Seattle Weekly Oct. 5, 2016

Washington's Big Dam Climate Nightmare by Brett Cihon

Scientists have identified man-made reservoirs as a huge source of heat-trapping methane. Will it be the last straw for Washington's controversial dams?

In late August, Washington State University professor John Harrison boarded a plane at Portland International Airport. The scientist found his seat and took some time to dig through his briefcase and order his papers before takeoff.

Harrison slept a bit during the 10-hour flight to Amsterdam, the first leg toward his final destination of Minsk, Belarus. But the man with thinning brown hair and a permanent smile took much of the flight to examine data on ebullition rates, CO2 fluxes, and other complex sciences. He also took the chance to read over the statements he was slated to give at the international conference of the Intergovernmental Panel on Climate Change (IPCC) in Minsk.

Harrison was so engrossed in his preparations for the conference that he likely missed the chance to look out the window as the plane flew east toward the Atlantic. Had he looked out, though, he could have spotted the Bonneville, The Dalles, the John Day, or any of the other 60-odd hydroelectric dams in the Columbia River watershed area. Expansive walls of concrete, churning turbines, and the placid waterways behind them that provide irrigation for crops, water supplies for towns, recreation for boaters, and renewable sources of energy for just about everyone in Washington.

Renewable, yes. But clean? Not as such.

Much of the reason Harrison was flying to speak at the IPCC was to discuss findings from a synthesis study he co-authored, released in the Oct. 5 issue of the journal *BioScience*. The study calls into question hydroelectricity's reputation as a climate-friendly source of energy. According to the study, reservoirs from around the world are an "important source of greenhouse gases (GHGs) to the atmosphere." The study suggests Washington's dams—from the expansive Grand Coulee down to the littlest blockade on a spring in King County—and the reservoirs behind them all pump out methane, a compound up to 85 times more potent a greenhouse gas than carbon dioxide.

The study also shows some of Washington's reservoirs may produce more of the powerful greenhouse gas than most, as agricultural lands around the waterways feed the methane-producing organisms with the material they crave. And with more than 90 percent of Seattle's energy coming from hydroelectric power, the study calls into question City Light's claim of having a zero carbon footprint.

"Reservoirs and dams are not greenhouse-neutral," Harrison says today.

Harrison may have missed looking out the window on his flight to Amsterdam. But his mind was certainly on dams and reservoirs—and how he could convince the IPCC and others to accept the latest numbers, and the stark conclusion he drew from them: "Through the construction of dams, people are changing the world we live in on a geologic scale."

Looking at placid, serene reservoirs like Lake Sacajawea behind the Ice Harbor Dam on the Snake River, it's easy to miss them as major carbon emitters. Gray smoke doesn't billow from the surface of their waters; black soot doesn't line their shores.

But, according to the 16-page *Bioscience* report, "Greenhouse Gas Emissions from Reservoir Water Surfaces: A New Global Synthesis," and

other recent studies, some reservoirs emit more greenhouse gases than fossil-fuel-based energy providers, such as natural-gas power plants.

Artificial reservoirs produce methane—a carbon atom bonded with four hydrogen atoms—in three key ways. First, the flooding of previously dry areas fuels a process called microbial decomposition. Put simply, microbial decomposition occurs when organic matter dies underwater, breaks down, and emits gas. Second, reservoirs often experience greater changes in water levels than natural lakes. During frequent water drawdowns, methane is released through increased ebullition—aka bubbling—rates, meaning that methane trapped in the reservoir is released more often.

The final way dams produce methane is by collecting organic materials that run into their reservoirs and decompose. The closer big reservoirs are to human activities like agriculture, the more methane they produce as organic materials like fertilizer wash into the reservoirs and then decompose. This is because, by their nature, reservoirs are typically oxygen-starved environments. When organic material decays in such environments, the gas produced is methane, whereas under normal circumstances it would emit more benign gases. This method is particularly pertinent in Washington's reservoirs: As farmers fertilize the hops, wheat, grapes, and other crops crowding the Columbia River Basin, for example, those organic materials get washed away, end up in reservoirs, and slowly break down in the oxygen-starved environment best suited for methane production.

Until recently, the study's authors say, only reservoirs in tropical areas were thought to be potent sources of methane. But after gathering data from all parts of the world, their study shows almost no difference in the amount of powerful greenhouse gases emitted from tropical vs. temperate reservoirs. "Temperate reservoirs were surprisingly more active than previously thought," Harrison says. "New studies in places like Oregon and Washington have shown reservoirs can be very active in [releasing] methane to the atmosphere." The study shows the amount of gas released was greatly underestimated: "Acre-to-acre methane production is about 25 percent higher than previously suggested," Harrison says.

And pound for pound, methane is a much stronger greenhouse gas than carbon dioxide in the short term. For example, if one molecule of methane and CO2 are each released on the same day, 10 years later the molecule of CH4 will have about 85 times more radiating force—the force that traps heat—than CO2. After 20 years, methane's power depletes and has only about 70 times the radiating force; after 100 years, about 34 times the force; and so on until the gas breaks down entirely. So methane's radiating force is able to heat the atmosphere much quicker than CO2, explains Abby Swann, an assistant professor with the UW Department of Atmospheric Sciences. "The methane is going to be a really, really good trapper," she says. "With CO2, you're guaranteeing that trapping of heat for a really, really long time."

The *BioScience* authors estimate that the world's reservoirs produce 1.3 percent of all human-caused GHG emissions on a 100-year timescale. That's comparable to the amount of GHGs coming from rice patties or biomass burning, the authors say, and roughly equivalent to Canada's total production of human-caused GHG. And that number is doubled—if not more—in the short term because of methane's radiating properties, Harrison says. While that percentage will decrease as the methane weakens, it's the short term that could be more important for the climate, says Rebecca Neumann, a UW professor of civil and environmental engineering. As the world's global average temperature speeds toward the important benchmark of 2 degrees Celsius higher than pre-industrial levels, eliminating methane could more quickly curb temperature increases. "If we're trying to mitigate near-term climate change, methane would be one place to put some effort," Neumann says. "It can have some impact on a short time scale."

Since methane is a much more powerful gas, reservoirs don't need to release epic loads of it

to put them on the same level as some carbon-based power plants. A 2013 study in *Environmental Science and Technology* estimates that about 10 percent of hydroelectric reservoirs produce more greenhouse gases per unit energy generation than CO2 emissions from natural gas combined-cycle plants. In other words, though natural-gas energy releases many more molecules of CO2 than reservoirs release CH4, some reservoirs are bigger GHG producers because of methane's potency. And, with the recent *BioScience* paper asserting previous CH4 production rates were underestimated, it's possible that a lot more than 10 percent of reservoirs are worse GHG producers than natural-gas power plants.

The world—and certainly Washington—loves hydroelectric power. More than a million dams are in existence around the globe, a 2011 study shows. And many more are on the way as countries turn to renewable sources for their energy consumption.

The problem, Harrison says, is that governments are jumping to hydroelectric without recognizing the costs. Thus his trip to Belarus, urging the multination IPCC to include methane emissions from reservoirs into countries' allotted GHG budget. As of right now, they're not; they're slipping through the cracks as countries try to reach their emission goals. "The problem is people aren't considering it," Harrison says.

Washington certainly doesn't appear to be considering it, either. In a state with more than 1,000 dams—a few with reservoirs stretching over 50 miles long—concern about CH4 production seems nonexistent. Seventy percent of the state's energy comes from hydroelectricity, with most of that coming from eight of the state's 10 largest power plants on the Columbia and Snake rivers. The city of Seattle receives more than 90 percent of its energy from hydroelectric plants, and touts the figures. A page from the city's website reads: "With more than 90 percent of Seattle's electricity generated from clean, hydroelectric power, it means something. It means we all enjoy low rates, and we can hold our chins high knowing that our electricity is 100 percent carbon-neutral."

Lynn Best, environmental officer at Seattle City Light, says the methane issue is not new. Other science on the subject shows that Seattle City Light's major dams—Ross, Diablo, Gorge, and Boundary—don't produce any more methane than a forest floor, she says.

Citing a 2004 study, Best says methane production at the four dams is almost nonexistent because of the prevalence of oxygen and their low intake of organic material. The city has even hired an independent evaluator with the Climate Registry to look into the dams' methane emissions, she says. No methane emissions were included in the evaluator's report of possible GHGs from Seattle City Light. "I think I want to be very clear," Best says. "We really don't see any evidence of methane or any measurable quantities of methane coming out. The fact that it's oxygen-rich makes it highly unlikely that there's any meaningful production of methane."

Best did emphasize, however, that she has not seen the latest study in *BioScience*. She said the city will certainly take a look at it and consider its implications for a grid with a vast majority of its power coming from hydroelectric. "Our idea of good inventory is to be as accurate as we possibly can," Best says. "It sounds like they've done an extensive study."

Harrison, for his part, says that out of the 75 reservoirs measured in the *BioScience* study, all were shown to release methane. That includes four reservoirs from Washington—Cle Elum, Keechelus, Kachess, and Lacamas—which have fairly similar base characteristics to the Seattle City Light dams. "All of the reservoirs we studied were net sources of methane to the atmosphere," Harrison said when asked if it's possible a reservoir could have no emissions. "From what we studied, it can't be true."

The study has implications in other places in the state, too. Earlier this year, a federal judge urged consideration of the removal of four dams on the

Lower Snake River—Ice Harbor Dam, Lower Monumental Dam, Little Goose Dam, and Lower Granite Dam—in an effort to save salmon runs, which are seriously imperiled by the concrete obstructions. The dams' removal would be a massive undertaking, and is often lobbied against with the argument that the four decades-old dams provide clean sources of energy. Joseph Bogaard, executive director at Save Our Wild Salmon and proponent of the Lower Snake River dam removal, believes some hydroelectric power can never be considered clean, even if reservoirs didn't produce a single bubble of methane. "It can't possibly be called clean because it's sending salmon into extinction," Bogaard said.

The cost and benefits of the dams on the Lower Snake need to be constantly re-evaluated, Bogaard says, especially as new studies are released. If the reservoirs produce a sizable amount of CH4, this needs to be factored into a cost-benefit analysis. He says that with clean energy as the only ace dam proponents have left up their sleeve, they're increasingly left without an argument. As dams continue to damage salmon runs and are shown to produce GHGs, it's time to move to newer energy sources that are more in line with the state's goals, he says.

"We have options here," Bogaard says. "We can stick with old, harmful technologies, or we can seize opportunities to innovate and look forward to the future."

Of course, Bogaard, Harrison, and others are not suggesting the state tear out every dam from Diablo down to The Dalles. The state has vast energy needs that must be met. Besides, dams and their reservoirs have functions other than power production—irrigation and flood control, for example.

And, Harrison and co-author Bridget Deemer argue, steps can easily be taken to help mitigate reservoirs' methane production. With nutrient inflows a huge factor in the amount of CH4 reservoirs produce, imagine gutters along the sides of dams, filtering out some organic material before it reaches the reservoir. Or simply siting new dams upstream of farmlands. "Nutrient controls could be an important piece of planning," Deemer says.

Deemer and Harrison also hope to see more reservoir-specific studies. For Washington and Seattle to get a better handle on how much CH4 is let into the atmosphere, more precise measurements at area dams need to be made. "You can always guess to how the world is working," Harrison says. "But until you measure it and know for sure, you don't know."

But the first step is accepting the reality that reservoirs produce methane in the first place. Harrison says his talk in front of the IPCC was well-received, and the body appears to be moving to a place where they mandate that countries monitor GHG emissions from reservoirs. His hope is that by 2019, reservoirs will be included in national inventories of GHG emitters.

Once these facts are accepted and added to the complex narrative of how best to curb climate change, then other decisions can be made, Deemer says. The goal is to dispel the myth of hydroelectric as a completely clean source of energy, while not damning it entirely.

"Any form of alternative energy has its cost," Deemer says. "There are costs, and we have to look at these. It's just one piece of the puzzle that needs to be factored in."

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