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# Synergies in increasing access to sustainable energy and access to clean water in developing countries

Experiences from EU-supported projects in ACP countries 2007-2019

7 AFFORDABLE AND CLEAN ENERGY

6 CLEAN WATER AND SANITATION

ACP-EU Energy Facility Monitoring

European Commission

DANISH ENERGY MANAGEMENT
DEM
FOR SUSTAINABLE IMPACT

**The ACP-EU Energy Facility (http://energyfacilitymonitoring.eu)**

This discussion paper is one in a series of discussion papers based on experiences from the ACP-EU Energy Facility (EF).

The EF was established in 2005 to co-finance projects on increasing access to modern and sustainable energy services for the poor in African, Caribbean and Pacific (ACP) countries, especially in rural and peri-urban areas. 173 project proposals have been granted co-funding from the EU for a total of 0.4 billion euros; 50% of the total project-budgets of 0.8 billion euros.

The projects have been, and are being, implemented in the period 2007-2021 with 90% of projects completed in 2019. The projects cover a wide range of technologies:

Electricity grid-extensions in rural and peri-urban areas, hydro-powered mini-grids, solar and hybrid-solar mini-grids, stand-alone solar solutions for businesses, households and public institutions, portable solar equipment mainly used for lighting, clean energy solutions for cooking such as improved firewood and charcoal cook stoves as well as biogas, biofuels for electricity generation, and capacity development of public institutions in the energy sector.

**Among the 173 Energy Facility projects, 28 are directly related to SDG 6 improving access to safe water.**

*Danish Energy Management (DEM) has been granted the contract of providing technical assistance for the monitoring of the EF projects in the period 2011-2019. This discussion paper is based on information and data gathered during this period as well as current research and experience from other development interventions.*

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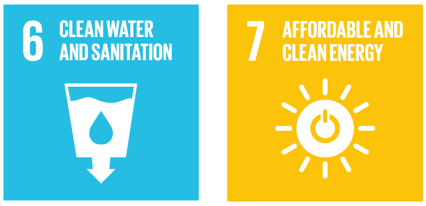
# Introduction

This discussion paper raises some of the key considerations on how energy access interacts with water access (the 'water-energy nexus', interaction between energy and water resources), on how some of the Energy Facility projects have improved water security[1], and on the business models used.

Water and Energy are strong elements supporting the realization of the SDGs, and the strong relationship between **SDG6 (clean water and sanitation)** and **SDG7 (access to affordable, reliable, sustainable and modern energy for all)** is fully recognized.




Moreover, access to energy and clean water is mandatory in view of the realization of other SDGs:


**SDG1 (No poverty)**: affordable energy is a prerequisite to eliminate poverty. Today poor people pay a large portion of their income for fuel.

**SDG2 (Zero hunger)**: pumping for irrigation can be powered by solar and wind.

**SDG3 (Good health and wellbeing)**: clean water and less air pollution will improve health conditions for the poor.

**SDG5 (Gender equality)**: today mostly women in rural areas with no access to water are responsible for carrying water. Making water more readily available will give them new opportunities for supporting the family.

The paper reviews some of the main energy uses in connection with the water value chain: energy for water pumping, energy for hot water, energy for water purification and treatment. It also addresses the issue of the protection of catchment basins, which is an important aspect of protecting water sources when developing hydroelectricity. Finally, it discusses the economic issues in mini grids where water services can be made a part of the business model.

[1] A definition of water security by the United Nations is: 'the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability' (UNU, 2013). The International Energy Agency defines energy security as: "the uninterrupted availability of energy sources at an affordable price" (IEA, n.d.).

## Background

The ACP-region, especially Sub-Saharan Africa, suffers from chronically overburdened water systems under increasing stress from fast-growing urban areas. Sub-Saharan Africa is the region most affected by water stress in the world. A major reason for this is the lack of infrastructure, particularly storage infrastructures that increases access to water in dry seasons. This is all the more the case because sub-Saharan Africa is subject to extreme climate variability. According to UNEP, currently, access to safe water in sub-Saharan Africa is worse than in any other area in the world, with only 57% having access to basic water services and only 24% having access to safely managed water[2]. Improving water and sanitation programs is crucial to spurring growth and sustaining economic development. Hence a vicious circle: poor economies are unable to develop because of water stress, and economic instability prohibits the development of the (often lengthy) programs to diminish water stress.

*Women fetching water*
*Photo: Danish Energy Management (DEM)*

There are many similarities between water and energy problematics. By 2050, the demand for energy will nearly double globally, while water demand is estimated to increase by over 50%. The water–energy nexus is emerging as a key security-of-supply risk for both the energy and water sectors.

*Solar Photovoltaics*
*Photo: Danish Energy Management (DEM)*

In most energy production processes; water is a key input. Water is required for extracting and processing fossil fuels as well as for generating electricity from various sources. Energy supply from fossil sources presently accounts for nearly 15% of global freshwater withdrawals annually[3].

Renewable energy mitigates climate change and also mitigates the withdrawal of fresh water sources. Water needs for solar photovoltaics (PV) and wind are negligible compared to conventional thermoelectric generation where substantial quantities of water are needed for cooling. Solar PV or wind could withdraw up to 200 times less water than a coal power plant to produce the same amount of electricity[4].

Each step of the water supply chain, including the extraction from the source, the treatment, the transport to end users, the return to the environment, and possible re-use, needs energy inputs.

[2] World bank: http://data.worldbank.org

[3] IRENA. Renewable Energy in the Water, Energy & Food Nexus. January 2015

[4] IRENA. Renewable Energy in the Water, Energy & Food Nexus. January 2015

The Energy Facility-projects energy generation is generally provided by renewable energy sources (or small-scale fossil fuel run systems), and analysis of these projects offers a change to better understand the conditions under which improved access to sustainable energy increases or facilitates access to clean water.

Table 1: Overview of the Energy Facility's project having contributed to increased access to clean water

| Relevance to SDG 6 indicators EUR | | | | |
|---|---|---|---|---|
| | 6.1 Access potable water | 6.3 Water treatment | 6.6 Water related ecosystems | Access to hot water |
| **# of projects** | **20** | **3** | **5** | **2** |

18% of the Energy facility-projects have specifically addressed access to clean drinking water. Out of those, 20 have addressed access through pumping to potable water, 5 have dealt with water related ecosystems, 3 with water purification and treatment, and one with water heating. Some of them address more than one of these technologies. Many Energy Facility projects have also promoted energy for agricultural irrigation applying similar technologies. These are dealt with in Discussion Paper 1 on how to use energy for agricultural production. The below analysis focuses on access to potable water.

## Energy to increase access to potable water

Energy is needed to pump water from the underground. Among the solutions out there, manual pumping is widespread in the rural areas of the ACP-region but is naturally a solution with limited capacity. With mechanisation comes the possibility for more water to be pumped. Pros and cons of manual water pumping, diesel- or petrol fuelled water pumping, solar photovoltaics, and wind-turbines will now be examined.

## Manuel water pumping

Manuel water pumping, often using the Afridev pump model largely widespread around Africa, has typical discharge rates of 0.8 to 1.35 m3/hour at depths from 15 to 45 m. For a typical 30 meters borehole, the discharge rate is 1 m3/hour. Hand pumps are often operated up to 12 - 16 hours per day, but the effective operating time is generally in the range of 6-8 hours per day, achieving a 6 – 8 m3/day water volume. Hand pumps are also useful in villages with a widely distributed population where several boreholes throughout the village with hand pumps would be more effective than pumping large volumes of water from a single borehole.

Table 2: Pros and cons for manual water pumping

| | | | |
|---|---|---|---|
| ✓ | Low investment cost | ✗ | Limited capacity: Only 6-8 m3/day |
| ✓ | Relevant for scattered settlements | ✗ | Time consuming for users |
| ✓ | Low running costs | | |

## Diesel or petrol engine-based pumping

Petrol run systems commonly use 0.5 horsepower (hp) electric submersible pumps powered with 4.5 kW petrol-run generators. This allows pumping from a 40 m depth borehole. With a maximum flow rate of 0.57 l/s, and a pump running 5, 10 or 15 hours per day, this would provide a daily water supply of 10, 20 or 30 cubic metres per day respectively.

Diesel-run systems offer some advantages: fast and easy installation and low investment costs. Their disadvantages are: fuel supplies are erratic and expensive (high operational costs), there are high maintenance costs, a short life expectancy, and noise and air pollution. If fuel supply is ensured, diesel pumps can work continuously and achieve 70%- 80% efficiency.

Table 3 Pros and cons for Diesel- and petrol water pumping

| | | | |
|---|---|---|---|
| ✓ | Scalable capacity: 10-30 m3/day | ✗ | High running cost |
| ✓ | Low investment cost | ✗ | Dependency on fuel supply |
| | | ✗ | Noise- and air pollution |
| | | ✗ | Short life expectancy |

## Solar photovoltaic water pumping

Contrary to diesel-run systems, PV systems offer nearly unattended operation, low maintenance costs, long lifetime and low average yearly costs. Their disadvantages are: high investment costs (although the price of panels has been declining), they generally require storage (water storage or battery storage) and their repair often requires skilled personnel.

The efficiency of solar pumps is not steady and changes throughout the day with the intensity of the sun and the angle with which the sunlight hits the PV panels. During low-light periods (in the morning and late afternoon) the efficiency can drop by 25% or more and during cloudy days the pump efficiency can be less. Under optimum sunlight conditions (on sunny days during midday) the solar powered pump works with near 100% efficiency.

*Solar photovoltaic water pump*
*Photo: DEM*

Table 4 Pros and cons for PV water pumping

| | | | |
|---|---|---|---|
| ✓ | Low running costs | ✗ | High investment cost |
| ✓ | Long lifetime | ✗ | Variable capacity if storage is not designed correctly |
| | Stable supply if storage is well designed | ✗ | Repairs require specialised skills |
| | Operates (largely) unattended | | |

## Wind pumps

Wind-run pumping can be implemented in the form of electric pumps connected on a wind farm (generally through a grid) or be implemented as mechanical wind pumps.

The benefit of wind run electric pumping is that it uses a renewable source of energy. The main drawback is often the irregularity of the resource, which may require storage. Other benefits and drawbacks are similar to those of the solar systems.

One of the benefits of wind-mechanical systems is their simplicity, and appropriate and sustainable solutions can employ local skills and material resources: wind pumps can be assembled and maintained using the materials and skills available in sub-Saharan Africa, which generally makes them an attractive option.

The amount of water that can be pumped depends on the wind regime, the pumping head and the size of the wind turbine. The table below[5] provides an example of the sizes and outputs for mechanical wind-run systems with resp. 10, 20 and 30 m3/day.

*Wind-run pump*
*Photo: DEM*

Table 5 Example of mechanical windpumping

| System | Rotor diameter | Water obtained in October (3.7 m/s mean wind speed) | Water obtained in April (4.6 m/s mean wind speed) |
|---|---|---|---|
| 10 $m^3$/day | 4.9 m | 11-18 $m^3$/day | 27-37 $m^3$/day |
| 20 $m^3$/day | 6.1 m | 19-27 $m^3$/day | 27-37 $m^3$/day |
| 30 $m^3$/day | 7.4 m | 29-42 $m^3$/day | 27-37 $m^3$/day |

Table 6 Pros and cons for wind energy water pumping

| Electrical wind energy water pumps | | | | Mechanical wind energy water pumps | | | |
|---|---|---|---|---|---|---|---|
| ✓ | Low running costs | ✗ | High investment cost | ✓ | Low running costs | ✗ | Variable capacity |
| ✓ | Long lifetime | ✗ | Variable capacity | ✓ | Low investment cost | ✗ | Variable output depending on wind speeds |
| ✓ | Operates (largely) unattended | ✗ | Requires high wind speeds to be effective | ✓ | Simple technology that can be repaired locally | | |

[5] The feasibility of renewable energy sources for pumping clean water in sub-Saharan Africa: A case study for Central Nigeria - Michael Cloutier, Paul Rowley* CREST (Centre for Renewable Energy Systems Technology), Loughborough University, Leicestershire LE11 3TU, UK, Elsevier

## Long-term sustainability of water services

Long term sustainability of water services is generally affected more by financial considerations than technical issues. In large parts of the world, the concept of water as a social good prevails over that of water as an economic good. As a result, it is commonly admitted that full cost recovery is not an appropriate objective in the case of water services[6].

*Women fethcing water*
*Photo: DEM*

Among the different price structures used by water utilities, Increasing Block Tariffs (IBTs) are by far the most common. In this price structure, water consumption is divided into blocks and the price of the additional cubic meter, or marginal rate, depends on the block into which it falls. The marginal rate increases with the block. Rates in the first block are typically much lower than costs, reflecting the notion that a minimal (subsistence) quantity of water should be available to all at low tariffs.

However, while social concerns are highly legitimate, UN DESA (the United Nations Department of Economic and Social Affairs) considers the responsibility to assist poor customers as belonging to the government, and not to the utility. Utilities should be allowed to charge sustainable tariffs (properly monitored), and subsidies to needy customers should be provided by the appropriate level of government. The advantages of such an unbundling are manifold: (i) it provides better incentives for utilities and governments, (ii) it makes consumer subsidies more transparent, (iii) sustainable tariffs are the best guarantee to sustained services in the medium to long run.

In most of the EF-projects where electricity and water services are offered, users only pay for electricity. In cases where specific water prices are established, a clear estimate is lacking to ensure that the tariffs collected will support long-term operation and maintenance costs, making it very likely that the payments will not be able to cover these costs.

The project, *Support to Efficient Utilization of Alternative Energy Sources to Improve the Livelihood of Pastoral and Agro pastoral Communities in Southern Ethiopia*, is an example of a payment scheme that combines user payments with local government support. The project included upgrading 5 boreholes with solar pumping systems for potable water among other activities. Financial management was organized differently depending on the type of activity. For the potable water supply, a Water Management Committee collected fees based on use applying already established user's fees ranging from 12.5 to 25 birr (38 to 77-euro cents) per cubic meter of water. The fees should cover operating costs while maintenance costs, such as repairs, would be the responsibility of the relevant district bureau. Long term sustainability in this model depends on the capacity of the local government to manage repairs which cannot always be assumed.

*Payment of water*
*Photo: Programa Comunitário para Acesso a Energias Renováveis*

In Nigeria, the project *Solar Energy Solutions for Motive power needs in energy poor Niger Delta communities* applied a purely community managed business model. One of the project objectives is to enhance

[6] UN DESA, Providing water to the urban poor in developing countries: the role of tariffs and subsidies

benefits derived from the community energy access through the provision of a community mechanised water borehole with pump, water treatment/reservoir and distribution network powered by the community solar energy access.

The facilities are organized and run by a Project Management Committee (PMC), whose focus is to engage community participation during project construction and handle all post installation management responsibilities, including overseeing the bank account where the monthly access by households will be deposited into, which takes care of maintenance (broken PV pipes & taps) etc.

Every member of the community has equal rights on the water and each household has agreed to contribute 200 Naira monthly (about 1 euro) into an account to be managed by the PMC, which will be used to replace the broken pipes and taps, etc. However, as is the case in many of the EF-projects applying this model, there is no evidence or feasibility studies showing that the 200 Naira will be sufficient to cover operation and maintenance costs and long-term financial/economic viability is put into question.

The project, *Renewable energy for local development*, in Guinea Bissau applied a variant of the community-based model where the implementing organisation (an NGO) remains part owner together with the local communities. The project takes a holistic approach to addressing the needs of poor farmers vulnerable to food insecurity, promoting the use of renewable energies (solar and Jatropha oil?) and providing access to water as well as electricity in community centers, health centers, mosques, and schools. The project also provides access to drinking water, water for irrigation, light in schools, health centers, mosques and community centers, as well as local opportunities for processing crops, and communities contributed to the works of the wells and constructing the community centers, which they now benefit from and feel the ownership of.

*Health clinic*
*Photo: DEM*

However, difficulties have been met on establishing the right payment system. First of all, it has proven difficult for communities to understand that they have to pay for a good (water) that was previously free of charge. Substantial efforts were put into explaining that it was not the water per se that was charged, but the energy service since the water pump considerably alleviated their work. Flexible tariffs were set to XOF 500/ month per adult person (around 1 euro), or 3000/year/family (5 euros), or XOF 25 / 25 liters of water (5 eurocents). However, by the end of the project revenues compared to costs of O&M and replacements only ranged between 12-66 %. So far, communities have been able to pay for the salary of a caretaker and smaller repairs but there is still a need to define a better functioning payment model.

**In conclusion:**

- The majority of Energy Facility projects in this area have focused on using renewable energy for the water pumping of potable water. Each type of water pumping technology offers advantages and presents disadvantages. Renewable energy solutions have proven effective either as pure solar or wind energy solutions or in combination with thermal engines in a hybrid solution. As opposed to the purely diesel/petrol-based solutions, hybrid solutions offer improved reliability and stability of the energy and water services, reduction of pollutions, increased operational life and reduced cost and more efficient use of power, if the relatively high investment can be realised.

- Replacing diesel run water pumping by electricity run water pumping offers advantages beyond purely environmental advantages, for example, avoiding the chore of carrying diesel fuel, and the associated hurdles.

- Mechanical wind pumping should not be underestimated when conditions are adequate because of the simplicity of the technology that may allow local fabrication and assembly and easy maintenance by local technicians.

## Water services as part of the off-grid business model

In terms of technology, it is clear that both solar and wind pumping technologies are pertinent, depending on the local conditions. The next question is whether renewable energy should by promoted through mini-grids or in standalone solutions only supplying water services. As indicated above, the majority of EF projects with a water dimension fully integrates the water service in the off-grid or mini-grid business model in the sense that, as shown in the below examples, the tariffs target the electricity (including the one used for pumping the water), but not the water itself. This solves the sensitive issue of pricing water. Moreover, in some projects, the water component is benefitting social institutions such as schools or health centres which, in some cases, would not be invoiced by the operator or could have problems paying in the long term, given their very limited budgets and limited possibilities to generate income.

*Solar photovoltaic installation at a school*
*Photo: DEM*

Insufficient pricing, affordability problems, insufficient management of clients (for example non-disconnection of 'bad payers' also largely affect the sustainability in this approach. Finding the right balance between affordability for the users and financial viability for the operator is the key question for the Energy Facility projects.

In Project *Projet d'Accès universel à l'électricité : Réseaux et Services publics d'électrification dans 20 localités rurales de 5 wilayas (Régions) en Mauritanie : PELEC 20*, 2 water-catchment areas benefit from pumping systems connected to solar micro-grids benefitting 20,000 people.

According to the Final Evaluation, the immediate impact of the project has been the substitution of diesel fuel by electricity, cancelling the transportation of 130 l diesel per day (in one of the catchments) and the associated economic saving. In this sense, access to clean energy and access to safe water are well integrated into the project.

The tariffs paid by households and other beneficiaries only target electricity, not water consumption. They are considered exorbitant since, while they ensure the operator's balance of accounts, they do not consider the beneficiaries' ability to pay. Sustainability should be consolidated through reliable tariffs and institutional mechanisms.

The opposite case is found in project *Electrification des communautés rurales avec des Micro-réseaux de Génération d'Energie Solaire Photovoltaïque Autogérés dans la Région de Zanzan* in Ivory Coast. The project electrified 7 rural communities through solar photovoltaic microgrids supported by diesel generators. The project includes 7 hydraulic pumps connected to the microgrids. Thanks to a very well-designed storage and diesel backup system, the mini-grids offer a stable supply of electricity.

In each concerned village, an association in charge of the operation and maintenance of the microgrid, and an installer association in charge of the specialized maintenance have been established. The system aims at covering operation and maintenance costs (including equipment replacement) through a business model that applies monthly fees in connection with each user's planned consumption; in case of over consumption, the electrical meters cuts the client off, and in this way end users learn to only use the amount of electricity that they can afford to cover the costs for. In this way, affordability is guaranteed.

This intelligent pricing system has many advantages but sustainability is still considered problematic in the specific case as the local management communities does not have a clear picture of whether long term costs are actually covered by the collected revenue. In addition, water pumping is not charged and neither is the local health centre, social rooms and public lighting.

In Liberia, the project *Light up our Futures* aims at increasing knowledge about and access to renewable energy that is affordable and sustainable for villagers in the Lofa County. The difficult situation in Liberia has affected implementation and the ability to introduce a viable payment scheme. The current scheme charges US$3/month for small homes, US$5/month or larger homes, US$14/month for businesses, and US$20/month for industrial businesses but the payment rate is only around 50%. As in the previous project, it does not seem that water production from the pumps would be paid for.

Combining energy access with water access has an obvious contribution on the three above project impacts, as can be seen in their overall objectives: Stimulation of the poor's growth potential and productivity in Mauritania, providing basic decentralized sustainable electrification infrastructures to improve the quality of life in seven isolated villages in Ivory Coast, and contribute to poverty reduction in rural communities in Liberia. Energy and water access services are naturally integrated but the formula for optimal institutional ownership and sufficient pricing have yet to be found.

The need for professional financial management of integrated energy and water access services is generally underestimated. One should not assume that local management committees can be trained, and their capacity built to ensure that revenues cover longer term O&M costs as well as replacements of equipment. The operator needs a sufficient client base to be able to generate revenues for professional management and integrating water services in the mini-grid business model could contribute to revenues but only if they are priced.

This sensitive question needs to be addressed on national level where tracks for tariff regulation (where they are not yet regulated) and harmonization of tariffs for kWh and possibly water cubic meter, also taking account of the development levels of the different regions in a given country should be pursued. Such tariffs should be officially published, so that project promoters could knowingly design projects containing adequate tariffs supporting their sustainability.

**Conclusions**

- The need for professional financial management of integrated energy and water access services is generally underestimated. One should not assume that local management committees can be trained / capacity build to ensure that revenues cover longer term O&M costs as well as replacements of equipment.

- The operator needs a sufficient client base to be able to generate revenues for professional management and integrating water services in the mini-grid business model could contribute to revenues but only if they are priced.

- The sensitive question of water pricing needs to be addressed on national level where tracks for tariff regulation. Such tariffs should be officially published, so that project promoters could knowingly design projects containing adequate tariffs supporting their sustainability.

## Energy for hot water

Water heating is a huge intervention area when looking at energy efficiency in urban and peri-urban areas of the ACP region. Heating water for domestic and commercial use is one of the most energy-intensive segments of the water cycle. In developed countries, energy use for water heating represents from 15% of household energy use in Europe to 30% in Japan[7]. In those developing countries, where access to energy sources (electricity, natural gas, oil) is already developed, water heating can represent up to 90% of the total energy input along the water cycle[8]. Moreover, especially in those countries where the electricity grids suffer from high rates of technical losses, electric water heating is not only an inefficient energy conversion process but may also have a destabilizing impact on the power systems.

[7] Leonardo Energy, 2012.

[8] Plappaly & Lienhard V, 2012

It is therefore adequate to replace conventional electrical water heating by the use of renewable energy sources such as geothermal (for large scale water heating?) and solar thermal. Solar water heating technologies have already realized high energy and emissions savings worldwide, including in some developing and/or emerging countries. For example, in Morocco, the Promasol program targets the installation of 440,000 sqm thermal solar collectors in 2012 and 1.7 million sqm in 2020. These figures amount to 1,190 GW/h annual thermal energy produced until 2020, 920,000 tons CO2 avoided per year, and 920 permanent jobs created. On this basis, although most of the devices are imported, a local installation and maintenance supply chain has steadily developed. Such examples could be usefully copied in some ACP countries.

The Energy Facility projects offers a few experiences with water heating: *Community Based Green Energy Project* in Kenya installed solar water heating systems in 5 schools. This participated in the creation of an enabling environment for improved performance in schools. Another project, *Amélioration des conditions de vie des enfants et de leurs familles grâce à un accès à des services énergétiques modernes, propres et abordables dans 30 communautés pauvres du cercle de Kita au Mali* installed solar water heating systems in 5 health centers / maternities. This allowed an increase in maternity attendance, a reduction of deliveries at home and of expenses for distance care.

## Solar water heating technologies

Solar water heating systems absorb solar thermal energy from the sun by a collector panel/s and make this energy available for water heating thus cost-effectively substituting expensive electrical heating devices as well as pollutants such as primary biomass fuels.

There are different kinds of solar water heating systems depending on how the water is heated and how it is passed to the water tank:

Direct Systems allow water to flow through a panel, heating it directly. They are suitable to small dimension water applications. Indirect systems heat up a sensitive liquid which then exchanges its heat with the body of water. They are suitable to larger size water applications. Active systems use energy to circulate water while passive solar water heaters rely on gravity and the tendency for water to naturally circulate as it is heated. Because they contain no electrical components, passive systems are generally more reliable, easier to maintain, and possibly have a longer work-life than active systems.

A direct-passive system is the simplest and most reliable system, but only suitable to small applications, and it is systems like this that has mostly been applied in EF-projects.

*Water heater*
*Photo: DEM*

Solar thermal systems are relatively maintenance free and only require an inspection of the piping for leaks and the cleaning of the collectors on an occasional basis. In some regions, it may also be necessary to inspect the transfer fluid for freeze protection and to remove the build-up of lime scale that chokes the collector and tank recirculating pipes over time. However, there is a great variation of quality among the used industrial water heaters and the offered service: reasons for this may include: (i) the lack of trained and certified practitioners (particularly in rural regions) for the installation and maintenance of the often imported equipment, (ii) the lack of standardization enforcement, (iii) sometimes the feasibility of import or transport of relatively fragile glass vacuum solar heaters.

Regulatory frameworks have also shown to be instrumental in the diffusion of solar heating water systems. For example, Burkina Faso Law of Finance 2013 included provisions relative to the deletion of custom charges and value added tax on solar energy equipment. In Kenya, Water Heating Regulations (since 2012) state that new buildings with more than 100 litres water requirement have to install solar heating systems, while the existing ones have 5 years to install solar systems covering a minimum 60% of their hot water demand.

## Energy for water purification and treatment

Reducing the water gap will increasingly involve desalination techniques in the many countries suffering from water stress. Desalination is considered the most energy-intensive water production[9] technique. However, depending on the desalination technologies, renewable energies can be used to provide the required energy input. This is the case for solar energy (solar photovoltaic as well as solar thermal) and for wind energy. One example can be found in India: IRENA[10] mentions the village of Kotri, where a reverse osmosis plant produces, from brackish water, 600 liters of water each day, reducing the salinity levels enough to make the water safe for consumption. The plant is run by a solar 2.5 kW power plant.

Besides desalination, there is a lot of interest in solar water disinfection (SODIS), a type of water purification that used solar energy to make biologically contaminated water clean. SODIS uses two components of the sunlight for the water disinfection. The first, UV-A radiation has a germicidal effect. The second component, infrared radiation, raises the water temperature and is known as pasteurisation when the water temperature is raised to 70°C-75°C. The combined use of both UV-A radiation and heat produce a synergetic effect enhancing the efficiency of the process.


*SODIS purification process*
*Illustration: SSWM(19-08-2019), https://sswm.info/sswm-solutions-bop-markets/affordable-wash-services-and-products/affordable-water-supply/sodis*

## Experiences with water purification from the Energy Facility projects

Desalination technologies have not been used in the framework of the Energy Facility where most projects are focussing on smaller scale water services. In some cases, SODIS solutions have been used.

[9] We associate here desalination with water purification, but it could indeed be dealt with in a water production section.

[10] IRENA. Renewable Energy in the Water, Energy & Food Nexus. January 2015

One example is the Community Based Green Energy Project in Kenya where 48 solar water purification systems were installed in 29 schools and 19 health centres, with positive effects on health through the reduction of the cases of water borne diseases. For the whole project, which includes many other components, financial sustainability was supposed to be achieved through beneficiaries' commitment to mobilize and operate a fund that will pay for the future service, maintenance and replacement costs of the systems. For community groups, the fund will be realized through a monthly group savings complimented by regular members' contribution. For the schools the parents will make an annual contribution towards the fund while the health facilities plan to save part of the money from the central and county governments. However, the final evaluation considers that the beneficiaries (especially the school and the women and youth groups) will certainly face difficulty in maintaining the system especially expensive components like batteries that will need replacing after a few years of use. It was expected that the ministry of health would take over maintenance of the more expensive system.

Another project in Kenya, *Solar energy for rural Kenya*, installed 5 decentralized, solar operated energy hubs functioning independently of grid-connection for the supply of renewable energy and clean drinking water. Those hubs provide up to 3.000 litres of drinking water each day. The business model is based on user payment (lease-till-own, monthly/consumption payments). Purified water is sold for 2 (1.8 eurocents) Kenyan shillings/liter. The hubs function as social businesses, with all the profits reinvested in the expansion of the business.

In the Dominican Republic, *Facilidad Sur Solar* supplies 1330 families in 10 communities with purified water from water purifiers. For each site; a local association has been created which is in charge of the maintenance and the collection of future water quotas to the users according to a business plan. A commercial model based on local associations in charge of O&M and monthly fees to end consumers has been put in place, but it has not yet been evaluated.

All three cases show that local community ownership forms a good point of departure for project sustainability when it comes to simple water purification technologies. In the case of the *'Facilidad Sur Solar'* project, the water supply is paid by beneficiaries according to a business plan, maintenance is the responsibility of local associations, and costs of water are 30/40% lower than commercial bottles and water plants. Costs should remain stable (as the treatment plants are powered by PV modules and don't fluctuate with prices of other forms of energy). Benefits are supposed to be affordable by all target groups but an affordability study should have confirmed the actual financial sustainability of purified water sold at a 30% to 40% lower price than bottled one.

Water purification may bring considerable and rapid impact in terms of public health, for relatively low costs. According to the World Health Organization (WHO), more than two million people per year die of preventable water-borne diseases, and one billion people lack access to a source of improved drinking water. Solar based water disinfection can effectively remove pathogenic contamination from the water. However, infectious diseases are also transmitted through other pathways, i.e. due to a general lack of sanitation and hygiene. WHO Studies on the reduction of diarrhea among SODIS users show reduction values of 30-80%.

## Protecting water sources

Water ways offer a renewable energy source that can be exploited by constructing a hydroelectric power plant associated with a small mini-grid to distribute the electricity to the local community. In isolated villages located in hilly and mountainous areas, small hydroelectric facilities are a relevant option to create access to electricity. But due consideration must be taken to safeguard the vital water resources.

For several reasons, many small hydroelectricity projects include a community-based component on water catchments protection. Several components affect the ecological situation of basins:

a) The climate, which determines the quantity of water coming into the watershed across the seasonal cycles, the variation of temperature and precipitation controlling the streamflow and water production.

b) The vegetation, through the benefits brought by the plant cover: The canopy intercepts and retains rainwater, thereby reducing erosion, and reduces wind speed, thereby reducing wind-caused soil loss. The grasses and trees are important as well for the catchment management.

c) The populations have also an important impact on the watershed situation, through for example, deforestation (which reduces the ability of soils to retain water), wetland drainage, urbanization, building of permanent structures in the floodplains, secondary impact of dam construction and exploitation.

Powerhouse
Photo: DEM

## Best practices in community involvement of protecting water resources

Local populations have a great impact on the conservation of the watersheds and their environment and, at the same time, their involvement at community level is absolutely needed for specific activities connected with the protection of the resource: the fight against deforestation which reduces the soil's ability to hold water, the protection of shores, the traditional construction of channels, etc. One important general lesson to draw from the Energy Facility projects is that the contribution of external financing must be realized with great finesse to leave to the population the space for mobilization, initiative and action.

The project, *Programa de electrification rural en Republica Dominicana*, in the Dominican Republic, has established 13 micro-hydro systems, managed by community organizations supported by the project. responsible for the management of the micro-hydro systems and strengthening the technical and administrative capacities to ensure the efficient management of micro-hydro systems. 424 ha have been reforested and greater awareness in communities on the protection of watersheds and natural resources has been created. The manual work carried out by the community on a voluntary basis (including the construction of a water channel) in this context, has allowed for strengthening the cohesion of the community and installing a high sense of ownership.

However, this is not the case in other EF-projects, where this type of voluntary work has been of insufficient quality, and dams, barrages, or canals have needed to be reconstructed after a couple of years. It is therefore important to harmonize the valuation of the workforce provided by the beneficiaries. This must be done on the basis of transparent and realistic detailed criteria, including the quality of the workforce.

Other examples from protection of water catchment areas in the Energy Facility include *Programa de electrificación rural en República Dominicana basado en fuentes de energía renovable* that has reforested 24 ha and has created greater awareness in communities on the protection of watersheds and natural resources. Additional areas within the micro watersheds which had good vegetal cover have been protected. The project *Hydroelectric Energy for 20 Isolated Rural Villages in the Ludewa District,* *Tanzania*, provides access to hydro-energy to the local population and ensures that the natural resources of the Madope catchment basin and of installations area are protected and sustainable practices for farming are introduced. In this context, User committees have been created and have benefitted from awareness raising measures, including on the introduction of anti-erosion measures and reforestation.

**Conclusions**

- Protecting water sources and catchment areas is a must, particularly in the case of projects including a hydropower component.
- When including a local community dimension, be aware that the value of the community labour is a very sensitive element to be considered by project promoters and communicated clearly.

## Conclusions and lessons learned

This discussion paper has examined how synergies exist between increasing access to clean energy and safe water as defined by Sustainable Development Goals 7 (Energy) and 6 (Water).

The majority of Energy Facility projects in this area have focussed on using renewable energy for water pumping. Each type of water pumping technology offers advantages and presents disadvantages. Renewable energy solutions have proven effective either as pure solar or wind energy solutions or in combination with thermal (diesel or) engines in a hybrid solution. Versus the purely diesel/petrol-based solutions, hybrid solutions offer reliability improved reliability and stability of the energy and water services, reduction of pollutions, increased operational life and reduced cost and more efficient use of power, if the relatively high investment can be realised.

Replacing diesel driven water pumps with renewable energy driven electricity pumps offers advantages beyond environmental sustainability, for example, reducing maintenance costs and avoiding the chore of carrying diesel fuel, and the associated hurdles.

Mechanical wind pumping should not be underestimated when conditions are adequate because of the simplicity of the technology that may allow local fabrication and assembly and easy maintenance.

In the framework of the ACP-EU Energy Facility, mini-grid water pumping solutions have generally not proved to be sustainable in the long term. Institutional issues and insufficient tariff adaptation (in terms of cost coverage as well as affordability) seem to be the general causes of these situations.

The need for professional financial management of integrated energy and water access services is generally underestimated. One should not assume that local management committees can be trained, and capacity built to ensure that revenues cover longer term O&M costs as well as replacements of equipment.

The operator needs a sufficient client base to be able to generate revenues for professional management and integrate water services in the mini-grid business model could contribute to revenues, but only if they are priced.

The sensitive question of water pricing needs to be addressed on national level where tariff regulation (where they are not yet regulated) is tracked, and tariffs for kWh and possibly water cubic meter are harmonized. This should also take into account the development levels of the different regions in a given country. Such tariffs should be officially published, so that project promoters could knowingly design projects containing adequate tariffs supporting their sustainability.

Solar water heating and water purification have not played a large role in the EF projects, but they offer low cost and efficient solutions. Water purification may bring considerable and rapid impact in terms of public health.

Protecting water sources and catchment areas is a must, particularly in the case of projects including a hydropower component. This should always include a local community dimension and experience from the ACP-EU Energy Facility shows that when doing so, the value of the community labour is a very sensitive element to be considered by project promoters and communicated clearly to the local community.

## Recommendations

- Whenever possible, projects should support local design, assembly, fabrication of water pumping, water heating, water purification equipment or part of this equipment. Mechanical windmills are a good example.

- Examine, at national level, plans for tariff regulation (where they are not yet regulated) and harmonization taking account of the development levels of the different regions, in order to reduce the price of kWh, and possibly water cubic meter, in the poorest regions. Such tariffs should be officially published, so that project promoters could knowingly design projects containing adequate tariffs supporting their sustainability.

- Systematically involve local communities in catchment protection projects, and precisely analyse and value their labour. When the corresponding works have a direct link with the construction of hydro-electric facilities, the valuation of this labour may be easier to calculate and, according to the business model, it can be paid, for example, in rights to electric connection.

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# Annex

**Table of EF related projects**

| | | | Contribution to SDG6 inidcators | | | |
|---|---|---|---|---|---|---|
| | Contract number | Project title | 6.1 Access potable water | 6.3 water treatment | 6.6 Water related ecosystems | Water heating |
| 1 | 2007/195-954 | Community Managed Renewable Energy Program For Rural Ethiopia | X | | | |
| 2 | 2007/195-957 | Rural Electrification Project in Cabo Delgado Province, Phase III lot 2 | X | | | |
| 3 | 2007/195-959 | Jatropha curcas y la producción al nivel comunitario de energía renovable a partir de biomasa vegetal | | | X | |
| 4 | 2007/195-974 | Somalia Energy and Livelihood Project (SELP) | X | | | |
| 5 | 2007/195-986 | Programa de electrificación rural en República Dominicana basado en fuentes de energía renovable | | | X | |
| 6 | 2007/196-007 | Projet d'Accès universel à l'électricité : Réseaux et Services publics d'électrification dans 20 localités rurales de 5 wilayas (Régions) en Mauritanie : PELEC 20 | X | | | |
| 7 | 2008/195-966 | Solar Energy Solutions for Motive power needs in energy poor Niger Delta communities | X | | | |
| 8 | 2008/195-967 | Promoting use of sustainable energy in Wajir District | X | | | |
| 9 | 2011/023-444 | Development of a Micro-Hydropower System on the Chiung River, Kato, Region No. 8, Guyana | X | | | |
| 10 | 2011/231-578 | Community Based Green Energy Project | X | X | | X |
| 11 | 2011/231-845 | Efficacité énergétique et Optimisation des systèmes d'électrification dans 20 localités défavorisées - PELEC II | X | | | |
| 12 | 2011/232-430 | Renewable energy for local development | X | | | |
| 13 | 2011/232-479 | Solar energy for rural Kenya | | X | | |
| 14 | 2011/263-711 | Rural Energy Activating livelihoods | X | | | |
| 15 | 2011/266-546 | Community empowerment for efficient production use and access of renewable and sustainable energy in rural areas in Malawi | X | | | |

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# Annex

**Table of EF related projects**

| | | | Contribution to SDG6 inidcators | | | |
|---|---|---|---|---|---|---|
| 16 | 2011/268-372 | Support to Efficient Utilization of Alternative Energy Sources to Improve the Livelihood of Pastoral and Agro pastoral Communities in Southern Ethiopia | X | | | |
| 17 | 2011/270-457 | Facilidad Sur Solar | X | X | | |
| 18 | 2011/273-991 | Programme d'accès aux services énergétiques, Commune rurale SAFO (PASE) | X | | | |
| 19 | 2011/280-322 | Best Options for Rural Energy and Access to Light and Electricity (BOREALE) | | | X | |
| 20 | 2012/232-482 | Mise en place de six micro-réseaux électriques photovoltaïques en zone rurale de l'Ile de Mohéli, Comores | X | | | |
| 21 | 2012/283-253 | Electrification des communautés rurales avec des Micro-réseaux de Génération d'Energie Solaire Photovoltaïque Autogérés dans la Région de Zanzan (Côte d'Ivoire) | X | | | |
| 22 | 2014/340-503 | Eco-Electrification Dynamique dans le nord et le centre-nord du Burkina Faso | X | | | |
| 23 | 2014/340-559 | Hydroelectric Energy for 20 Isolated Rural Villages in the Ludewa District, Tanzania | | | X | |
| 24 | 2014/343-720 | JIRO KANTO - Electrification rurale de 12 communes de la région Alaotra Mangoro à Madagascar | | | X | |
| 25 | 2014/344-342 | Solar PV Mini Grids for Two Rural Towns of Areza and Maidma and Surrounding Villages in Eritrea | X | | | |
| 26 | 2014/352-925 | Somali Energy Transformation (SET) Project | X | | | |
| 27 | 2014/352-933 | Amélioration des conditions de vie des enfants et de leurs familles grâce à un accès à des services énergétiques modernes, propres et abordables dans 30 communautés pauvres du cercle de Kita au Mali | X | | | X |
| 28 | 2014/353-458 | Light up our Futures | X | | | |