estimated Capital Cost:

ORA cannot support a pathway forward incurring the estimated capital cost projections of $375 to $425 billion, in addition to the current system and committed procurements. As mentioned in my comments above, we still haven't paid off the debt from the green energy rush.

5. Hydrogen:

The ORA supports investment and innovation in green hydrogen as well as any other green fuels. Once we have the infrastructure to support green hydrogen vehicles, they will no doubt outsell electric vehicles. The production, storage and use of hydrogen are evolving quickly and seem promising.

Electric vehicles are not practical in northern Ontario where temperatures can reach –30°C, or where we have to travel long distances to shop and visit friends and family. Driving to Guelph from Sudbury would use about a tank of gas; however, driving an electric vehicle that far would mean having to stop at least 3 or 4 times to recharge. Driving this distance in winter temperatures would reduce the mileage even further. Electric vehicles are not practical or advisable for longer distances. This is why it is doubtful that the forecasts made by the IESO for electricity requirements into the next decade or more are very questionable and uncertain at best.

Industry should invest in new technology, rather than projecting these costs onto electricity consumers (ratepayers).

6. Greater Investment in Non-Emitting Supply, including Energy Efficiency Programs:

Again, investment in non-emitting supply should be made by industry, not the government or ratepayers or taxpayers.

Energy efficiency programs could provide rate discount incentives for consistent energy use reduction, reduction during peak demand, or using less energy during a particularly hot spell.

7. Development of New Hydroelectric Generation:

The Ontario Minister of Energy recently announced that Ontario Power Generation and the Ontario Waterpower Association are recommending 3,000 to 4,000 MW of hydro potential in northern Ontario and another 1,000 megawatts in the rest of the province. This could amount to several hundreds of new dams with reservoirs spewing out methane for 100 years or more. This is a big problem because there are no up-front decommissioning funds required to remove these hydroelectric dams when the water crisis reaches untenable levels. It also means that hydropower facilities will continue to emit copious amounts of methane for the full life of the facility.

ORA is strongly opposed to any new hydropower. It is not a wise or acceptable choice if the goal is to achieve a pathway to decarbonization. As explained above, hydropower facilities can last for 100 years or more and are particularly problematic as GHG polluters because methane is released throughout the entire life cycle of the facility.

Methane is generated in reservoirs from bacteria/microbes living in oxygen-starved environments. These microbes eat organic carbon from plants for energy, just like people and other animals, but instead of breathing out carbon dioxide, they breathe out methane.

The fuel for these emissions is the rotting organic matter (biomass) left behind when the reservoir is initially flooded, as well as the vegetation, litter, and organic matter that washes into the system regularly from rain events and seasonal flooding. Lakes and rivers can be a source or a sink of GHG emissions; however, when this organic matter and sediment continually accumulate in the reservoir behind the dam, it fuels emissions and guarantees the continued release of methane from the reservoir throughout the life of the dam.

Methane is a potent GHG with a heat-trapping capacity 28 to 34 times greater than carbon dioxide over a 100-year time scale and measured over a 20-year time period, that ratio grows to 84 to 86 times.[16] This is bad news as we already have a serious methane problem. Indeed, Canada, along with 100 other countries, made a global pledge to slash methane emissions by 30% below 2020 levels by 2030.

With smaller dams, storage becomes increasingly important. Reservoirs silting up or becoming overloaded with nutrients are common problems. They are at least as serious where shallower water bodies are created. The shallower a water body, the more vulnerable it is to thermal warming and the more eutrophic it can become. Likewise, methane generation occurs largely where water and sediment meet. This means that a shallower water body is likely to release more methane per unit area than a deeper water body. Shallow reservoirs are not unlike paddy fields and biomass generation, which are known to contribute substantially to methane emissions.[17]

A recent study out of Quebec quantified the long-term historical and future evolution of GHG emissions from 1900 to 2060, examining the cumulative global surface area of 9,195 reservoirs in four different climate zones (boreal, temperate, subtropical, and tropical) around the world. It reported:

> *"reservoir-induced radiative forcing continues to rise due to ongoing increases in reservoir methane emissions, which accounted for 5.2% of global anthropogenic methane emissions in 2020. We estimate that, in the future, methane ebullition and degassing flux will make up >75% of the reservoir-induced radiative forcing, making these flux pathways key targets for improved understanding and mitigation.*

In addition, the IPCC National Inventory Guidelines also report on several key factors to take into account when considering hydroelectric projects with flooded lands [reservoirs].

> *"Flooded Land emits CO_2, CH_4 and N_2O in significant quantities, depending on a variety of characteristics such as age, land-use prior to flooding, climate, upstream catchment characteristics and management practices. Emissions vary spatially and over time."*[18]

> *"Flooded Land is defined as: water bodies where human activities have caused changes in the amount of surface area covered by water, typically through water level regulation. Examples of Flooded Land includes reservoirs for the production of hydroelectricity, irrigation, and navigation."*[19]

> *Emissions of CH_4 from Flooded Land are primarily the result of CH_4 production induced by anoxic conditions in the sediment (see Annex 7.1). Methane can be emitted from small lakes or reservoirs via diffusive, ebullitive, and downstream emissions. Downstream CH_4 emissions are subdivided into degassing emissions (see Glossary) and diffusive emissions, which occur downstream from the flooded land. Methane emissions are generally higher in waterbodies with high organic matter loading and/or high internal biomass production, and low oxygen status. Due to their high emission rates and large numbers, small ponds of area < 0.1 ha have been estimated to generate 40 percent of diffusive CH4 emissions from open waters globally (Holgerson & Raymond 2016). Whilst emissions from natural ponds can (at least in part) be considered natural, those from small constructed waterbodies are the result of anthropogenic activity.*[20]

Many small hydroelectric facilities rely on peaking/cycling operating strategies to maximize power generation during peak demand hours. The hourly and/or daily water level fluctuations and repetitive wetting and drying effects over vast areas of the reservoir amplify the volume of GHGs released into the atmosphere.

For instance, an IPCC Climate Change 2022 report also warns that "*While hydropower reduces emissions relative to fossil fuel-based energy production, hydropower reservoirs are being increasingly associated with GHG emissions caused by submergence and later re-emergence of vegetation under reservoirs due to water level fluctuations (Räsänen et al., 2018; Song et al., 2018; Maavara et al., 2020)."*[21]

Some say, "*What about run-of-river hydro*? A true run-of-river hydropower facility has no water storage capacity. In fact, building a true run-of-river facility is often not cost-effective on smaller rivers because of the high construction cost and the small and intermittent amount of power generated as a result of low and unreliable flows. The Independent Electricity Systems Operator (IESO) in Ontario reported run of river efficiency to be as low as 15 to 30% of Installed Capacity.[22]

Run-of-river dams are vulnerable to water shortages, and this will only increase as temperatures continue to rise.[23] Sediment and leaf litter are trapped behind the dam and will release GHG emissions at the turbine intake, spillway, and outflow downstream of the dam.

To further highlight this point, a 2014 analysis was conducted by the IESO to determine the best means of electricity connection to remote First Nation communities and to enable forecasted growth of the Ring of Fire mining operations in northern Ontario. The analysis concluded that "*Northern hydroelectric generation is an energy-limited resource known to have significantly reduced output and availability during drought conditions of the river system supplying these generating units.*[24] In fact, the recommendation of their report was to not build any new hydroelectric facilities but primarily to build new transmission lines.

The daily, seasonal, and annual variations of small hydro operations are also intermittent and unreliable. This is because generation peaks during the high flows of spring when power is in low demand and produces at its lowest during the hot summer months when consumption and demand are most heightened. During the low flow season of summer or during drought conditions, many true run-of-river and even some peaking (storage) facilities, especially on smaller rivers, cannot operate efficiently and must be shut down. This problem can only become more prevalent as climate change intensifies and temperatures rise. This is a time when we must be working to increase stream resilience.

The role of hydropower in helping provide power system balance and stability will also be affected by climate-related events, which have reduced water availability in many regions over the last few years, straining power grids and raising questions about the resilience of electricity systems.[25]

A cost/benefit analysis should be required to determine whether these types of projects are environmentally and/or economically sustainable and whether they should even qualify for certification and CECs.

The IPCC reports that "*hydropower plants without or with small storage may be susceptible to climate variability, especially droughts, when the amount of water may not be sufficient to generate electricity (Premalatha et al. 2014) (Section 6.5).*[26]

Turning a blind eye to the many significant and ongoing environmental impacts of waterpower and the blatant disinformation and reasoning behind the claims of non-emitting, clean, green and renewable hydropower brings to mind the tobacco and oil and gas industries in the 1960s and 1980s. The tobacco industry knew the dangers of smoking to a person's health, yet despite the dangers still misled the public into believing it was safe. The oil and gas industry has known all along that oil and gas emissions will lead civilization off a climate cliff, and yet has failed to act. Most importantly it is the responsibility of this government to take meaningful action to protect the future of its citizens, to be transparent and truthful, and to act in the best interests of its citizens and the global community as a whole.

Hydroelectric must also finally be recognized for its significant and ongoing GHG emissions that will have long-lasting implications on our ability to achieve our GHG emission reduction goals. Its reservoirs are likely much worse contributors to world GHG emissions than previously thought, as *"carbon emissions from dams have been significantly underestimated. On a global average, they release twice as much carbon as they store. Their image as a net carbon store in the global carbon cycle must be reconsidered*."[54]

8. Transmission Lines:

ORA supports the use of transmission lines to help balance the intermittent sources of electricity (wind and solar) and to ensure a cost-effective supply can be delivered to meet growing demands and electrification and economic growth.

9. Other - Clean Energy Credits:

The ORA is concerned that Ontario Power Generation (OPG) promotes its hydroelectricity as "clean" and "non-emitting" and has made over $5.5 million by privately selling Clean Energy Credits (CECs) to GHG polluters since 2013, as disclosed in a 25 August 2022 article by The Narwhal.[27]

These CECs are purchased by companies and governments to offset their own emissions from fossil fuel-generated electricity to help reach their climate goals. A CEC guarantees that one megawatt-hour of electricity comes from non-emitting sources like hydro, wind, solar or nuclear.[28]

The Ministry of Energy declared in its March 2023 news release that "*Ontario Power Generation (OPG) will begin offering its CECs for sale immediately. The Independent Electricity System Operator (IESO) expects to begin selling IESO-held CECs in the summer of 2023*"[29]; however, it is public knowledge that OPG has been selling CECs since 2013. It is also public knowledge that for 10 years OPG did not disclose its CEC sales and instead actively promoted sales through its misleading rhetoric of clean and non-emitting hydropower. It would be highly relevant to clients purchasing CECs, to know that hydroelectric does indeed generate significant amounts of GHG emissions, at times reaching levels of those coming from natural gas facilities, and that they are in fact paying to generate more GHGs, including methane.

The ORA copied Ken Hartwick, OPG, on our 16 September 2022 submission regarding Environmental Registry posting ERO-019-5816 - Development of a Clean Energy Credit Registry, to inform him of the thousands of peer-reviewed third-party independent studies reporting that GHG emissions are generated in the hydroelectric reservoir, turbine intake, spillway and downstream of a hydroelectric dam. It is not credible to believe this was news to Mr. Hartwick.

The Minister of Energy can create a clean energy registry for "Eligible Ontario-based non-fossil fuel generation facilities"; however, the generation of electricity from these facilities is not the only thing that should be "verified and tracked", the GHG emission levels coming from "clean" electricity generators should also be verified, tracked and made available to the public online.

Until this provincial government requires "clean" electricity generators selling CECs to detect, measure and publicly report all GHG emissions to a Clean Energy Registry, we are on a false path to zero emissions. This will allow GHG emissions released into the atmosphere to continue to rise while negative climate change effects continue to accelerate.

Recommendations:

1. The Minister of Energy must reject the notion of opening the province up to any new hydroelectric projects. This is a crucial decision as hydroelectric dams are built to last for 100 years or more and will continue to pollute our atmosphere for the life of the facility.

2. If OPG continues to sell CECs it has a moral obligation, if not a legal one, to detect, measure and publicly report data daily, in real-time, of all GHG emissions (CH_2, CH_4 and N_2O) coming from each of its hydroelectric reservoirs.
3. It is also crucial that GHG emissions and their feedbacks are effectively quantified and reported to the appropriate federal and provincial Ministers to guide decision-making toward our climate goals and the sale of CECs. It is also imperative that GHG emission data coming from all hydroelectric reservoirs is included in Canada's annual IPCC National [GHG] Inventory Report.
4. OPG should use a sensitive drone-based system for mapping GHG daily to easily and cost-effectively measure all emissions within the zone of influence, including its headpond, turbine intake, spillway and downstream of the dam.[30]
5. Use the dollars from the Future Clean Energy Fund to decommission old and unsafe dams to help offset some of the GHG emissions generated from its existing hydropower facilities.

ORA's submissions to The Honourable Todd Smith, Minister of Energy and to The Honourable Steven Guilbeault, Minister of Environment and Climate Change Canada are much more fulsome in the areas of GHG emissions coming from hydropower and Clean Energy/Electricity Credits and should be referred to if additional information is required.

Thank you for this opportunity to comment!

Respectfully,

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Cc: The Honourable Todd Smith, Minister of Energy - MinisterEnergy@Ontario.ca

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[1] *Yang, Le; Lu, Fei; Zhou, Xiaping; Wang, Xiaoke; Duan, Xiaonan; Sun, Binfeng. Progress in the studies on the greenhouse gas emissions from reservoirs.*
Online: https://www.sciencedirect.com/science/article/pii/S1872203214000249

[2] *Wang, G., Fang, Q., Zhang, L., Chen, W., Chen, Z., Hong, H. 2010. Valuing the effects of hydropower development on watershed ecosystem services: Case studies in the Jiulong River Watershed, Fujian Province, China, Estuarine Coastal and Shelf Science. 86.3*

[3] *Institute for Fisheries Resources.1996. Cost of Doing Nothing: The economic burden of salmon declines in the Columbia River basin. Report No. 1 of 3.*
Online: https://pcffa.org/wp-content/uploads/2016/10/CDNReport-Columbia.pdf

[4] *MacGregor, R., Casselman, J., Greig, L., Dettmers, J., Allen, W.A., McDermott, L., and Haxton, T. 2013. Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario. Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources, Peterborough, Ontario. x + 119 pp. P-45.*

[5] *MacGregor, R., Haxton, T., Greig, L., Casselman, J.M., Dettmers, J.M., Allen, W.A., Oliver, D.G., and McDermott, L. 2015. The demise of American Eel in the upper St. Lawrence River, Lake Ontario, Ottawa River and associated watersheds: implications of regional cumulative effects in Ontario. Pages 149–188 in N. Fisher, P. LeBlanc, C. A. Rose, and B. Sadler, editors. Managing the impacts of human activities on fish habitat: the governance, practices, and science. American Fisheries Society, Symposium 78, Bethesda, Maryland.*

[6] *Carew-Reid, J., Kempinski, J., and Clausen, A. 2010. Biodiversity and Development of the Hydropower Sector: Lessons from the Vietnamese Experience – Volume I: Review of the Effects of Hydropower Development on*

Biodiversity in Vietnam. ICEM – International Centre for Environmental Management, Prepared for the Critical Ecosystem Partnership Fund, Hanoi, Viet Nam. Online:https://www.icem.com.au/documents/biodiversity/bioHPdevt/Volume%20I%20Biodiversity%20and%20development%20of%20hydropower-Vietnam%20experience.pdf

[7] *Bodaly, R.A., Beaty, K., Hendzel, L., Majewski, A., Paterson, M., Rolfhus, K., Penn, A., St. Louis, V., Hall, B., Matthews, C., Cherewyk, K., Mailman, M., Hurley, J., Schiff, S., Venkiteswaran, J. Experimenting with Hydroelectric Reservoirs, 3 pp. Environment Science and Technology. American Chemical Society. Online: http://library.certh.gr/libfiles/PDF/GEN-PAPYR-1135-ENVIRONMENTAL-by-BODALY-in-EST-V-38-ISS-18-PP-346A-352A-Y-2004.pdf*

[8] *Kelly, C.A. et al. (1997). Experimental Lakes Area Reservoir Project (ELARP). Increases in fluxes of greenhouse gases and methyl mercury following flooding of an experimental reservoir, Environ. Sci. Technol, 31(5), 1334-1344, doi:10.1021/ES9604931.*

[9] *Wilcove D.S., Rothstein, D., Dubow, J., Phillips, A., Losos, E. 1998. Quantifying threats to imperiled species in the United States BioScience 48: 607–615. Online: http://faculty.washington.edu/timbillo/Readings and documents/global div patterns origins/general tropical biodiv conservation/Wilcove_et_al Bioscience_1998 Quantifying_threats_to biodiv.pdf*

[10] *World Commission on Dams. 2000. Introduction to Global Change, Working Paper of the World Commission on Dams, Secretariat of the World Commission on Dams, Cape Town, South Africa.*

[11] *Ontario Ministry of Natural Resources 2013. Restoration of Atlantic Salmon to Lake Ontario: past, present and future.*

[12] *MacGregor, R., Casselman, J., Greig, L., Dettmers, J., Allen, W.A., McDermott, L., and Haxton, T. 2013. Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario. Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources, Peterborough, Ontario. x + 119 pp. P-45.*

[13] *Golder Associates Ltd. 2011. Recovery Strategy for Lake Sturgeon (Acipenser fulvescens) – Northwestern Ontario, Great Lakes-Upper St. Lawrence River and Southern Hudson Bay-James Bay populations in Ontario. Ontario Recovery Strategy, Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vii + 77 pp.*

[14] *Committee on the Status of Endangered Wildlife in Canada (COSEWIC). 2006. COSEWIC assessment and update status report on the lake sturgeon Acipenser fulvescens in Canada. Ottawa. Online: http://www.sararegistry.gc.ca/document/default_e.cfm?documentID=1376*

[15] *Haxton, T.J., Friday, M., Cano, T. and Hendry, C. 2014. Variation in lake sturgeon (Acipenser fulvescens Rafinesque, 1817) in rivers across Ontario, Canada*

[16] *Myhre, G., Shindell, D, Breon, F.-M., Collins, W., Fuglestvedt, J., Huang, J., Koch, D., Lamarque, J.F., Lee, D., Mendoza, B., Nakajima, T., Robock, A., Stephens, G., Takemura, T., Zhang, H., Anthropogenic and natural radiative forcing. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Chapter 8, Table 8.7; Stocker, T. F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S. K., Boschung, J., Nauels, A., Bex, V., Midgely, P. M., Eds.; Cambridge University Press: Cambridge, U.K. and New York, U.S.A., 2013.*

[17] *Abbasi, T. and Abbasi, S.A. 2011b. Small hydro could add up to big damage. SciDev.Net 20/06/11. Online: http://www.scidev.net/global/water/opinion/small-hydro-could-add-up-to-big-damage-1.html*

[18] *2019 Refinement of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 7, Wetlands, 7.3 Flooded Land. P-6/52.*

[19] *2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands, Chapter 1, Introduction, Note 6: Is this a 'Flooded Land'? P23/354*

[20] *2019 Refinement of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 7, Wetlands, 7.3 Flooded Land, CH_4 emissions. P-6/52.*

[21] *IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844. 4.3.2 Observed Impacts on Energy and Industrial Water. P-597/3068 Online: https://www.ipcc.ch/report/ar6/wg2/*

[22] *North of Dryden Integrated Regional Resource Plan – January 27, 2015, by OPA/IESO. P-56 & 124. Online: http://www.noma.on.ca/upload/documents/north-of-dryden-report-2015-01-27.pdf*

[23] *IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844. 4.3.2 Observed Impacts on Energy and Industrial Water. P-597/3068 Online: https://www.ipcc.ch/report/ar6/wg2/*

[24] *North of Dryden Integrated Regional Resource Plan – January 27, 2015, by OPA/IESO. P-56 & 124. Online: http://www.noma.on.ca/upload/documents/north-of-dryden-report-2015-01-27.pdf*

[25] *World Energy Outlook 2022, International Energy Agency. P-293/524 Online: https://iea.blob.core.windows.net/assets/830fe099-5530-48f2-a7c1-11f35d510983/WorldEnergyOutlook2022.pdf*

[26] *Clarke, L.,Y.-M.Wei,A. De La Vega Navarro,A. Garg,A.N. Hahmann, S. Khennas, I.M.L.Azevedo,A. Löschel,A.K. Singh, L. Steg, G. Strbac, K.Wada, 2022: Energy Systems. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.008. Chapter 6, 6.4.2.3 Hydroelectric Power. P-753/2258*
Online: https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf

[27] *Ontario Power Generation has made $5.5 million privately selling clean energy credits, by Fatima Syed, The Narwhal, 25 August 2022.*

[28] *Doug Ford killed carbon credits. Ontario Power Generation is still selling them, by Fatima Syed, The Narwhal, 5 May 2022.*

[29] *Newsroom Backgrounder: Ontario Launches Clean Energy Credit Registry and Establishes Future Clean Energy Fund, March 29, 2023.*

[30] *Gålfalk, Nilsson Påledal, and Bastviken, "Sensitive Drone Mapping of Methane Emissions without the Need for Supplementary Ground-Based Measurements. 2021"*
Online: https://pubs.acs.org/doi/full/10.1021/acsearthspacechem.1c00106