Portland, Oregon, USA case study:

How Portland uses satellite leak detection to reduce (and track) water loss and carbon emissions

Introduction

The Portland Water Bureau is committed to being a leader on climate action by reducing its carbon footprint through measures including water loss reduction. The following case study provides an example of a drinking water utility with a decades-long commitment to tracking carbon emissions that used the International Water Association's (IWA) Leakage Emissions Initiative (LEI) Calculator to complement its water loss reduction effort. This case study analyzes the impact of a project that used satellite leak detection technology to reduce water loss and demonstrate how the LEI Calculator can measure the associated carbon reduction of this work quickly and effectively.

Background

Utility and service area

The Portland Water Bureau is part of the City of Portland's Public Works Service Area and provides drinking water to residents in and around Portland, Oregon, in the Pacific Northwest region of the United States. The Portland Water Bureau serves nearly a million people in its retail service area and through wholesale water contracts. Portland maintains a treated water system that has 2,250 miles (3,621 km) of distribution and transmission mains and 190,000 services. Mains are primarily composed of ductile and cast iron, and most services are copper. Most of Portland's water mains are in good condition and typically remain in service beyond their assumed effective useful life due to favorable soils and mild climate.

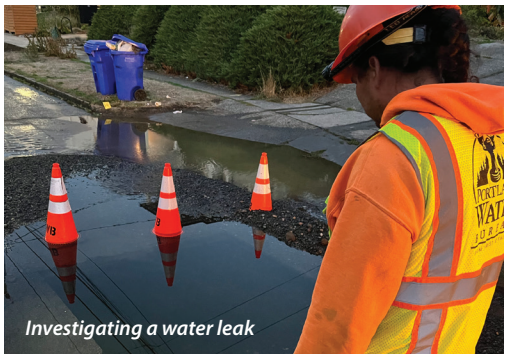

Bull Run Watershed


Groundwater tank

Unlike many utilities in the Western United States, the Portland Water Bureau is fortunate to not have major water supply availability constraints. This is because its primary water source, the Bull Run Watershed and its reservoirs, receives an average of 130 inches (330 cm) of rain a year. In addition, Portland has invested in both customer-side efficiency and a supplemental groundwater system, which provides important water supply and climate resilience, to further protect the city from a water supply shortage. So while water supply availability is not a major concern in the near term, the City of Portland is dedicated to using its resources efficiently and to increasing resilience to climate change and other stressors.

Water loss goals

The State of Oregon requires that utilities have water loss rates below 10 percent of water supplied. The Portland Water Bureau began tracking water loss in fiscal year (FY) 2012–13 and is consistently above this 10 percent threshold (see figure 1). Most years, the drinking water system averages a 14 percent water loss rate. In 2022, the Portland Water Bureau submitted its **Water Loss Action Plan**, which documented how the bureau will reduce water loss in the drinking water system to the required level. Given the low level of main breaks for a water system its size, the Portland Water Bureau believes a significant portion of real loss is from numerous small, hidden leaks rather than main breaks.



Investigating a water leak

Figure 1: Water loss key performance indicators by fiscal year (July 1–June 30)

	FY 2019–20	FY 2020–21	FY 2021–22	FY 2022–23	FY 2023–24
Real losses (gallons per connection per day)	40.5	47.2	22.7	41.0	35.6
Apparent losses (gallons per connection per day)	5.4	5.8	5.7	5.8	5.7
Total losses (gallons per connection per day)	**45.9**	**53.1**	**28.4**	**46.8**	**41.3**
Real losses (MG)	2,764.9	3,232.1	1,553.3	2,819.7	2,455.2
Apparent losses (MG)	368.8	399.2	393.2	396.2	392.0
Total water losses (MG)	**3,133.70**	**3,631.28**	**1,946.50**	**3,215.86**	**2,847.15**
Infrastructure leakage index (ILI)	2.5	2.9	1.4	2.5	2.2
Water loss as % of water supplied	15.25%	17.08%	9.89%	15.12%	13.70%

Downtown Portland from the Willamette River

Carbon emissions goals

The Portland Water Bureau is also committed to achieving net zero greenhouse gas emissions by 2050. Net zero is defined as the state where greenhouse gases, including carbon dioxide, nitrous oxide, and methane, are added to the atmosphere and removed from the atmosphere at equal rates. The Portland Water Bureau's **Net Zero Strategy** outlines several actions and measures to mitigate emissions, and one of the primary strategies is to reduce the bureau's electricity use. This includes the electricity used to treat and pump water in its distribution system. Approximately 8 percent of the water utility's carbon emissions are embedded in real water loss, meaning there is a strong opportunity to reduce both water loss and carbon emissions by reducing real loss in the system.

Energy use profile

Approximately 79 percent of the Portland Water Bureau's Scope 1 and 2 emissions are from electricity use. This includes the energy used to treat and move water from its source to customers' homes and businesses. Today, the Portland Water Bureau uses less energy than most drinking water utilities for two reasons: (1) most of its system is gravity fed, and (2) the utility does not currently filter the water coming from its primary water source. Water quality is maintained through treatment (chlorine) and aggressive monitoring and flushing as needed. However, the Portland Water Bureau is required to construct a drinking water filtration system by 2027, which could double the water utility's total electricity use. Therefore, the benefit of reducing energy use will be even greater in the future.

Satellite leak detection technology provides points of interest to investigate

Project summary: Satellite leak detection

One of the 29 actions the Portland Water Bureau listed in the Water Loss Action Plan is to use a satellite technology that allows the utility to scale its leak detection efforts to match the size of its treated water system without adding significant costs. In FY 2023–24, Portland partnered with Asterra to conduct a satellite leak detection survey of the utility's service area. **This technology** uses satellites to scan for underground pools of water that match the chemical profile of treated water. For Portland, the key indicators were chloramine residuals and conductivity. Asterra provided the utility approximately 650 points of interest to investigate. The utility then used acoustic leak detection equipment at these points of interest to find and fix leaks. By the end of the project, approximately 280 leaks were found and repaired, 85 percent of them non-surfacing. The scan found additional leaks on customer property; staff notified affected customers of the leaks and repaired leaking meter couplings. The scan also found main breaks and leaks that were repaired by staff as part of regular operations. Most of the leaks found during this project (both in number and volume of water lost) were on service connections. Based on the Portland Water Bureau's annual water audit, the satellite study and repair work reduced annual water loss by about 365 million gallons (1.3 billion liters).

A Portland Water Bureau employee evaluating a leak

Water loss audit and carbon reduction calculation

The Portland Water Bureau tracks its water loss following the standards set by the American Water Works Association (AWWA), including the *M-36 Manual: Water Audits and Loss Control Programs*, and uses **AWWA's Free Water Audit Software**. The data used in the audit and the results from the audit are used to estimate the carbon reductions using the IWA LEI Calculator. More details on inputs and methodology are given below.

LEI methodology and calculation

The IWA developed a tool for estimating carbon emissions to complement the AWWA audit software and similar tools worldwide. The IWA wanted to help quantify and make the connection between water loss and carbon emission goals. The LEI Calculator requires users to input a few pieces of information to calculate carbon reductions. Inputs include total water produced, total power cost, power cost per kilowatt hour (kWh), CO_2 associated with the electricity source used, and target leakage volume reduction. The inputs are highlighted yellow in Figure 4, and more information on how Portland calculates those inputs is given in the following sections.

System input: Total water produced

Portland has two high-quality water sources. The Bull Run Watershed is a surface water source 26 miles east of downtown Portland, and the Columbia South Shore Well Field is a groundwater source just east of the Portland International Airport. Approximately 94 percent of water served comes from the Bull Run, and groundwater is used as a supplement when needed during emergency events or dry summer periods. The volume of all water produced is recorded at the point of final treatment by ultrasonic magnetic meters. This includes water that is sold and exported to other utilities. Figure 2 shows water supplied by source over the last five fiscal years.

Figure 2: Water supplied in million gallons*

	FY 2019–20	FY 2020–21	FY 2021–22	FY 2022–23	FY 2023–24
Surface water (Bull Run)	31,095.75	33,695.99	30,875.33	31,794.19	30,213.29
Groundwater	1,820.52	408.38	1,648.39	2,508.42	3,258.57
Total water supplied	**32,911.17**	**34,095.95**	**32,524.11**	**34,268.06**	**33,474.07**

*Totals do not add perfectly due to adjustments made for tank level changes in the City.

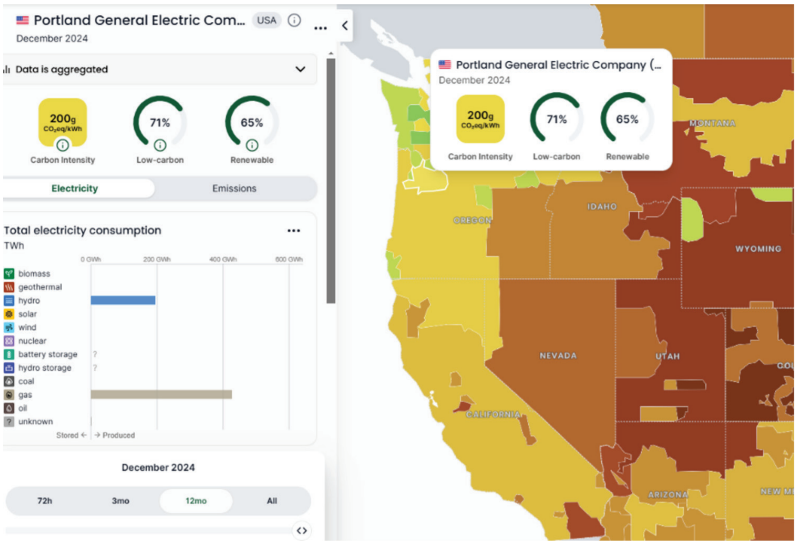
System input: Cost of power and total power cost

The Portland Water Bureau purchases most of its electricity from Portland General Electric (PGE), with additional electricity purchased from Pacific Power. For the "cost of power" input, the cost per kWh was pulled from a bill or uses the rate listed on the electric utility's website. The "total power cost" was pulled from a database where Portland staff enter all electricity bills as they are received.

System input: Energy intensity

To estimate the carbon intensity of energy usage, Portland used the **Electricity Map tool**. This tool was suggested by IWA and used for this work because it is easy to use and readily available. The carbon intensity was pulled at the end of the fiscal year for the previous 12-month period. The Portland Water Bureau does a detailed carbon footprint analysis each calendar year to align with greenhouse gas accounting protocols, but the water audit is completed on a fiscal year basis to align with the utility's other programmatic reporting. This reduces duplicate work and allows for carbon impact to be presented along with all other water audit data to stakeholders.

Figure 3: Snapshot of Electricity Map




Hydroelectric Project at Dam 1

The Electricity Map tool collects energy data from around the world and summarizes it in an easy-to-use platform. It displays information such as sources of energy and their carbon intensity. PGE generates electricity from a **variety of sources**, including approximately 35 percent from renewable sources (21 percent hydro, 10 percent wind, and 4 percent solar in 2023). While PGE is increasing renewable energy production, carbon-intensive sources (mostly natural gas) continue to be a part of the energy provided to Portland. The average carbon intensity for the Portland region in FY 2023–24 was 233 grams of CO_2 equivalent per kWh. The Portland Water Bureau supplements its electricity use with on-site solar and micro-hydro generation. This energy intensity calculation only accounts for the energy purchased from PGE.

Leakage reduction

As a result of the satellite leak detection in FY 2023–24, Portland observed a real water loss reduction of 365 million gallons compared to the previous year. This reduction occurred despite a historic ice storm and freeze event in January 2024 that caused a spike in main breaks and system leakage. No additional projects to reduce real loss were conducted in FY 2023–24 and the leak verification work was performed during the same period as the FY 2023–24 water audit, so the utility concludes that loss reductions can reasonably be attributed to the satellite project.

The LEI tool's primary use is to estimate the carbon impact of a given program or pilot. The tool helps decision-makers choose between projects and elevate reducing water loss as a carbon mitigation strategy. But the tool can also be used retroactively to determine the result of a carbon-reducing action. Portland input "365" in the "Target Leakage Volume Reduction" cell in the LEI tool to understand the carbon impact of the satellite survey and repair work.

Figure 4: FY 2023–24 results using the LEI Calculator

	Imperial unit example		SI units example		Calculation notes
Total water produced	33,474	MG/yr	126,713,139	m^3/yr	From standard water balance
Total power cost	3,229,364	$/yr	3,229,364	USD$/yr	From utility's energy bill
Cost of power	0.14508	$/kWh	0.14508	USD$/kWh	From utility's energy bill
CO_2 associated with source	233	g/kWh	233	g/kWh	From utility's energy source(s) **app.electricitymaps.com/map?aggregated=false**
CO_2 equivalent emission rate	**514**	lb/MWh	**233,000**	g/MWh	Conversion from kW to MW (multiply by 1,000)
Total power	**22,259**	kWh/yr	22,259,193	kWh/yr	Energy cost ($/yr) divided by utility energy cost rate ($/kWh)
Energy intensity	**1**	Wh/gal	**0**	kWh/m^3	Utility energy usage divided by volume of water supplied
Carbon intensity	**0.0003**	lb/gal	**41**	g/m^3	Multiply reference carbon intensity by utility energy intensity
Target leakage volume reduction	365	MG/yr	**1,379,972**	m^3/yr	Manual inputs to calculate target carbon reduction
Carbon reduction	**124,523**	lb/yr	**56,482,501**	g/yr	Multiply target by carbon intensity
Carbon reduction	**62**	tn/yr	**56**	mt/yr	Conversion to metric tons per year (divide grams by 1,000,000)

Verification of data and calculations

The Portland Water Bureau has tracked and calculated its Scope 1 and 2 carbon emissions since 2007. Staff compared the results from the LEI Calculator to past carbon footprint reports to ensure that the calculator results aligned. The utility's water loss analyst and climate analyst checked the assumptions—in particular, the carbon intensity rating of the electricity map—to ensure that outputs were in line with the results of the utility's carbon footprint analyses.

Portland Water Bureau's staff play a vital role in keeping the city healthy and thriving!

Conclusion

The LEI Calculator is easy to use, with a clear methodology that utilities can follow to efficiently attribute carbon reductions to their water loss goals or results. A water utility's water auditor can use the tool to gather high-level data in a time-efficient manner to help effectively demonstrate the benefits of water loss work.