FACT SHEET DRINKING WATER

Introduction

Access to drinking water is essential for socioeconomic development and for the overall health of communities around the world. Currently, half of the world's drinking water from unsafe sources comes from Africa; and sub-Saharan Africa (SSA) is the only region where progress in access to drinking water has been outpaced by population growth.[1] Globally, diarrhoeal diseases caused by contaminated water are the second leading cause of child mortality.[2] The energy-water nexus is placed at the centre of the Sustainable Development Goals (SDGs) as it has direct implications for agriculture, health, poverty reduction, education, women's empowerment, and many other SDGs.

Solar pumping has become a particularly promising option for supplying rural communities with drinking water due to the remoteness of many off-grid areas and the related challenges of distributing diesel there, as well as the decreasing cost of solar energy systems over the past decades. This fact sheet focuses on the use of solar energy for the production of drinking water.

70%

of people in sub-Saharan Africa have no access to safe drinking water.

Key Facts of the Application Environment

According to the World Health Organization (WHO), people need at least 50 litres of safe water per person, per day[2] for health, hygiene, and domestic purposes. The strict minimum is 2 litres per person, per day for drinking purposes. Yet, only 30% of people living in SSA currently have access to safe drinking water[3]—with sharp national discrepancies between the rich and the poor as well as between rural and urban communities. In urban areas, households without running water often pay 10 to 20 times more than those with a connection to piped water. For example, in Lusaka, Zambia, 50 litres of piped water costs $0.0005, but water is about 220 times more expensive[2] when procured from a water vendor. In urban areas, 54% of people have access to safe drinking water compared to only 13% in rural areas. For those without access to safe water sources, the World Health Organization (WHO)[4] recommends boiling the water because this kills all pathogens, but it requires a significant amount of energy, which is often produced by burning hand-picked firewood or coal. Using these fuels for boiling water is often unaffordable for many people and has negative health impacts.

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Community infrastructure (including schools and hospitals) is also affected by the lack of access to clean water. For example, half of SSA's health care facilities lack access to basic water services,[5] which increases the risk of patients developing secondary infections. Finally, the lack of affordable drinking water represents an environmental challenge because improperly disposed water bottles or sachets severely contribute to the pollution of soils and rivers.

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54% vs 13%

In urban areas, 54% of people have access to safe drinking water compared to only 13% in rural areas.

Application in a Nutshell

Technology	Water pumping and treatment for drinking water production using solar energy.
Application	Drinking water systems, water kiosks, consigned bottle delivery service, community water taps, and others.
Technology Overview	Solar-based drinking water systems for off-grid settings have three main components: 1) a solar pump, 2) a water filtration and purification system, and 3) distribution infrastructure.
Economic and Financial Feasibility	The affordability of drinking water is a key challenge in a context of low ability to pay and relatively high investment costs (due to the nascency of the technology, lack of economies of scale, and high logistical costs), which should be considered. Urban areas and dense rural population centres may be the most appropriate settings for installing such solar-powered water pump systems, as the water they produce can compete with water sold by street vendors or tanker trucks as well as with bottled water.[6]
Benefits and Outcomes	Access to safe and affordable water is linked with positive outcomes in most sustainable development goals. It has major health benefits, including: reducing child mortality and malnutrition; reduces the time required by women to collect water; and improving economic and educational opportunities.
Constraints and Risks	Technical constraints are mainly linked to water availability and natural water quality. Other constraints include: logistical costs; the need for continuous operation and maintenance; surveillance and quality control; ability and willingness to pay; and demand patterns. Some of the risks include: regulatory and political risks as well as resistance to the adoption of new and safe water sources.
Future Perspectives	Prepaid digital payment solutions or PAYGO (pay-as-you-go) can improve cash flow management while also serving as consumer relationship management systems. Additionally, integrated planning will be necessary for optimal synergies among SDGs to materialise.

10 to 20 times more

In urban areas, households without running water often pay 10 to 20 times more than those with a connection to piped water for a lesser quality.

Further Case Studies

- Social enterprise focused on the bottom of the pyramid‘s need for clean and safe water access through delivering fast, affordable and reliable water infrastructures across Africa - Water Access Rwanda
- Ultrafiltration as well as blended RO-hybrid water treatment systems in Tanzania and Zambia - Jibu
- Installation, operation and maintenance of solar water desalination systems for off-grid communities throughout Africa - Waterkiosk

Figure 1: An example of a drinking water system in a rural setting. Reprinted with permission from Pump&Drink by Sotrad Water.

Technical Information

Typically, drinking water systems for off-grid settings have three main components: 1) a solar pump, 2) a water filtration and purification system, and 3) distribution infrastructure.

1 The solar pump is powered by solar PV panels and controlled by a pump controller. Surface pumps can be used for surface water sources (such as lakes or streams) as well as for shallow wells, as long as the depth of the water does not exceed the pump suction (usually about 7 metres under real conditions).[7] For deep wells or boreholes, which can be necessary in some contexts to ensure year-round supply, submersible pumps can be used. A float switch in the well or the borehole can protect the pump by switching it off when the water level is too low. A direct current (DC) brushless pump can be used to avoid the insertion of an inverter between the solar panels and the pump.

2 Water is treated in several ways. Depending on the quality of the water source, a combination of techniques is often required. Techniques include: clarification/filtration, purification, and sterilisation/disinfection.

- Clarification/filtration: suspended particles need to be removed from the water to ensure the effectiveness of purification and disinfection. Some filters include several layers with pre-filters that remove suspended particles and membranes, which can provide comprehensive protection against parasites, bacteria, and viruses.
- Purification: contaminants (e.g. herbicides, pesticides, and pungent tastes or odours) can be removed by activated carbon or charcoal. In some regions, groundwater is naturally rich in arsenic and mining can lead to mercury pollution. Chemical purification can be achieved through reverse osmosis, during which water is forced through a special, selective membrane with microscopic pores. Reverse osmosis is both energy and capital-intensive, and thus may compromise the financial viability of the system in a rural electrification context.
- Sterilisation/disinfection: sterilisation using ultraviolet (UV) light presents many advantages, it is simple; effective because 99.99% of pathogens are killed; safe; inexpensive; and energy-efficient. Chemical disinfection (e.g. with chlorine) has persistent effects and can be of use when the water is stored in a reservoir prior to distribution or when subsequent contaminations occur.

3 The distribution infrastructure varies depending on the business model. In this section, community water taps and water kiosks will be covered. Community water taps generally include an elevated water reservoir to ensure an uninterrupted water supply by using gravity. They also include: a float switch in the water tank, which is used to switch off the system when the tank is full; self-closing taps on the ground to minimise water loss; and taps at heights that enable people to fill their containers while holding them on their heads, which can spare their backs. Solar street lighting can also be provided, so community members can get water in the evening, freeing them during the day for income-generating activities. Water kiosks are small shops, where the water is bottled after treatment and sold in consigned canisters either on-site or by delivering them directly to their customers.

Comprehensive technical standards for water kiosks or water distribution infrastructure do not exist, as systems vary in their design, applicability, and capabilities. However, they can be approached on a component basis. For example, the Global LEAP awards, an international initiative to promote lighting and energy access, guarantee the quality and performance of solar water pumps. Other components for which the market is more mature may be subject to International Electrotechnical Commission (IEC) standards. Typically, the infrastructure has a 10-year lifespan, but some parts (e.g. UV lights) may need to be replaced each year. Also, increased consumption over time may require replacing the whole system before the end if its lifespan with a larger infrastructure.

Ensuring the quality of the water produced and distributed is paramount. The WHO has issued guidelines for drinking-water quality,[8] and many other standards exist. These standards define expectations related to drinking water quality as well as the minimum requirements for materials that are in direct contact with goods for human consumption. Such standards are enacted on the national level.

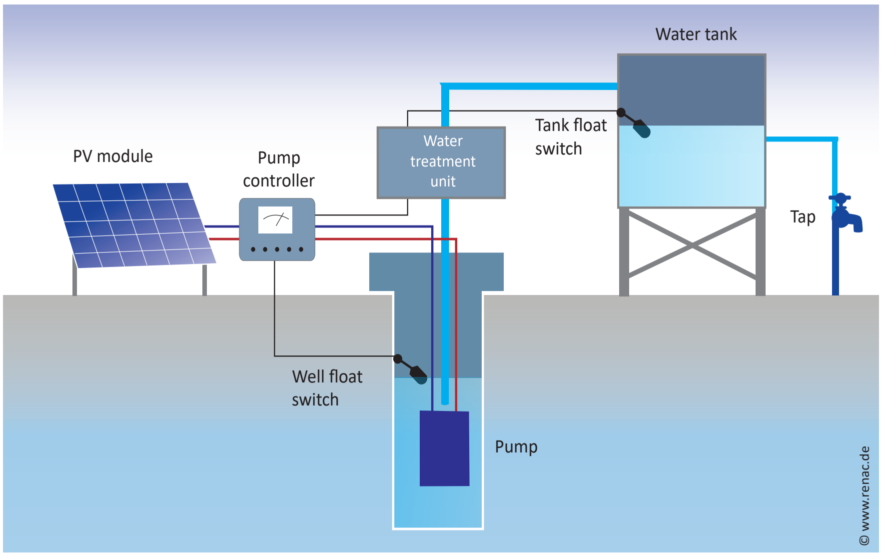

Figure 2: Drinking water system using a submersible pump. Source: RENAC.

Economic and Financial Feasibility

Water kiosks and community taps have historically been delivered as turn-key solutions, with NGOs or public bodies financing these projects. However, the private sector is increasingly interested in operating these systems. Social firms (like Oshun Connect in Senegal and Burkina Faso) have tested a franchising water kiosk model. Others have hybrid community-based models, such as Sotrad Water with projects in Ivory Coast, Togo, and Democratic Republic of the Congo (DRC); or Africa Solaire in the DRC. To maximise revenue collection and lower operational costs, cashless pre-paid models, such as PAYGO, are often implemented.

In densely populated, economically developed centres, kiosks or community taps can make drinking water accessible to those who could not yet afford it and offer a much cheaper alternative to those buying from more expensive water sources (e.g. water sachets or bottles). A high level of suppressed demand and the impact of the substitution effect ensures a regular client base, which in turn, ensures the financial viability of the drinking water business.

In more rural settings, careful modelling needs to be carried out. The upfront investment is high, particularly when a borehole needs to be dug (costing between $50,000–$250,000). Logistical costs also need to be considered for installation and operation and maintenance (O&M)—for example, for yearly replacement of UV lights and surveillance of water quality. In order to keep water prices low and ensure a sufficient return on investment, subsidies will be necessary for the short-term and medium-term until the market matures.

Table 1: Typical water prices in Africa[9] in 2022 (Retail price $/L)

Kiosks or community taps	Water sachets	Bottled water
From $0.01/L	$0.10/L	$1–$1.5/L

Benefits and Outcomes

Access to safe and affordable water is linked with positive outcomes in most sustainable development goals. It has major health benefits, including a direct reduction in child mortality and malnutrition, which materialises in increased productivity and education. Around 3,000 child deaths[2] in Zambia each year, and about 50% of child malnutrition worldwide, are directly linked to unsafe water and improper sanitation. In SSA, women and girls spend an average of 30 minutes[10] per round trip collecting water, resulting in close to 16 million hours spent per day on this activity.[11] Access to safe water also directly contributes to women's empowerment, reducing the drudgery of water collection and freeing time for income-generating activities. Affordable water reduces inequalities, which in the context of climate change and increased scarcity, contributes to social peace and stability.[12] Finally, the operation of water kiosks/taps can provide community jobs and serve as anchor customers in the context of rural electrification.

Figure 3: The relationship of SDG 6 with other SDGs. From "United Nations Economic and Social Commission for Asia and the Pacific [UN ESCAP] 2017," by GRID-Arendal/Studio Atlantis.[13]

Constraints and Risks

One important constraint associated with making safe drinking water available using solar-power-based systems is selecting the most suitable technological solution and sizing it appropriately. To do so, water availability, its natural quality, and the demand patterns associated with it need to be considered. Although O&M is required for all types of infrastructure, water in particular requires continuous quality surveillance. To meet this obligation and avoid the risks associated with unsafe drinking water, water kiosks/taps are often equipped with remote control and monitoring systems. Additionally, sustained revenue collection and investment in O&M are particularly challenging for public or non-profit investments. Community involvement is essential in rural settings, as community members can ensure the safety of the infrastructure and carry out basic maintenance. Local buy-in, particularly from influential figures (e.g. heads of villages), is critical, and early community engagement and awareness raising may help rural communities overcome resistance to adopting a new water source. Finally, water infrastructure may be subject to strict regulations, such as licensing, concessions, and other authorisations. Social tariff caps may apply to water in some countries (e.g. \$1.4/m^3 in Ivory Coast) and this is a significant barrier to the deployment of privately owned and operated water infrastructure.

Future Perspectives

The total addressable market for decentralised water infrastructure is large, particularly when taking into account the need to replace and upgrade manual water pumps. The sharp decrease in the cost of off-grid solar solutions in recent years has unlocked the potential of water kiosks/taps in rural settings.

Financial viability and access to finance remain challenging—and related business models are still nascent, requiring piloting and continuous improvement. Like in the off-grid solar industry, the use of pre-paid digital payment solutions (PAYGO) may serve as a consumer relationship management system, facilitating the retail of complementary services (e.g. phone charging), while avoiding risks related to cash-based business models (e.g. low collection rates and theft). Additionally, the addition of water pumping capacity for irrigation purposes could strengthen the financial viability of such infrastructure while contributing to food security locally.

Finally, given the important links between rural electrification initiatives and other SDGs, cooperation programmes and governments are increasingly promoting an integrated approach, which will likely support clean water suppliers in accessing cheaper and longer-term financing.

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