Leakage Emissions Initiative: Establishing a Standard Carbon Balance for Drinking Water Utilities

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Introduction

Importance of Reducing Carbon Emissions and how it relates to Real Loss

Interest in carbon reduction to combat climate change has been growing rapidly since the mid 2000's. In 2015, the Paris Accords were established to influence a societal change to a carbon neutral future. The Paris Accords specifically seek to limit the mean rise in global temperatures to below 2 degrees Celsius above pre-industrial levels, among other stated measures intended to benefit humanity in combatting climate change. These Accords are responsible for numerous policies and legislation enacted by the European Union and 193 other signatory member states to align financial incentives with a greener future. The financial incentives aim to inspire breakthroughs in technology for production of greener energy and/or direct reduction of carbon emitting practices. Reduction of carbon-emitting practices that accompany the production of useful items and services is as critical to carbon neutrality as production of greener and more sustainable energy.

Real Loss (leakage) is generally defined by the International Water Association (IWA) as leakage resulting from failed distribution system infrastructure. Unmanaged leakage is a problem that is already being addressed by various global entities. However, the carbon impact of that leakage has not been definitively established. Every unit of water distributed by a utility, results in the production of a certain amount of greenhouse gas emissions (carbon cost) due to the energy expended in the extraction, treatment, pumping and distribution of that unit of water. These emissions are known as Scope 2 emissions, which are indirect emissions an entity is responsible for as a result of purchasing carbon intensive electricity used in an entity's operations[1]. Every unit of water lost to leakage results in carbon emissions that would otherwise be avoided if such leakage were reduced. In general, it is not economically viable for a utility to eliminate 100% of its leakage. However, utilities can, and should, strive to achieve the technical minimum that is possible. Excessive leakage provides no benefit for the utility or its customers and therefore, carbon emitted in the process is unnecessary. It can also be reasoned that for those utilities with renewable energy sources, excessive leakage represents a waste that could be otherwise used to further offset carbon-emitting energy sources.

The intent of the Leakage Emissions Initiative (LEI) is to incentivize utilities to aggressively identify and reduce leakage, generating carbon credits which can then be sold to organizations seeking to achieve carbon neutrality. This begins with utilities adopting the Standard IWA/AWWA Water Balance (Standard Water Balance) and the newly added Carbon Balance methodology. A new revenue stream from

[1] "Scope 1 and Scope 2 Inventory Guidance." EPA, Environmental Protection Agency, 9 Sept. 2022, https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance#:~:text=Scope%202%20emissions%20are%20indirect,of%20the%20organization's%20energy%20use.

Generation of environmental attributes could serve to fund further improvements to a utility's infrastructure that may not happen without additional funding.

Current State of Real Loss (Why now?)

Reduction of Real Loss is an important task on its own merits which invariably yields an economic benefit. The topic of water conservation has been a growing endeavour for decades as communities and regions seek to limit the impact of variability in historical rainfall patterns and over-drawn water resources by ever-increasing water demand. While these issues have not been ignored, they need additional stimulus to garner support for meaningful change from the public at large. Carbon reduction, on the other hand, is at the forefront of the minds of consumers, corporations, and governments alike. It is not intended that carbon emissions be the sole reason for an extended discussion on the reduction of a utility's leakage. However, it is clear that carbon emissions from leakage can be significant and can be reduced through the implementation of economically viable intervention measures. Leakage reduction serves both the conservation of water resources and reduction in carbon emissions.

Defensibility

It is vital that all stakeholders understand the data reliability of the programs created to incentivize change. Reliable tracking of carbon emissions is essential when seeking to achieve carbon emissions reductions. The IWA Water Loss Specialist Group (WLSG) LEI seeks to standardize a verifiable and repeatable methodology with which utilities and corporations can measure and assess their own carbon emissions as it relates to water usage and leakage. This methodology should be transparent and based on logical quantification of the variables that differentiate one utility's operations from the next. This approach will validate the stated value of any representative environmental attributes generated because of carbon emissions reductions from reduced leakage.

Continued Improvement of Methodology

The contents of this white paper are intended to serve as a base from which the industry can begin to quantify and reduce the carbon emissions through leakage reduction. This methodology should be improved continuously as more industry professionals become involved and more support is gathered from larger and more influential institutions. Much like the existing Standard Water Balance, the carbon tracking methodology presented herein will evolve as the industry continues to do so, and as leaks are identified and repaired, infrastructure is replaced, and the management of treatment, pumping, and measurement of drinking water is enhanced.

Key Concepts

Water Balance

Understanding a utility's carbon footprint requires an understanding of the core concepts of a utility's water balance. The Water Balance is a term used to describe the complete input and end use of drinking water within a utility. The Standard Water Balance was the result of an analysis by the IWA Water Loss Task Force and the Performance Indicators Task Force of various best practices from multiple countries, with the original version published in 2000[2]. The Standard Water Balance has further evolved since that

[2] Lambert, A, and Dr. W Hirner. "Losses from Water Supply Systems: Standard Terminology and Recommended Performance Measures." Water Sector Trust Fund - Financing the Water Sector, International Water Association, https://waterfund.go.ke/.

time and is now utilized across the world by utilities, technical organizations, consultants, regulators, and international funding agencies. It is critical to understand the Standard Water Balance when trying to quantify a utility's resulting Carbon Balance. The Standard Water Balance establishes a volume for all sources, uses, and losses, quantified from a utility's own specific data. The LEI aims to add a Carbon Balance that quantifies the amount of carbon attributed to each of those same sources, uses, and losses (including leakage) for a given utility.

Real Losses (Leakage)

Real Loss generally represents the amount of water that is lost by utilities due to physical leaks. This leakage is quantified within the Standard Water Balance. Portions of this leakage can be reduced or avoided entirely by proper pressure management and renewing or repairing existing infrastructure. While this paper seeks to quantify and reduce the carbon emissions component of leakage, the end result will also deliver benefits in the form of supply-side water conservation through reduced leakage, increased availability and reduced production costs. Utilities should already be doing what they can to reduce leakage. However, additional emphasis is needed for finding, funding, and repairing infrastructure to reduce leakage long term. Many utilities enact only temporary mitigative measures to control leakage, and some may not manage leakage at all if they do not have the resources available. In most cases, existing excessive leakage levels are a direct result of a limitation of resources available to implement leakage reduction strategies.

Energy Intensity

Energy intensity is defined as the amount of energy used to produce a given level of output. In the context of drinking water systems, energy intensity is the amount of energy it takes to extract, treat, and deliver water. Depending on where water is sourced from, a utility may use more or less energy in the scope of such extraction, treatment, and distribution. Some utilities may be able to deliver water with minimal energy inputs thanks to a variety of factors such as gravity delivery, reduced treatment needs, and minimal head losses in the pipes. Other utilities may have vast amounts of energy usage due to intense pumping requirements, poor source water quality, high head losses, and/or desalination. Excessive leakage can lead to over-sized infrastructure. The combination of these factors establishes a utility's energy intensity.

Carbon Intensity

Carbon Intensity is the variable by which the carbon cleanliness of a utility is measured. A utility will use energy from a specific source or combination of sources in the extraction, treatment, and distribution of water. The carbon emissions associated with that energy can be measured by determining the electricity production source that a utility's power company uses. A large majority of power companies will use a mix of several different production sources such as coal, gas, and renewables. When the energy carbon emissions variable is determined, it can be linked to the amount of energy used by the utility. This yields an amount of carbon emissions per unit of water which can then be applied to each component in the Standard Water Balance, including leakage.

Components of the Carbon Balance and Calculations

The Carbon Balance is calculated using a utility's existing data from the Standard Water Balance in conjunction with a carbon intensity calculation based on the utility's total energy usage and the carbon intensity of its energy source(s). The total energy usage is divided by total water produced annually to determine the energy intensity of the utility per unit of water (i.e. m^3 or MG) basis. The energy intensity is then multiplied by the utility's identified emissions rate. This rate can be derived from referenced sources. An example is published by ElectricityMaps.com[3] (see Figure 1). The resulting figure is a specific carbon intensity that typically identifies grams of carbon emitted per unit of water production. This carbon intensity value can be applied to every component of the water balance to determine which operational components are most responsible for a utility's total carbon emissions.

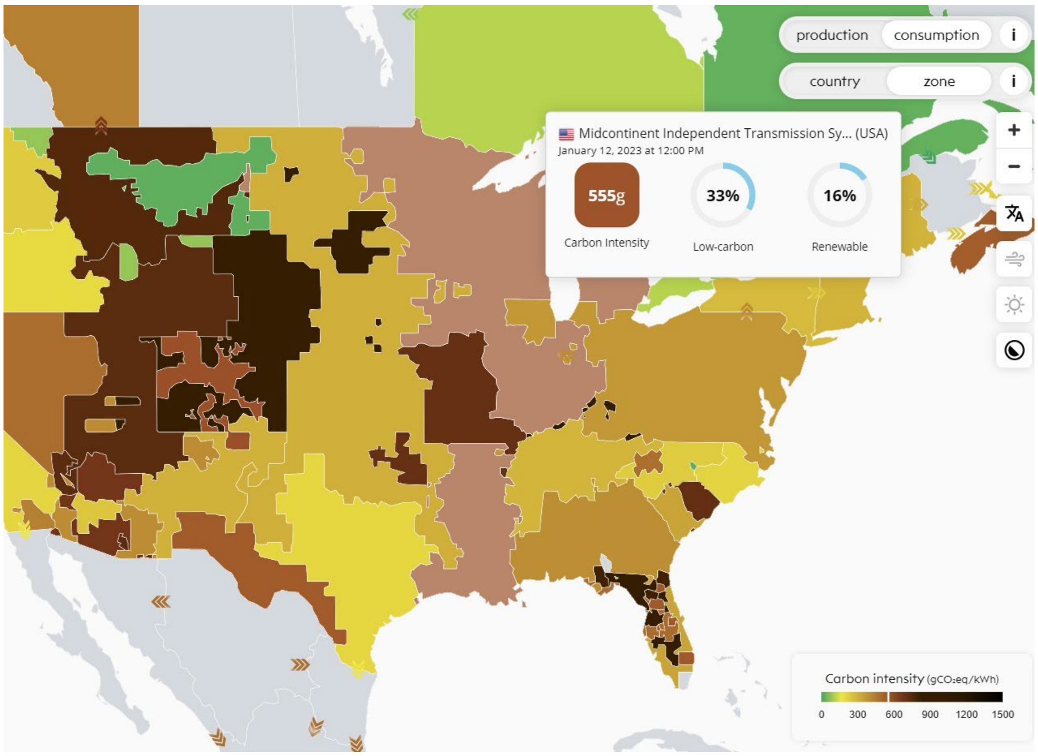

Figure 1 Carbon intensity data pulled from ElectricityMaps.com (United States)

[3] "Live 24/7 Co_2 Emissions of Electricity Consumption." Electricity Maps | Live 24/7 CO_2 Emissions of Electricity Consumption, https://app.electricitymaps.com/map?aggregated=false.

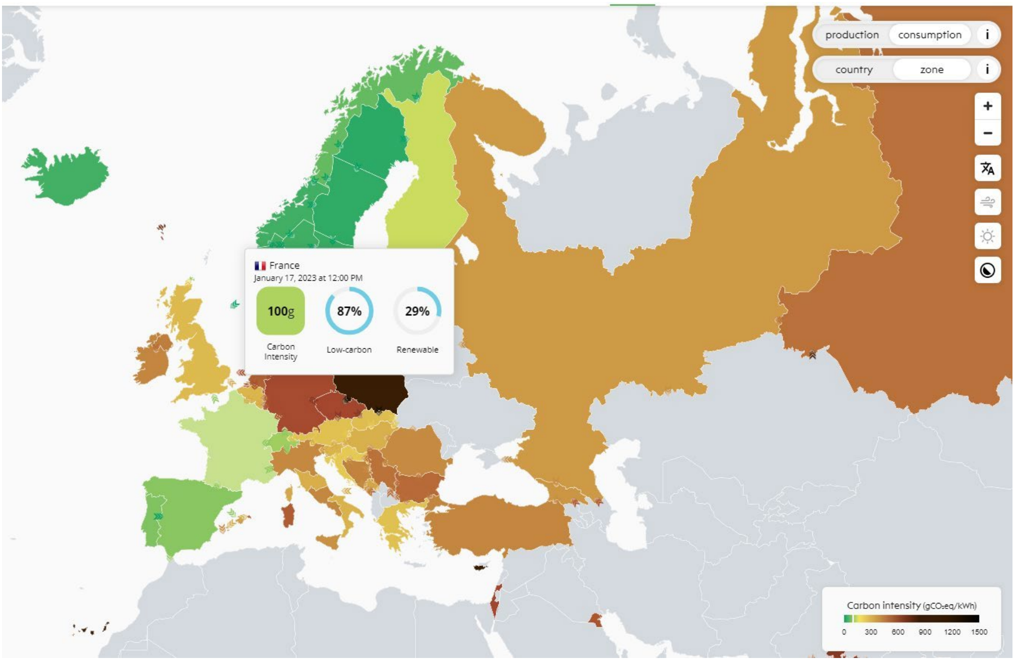

Figure 2 Carbon intensity data pulled from ElectricityMaps.com (Europe)

There are multiple variables that will differentiate one utility's carbon intensity from that of another, but the energy source is one of the largest components. For instance, a utility will emit more carbon emissions when it procures energy from an electric utility who sources more electricity from coal-powered stations. Likewise, a utility would emit less carbon emissions if it sourced more from renewable energy. This energy mix can vary widely depending on where the utility is located across the globe. In some cases, the reduction in leakage could allow the electricity company to optimize its energy generation sources to lower the overall carbon emissions.

Leakage Carbon Reductions Calculator (Actual data from a Midwestern U.S. utility – See Figure 1)

Term	SI Units Example	Units	Calculation Notes
Volume of Water Supplied	175,783,167	m^3/Yr	From Standard Water Balance
Reference Carbon Intensity	555	g/kWh	From utility's energy source(s) https://app.electricitymaps.com/map?aggregated=false
Utility Energy Usage	84,444,444	kWh/yr	From utility's energy bill*, excluding overhead energy usage not required for water production and distribution
Utility Energy Intensity	0.48	kWh/m^3	*Utility Energy Usage* (kWh/yr) divided by *Volume of Water Supplied* (m^3/Yr)
Utility Carbon Intensity	266.62	g/m^3	Multiply *Reference Carbon Intensity* (g/kWh) by *Utility Energy Intensity* (kWh/m^3)
Target Leakage Reduction	**14,176,367**	m^3/Yr	Manual input to calculate
Target Carbon Emissions Reduction	**3,779,651,284**	g/Yr	Multiply *Utility Target Leakage Reduction* (m^3/Yr) by *Utility Carbon Intensity* (g/m^3)
Target Carbon Emissions Reduction	**3,780**	mt/Yr	Convert to Metric Tons per year (divide grams by 1,000,000)

* *Energy Cost* ($/Yr) divided by *Utility Energy Cost Rate (avg)* ($/kWh) (only if actual power usage not available). See *Figure 3* below.

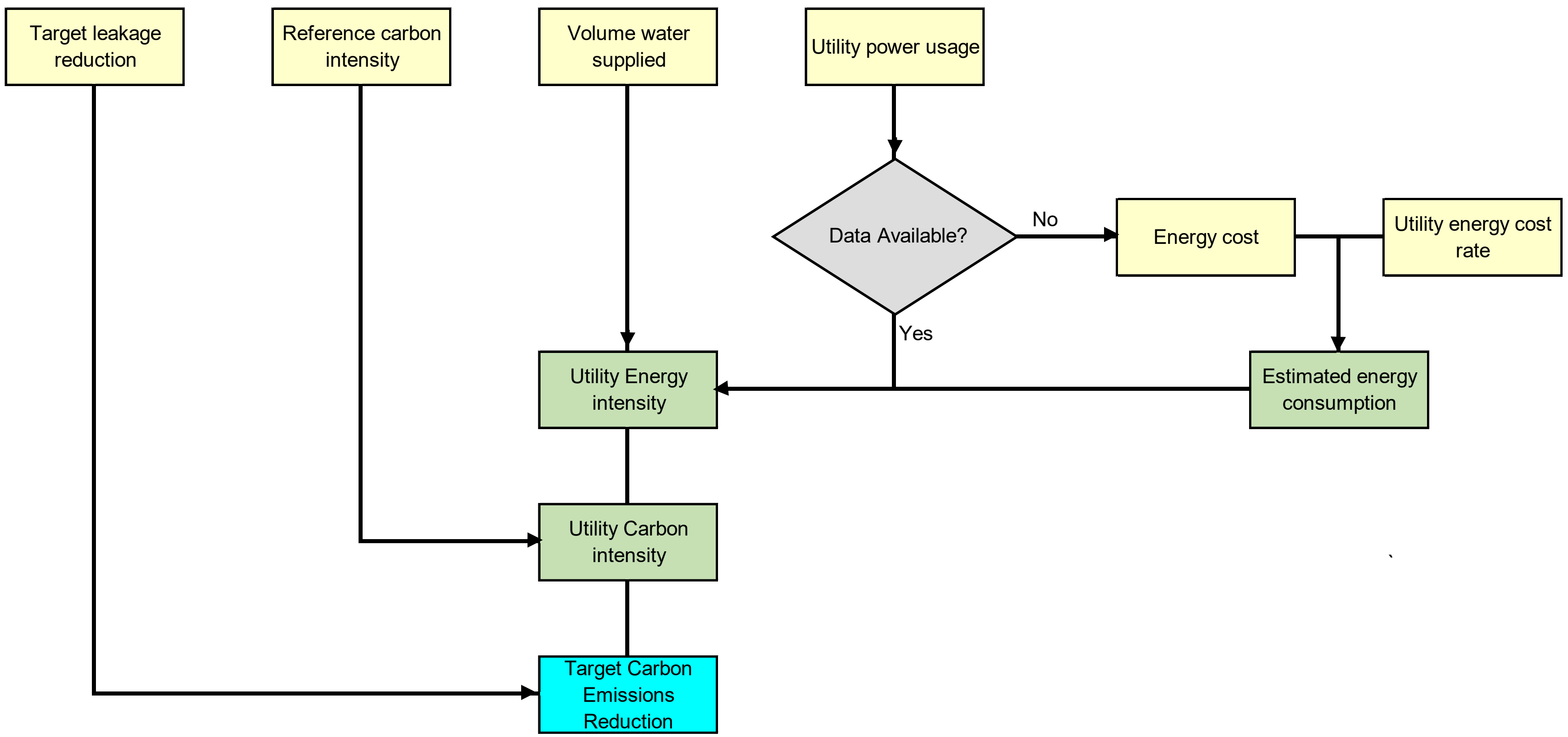

Figure 3 Leakage Emissions Methodology Flow Chart

Technical Performance Indicators for Carbon Emissions from Real Loss

Calculated Total Carbon Emissions in Tons

Carbon markets have existed as far back as the early 2000s and the vast majority of carbon avoidance and reduction projects measure their effectiveness in tons of carbon saved. Companies seeking to achieve carbon neutrality likewise measure their total emissions in tons of carbon. As such, it is most effective for the Carbon Balance to measure carbon emissions for a utility's operations in tons of CO_2 equivalent.

Targeted Reduction of Carbon Emissions in Tons

The goal of carbon avoidance from leakage reduction is naturally linked to the existing leakage level. An initial Carbon Balance study is required to determine the baseline level of leakage from which a utility will seek to reduce its leakage and hence the carbon emissions associated with it.

In most cases utilities are not capable of eliminating 100% of their leakage. Even the smallest of utilities can have hundreds of kilometres (or miles) of infrastructure that make it uneconomical to detect and repair every leak. Ideally, most utilities should target an economically feasible target level of leakage. This targeted leakage reduction amount will be multiplied by the carbon intensity of a utility's unit water to calculate a targeted level of carbon reduction. By forecasting an amount of carbon reduction over a number of years, a project can also seek financing for improvements with the promise of reducing carbon emissions over a specific timeframe.

At the outset of the project, a Water and Carbon Balance could be defined for each year to quantify the benefits. Environmental attributes could then be generated according to leakage emissions reduction and transacted to generate revenue for the project funder, be it the utility or a third party.

Calculated Carbon Emissions per Unit of Water

When carbon intensity of energy usage is determined, a utility can then calculate approximately what amount of carbon is being emitted per unit of water delivered. This Carbon Intensity Value can then be multiplied by the amount of water attributed to every element within the carbon balance. This will allow a utility to understand exactly how much carbon they are emitting across their entire water supply chain.

Financial Incentives for Reduction of Leakage Based Carbon

At the time of publishing, there does not exist a cap-and-trade or other similar market structure to incentivize investment in leakage emissions reduction. What follows is contemplation of a framework for such a market structure.

Validation and Verification of Carbon Reduction

The value of all carbon reduction certificates could be tied to the amount of carbon reduced and the verification of that amount by a carbon registry. Carbon registries corroborate the legitimacy of the methodology applied to quantify the carbon reduction by setting standardized rules and guidelines for carbon offset protocols that projects must follow to register their offsets under a specific registry. There are numerous carbon registries operating globally but a limited number of them are trusted by most corporations and governments worldwide. If a protocol is enacted by a country, that government could set the standards and guidelines that would include instruction on how to validate the legitimacy of a project's offsets. They may opt to assess the credits themselves or allow third parties to register as verification bodies who would audit registered projects in accordance with a specific protocol to ensure that they are properly generating any environmental attributes.

Registering Carbon Leakage projects would be a critical step to building credibility for any type of leakage emissions protocol, providing a mechanism to verify the leakage emissions reductions. The value of any environmental attributes associated with leakage emissions reductions would therefore be directly tied to the validation of said reductions.

Carbon Leakage Credits

Carbon Leakage Credits (CLCs) could be environmental attributes that are generated each year when a utility reduces their leakage below the initially set benchmark. When these credits are generated in accordance with a protocol, they could then be sold to corporate organizations who may apply them to offset their own carbon emissions. A project could forecast a target level of leakage reduction to seek financing for improvements needed to achieve said reduction. Each CLC would represent one ton of carbon avoided by a utility reducing its leakage below its benchmark leakage level. When the initial leakage benchmark is set, a carbon balance is conducted each year to measure how effective a utility's improvement efforts were. As more leakage is reduced below the benchmark, more credits are generated. The implementation of CLCs are intended to incentivize aggressive reduction of leakage by utilities. These credits may be warranted when current efforts to curtail leakage are hindered by financial difficulties, and the leakage emissions would likely continue without further financial incentive. These credits could also represent a quantifiable amount of water conservation that would likely have not been achieved without the implementation of such a program. Conservation of drinking water supplies has been a growing issue worldwide. CLCs could be the only credit that represents reduction of both carbon emissions and water usage.

Promote Outside Corporate Investment on a Community Level

The representative reduction of carbon through generation of environmental attributes is a model that has been in place for decades. This has enabled the implementation of carbon reduction projects that likely would not have existed without a supplemental revenue stream. Corporate entities engaged with the Leakage Emissions Protocol could then identify and work with local utilities to help them reduce their leakage, thereby positively impacting a specific community by promoting both carbon reduction and water conservation.

Conclusion

The water utility industry itself has sufficient awareness of the importance of managing real loss. However this is rarely connected to the environmental impact of consuming energy to produce water which is then lost before it reaches the customer. Because of this, funding for continued improvement of real loss management is getting harder to come by whereas that for reducing carbon emissions has seen an explosion over the past two decades.

Consumers are much more likely to be influenced by the carbon impact that their purchasing choices have. Although water conservation is certainly due the same influence and awareness, the reality is that more information on the overall impact that real loss has should be shared. This additional awareness can help influence outside corporate investment for long term sustained improvements to infrastructure and technology upgrades that can encourage water utilities to improve their operations and make step to achieve carbon neutrality. Outside investment can also assist to individually improve specific communities who are underfunded or disadvantaged. Investors benefit by building local goodwill, generating positive public relations, and being able to retire environmental attributes that will offset their own carbon emissions and water usage. This initiative may also pave the way for a water specific environmental market that operates off of water conservation demand alone.

Real loss is an unnecessary drain on valuable resources that could be responsibly consumed elsewhere. It would have been ideal to eliminate real loss entirely if it were physically and economically feasible. Since in most cases it is not, it is necessary to find a balance of sustainable leakage that can be eliminated. The implementation of a Carbon Balance (see *Figure 4*) as part of the Standard Water Balance will help to influence applying protocols and generation of environmental attributes that will help strengthen the economic feasibility of finding and repairing more leakage. The end result is a newfound urgency and action to assist utilities and society as they continue to strive for environmental sustainability.

Example Carbon Balance

In the future, water balance calculators such as AWWA Free Water Audit Software version 6.0™ could be modified to present metric tons of CO_2 for each of the balance components. The example utility is shown below.

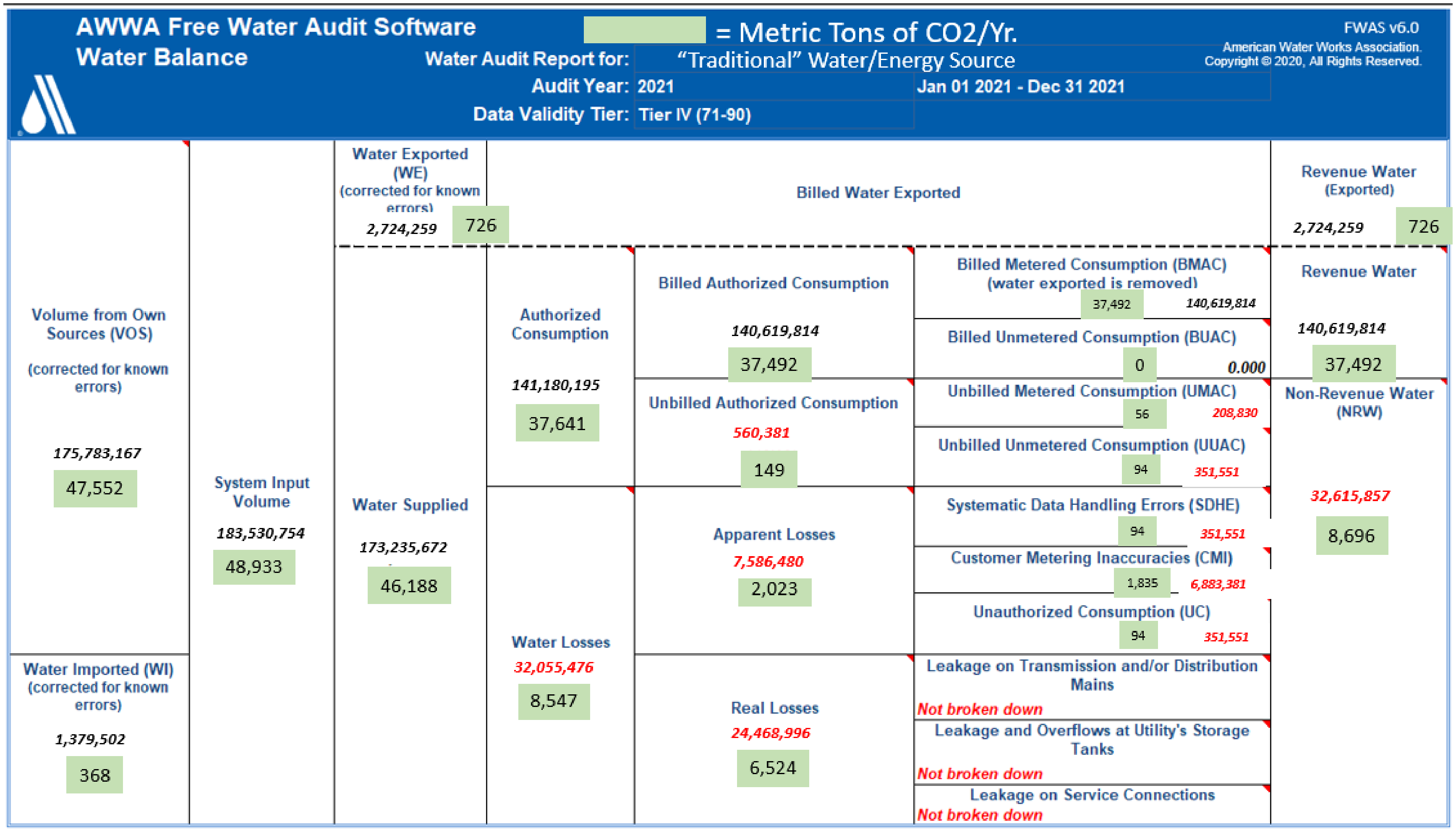

Figure 4 Example Carbon Balance for a US utility (water units in cubic meters per year; carbon emissions units in metric tons per year)

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Leakage Emissions Initiative Collaborative Website

https://www.leigroup.org/