ELECTRIC POWER RESEARCH INSTITUTE

Water Footprint Tool Evaluation

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Technical Update, November 2017

EPRI Project Manager

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NOTE

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ABSTRACT

Significant quantities of water are used in electric power generation for different purposes, with the vast majority of water used for cooling systems in thermoelectric operations. A water footprint is a measure of water consumed to produce a product. Electric utilities apply a variety of water metrics for internal performance assessment and planning purposes as well as for external reporting. EPRI is interested in gaining an improved understanding of how water footprinting may 1) serve as a useful utility method to track and benchmark water consumption and water use efficiency, 2) identify opportunities for improvement, 3) help utilities assess water risk, and 4) provide information needed to evaluate management decisions. Water footprinting can also be useful for public disclosure and investment reporting.

A number of water stewardship and water footprinting tools are available that provide the framework for organizations to inventory their water withdrawal and consumption and conduct risk assessments. A review of these tools was conducted to understand which, if any, are suited to the unique needs of the electric power industry. A key question was whether any of the existing tools have the capability to sufficiently calculate the operational water footprint of individual power plants and multiple facilities and then aggregate the water footprint metric across a broad fleet of power plants located in multiple basins.

The purpose of this technical update is to

- Provide a review of existing water footprint tools
- Describe the unique considerations when assessing a water footprint for electric power generation facilities
- Summarize the potential relevance and value of existing tools to calculate water footprints for electric utilities

Keywords
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Water resources
Water risk

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PRIMARY AUDIENCE: Water, operations, and strategic planners at power companies

SECONDARY AUDIENCE: Researchers and members of the public interested in water footprint tools

KEY RESEARCH QUESTIONS

A water footprint is a measure of water consumed to produce a product. A number of water stewardship and water footprinting tools are available that provide the framework for organizations to inventory their water withdrawal and consumption and conduct risk assessments. A review of these tools was conducted to understand which, if any, are suited to the unique needs of the electric power industry. A key question was whether any of the existing tools have the capability to sufficiently calculate the operational water footprint of individual power plants and multiple facilities and then aggregate the water footprint metric across a broad fleet of power plants located in multiple basins.

RESEARCH OVERVIEW

EPRI membership has been interested in development of an electric power-specific water footprint calculator to support water management, reporting, benchmarking, and disclosure activities. As a first step, a literature review was conducted to determine whether a water footprint tool already exists that may serve this purpose. This technical update describes the key features of available water footprint methodologies and tools and explores their relevance to the electric power sector. The findings of this review set the stage for future work to conceptualize and potentially develop a water footprint evaluation tool tailored to the needs of the electric power sector.

KEY FINDINGS

- A total of 17 web-based and Excel spreadsheet-based water footprinting frameworks were identified. These methodologies and tools address a range of objectives including water use accounting, water risk evaluation, response formulation, and quantification of water risks in monetary terms.
- None of the tools reviewed as part of this study were found to directly address all water footprint assessment needs of the electric power industry. However, methodologies exist that can serve as the foundation for a new tool tailored to meet EPRI member needs.
- Five tools were found to be partially relevant to the electric power sector. Shortcomings of these tools include lack of representation of the electric power sector, absence of an accounting component, lack of ability to address different cooling technologies or supply chain water use, and limited ability to support water footprint comparison with other facilities or companies.

WHY THIS MATTERS

The value of this project lies in the clear descriptions of the concepts and methodologies behind the various water footprinting tools. This study addresses industry considerations when selecting a water footprinting tool as well as the potential of the 17 tools examined to fulfill utility requirements.

HOW TO APPLY RESULTS

The purpose of this technical update is to

- Provide a review of existing water footprint tools
- Describe the unique considerations when assessing a water footprint for electric power generation facilities
- Summarize the potential relevance and value of existing tools to calculate water footprints for electric utilities

By using this update, power companies can decide whether to use one of the existing water footprint tools or whether a new tool would be most helpful in meeting operational goals.

LEARNING AND ENGAGEMENT OPPORTUNITIES

- *Water Footprint Tool Conceptual Design* (EPRI 3002012040)
- *What is a Water Footprint? Introducing the Concept within the Larger Context of Water Risk Analysis and Management* (EPRI 3002009452, 2016).

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PROGRAM: Water Availability and Resource Risk Management, Program 55

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INTRODUCTION

Significant quantities of water are used in electric power generation for different purposes, with the vast majority of water used for cooling systems in thermoelectric operations (Macknick et al, 2011). Electric utilities use a variety of water metrics for internal performance assessment and planning purposes as well as for external reporting (EPRI, 2015). EPRI is interested in gaining an improved understanding of how water footprinting may serve as a useful method that the electric power sector can use to track and benchmark water consumption and water use efficiency, identify opportunities for improvement, assess water risk, and evaluate management decisions. Water footprinting can also be useful for public disclosure and investment reporting (EPRI, 2016; EPRI, 2010).

A number of water stewardship and water footprinting tools are available that provide the framework for organizations to inventory their water withdrawal and consumption and conduct risk assessments. A review of these tools was conducted to understand which tools, if any, are suited to the unique needs of the electric power industry. A key question was whether any of the existing tools have the capability to sufficiently calculate the operational water footprint of individual power plants and multiple facilities, and then aggregate the water footprint metric across a broad fleet of power plants located in multiple basins.

The purpose of this memorandum is to:

- Provide a review of existing water footprint methodologies;
- Describe the unique considerations when assessing a water footprint for electric power generation facilities; and
- Summarize the potential relevance and utility of existing tools to calculate water footprints for electric utilities.

2
THE WATER FOOTPRINT CONCEPT AND METHODOLOGIES

The concept of a water footprint originated in the 1990s with the term "virtual water" (Allan, 1998). Virtual water is a measure of the amount of water "embedded" within a product, and it refers to the volume of water consumed, as measured throughout the entire production chain of a product. Arjen Hoekstra and colleagues expanded this concept and founded the term "Water Footprint" by distinguishing between the different types of water consumed (Hoekstra, 2003). Water footprints can be assessed for products, facilities, consumers, businesses and nations.

Two methodologies currently exist for water footprint assessment: the ***volumetric*** water footprint method (Hoekstra et al., 2011) and the ***impact-based*** water footprint method (ISO 14046, 2014). The volumetric method is concerned with measuring the volume of freshwater consumed, whereas the impact-based method is concerned with assessing the impacts associated with water consumption. The volumetric water footprint concept was first introduced in 2002 by Professor Arjen Hoekstra, and the Water Footprint Assessment (WFA) methodology was published in 2009 (draft version) and 2011 (final version). The impact-based approach to water footprinting (WF) initially took shape in 2009 (Ridoutt et al., 2009; Pfister et al., 2009; Ridoutt and Pfister, 2010), and a framework document for this approach was published in 2014 (ISO 14046, 2014). Each of these methodologies is described below.

WFN Methodology

The volumetric water footprint methodology (Hoekstra et al., 2011) was developed by the Water Footprint Network (WFN) [1]. A water footprint is an indicator of freshwater use that measures the volume of freshwater consumed over the full supply chain and direct operations. The volumetric water footprint measures both consumptive (i.e., blue and green water footprint) and degradative (grey water footprint) freshwater use. The three components of a water footprint are described below:

- Green water footprint refers to the consumption of rainwater (insofar as it does not become run-off).
- Blue water footprint refers to the consumption of surface and ground water resources.
- Grey water footprint refers to pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants given natural background concentrations and existing ambient water quality standards. Grey water footprints can also be calculated for thermal pollution of freshwater sources.

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[1] Note that on 8/25/2017, the WFN announced that it would dissolve as an organization due to financial reasons; however, the organization recognized that its mission "to promote the transition towards sustainable, fair and efficient use of freshwater resources worldwide" will continue to be promoted through collaboration between partners. For example, the Water Footprint Research Alliance aims to intensify its efforts in research, education, capacity building and outreach in the field of water footprint assessment. http://waterfootprint.org/en/about-us/news/news/water-footprint-network-files-bankruptcy/

Water footprint assessments can be undertaken at various scales (single catchment, regional, national, etc.), and for different entities (products, facilities, processes, organizations, etc.). The water footprint of one single process step (a unit process) is the basic building block of all water footprint accounts. The water footprint of a product (e.g., unit of power production) is the sum of the water footprints of the various process steps relevant in the production of the product measured over the supply chain and direct operations. According to the WFN methodology, a full water footprint assessment consists of four distinct phases (Figure 2-1).

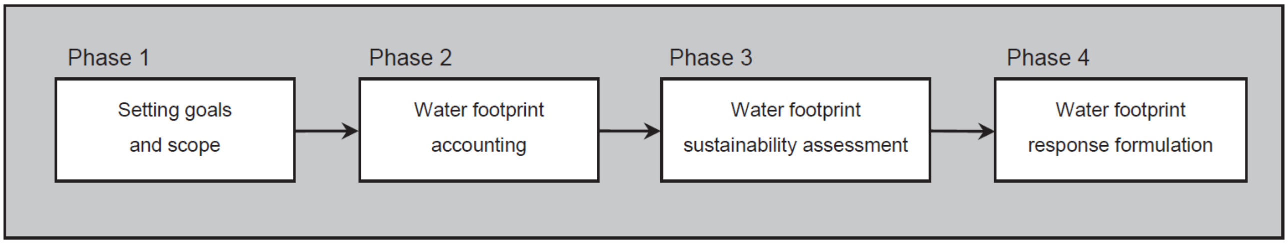

Figure 2-1
Four phases of a water footprint assessment (Hoekstra et al., 2011)

A water footprint assessment begins with setting the goals and scope of the water footprint study. The goals of the assessment clarify the purpose of the study. The scope of the assessment defines the inventory boundaries (i.e., what to include and what to exclude) and the spatial and temporal scale of the study. Together, the goal and scope indicate which data will be used, how many phases of the assessment will be addressed, and the level of detail required to achieve the desired results. Phase I also defines whether the accounting phase will include an inventory of the green, blue and/or grey water volume associated with the processes for making the product. After the accounting phase, a sustainability assessment is used to evaluate whether water use is environmentally sustainable, resource efficient and equitably allocated. This includes looking at the local resource and considering the sustainability of the use in that local watershed. The last phase of the assessment is the response formulation. Using the information gained in the accounting and sustainability assessment phases, response strategies that reduce the water footprint and improve water sustainability can be prioritized for implementation.

ISO 14046 methodology

The International Organization for Standardization (ISO) developed the Water Footprint Standard (ISO 14046, 2014). This standard describes the principles, requirements, and guidelines for conducting and reporting a water footprint assessment based on life cycle assessment (LCA). The LCA provides a framework to assess environmental impacts associated with all stages of a product's life cycle. The ISO methodology can be applied for a water footprint assessment of products, processes and organizations. Based on the ISO methodology, the term "water footprint" is not a volumetric measure of freshwater appropriation, but a *local environmental impact*. The ISO methodology defines the water footprint as the "metric(s) that quantifies the potential environmental impacts related to water." Therefore, this method does not primarily report the volumes of water consumed, but instead reports potential impacts caused by water use and consumption.

The method includes an inventory analysis, which accounts for water consumed along the life stages in the product, followed by an impact assessment, which includes selection of an "impact category indicator" of interest. Potential water related impact categories relate to various environmental mechanisms and include water consumption, aquatic eutrophication, thermal pollution, aquatic acidification, and aquatic ecotoxicity. The results of the inventory analysis are multiplied by a "characterization factor" associated with the impact category of interest. One type of "characterization factor" that relates to water consumption impact is the "Water Stress Index" (WSI), which ranges from 0 (i.e., low risk) to 1 (i.e., extreme risk) for a given location and accounts for local differences in water scarcity (Pfister, 2017). By multiplying water consumed by a local WSI, ranging from 0 to 1, the water consumption is expressed in terms of H_20-equivalents (Boulay et al., 2015; Boulay and Lathuillière, 2017). For example, one liter of water consumed in an area with a WSI of 0.6 would count as 0.6 liters of H_20-equivalents. Individual process steps in the inventory analysis are weighted with the appropriate WSI prior to aggregation to a single value. If process steps of an operation are situated in various locations characterized by different WSI values, the water inventory results at each location are weighted by the respective WSI value prior to aggregation. The resulting aggregated value from the impact assessment is referred to as the *water scarcity footprint*. The ISO method states that the term "water footprint" shall be used only when it can be demonstrated that all significant potential environmental impacts related to water are addressed by the selected impact categories. A non-comprehensive assessment must be reported with an appropriate qualifier, e.g. "water scarcity footprint", "water eutrophication footprint", "non-comprehensive water footprint."

The ISO water footprint assessment consists of four main phases (Figure 2-2):

1. Goals and scope definition, which includes system description and methods chosen;
2. Water footprint inventory analysis, which accounts for water use for each process in the life cycle of a product;
3. Water footprint impact assessment, which assesses the potential impacts of inventory analysis results on the environment, and;
4. Interpretation of results, which involves discussion of the results and any opportunities to reduce the environmental impacts.

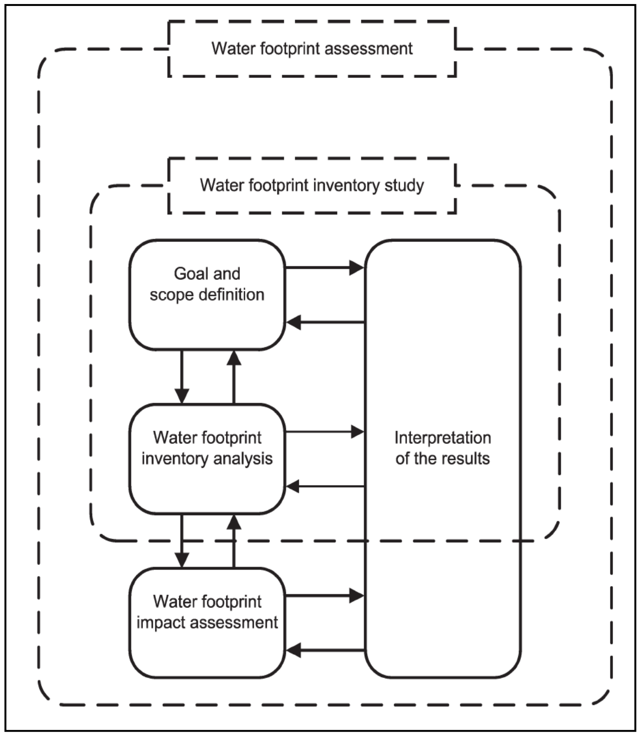

Figure 2-2
Steps in the ISO water footprint assessment (ISO 14046, 2014)

3 COMPARISON OF THE WFN AND ISO 14046 METHODOLOGIES

The WFN methodology is primarily intended to support better water management, including its use and allocation. Studies using the WFN methodology have reported the total volume of freshwater that is consumed to produce goods, aggregating green, blue and grey water. Accounting for water volumes is a key element, and the water footprint is expressed in terms of the total volume of freshwater consumed. Using this approach, efficiency of water use can be assessed by comparing the water footprint of a specific process or product to a water footprint benchmark for that process or product (Hoekstra, 2016).

The ISO methodology aims at quantifying potential environmental impacts related to water consumption. Each instance of water consumption is assessed using locally applicable impact assessment parameters (e.g., WSI), and this allows identification of specific instances of water consumption with the greatest potential for environmental impact. The impact-based water footprint results are expressed in terms of H_20 equivalents, an approach that is analogous to the CO_2 (carbon-dioxide) equivalents used in the reporting of carbon footprints. In the case of carbon footprints, emissions of different greenhouse gases (e.g., methane, ozone) are not simply aggregated; they are first multiplied by the relevant “global warming potential” (GWP) relative to carbon dioxide, which has a GWP of 1, and then expressed in terms of a common unit (i.e., CO_2 equivalents). Similarly, the water scarcity weighted water footprint is expressed in terms of H_20 equivalents.

Based on review of the two methods, the volumetric WFN methodology provides a more meaningful measure of a water footprint indicator for electric utilities than the impact-based ISO methodology. The WFN method aligns more closely with the electric power companies needs for tracking water volumes, calculating current water use for the purpose of measuring a company’s comparative performance (internal and/or external), measuring progress against corporate targets and reporting corporate sustainability metrics (e.g., water *use intensity*, CDP Water disclosure). The blue water footprint reflects the water consumed during cooling and other processes, while green water footprint may be relevant for power plants fueled by biomass, and grey water footprint may be relevant for thermal pollution. It should be noted that a water footprint “number” captures only the accounting phase of a four-phase water footprint assessment, which also involves sustainability assessment and response formulation. The impact-based ISO methodology is not aligned with the interest in benchmarking trends in the electric power sector that are based on water volumes. Rather, the ISO methodology focuses on the impact associated with the water consumption. The units for an impact-based water footprint are expressed in terms of H_2O-equivalents which lack physical meaning and may be difficult to interpret. A comparison of the main attributes of the two methodologies is provided in Table 3-1.

Table 3-1
Comparison of the main attributes of the WFN and the ISO methodologies

WFN	ISO 14046
Quantifies *volume* of water consumed	Quantifies *impacts* associated with water consumption
Focused on water resources management	Focused on environmental impacts associated with the water consumption
Prescriptive method for WF accounting	No recommended accounting method but provides principles, requirements, and guidelines
Includes direct (operations) and indirect (supply chain) water use	Includes direct (operations) and indirect (supply chain) water use
Accounting of water volumes is a key element	Volume consumed is an input; volume is adjusted using scarcity indicators to characterize impacts with water consumption
Differentiates green, blue and grey water	Only considers blue water
Output: gallons/MWh (e.g., product WF) or gallons (WF for a facility or fleet of facilities)	Output: gallons of H_20-equivalents/MWh (e.g., product WF) or gallons of H_20-equivalents (WF for a facility or fleet of facilities)

4
CONSIDERATIONS FOR THE ELECTRIC POWER SECTOR

When applied to direct operations, a water footprint is consistent with a water *use intensity* metric (EPRI, 2015), which is the volume consumed per product produced (e.g., gallons per MWh). The existing body of literature reports *water use intensity* metrics that are generalized by fuel type or cooling technologies or both (Macknick et al, 2011; Macknick et al., 2012; Dodder, 2014; Meldrum et al., 2013; Mekonnen et al, 2015; Spang et al., 2014; Harris and Diehl, 2017 and EPRI, 2008). However, the wide range of water footprint values reported in the literature renders literature values less useful for facility-specific water footprint evaluation or reporting (internal or external) purposes. Also, some of the literature based water use intensity metrics are based on water consumed, while others are based on water withdrawal.

Calculation of an operational water footprint requires careful consideration of the unique aspects of an electric generating unit, such as cooling systems type and fuel type. Units with once-through cooling withdraw large volumes of water but consume very little of that water. Units with recirculating cooling will withdraw much smaller volumes of water per MWh generated; however, the majority of the water withdrawn is consumed through evaporation. An operational water footprint based on water consumption may differ greatly for a once-through cooling unit as compared to a unit with recirculating cooling. Therefore, it is important to recognize the underlying cooling system when calculating a water footprint for a thermoelectric facility. For some facilities, it may be relevant to track both withdrawal and consumption using a water footprint (i.e., water use intensity) approach.

The water footprint of a business or process typically is calculated as the sum of direct (operational) water footprint and indirect (supply-chain) water footprint. An operational water footprint accounts for water consumed during a business or process operation, while the supply chain water footprint accounts for water consumption associated with input materials used in process operation or water consumed by a business' supply chain. For the electric power sector, the indirect water footprint may include fuel supply and power plant construction. With the exception of plants that rely on biofuels, the operational water footprint for thermoelectric power generation typically far exceeds the indirect water footprint (Mekonnen et al., 2015). However, for some forms of renewable energy (e.g., wind and photovoltaic) indirect water use due to construction may exceed the operational water footprint (Mekonnen et al., 2015).

The water footprint of an electric utility can serve as a useful indicator of water use intensity as well as provide the basis for comparison of water use intensity across facilities. However, aggregation across multiple facilities should be done carefully to account for unique characteristics related to fuel type, cooling system type, and source water body type (e.g., surface or groundwater).

Important features or characteristics of a water footprint calculator that are likely to be relevant to the electric power sector include:

- Water footprint indicator expressed in units relevant to the sector (e.g., gallons/MWh);

- Sufficient granularity to calculate water footprints for individual facilities (or units) with different fuel types and/or cooling systems;
- Aggregation capabilities to "roll up" the individual water footprints into a value that represents a group of facilities based on type, geographic area, water source type, or other criteria;
- Ability to calculate water use intensity for withdrawal as well as water footprint for consumption;
- Can facilitate benchmarking of water footprints across facilities or with other companies; and
- Ability to track longer term trends in the calculated water footprint for individual facilities or groups of facilities.

Other features or concepts of potential interest to the electric power sector may include:

- A secure web-based platform rather than a desktop-based platform;
- Inclusion of both the indirect (supply chain) and operational water footprints for each facility;
- Linkage of the tool with a broader water management/stewardship process that would:
    - Provide context to support risk assessment (e.g., consumption relative to supply);
    - Support development of a response strategy; and
    - Produce metrics aligned with external reporting (e.g., CDP water).

5
SUMMARY OF EXISTING TOOLS

A large number of tools are currently available to support corporate water management and water stewardship initiatives. Seventeen tools were examined for potential applicability as a water footprint calculator tailored to the electric power sector.

The set of examined tools share a common vision of helping companies towards managing freshwater resources in ways that are efficient and sustainable. However, they vary in objectives (water footprinting, water use accounting and risk assessment frameworks) and spatial scope (individual person or site, industry, portfolio of industries or a nation). The existing tools can be broadly classified into three categories:

- Water accounting tools with partial applicability to calculate water footprints for electric power sector;
- Risk evaluation tools that may be relevant to the risk assessment and response formulation (phases 3 and 4) of a water footprint assessment; and
- Other tools that are not relevant to electric power sector water footprinting.

A brief summary of each tool organized within the three categories is provided below. More detailed information is available on the web pages for each tool, through the URLs embedded in the tool descriptions provided below and listed in Appendix A.

Tools with Partial Applicability

Five of the tools reviewed show potential to be partially applicable for the needs of the electric power sector. These tools either incorporate at least some aspect of the appropriate methodology framework (e.g., WFN) or contain other essential features. However, none of the tools adequately represent all the desired components of a water footprint evaluation tailored to the electric power sector. Key features and limitations of these tools are identified in Table 5-1, followed by a brief description of each tool.

Table 5-1
Water accounting tools with partial applicability to evaluate electricity sector water footprint

Tool	Key Features	Limitations
WFAT (Water Footprint Assessment Tool) (*developed by WFN*)	Web-based. Calculates operational and supply chain WF (consumption). Includes all 4 phases of WF assessment. Evaluates individual or multiple facilities.	Electric power sector not represented: no option for "MWh" and does not account for different cooling technologies, fuel types or water source types.
SME (Small and Medium Enterprise) Water Footprint Calculator (*developed by WFN*)	Web-based. Calculates operational and supply chain WF (consumption). Detailed breakdown of supply chain components.	Focus on food, textile and metal industries. Applicable to select European countries.
GWT (Global Water Tool) (*developed by WBCSD*)	Excel-based. Assesses water use and risks relative to availability in global operations and supply chain. Detailed tracking of volumes of water withdrawal and discharge by source. Creates key water reporting indicators.	Does not calculate an operational water footprint (i.e., water use intensity is an input). Supply chain water use is not considered explicitly.
LWT (Local Water Tool) (*developed by GEMI/WBCSD*)	Excel-based. Assesses water use and risk relative to availability at a specific site or operation. Detailed tracking of volumes of water withdrawal and discharge by source. Calculates operational water footprint (water consumption per unit of production). Creates key water reporting indicators.	Applied for a single site, not multiple facilities. Does not consider supply chain water use.
GWT for Power Utilities (*developed by WBCSD*)	Excel-based. Version of GWT adapted to electric power sector. Input data and metrics for thermal, solar, hydropower and geothermal. Considers cooling vs. process water. Detailed tracking of volumes of water withdrawal and discharge by source.	Calculates a facility-level water intensity metric based on withdrawal, not consumption (not a water footprint by definition). Does not consider supply chain water use. Different types of cooling technologies not represented. Not updated since 2012.

Water Footprint Assessment Tool (WFAT) *Link***:** The Water Footprint Assessment Tool is an online web application that is based on the water footprinting methodology developed by the WFN. The interface guides the user through all phases of a product water footprint assessment including goal and scope setting, water footprint accounting, sustainability assessment and response formulation. The WFAT quantifies and maps the operational and supply-chain water footprints of a facility or a product and identifies ways reduce the water footprint. Inputs to the tool include annual water withdrawal and discharge as well as annual production. The primary output is an annual water footprint for each facility (i.e., volume per unit production). The resulting footprints are mapped against blue water scarcity data for major river basins to indicate a general level of water scarcity risk. However, the electric power sector is not specifically represented in the WFAT. For example, the user cannot input power generation quantity to inform the denominator of the WF. As a result, the tool does not report the *use intensity* metric as a "per MWh" indicator. Also, there is no provision to evaluate the water use associated with the different cooling technologies (i.e., once-through cooling vs. recirculating cooling), fuel sources (i.e., coal, natural gas, etc.,) or water source types (e.g., surface water or groundwater).

SME water footprint calculator* Link*: The Water Footprint Calculator is an online screening level tool for small and medium-sized enterprises (SMEs) developed by the WFN. It is intended for SMEs in Europe (Belgium, Croatia, Greece, Italy, Netherlands, and Portugal), and it provides a step by step calculation of the direct water use of facilities operation and the indirect water use of the products' supply chain. The calculator is driven by underlying, preloaded questionnaires and datasets that are primarily focused on the food, textile and metal industries. Inputs include coarse, annual numbers for water withdrawal and discharge and a breakdown of supply chain components (e.g., raw materials, packaging). The operational WF does not account for different source water types, cooling water system types or fuel types. Calculations and outputs do not facilitate sufficient granularity at a facility level or aggregation for multiple facilities. Due to these limitations, the SME water footprint calculator is not directly suitable for assessing water footprint for the electric power sector.

The WBCSD Global Water Tool (GWT)* Link*: The GWT was developed by the World Business Council for Sustainable Development (WBCSD). It is an Excel-based tool for companies and organizations to assess and communicate their water use and risks relative to water availability in their global operations and supply chains. The tool tracks water inventory (e.g., water use, discharge, recycling and consumption) of companies and couples this information with watershed and country-level data to create performance metrics and key water reporting indicators, and to establish relative water risks. The water reporting indicators created by GWT include GRI, CDP water, Bloomberg and Dow Jones Sustainability Indexes. Outputs produced by GWT allow companies to assess and communicate their water risks relative to water availability in their global operations and supply chain.

The inventory portion of GWT contains some components that are relevant to calculating a water footprint. For example, the GWT includes detailed tracking of volumes of water withdrawal and discharge by source (e.g., surface water, ground water, ocean) and type (e.g., freshwater and non-freshwater) and volumes of water reused and recycled; however, the tool does not calculate an operational WF as an output. Rather, water *use intensity* is an input in the GWT that is mainly used for the purpose of creating water reporting indicators. Data are entered on a per facility basis, but options to aggregate the individual water footprints are limited. Due to these limitations, the GWT tool is not directly suitable for assessing water footprint for the electric power sector.

The GEMI Local Water Tool (LWT)* Link*: The LWT was developed by the Global Environmental Management Initiative (GEMI) in cooperation with the WBCSD. It builds upon features of the GWT, but it is applied to a single facility and it provides additional information at a finer spatial resolution. It is an Excel-based tool for companies and organizations to evaluate the external impacts, business risks, opportunities, and management plans related to water use and discharge at a specific site or operation. It is similar to the GWT in that it uses water inventory and watershed data to quantify the relative impacts and risks associated with water use and wastewater discharge. The LWT creates key water reporting indicators including GRI, CDP water, Bloomberg and Dow Jones Sustainability Indexes. It differs from the GWT in that it provides interconnectivity between global and local risk assessment. Companies can use the GWT to identify and prioritize high risk sites in their portfolios and then employ the LWT to further evaluate specific high risk locations and identify actions to manage risks.

The inventory portion contains some components that are relevant to calculating a water footprint. For example, the water inventory section of LWT includes detailed tracking of volumes of water withdrawal and discharge by source (e.g., surface water, ground water, ocean) and type (e.g., freshwater and non-freshwater) and volumes of water reused and recycled. The water *use intensity* metric (water consumption per unit of production) is calculated by LWT mainly for the purpose of creating water reporting indicators. The LWT is applied for a single facility, rather than a group of facilities.

The Global Water Tool for Power Utilities *Link****:*** The GWT for Power Utilities is a version of the GWT that was adapted by CH2M HILL and Électricité de France (EdF) with input from power companies worldwide. It is Excel-based and allows power companies to customize data input and metric output for the four main types of power production (i.e., thermal, solar, hydropower and geothermal) as well as create sector-relevant intensity metrics. The hydropower sector is not fully implemented in the tool. The tool enables calculation of water consumption, efficiency and intensity metrics, establishes relative water risks in a company's portfolio to prioritize action, and creates key water reporting indicators including GRI, CDP water, Bloomberg and Dow Jones Sustainability Indexes.

The inventory portion contains several components that are relevant to calculating a water footprint. Similar to the GWT and LWT, the water inventory section of this tool includes detailed tracking of volumes of water withdrawal and discharge by source (e.g., surface water, ground water, ocean) and type (e.g., freshwater and non-freshwater) and volumes of water reused and recycled. Additionally, withdrawal and discharge volumes are tracked by cooling and non-cooling process water. The tool calculates water consumption volume and water *use intensity* metrics (e.g., a water footprint) for each facility, by each sector and for all facilities combined. The average water *use intensity* metric for each sector and all facilities combined is calculated in terms of water consumed. However, one drawback is that the water *use intensity* metric at the facility level is calculated based on water withdrawal rather than water consumption. Also, the tool does not consider supply chain water use and different types of cooling technologies not represented. Finally, the tool has not been updated since 2012.

Risk Assessment Tools

A few of the risk assessment tools reviewed as part of this study can be used to understand and quantify water risks at various scales (i.e., local, watershed, national, etc.). Some of the risk tools require facility water withdrawal and/or consumption data as inputs, while others rely on global, preloaded datasets estimated for the electric power sector on the whole. None of the tools calculate an operational and/or supply chain water footprint on a facility basis. These tools can be used by the power industry for broader risk evaluation and risk management efforts. Along with a water footprint calculator, some of these tools may be relevant for supporting the sustainability assessment and response formulation phases (i.e., phases 3 and 4) of a water footprint assessment. A brief description of each tool is provided below.

Water Risk Filter ***[Link](#)*****:** The Water Risk Filter is a web-based developed by World Wildlife Fund for Nature (WWF) in collaboration with German development bank Deutsche Entwicklungsgesellschaft (DEG) that allows investors to assess the exposure to water-related risks of an investment portfolio. The tool can identify water risk in supply chains and investment portfolios, as well as provide practical steps to mitigate risk.

Aqueduct *Link***:** Aqueduct is an online mapping tool developed by the Water Resource Institute (WRI). The mapping tool enables companies, investors, governments, and other users understand and quantify water risks at a local scale throughout the world. The tool can provide water risk information related to a number of issues including water supply, water quality, potential regulatory pressure, governance, climate change impacts, and socio-economic dynamics, while tracking the distribution of population, industry, and irrigated agriculture.

Aqua Gauge *Link***:** Aqua Gauge was developed by Ceres, a non-profit organization, and provides an Excel-based tool that allows investors to "scorecard" a company's water management activities against detailed definitions of leading practice. The Aqua Gauge assessment covers various aspects of water risk management from policy development and data gathering, to business planning and goal-setting, stakeholder engagement and disclosure.

Collecting the Drops: A Water Sustainability Planner *Link*: This tool was developed by the Global Environmental Management Initiative (GEMI) to help companies better understand an organization's relationship to water, while gauging opportunities and risks. This tool is segregated into three focus areas or Modules that guide a facility user through: the process of assessing the facility's specific water uses in comparison to the availability of water in the region; the impacts these operations pose on the available water resources; and the identification of factors that may pose a risk for the facility's operation.

Water for Energy Framework (W4EF) *Link***:** W4EF, developed by Électricité de France (EdF), is a framework to assess energy companies' water use, potential water management risks, and related impacts. The methodology is meant to be applied at the local water management level but also to be aggregated to obtain global indicators for a power sector, power producing process, etc. Inputs to the tool include water withdrawal, discharge and consumption at a site-level. The tool calculates a series of fractional (i.e., dimensionless) indicators that express risks associated with a facility's access to water, interaction with water ecosystems, and interaction with other human needs for water.

Tools Not Directly Relevant

Other tools exist that contain a water accounting framework, but they are not applicable to the electric power sector due to lack of relevance or context. These tools focus on personal water footprints, national water footprints, or quantifying the costs associated with water risk and water management:

- *Personal water footprint calculator* developed by the WFN *Link*
- *GRACE's Water Footprint Calculator (WFC)* based on the WFN methodology *Link*
- *National water footprint explorer* developed by the WFN *Link*
- *Water Risk Monetizer* developed by Ecolab *Link*
- *The True Cost of Water* developed by Veolia *Link*

- *Water Impact Index (WiiX)* developed by Veolia *Link*
- *WaterMAPP* developed by GEMI *Link*

A brief description of each tool is provided in Appendix A.

6 DISCUSSION

A review of 17 existing water accounting and risk assessment tools was conducted to understand the full landscape of available tools in terms of potential applicability to evaluate water footprint for the electric power sector. These tools are available either in a web-based or an Excel-based platform. These tools address various objectives including water use accounting, water footprinting, water risk evaluation and quantifying water risks in monetary terms. None of the existing tools reviewed directly addresses all of the needs related to calculating water footprints for the electricity power industry. However, five tools are identified that are found to be partially relevant:

- Water Footprint Assessment Tool (WFAT)
- SME Water Footprint Calculator
- The WBCSD Global Water Tool (GWT)
- The GEMI Local Water Tool (LWT)
- The Global Water Tool for Power Utilities

The SME water footprint calculator is the least relevant among the five tools due to its European context and lack of representation of the power industry. The WFAT is based on the WFN methodology and provides the framework for the assessment of supply chain and operational water footprints, as well as evaluation of all four phases of a water footprint assessment. A water footprint for a product, a single facility or a fleet of facilities can be evaluated. However, the electric power sector is not specifically represented in the tool. For example, the tool does not have the option to enter electricity as the production amount or support benchmarking of the electric power sector to compare current company performance against other facilities or companies.

The GWT, GWT for Power Utilities and the LWT were all developed to help companies evaluate business risks and identify external impacts and opportunities related to water use. However, these tools utilize a common framework for water accounting that can be applied to evaluate water footprinting for the electric power sector. Another common aspect of these tools includes creation of key water reporting indicators (GRI, CDP Water, Bloomberg and Dow Jones Sustainability Indexes). The water inventory section of these tools includes tracking of water withdrawal and discharge information by surface, ground and municipal water sources. Water consumption is calculated as the difference between water withdrawal and discharge.

The GWT for Power Utilities is customized for the electric power sector and, therefore, is most relevant among the three tools as a potential tool for water footprint evaluation. There are several advantages associated with the GWT for Power Utilities. In addition to tracking of water withdrawal and discharge by source, the GWT for Power Utilities also tracks the operational water use by cooling and non-cooling process water. Multiple power sectors, including thermal, wind and solar, geothermal and hydropower are represented. The tool enables calculation of water consumption, water *use intensity* metrics and other key water reporting indicators, and it establishes relative water risks based on country and watershed level data.

Several limitations associated with the GWT for Power Utilities are noted. The *use intensity* metrics at the facility level are calculated based on water withdrawal, which is not consistent with the water footprint indicator. Different types of cooling technologies (i.e., once-through, recirculating, dry-cooling) are not represented and there is no option to represent potential evaporation associated with thermal discharges to surface water sources. Also, the tool does not estimate grey water footprint associated with thermal loads. Only water use in direct operations can be assessed; water use in the supply chain cannot be evaluated. The tool does not incorporate a relevant database to support benchmarking of electric power sector to compare current company performance against other facilities, companies or industry standard. The current version of the tool is dated 2012 and it appears that the tool has not been recently updated. Despite the limitations of the GWT for Power Utilities relative to the needs for the electric power sector, it may serve as a useful starting point or template for the development of an electric power footprinting tool.

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TOOL DESCRIPTIONS

Water Accounting Tools with Partial Applicability

Water Footprint Assessment Tool
http://waterfootprint.org/en/resources/interactive-tools/water-footprint-assessment-tool/

SME Water Footprint Calculator
http://waterfootprint.org/en/resources/interactive-tools/water-footprint-calculator-smes/

The WBCSD Global Water Tool (GWT)
http://www.wbcsd.org/Clusters/Water/Resources/Global-Water-Tool

The GEMI Local Water Tool (LWT)
http://gemi.org/localwatertool/

The Global Water Tool for Power Utilities
http://www.wbcsd.org/Clusters/Water/Resources/Global-Water-Tool

Risk Identification Tools

Water Risk Filter
http://waterriskfilter.panda.org/en/Assessment#PortfolioTab/facility/992

Aqueduct
http://www.wri.org/our-work/project/aqueduct/

Aqua Gauge
https://www.ceres.org/resources/tools/ceres-aqua-gauge-comprehensive-assessment-tool-evaluating-corporate-management

Collecting the Drops: A Water Sustainability Planner
http://waterplanner.gemi.org/index.htm

Water for Energy Framework (W4EF)
https://www.eip-water.eu/W4EF

Tools Not Directly Relevant

Personal water footprint calculator. An online tool developed by the WFN quantifies the environmental burdens imposed by individuals' demand for water. The calculator accounts for direct and indirect water usage that is associated with the personal lifestyle, consumption behaviors and country of residence of an individual. This tool is not applicable to private corporations or the electric power sector.

http://waterfootprint.org/en/resources/interactive-tools/personal-water-footprint-calculator/

GRACE's Water Footprint Calculator. Developed by the Grace Communication Foundation based on the WFN methodology. The calculator quantifies the total water footprint of an individual based on behavior patterns (e.g., energy and fuel consumption, shopping habits, meal habits, recycling habits, household uses, etc.). This tool is not applicable to private corporations or the electric power sector.

http://www.watercalculator.org/

National water footprint explorer. An online tool developed by the WFN. The tool provides information on the total water footprint of a county and the per capita water footprint of a country. The tool also provides information on how much of the total water footprint lies within a country (internal) and how much is related to water used for imported goods (external). This tool is not applicable to private corporations or the electric power sector.

http://waterfootprint.org/en/resources/interactive-tools/national-water-footprint-explorer/

Water Risk Monetizer. Developed by Ecolab, it is an online tool designed to help businesses quantify water risks in monetary terms. This tool uses readily available information about water use, water costs, water quality, and revenue and production projections at a facility level to calculate the full value of incoming and outgoing water based on local water scarcity. The information provided by the Water Risk Monetizer can help businesses better understand water risks and the potential cost implications of water scarcity at a particular facility.

https://www.waterriskmonetizer.com/

The True Cost of Water. Developed by Veolia and intended to help businesses assess the financial implications of various risks and impacts concerning water. The tool provides a detailed understanding of all the costs associated with water management, as well as the costs inherent in missed opportunities. The tool relies on three different levels for monetizing the total cost of water resources: direct costs, such as the price of water, operational costs and investments in water infrastructure; indirect costs, such as administrative, legal and corporate social responsibility costs; and costs related to risks, which could include the financial consequences of water shortages, flooding, financial and regulatory risks, and even reputational risks.

http://www.veoliawatertechnologies.com/en/sustainability/true-cost-water

Water Impact Index (WiiX). Developed by Veolia to measure the impact of activities on a local water resource. The tool, based on the ISO standard related to water footprint assessment, integrates volume, quality and local stress factors into a single indicator. The WiiX measures two types of impact: 1) direct impact, linked to a facility's water withdrawal and discharge, and 2) indirect impact, related to energy and chemical consumption to treat water and sludge.

http://gb.waterimpactindex.com/intro/accessCalculator.do

WaterMAPP. An Excel-based toolkit developed by GEMI to assist companies that help organizations build their own program to reduce water and energy use in buildings. The toolkit includes a Water Scorecard to assess water efficiency, a Water Efficiency Calculator to estimate water and financial savings from cooling tower or free-air cooling improvements, and a Cycles of Concentration Estimator. WaterMAPP can be applied to identify opportunities to reduce water and energy use associated with cooling towers used in commercial/industrial buildings. Cooling towers used in the power sector for electricity generation are not represented.

http://gemi.org/EDFGEMIwaterMAPP/

Export Control Restrictions

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