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Greenhouse gas emissions provide a key indicator for optimizing water delivery: a case study from southern Ethiopia

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Greenhouse gas emissions provide a key indicator for optimizing water delivery: a case study from southern Ethiopia

Greenhouse gas emissions should become a part of utilities' key performance indicators. Energy used to produce water affects carbon footprint of utilities. The data from studies indicate that water scarce regions use more energy to abstract, treat and distribute water. Rising water demand means rising energy consumption. Efficient energy consumption can be achieved by optimizing water delivery and reduction of non-revenue water.

In late 2023, People in Need has launched the second phase of its project that focuses on supporting water utilities and enterprises in selected towns in Ethiopia. The first phase was implemented in 2019 – 2021 and showed some promising trends in utilities' operability; for example, increasing number of utilities with balanced budget. In the context of intensifying climate change, the ultimate goal of the program is balancing an increasing water demand with constant water availability, i.e. optimized use of limited water resources while focusing on efficient energy use.

Nine towns in Ethiopia (Southern and Oromia regions) are taking part in the project. The population of the towns ranges from 30 000 to 90 000 inhabitants. Even though general access to water reaches 65-70%, only 40 % of the total population has access to adequate water services provided by utilities. This means that as many as 60% of the towns' populations accesses water from alternative sources not provided by the utility. This presents several risks for the consumer, such as poor water quality. Moreover, water collected at public water points is more expensive than water distributed by the pipeline network. It is a paradoxical situation, as water must be manually carried to homes and is prone to contamination during transportation and storage. Even though utilities are able to keep track of the financial flow and balance (income vs expenditure) via a single-entry accounting system, there are huge gaps in measuring and recording water production and distribution rates. Due to a lack of functional water metering devices, utilities only estimate production and consumption volumes. Most of the revenues are allocated to salaries and energy cost therefore leaving little space for any investment in infrastructure. Consequently, utilities fulfil less than 40% of the key performance indicators (KPIs)[1] and only 55% of customers are satisfied with the services provided.

Energy used to produce water affects carbon footprint of utilities. Efficient energy consumption can be achieved by optimizing water delivery and reduction of non-revenue water. The cleanliest energy is the one which is not produced and reduction of Non-Revenue Water (NRW) will reduce pressure on increased water production. Reduction of energy used for abstraction results in lower greenhouse gases (GHG) production and contribute to climate change mitigation.

[1] KPIs measure parameters such as proportion of population served, levels of intermittent supply or share of Non-Revenue Water.

Although the application of the Water-Energy Nexus concept and its influencing factors for water supply in utilities in Africa lacks sufficient research, several studies show data of energy consumption calculated amount of kWh per $1m^3$ of abstracted water. In Kenya for example, nation-wide study on energy use for drinking water supply estimates 1.1-2.4 kWh/m^3 while utilities in South Africa use between 0.30 to 0.47 KWh.[2] The study results from China showed that the energy use per cubic unit of water supply in Beijing increased from 1.80 kWh to 3.65 kWh from 1979 to 2017[3]. Whereas Stillwell et al.[4] estimated that in the United States producing 1 m^3 of surface water requires 0.06 kWh of energy and producing the same amount of groundwater from 40 m and 120 m depth requires 0.14 kWh and 0.5 kWh, respectively. The data from studies indicate that water scarce regions use more energy to abstract, treat and distribute water. Rising water demand means rising energy needs in unstable supply environment and leads to intermittent water delivery.

Contributing to climate change mitigation

The project assesses utility carbon emissions and energy consumption; and attempts to identify areas for greenhouse gas emissions' reduction via effective use of resources and water conservation.

The methodology used is based on the Climate smart utilities concept and helps to meet the service goals while being accountable for climate change.

A comparison study to assess energy consumption was conducted in two out of 9 utilities targeted by the project. The objective was to assess the amount of GHG produced by water production and (in long term) propose steps to increase effectiveness of water services and energy savings.

Halaba Kulito town and Shone population is about 90 000, and 67 000 people respectively. Both utilities struggle with reliable and systematic data collection and management. Energy is used for abstraction only. There is no raw water treatment (water is pumped directly to reservoirs and further transported to distribution system and end users) and neither of the towns has sewerage system. Information about water transportation/distribution volumes to the end user is not known.

An operational indicator was set in kWh/m^3 for water abstraction. Calculations of energy consumption confirmed that it takes between **1.42 – 1.96 kWh to abstract $1m^3$ of water** with average total dynamic head (TDH) of 90 – 180m. The figure confirms the assumption that decentralised water supply in African small cities exceeds average water production energy needs. In order to get information about GHG production, Energy Performance and Carbon Emissions Assessment and Monitoring Tool (ECAM)[5] was used. The table below shows set baseline GHG production benchmark of the two targeted utilities and the project has an ambition to reduce utilities´ CO_2 production.

Water utility	**Population served**	**Service coverage in %**	**Monthly volume produced in m^3**	**Energy consumed in kWh**	**kWh/$1m^3$**	**Monthly GHG emissions[5] kg CO_2**	**NRW ratio in %**
Shone	24 120	36.00	12 550	23 850	1.96	1 873	15.95*
Halaba	43 250	49.49	76 350	108 814	1.42	2 278	1.15*

**Reliable data not available*

Conclusion and discussion

Conducted study confirms the importance of water-energy-carbon nexus. Linking energy use and associated costs to water losses can inform water utilities on how much energy is lost with NRW and the revenue loss at each water supply process. Consequently, share of NRW is proportionally equal to the

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2 Pauline Macharia, Norbert Kreuzinger and Nzula Kitaka: Applying the Water-Energy Nexus for Water Supply—A Diagnostic Review on Energy Use for Water Provision in Africa (2020)

3 Jiahong Liua,c, Dong Wanga,b, Chenyao Xianga, Lin Xiaa, Kun Zhanga,b, Weiwei Shaoa, Qinghua Luanb: Assessment of the Energy Use for Water Supply in Beijing, (Applied Energy Symposium and Forum 2018: Low carbon cities and urban energy systems, 5–7 June 2018, Shanghai, China)

4 Stillwell A S, King C W, Webber M E. Desalination and Long-Haul Water Transfer as a Water Supply for Dallas, Texas: A Case Study of the Energy-Water Nexus in Texas[C] (2010)

5 https://climatesmartwater.org/ecam/

amount of energy that is wasted and reduction of NRW will reduce emissions of GHG. Energy use can be included in utility KPIs and set as a benchmark for optimisation of water production costs.
Recommendations for further research include addressing the questions: how to increase service to the population while keeping GHG emissions on similar levels? What are the priority actions: replacing certain ineffective energy sources (especially diesel generators) with clean energy source (principle of build-back-better), reduction of NRW or focus on increased abstraction while keeping in mind sustainable use of available water resources?

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