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WATER and ENERGY for FOOD

Technology Compendium

Innovative solutions for agriculture

Implemented by

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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INTRODUCTION

As we look to the future, innovation remains at the core of addressing the most pressing challenges of our time. Whether it is transforming urban infrastructure, expanding access to knowledge, or managing natural resources more efficiently, innovative solutions are crucial.

In agriculture, these innovations have a particularly profound impact as companies get to scale up technologies that will act as game-changers in overcoming critical issues, such as water scarcity, energy shortages, and food insecurity.

Especially in Sub-Saharan Africa, where these challenges are deeply interconnected, it is important to pursue solutions grounded in the Water-Energy-Food (WEF) Nexus. Recognizing this, the international Water and Energy for Food (WE4F) initiative has focused over the past four years, on supporting innovative technologies that bridge these crucial sectors. By breaking down silos and fostering collaborations across the nexus, WE4F is not only addressing immediate needs but also laying the foundation for long-term climate resilience and food security.

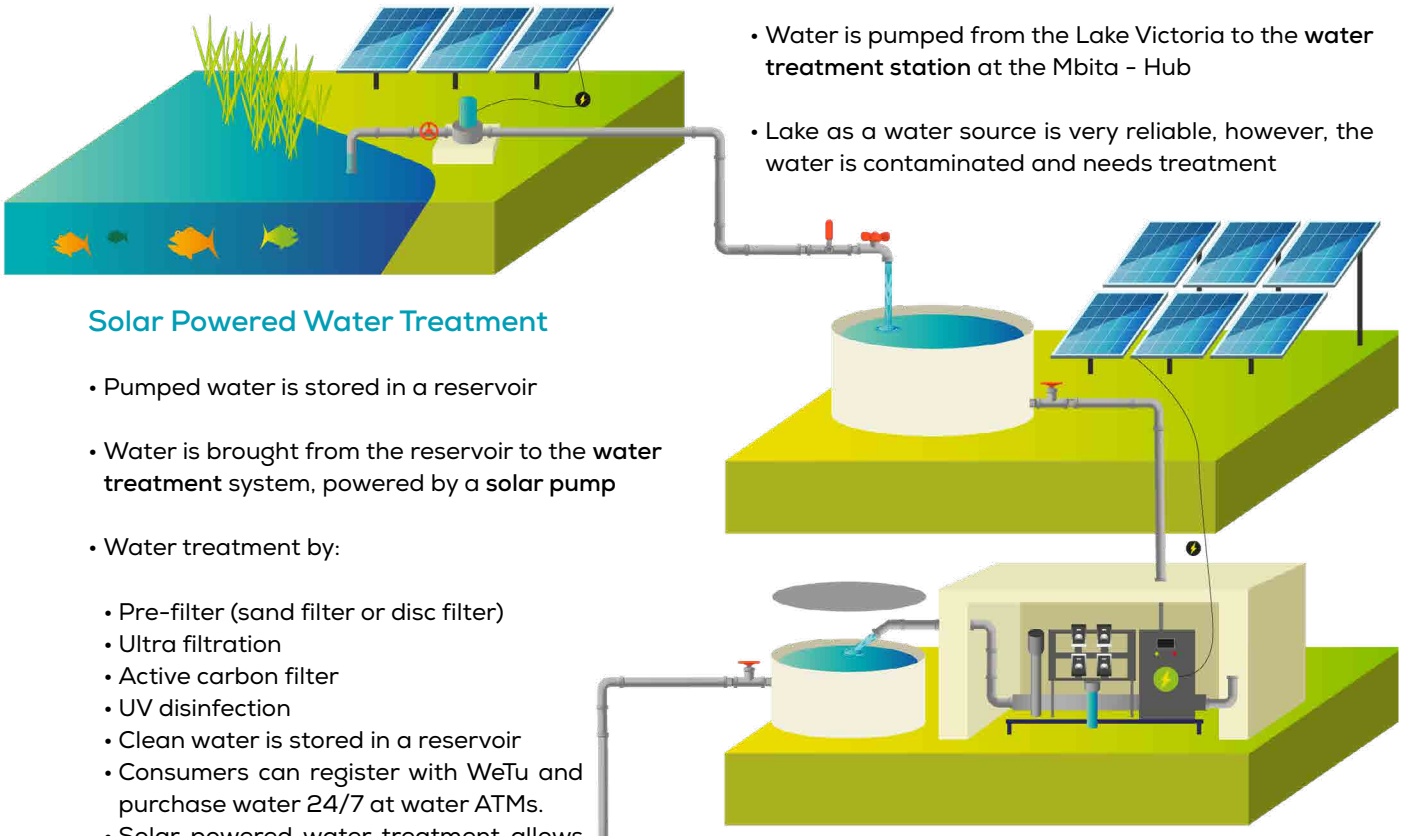
The initiative is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ), the European Union (EU), the Ministry of Foreign Affairs of the Government of the Netherlands, the Norwegian Agency for Development Cooperation (Norad), Sweden through the Swedish International Development Cooperation Agency (Sida), and the U.S. Agency for International Development (USAID). This compendium showcases a variety of technologies in East and West Africa, that were scaled and disseminated by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ).

The technologies highlighted in the following pages range from solar-powered irrigation and cooling systems, to biodigesters and digital tools, all demonstrate the power of innovation in overcoming complex challenges. By bridging different sectors, these solutions have the potential not only to transform agriculture and food systems in Sub-Saharan Africa but also to drive sustainable and efficient change on a global scale.

AGRICULTURE WATER MANAGEMENT & IRRIGATION

Water is fundamental to agriculture, making it a critical resource for global food production. However, the use and management of water within the agriculture sector faces many challenges, a point underlined by alarming statistics. It is complex balance of interests between agriculture, which feeds the world, and water, which give life to people, the environment, and industries. To address this complexity, innovative solutions and technologies are essential to align water use and agricultural practices sustainably and efficiently. From hydroponics in water-scarce regions to solar-powered irrigation systems, these innovations are having a lasting impact on water usage. In this chapter, discover all water-related technologies that WE4F scaled and disseminated over the past years.

Solar Powered Water Treatment and Solar Ice Production

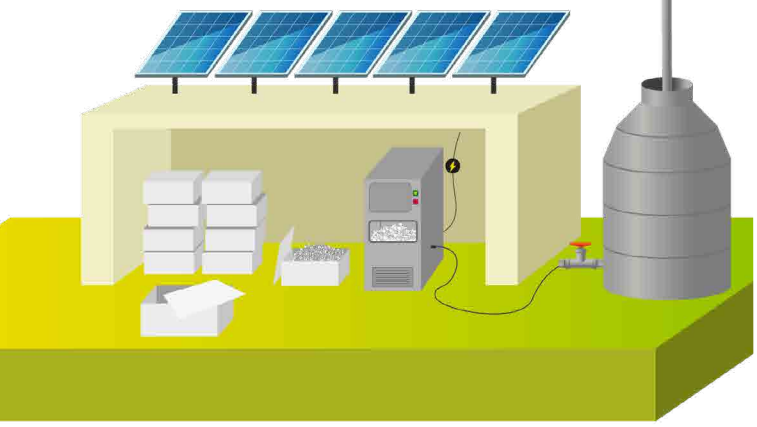


Abstraction of Lake Water with Solar Pump

- Water is pumped from the Lake Victoria to the **water treatment station** at the Mbita - Hub
- Lake as a water source is very reliable, however, the water is contaminated and needs treatment

Solar Powered Water Treatment

- Pumped water is stored in a reservoir
- Water is brought from the reservoir to the **water treatment** system, powered by a **solar pump**
- Water treatment by:
  - Pre-filter (sand filter or disc filter)
  - Ultra filtration
  - Active carbon filter
  - UV disinfection
  - Clean water is stored in a reservoir
  - Consumers can register with WeTu and purchase water 24/7 at water ATMs.
  - Solar powered water treatment allows the usage of lake water for household consumption



Solar Ice Production

- Part of the treated water is used for the production of ice, powered by **solar energy**
- The water flows from a storage tank into the **ice-flake machine**
- Produced ice is sold to fishermen, processors or market women
- Excess solar energy from the WeTu Hub in Mbita is used to produce ice at a very competitive price

Solar powered irrigation - Providing water where there is no rain

What is a solar powered irrigation?

Solar powered irrigation systems consist of electric water pumps that are connected to solar panels. The pumped water is either directed directly to the field or into a water tank from where it is released at a later point in time. This makes water available even in the absence of rainfall.

Most water pumps utilized for irrigation purposes worldwide are powered by engines running with fossil fuels or on electricity supplied from the grid. As energy prices have increased, solar pumps for irrigation have become an economical and environmentally viable alternative.

What are the main features?

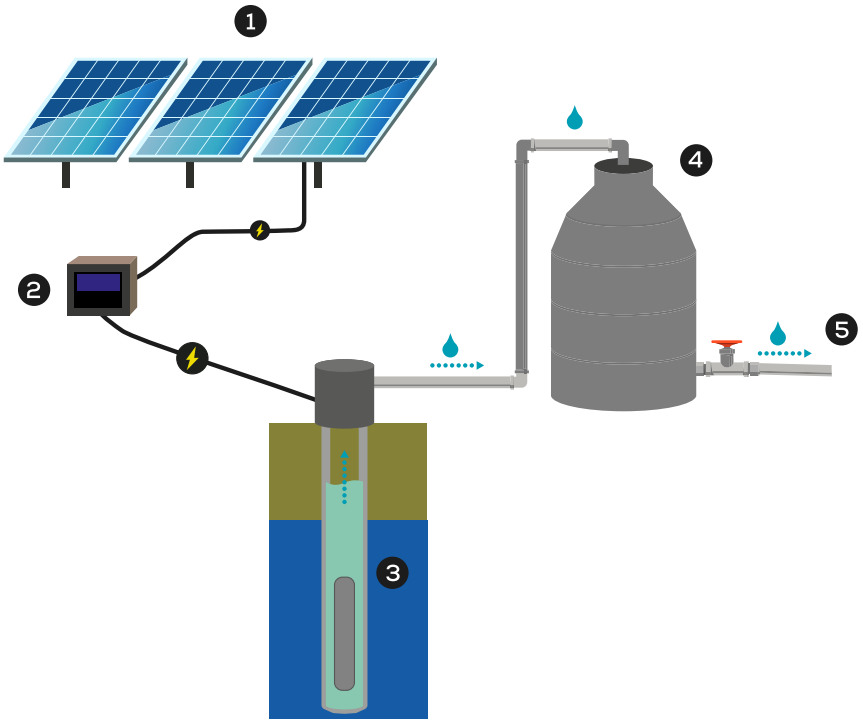
Solar water pumps are available in different sizes. Depending on the depth of the borehole, the water requirement and the solar radiation, a suitable system can be designed. Compared to conventional pumps, the solar alternatives come with higher initial investment costs but have no operational costs. A typical pump for a smallholder farmer with 2 acres of land can pump up to 1500 litres per hour from an 18 m deep well, using 600 Wp of PV. During the hours of sunshine, the water is pumped into a water tank. From there it is distributed to the field when needed. The solar water pumps are ideally used for drip irrigation.

What are common uses?

Solar powered water pumps are used for the irrigation of crops and watering livestock. Under irrigation crops can get the ideal amount of water and yields can be increased significantly, leading to a higher income for the farmers. The effects of climate change, especially droughts and undpredictable rainfalls can be mitigated by the use of solar powered water pumps.

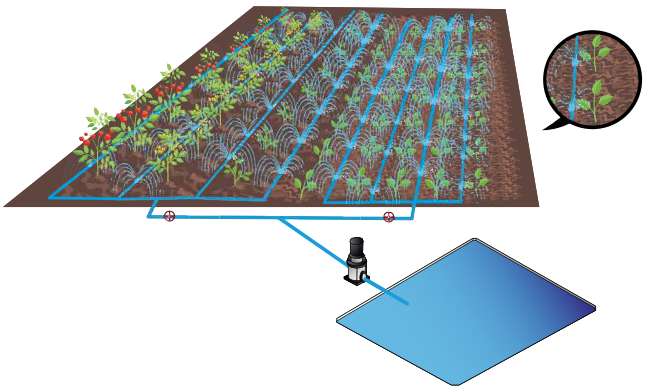
Market development

The market potential for solar powered water pumps in East Africa is high. Pumps are locally produced or can be imported from international suppliers. To tackle the initial investment cost, some companies are offering finance, such as pay-as-you-grow or payment plans, that make the product more accessible to farmers.



1. Solar generator
2. Pump control
3. Solar pump
4. Water tank
5. Irrigation

Laser spray irrigation, solar irrigation and automated irrigation

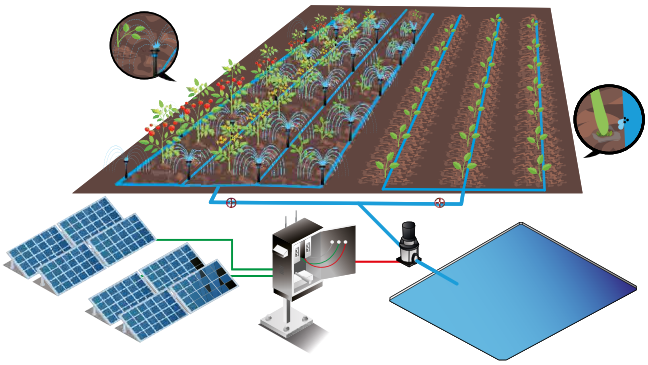


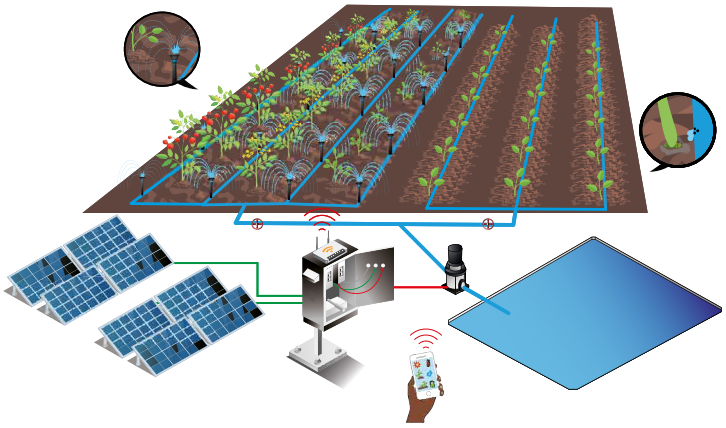
Laser spray irrigation system

- Irrigation of crops using plastic duct:
  - perforated at regular intervals, producing **a rain-like spray** of fine, short-reach droplets.
  - connected to a pump **powered by solar or other energy sources.**
- Operates at **low pressure** and requires less energy than sprinkle irrigation.

Solar irrigation system

- Equipped with a solar pump **powered by photovoltaic solar panels** that generate electricity.
- A **control box** is installed between the pump and the solar panel.
- A control system is installed between the **water source (borehole, etc.)** and the **reservoir** or the plot.
- The installation of a battery or reservoir is optional and enables watering to take place at night or during periods of low sunlight.
- Water is applied to the plot either via an **irrigation network (drip, strip, etc.)** or manually.





Tele-irrigation

- Allows **remote control of the irrigation system** via:
  - a **mobile application** through a signal/call/sms emitted by a cell phone that controls the setting, activation and shutdown of the system;
  - a **relay box** installed between the pump and the solar panel, equipped with a GSM chip, and controlling sensors on the pump or the pipe network.

Hydroponic farming – Doing more with less

What is a hydroponics?

Hydroponic farming is a way of producing crops, such as vegetables or fruits, without soil. Different types of substrate can be used as a growing media, while the nutrients required by the plants can come from various sources, like fish excrement, manure, chemical fertilizers or artificial and organic nutrient solutions. Nutrients are dissolved in the water that circulates through the system, reducing the consumption to a minimum. In hydroponics, the environmental conditions (temperature, light, water, nutrients, pests, diseases) can closely be monitored and controlled, allowing optimal growing conditions, including locations that are not suitable for conventional crop production.

What are the main features?

Hydroponic systems can be constructed with locally available materials, such as PVP-pipes, plant pots and shade nets. Typical growing media include volcanic rock mixed with coco peat, gravel, or peat moss. Local companies can produce artificial solutions to provide nutrients for their systems. An alternative is to experiment with organic substances to tailormake nutrient solutions for specific crops. Systems are scalable in size and complexity and can be used from individual to large-scale level. Hydroponics allow plants to grow under optimal conditions, leading to high yields, low pest and disease rates, and reduced growing time.

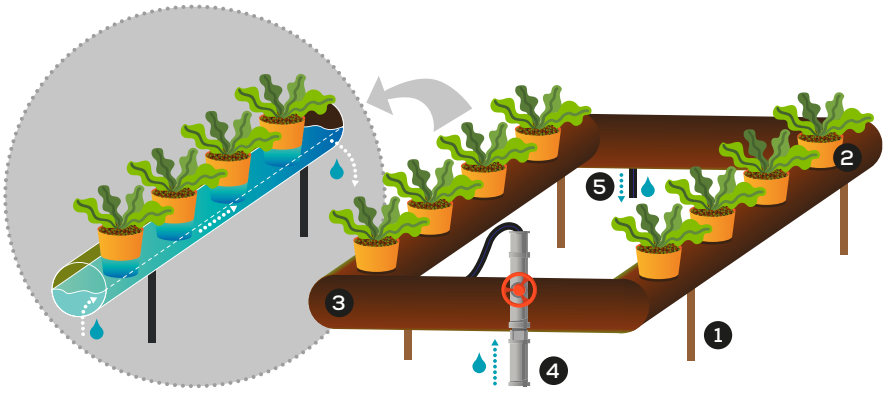
What are common uses?

WE4F's partners use the hydroponic system to produce different high-value and nutritious vegetables and fruits, including Spinach, Kales, Melons, Passion Fruit, Tomato, Courgette, Pumpkin or Chili.

Market development

The market potential for hydroponics in East Africa is high, especially in contexts where conventional agriculture is difficult. Especially in arid and drought-prone regions, hydroponics offers a viable production method. As land and water resources are under increasing pressure, hydroponics is a way of doing more with less.

While do-it-yourself solutions are possible, some companies on the market also provide custom-made systems.



1. Supporting structure
2. Plant pots
3. PVP pipes
4. Water and nutrient input
5. Circulation system

Hydro-powered pump - water pumping without fuel, electricity or emissions

What is a hydred irrigation?

Water that is in motion, for example in rivers, streams or canals, contains energy that can be transformed for other usages. The water wheel pump is a hydro-powered pump. It incorporates a pipe wrapped around a horizontal axle, generating a spiral tube that is fastened to a water wheel. Flowing water causes the wheel to spin, forcing water into the inlet of the tube with each rotation. This results in pressure required for pushing the water to the outlet. The water is delivered directly to the field, or first into a storage tank, from where it is distributed.

What are the main features?

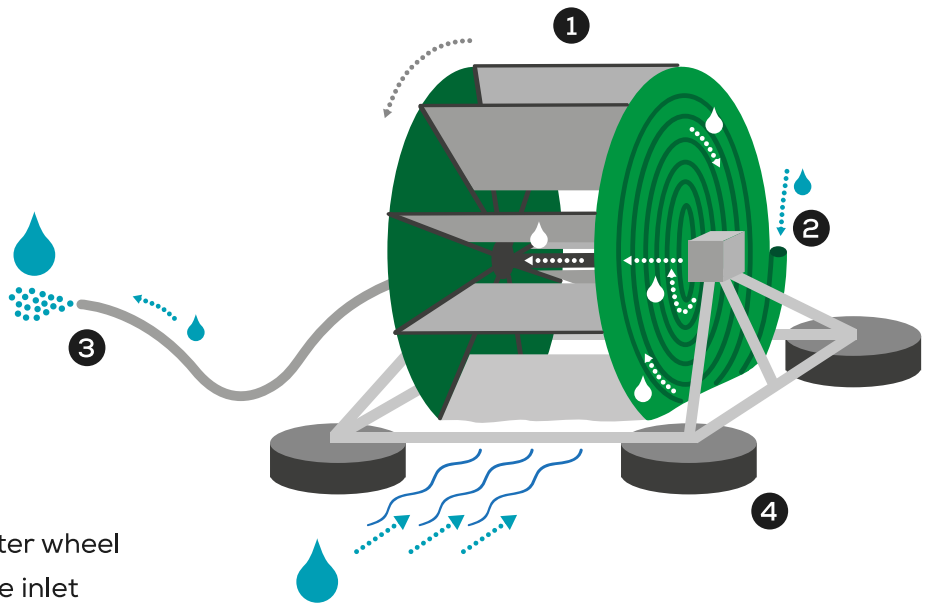
The hydro-powered pump does not need any fuel or electricity, presenting a climate-friendly way of pumping water. In comparison to solar powered pumps, the hydro powered pump can work all through the day. The system installed by WE4F pumps 20 to 40 m^3 per day to an elevation of up to 20 m or a distance of 1 km. The performance of the pump depends on the characteristics of the water source, the higher the flow rate, the higher is the amount of pumped water.

What are common uses?

Hydro-powered pumps are used for the irrigation of crops. Under irrigation, crops can get the ideal amount of water for higher yields and increased income for the farmers. The pump can mitigate the effects of climate change and unpredictable rainfalls, as long as a water source with sufficient flowrate and volume is accessible.

Market development

Hydro-powered pumps, such as water wheel pumps or hydraulic ram pumps are based on long-known mechanic principles, but are mostly produced in an artisanal way. Only a few manufacturers provide their their systems for a larger market. The technology is very sturdy and only consists of mechanical components that are easy to maintain, giving it a high potential for users in rural regions with access to streams or rivers.



1. Water wheel
2. Tube inlet
3. Water outlet
4. Anchoring plates

ENERGY EFFICIENCY AND PRODUCTIVE USE OF ENERGY

Renewable energy, especially solar energy, has a high potential to power agricultural processes more sustainably. If they are used as a part of value addition, they are defined as productive use of renewable energy (PURE). Solar energy can power several technologies including mills, dryers, cold rooms, freezers, and water pumps. Solar energy is either used directly or indirectly by converting it into electricity. If used directly, solar energy can help to dry a wide range of products, from fruits and vegetables to firewood. Converted to electricity, the energy can be used in an even more versatile way to power electric appliances.

PURE has many advantages over conventional energy, including lower operating costs, independence from the electric grid, and little to no greenhouse gas emissions. Additionally, PURE can create new employment opportunities in rural areas, for example in the field of milling, cooling, or drying as a service for others. With the abundance of sunshine in Sub-Saharan Africa, and the decreasing costs for solar components, these technologies have a great potential to transform future agriculture and food systems. WE4F has supported several PURE technologies, some of which are highlighted within this chapter.

Solar powered mill – Giving second grade fruit another life

What is a solar mill?

In agricultural processing, mills are used to break a product into smaller pieces to allow for different uses. Solid materials such as grains or dried fruits can be processed into flour or powders. Conventional mills often operate with a diesel engine, that is inefficient, polluting and has high operational costs. Solar mills are powered by PV-panels and easy and cheap to operate, reliable, properly sized and environmentally friendly.

What are the main features?

The mill installed by WE4F is a hammer mill that crushes the product into smaller pieces by repeated blows of little hammers, until the wanted particle size is reached.

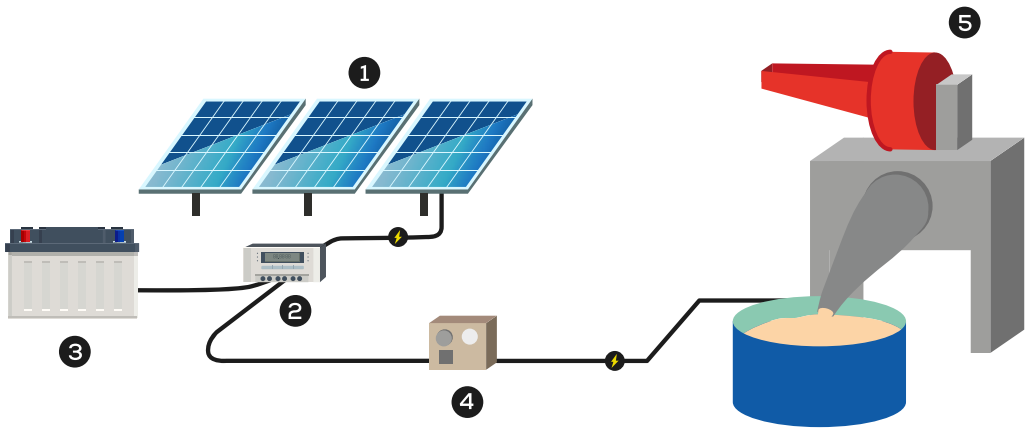
The mill is driven by an electric motor (brushless, 48 V, 1.3 kW), powered by solar energy (2 kWp). The system comprises a battery bank (800 Ah), that allows a continious operation of the mill even under unfavourable weather conditions or during times after sunset. The mill can process up to 500 kg of product per day, and allows value addition to different types of product.

What are common uses?

WE4F's partner uses the mill to produce fruit powders from previously dried pineapple, banana and mango. The partner uses lower quality fruits that do not meet market expectations but still make for nutritious food powders. They can be used to prepare drinks or for cooking. Other usage of the mill is the production of flour from cassava, maize or other grains.

Market development

The market potential for solar milling in East Africa is high. However, manufacturers have to balance cost, throughput and efficiency to meet market needs. Reducing costs by increasing energy efficiency and consumer outreach and education can unlock higher demand. Used for processing of low value food crops (cassava, maize), solar milling does not have high value addition potential compared to other productive use appliances, as market fit and business case are challenging. There are only a few suppliers, including companies in Kenya and Europe.



1. Solar generator
2. Charge controller
3. Battery bank
4. Motor control
5. Milling unit

Solar powered flake ice machine - Cooling agricultural value chains as a business

What is a solar powered flake ice machine?

There is significant food loss in East Africa due to interupted or non-existent cold chains safely store and aggregate agricultural produce. Ice machines are typically powered by either diesel generators or the grid, thus generating high running energy costs and emissions. The solar ice machine uses a photovoltaic system integrated with a conventional ice maker, making it cheaper and more climate-friendly to produce ice.

What are the main features?

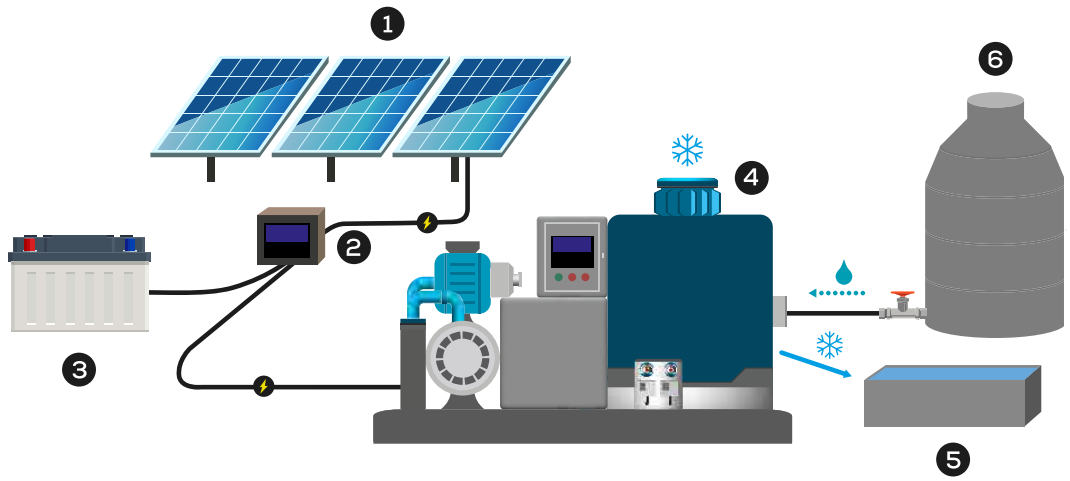
A flake ice machine yields consistently sized ice that is easy to pack, ensuring even and consistent cooling. The flake ice thickness is around 1.5~2.2 mm. The ice making machine has total power consumption of 22.75 kW and can produce up to 5 tons of ice in 24 hours. The system is powered by a 30 kWp solar generator coupled to a battery bank and 3-phase inverter. Optimal insulation helps to keep the ice cold for a long time.

What are common uses?

Flake ice is mostly used for the preservation of fish but can also help to cool other meat types and horticultural products. It can be transported, e.g. on fishing boats, so that the product can be cooled instantly and during transit to markets. With the dimensions of the ice flakes, the surface area in contact with the product is high, supporting a quick and uniform cooling. As the flake ice melts, it helps to moisten the product, keeping its quality high.

Market development

The production and sale of flake ice is a profitable business in regions where demand from, e.g. fisher communities, is high. Different sizes of conventional flake ice machines exist in the market, designed to be powered with electricity from the grid. Solarizing these conventional machines requires the introduction of inverters and batteries, resulting in large intitial investment cost. However, payback periods can be short due to the low running costs. A number of companies are slowly getting into the market with specialised ice machines that are designed for the use with photovoltaics.



1. Solar generator
2. Controller & inverter
3. Battery bank
4. Flake ice machine
5. Flake ice
6. Water tank

Solar cold room – Optimizing resource efficiency through cooling

What is a solar cold room?

Cold rooms are refrigerated spaces that provide chilled storage for large quantities of agricultural goods. A solar cold room is powered with electricity generated through photovoltaic panels. In a containerized solution, the room is housed in a modified standard overseas container (20-foot or 40-foot) making them mobile and robust for the installation and use outdoors.

What are the main features?

The containerized solar cold storage installed by WE4F is housed in a 20-foot container with PV-panels installed at the top. It has an inner storage volume of 21 m³ and a temperature range that can be set from 4 °C to 20 °C, depending on the product to be cooled. It consists of 7 kWp PV that powers the cooling system and distribution pumps. A themal ice storage combined with batteries allow the functioning of the system also at hours without solar irradiation.

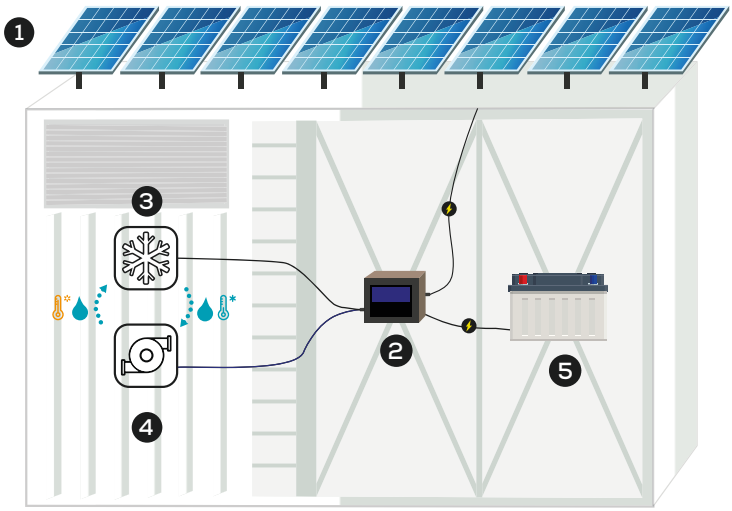
What are common uses?

The cold storage retains the quality of agricultural goods and increases their shelf life. It can be used for fruits, vegetables, flowers and other perishable commodities along the whole value chain. The cold storage helps to reduce post harvest losses, especially during peak seasons at field, cooperative or market level.

Market development

The market potential for solar cooling in East and West Africa is high. Large amounts of agricultural products are lost post-harvest due to a lack of cooling facilities. Cooling helps reduce food losses and by extension, resource use inefficiencies.

Today, a large number of manufacturers worldwide provides containerized cold storage solutions, offering slightly different approaches and business models. Accessibility to the systems can be improved by adapted financing mechanisms such as rental solutions, pay-as-you-cool or cooling as a service. Also, Do-It-Yourself solutions are available, that promote the use of locally available components for the construction of cold storage.



1. Solar generator
2. Controller & inverter
3. Cooling unit & ice storage
4. Pump
5. Battery bank

Solar milk cooling – Reducing milk spoilage through cooling

What is a solar milk cooling?

Raw milk is a highly perishable product, the quality of which deteriorates sharply if not further processed through cooling or heating. In rural areas, spoilage of milk is high due to the lack of cooling facilities. Conventional cooling systems are connected to the grid which may not be available, reliable or accessible due to high electricity prices. A solar milk cooling system is based on solar panels that generate electricity to run the system, making it a reliable and environmentally friendly alternative. Different solutions for either direct or indirect cooling of milk exist.

What are the main features?

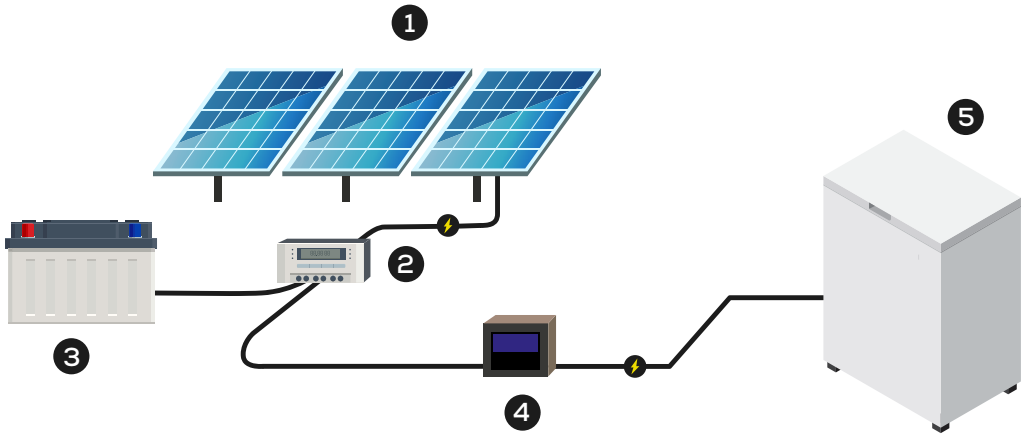
The system managed by WE4F is a freezer that is connected to solar panels. It works on direct current and has a special unit that controls the compressor speed and temperature in the freezer depending on the availability of solar energy. In the freezer, blocks of ice are produced that are placed into a special compartment and inserted into an insulated milk can. 600 Wp of PV is connected via a charge controller with two 65 Ah batteries and the cooler. 16 kg of ice can be produced daily, sufficient to cool down 40 liters of milk and keep its temperature below 10°C for at least 12 hours. The freezer can store 24 ice blocks of 2 kg each which also deals as a thermal energy storage, allowing the systems many days of autonomy.

What are common uses?

Milk can be cooled over night or during transportation to markets, thereby allowing for better prices as a result of increased milk quality. Through refrigeration, the quality of evening milk can be maintained to be sold together with the morning milk, creating an additional line of income.

Market development

The solution managed by WE4F was developed by the University of Hohenheim. It utilizes commercially available equipment coupled with an adaptive control unit for its conversion to a smart ice-maker. While the system is technically viable, the initial costs are still high if all parts are imported. Current developments focus on a Do-It-Yourself approach, which uses locally available components.



1. Solar generator
2. Charge controller
3. Battery bank
4. Control unit
5. Freezer

Wood seasoning shed for enhanced energy efficiency

What is a wood seasoning shed?

There is an inverse relationship between the moisture content of wood fuel and its calorific value. The higher the wood fuel moisture content, the lower the calorific value and vice versa. Low wood fuel calorific values translate to higher wood fuel consumption for the same level of output. A low-cost, high efficiency seasoning shed for drying fuelwood is critical in reducing the moisture content of wood before it is fed into boilers for thermal energy generation.

What are the main features?

The developed 1000 m^3 capacity greenhouse tunnel type wood fuel seasoning shed is constructed of light gauge hollow tubes or lack pipe metal, heavy gauge and UV-treated polythene cover sheets. The seasoning shed is equipped with sensors to monitor environmental parameters such as humidity, wind and temperature. A digital wood moisture meter is provided to track wood seasoning progress. A special Android-based monitoring app is used to capture and track the drying process.

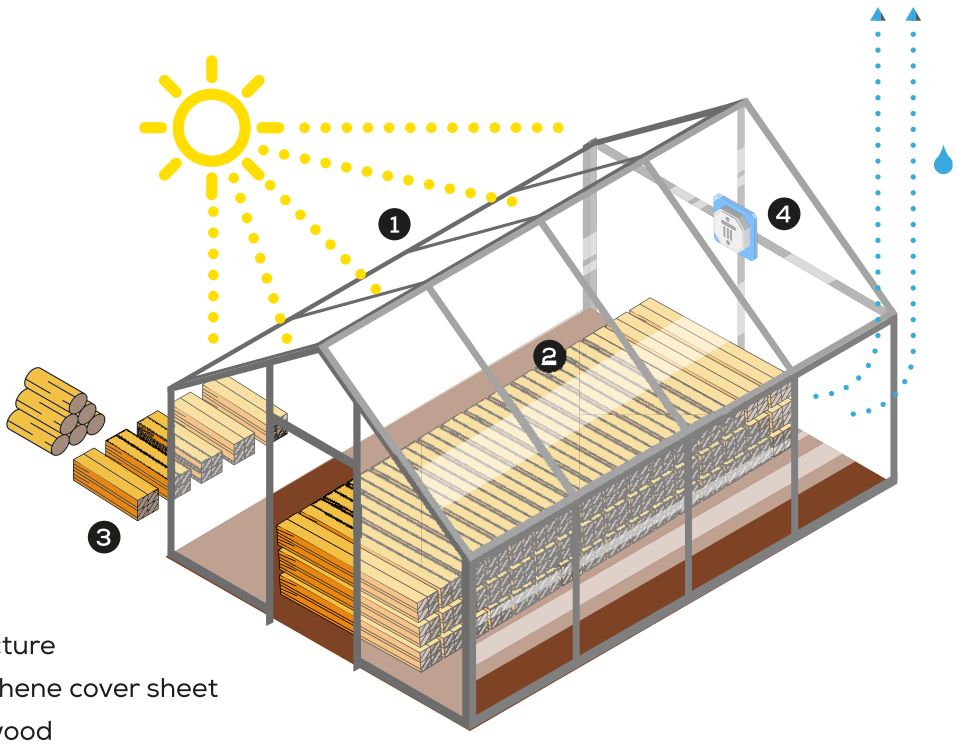
What are common uses?

The low-cost, high efficiency fuel wood seasoning shed provides a cheaper and effective alternative towards the improvement of fuelwood energy density and flammability. This leads to less fuelwood consumption, saving energy costs and reducing the number of trees cut down.

Market development

Wood seasoning sheds have been in existence for a long time and are commonly used in tea factories to reduce their biomass fuel consumption, water use for steam generation, deforestation and carbon emissions. However, most of them are expensive, ineffective and serve as wood storage instead of a dedicated dryer.

The commercial viability of this newly developed low cost, high efficiency fuel shed is high and can be easily adopted by tea factories that rely on the combustion of fuelwood. Once piloted, several other tea factories opted for similar fuelwood sheds.



1. Structure
2. Polythene cover sheet
3. Firewood
4. Sensors

Solar drying and dehydration to prevent post-harvest losses

What are solar dryers and dehydrators?

Solar dryers and dehydrators are technologies that enable the reduction of the moisture content of agricultural goods, using solar energy. These structure keeps the product safe from dust, rain and insects, while achieving higher drying temperatures. This approach is more advanced and advantageous than conventional drying in the direct and open sun. Solar drying and dehydrators technologies range from tunnel dryers, drying boxes, cabinet dryers, or greenhouse dryers.

What are the main features?

Solar dryers and dehydrators are available in a variety of forms and sizes. The top of the dryer is made of a transparent material that allows the sunlight to pass through. The inside surface is usually black, to absorb the incoming solar radiation and heat up the drying chamber. Solar dryers have a controlled air flow that removes the humid air from the inside of the chamber. When a product is placed into the dryer and exposed to the sun, it will heat up and reduce its moisture content. Depending on the product, the moisture content is reduced from about 90 % to 10 %.

What are common uses?

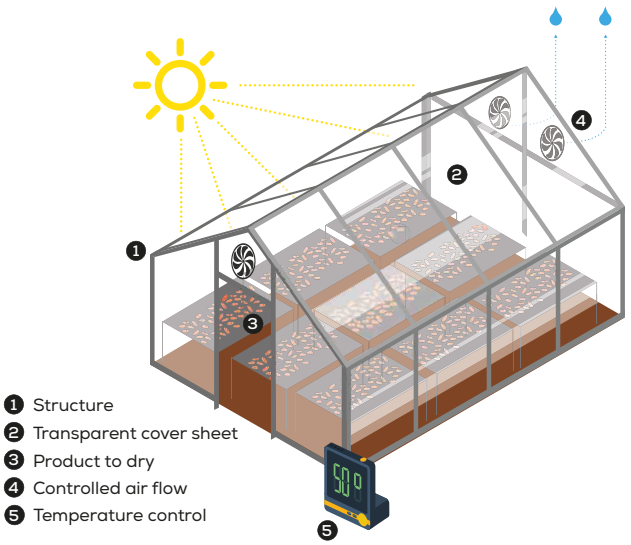
Solar drying, which is powered entirely by solar energy, helps preserve food by reducing moisture content and the growth of bacteria, yeasts, and mold. In a greenhouse or other type of dryer, products are also protected from dust, rain and insects. Perishable products such as mangoes or pineapples can be made into dried fruit. Other common products that can be dried include cassava, chilies, tomatoes, and a variety of herbs. Once dried, they can be preserved for several months and help reduce post-harvest losses.

What are the different Technologies?

The following graphics show different models of solar drying technologies supported and disseminated by WE4F in East and West Africa.

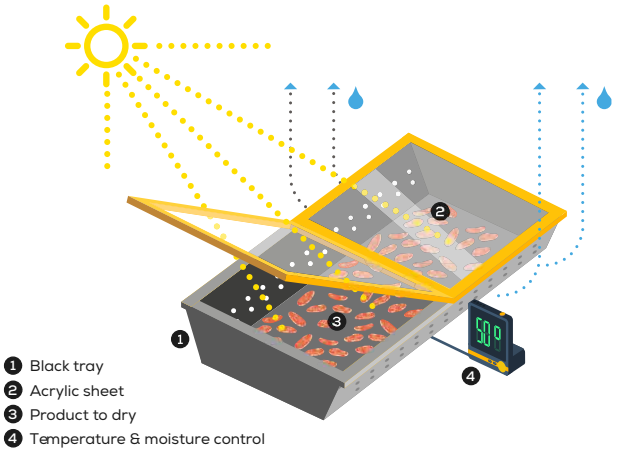
Greenhouse Solar Dryer:

This graphic illustrates the solar greenhouse drying process. The greenhouse features shelves for arranging the fruit, vegetables or herbs and glass windows that allow sunlight to enter, heating the interior. This natural, energy-efficient method ensures effective drying and long-term storage.



Solar Dehydrator Box:

This dehydrator tested by WE4F in East Africa consists of a black tray, covered by acrylic sheets. Each tray provides a drying area of 0.35 m², allowing the drying of around 2 kg of fresh product.



Solar Dehydrator:

This solar dryer features 12 trays, each 1m², offering a total drying surface of 12m² and a capacity for 80-100 kg of fresh food. The photovoltaic panel captures sunlight, converting it into electrical energy, which is stored in a battery and used to power a fan. This fan pushes cold air through a thermal collector, where it's heated by sunrays captured by wavy baffles. The heated air is directed into the drying cabin, where it absorbs moisture from the food, which can lose 60-70% of its weight. The humid air is then expelled by the aerator.

1 Ventilator 2 Charge controller 3 Solar panel 4 Thermal collector 5 Aerator

6 Doors 7 Insulated wall panels 8 Trays 9 Deflector

Market development

The market potential for solar dryers and dehydrators is high in regions with agricultural production and a high number of sunny days. The technical basics are well assessed and different products in type and size are available on the market. Most of the dryers can be constructed with locally available materials. Their high drying efficiencies and low-operating costs have led to a rise in demand for them in agricultural processing. However, their dependence on strong and direct sunlight brings a certain risk to the operation, especially for bigger processing companies.

CIRCULAR ECONOMY AND BIOGAS

Farm inputs, such as energy, fertilizer, and animal feed, often present the largest share of production costs in agriculture. Particularly fertilizers are often imported from outside Africa and are vulnerable to external shocks, like inflation, and rising fuel prices and even violent conflicts in producer countries. To counteract this development, a circular economy approach aims at promoting, reducing, reusing, recycling, and recovering materials in production, distribution, and consumption processes. This ultimately ensures sustainable resource management, which promotes economic prosperity and environmental quality. In this sense, WE4F has supported several technologies that transform wasted by-products into valuable farm inputs, including organic fertilizers, animal feed, biogas, or briquettes, through processes involving black soldier flies, composting, biodigesters or hydraulic presses. Discover some of these technologies in the following chapter.

INNOVATIONS FOR AGRICULTURE

Processing agricultural waste into organic fertilizers

Regenerative agriculture has enormous potential to transform agriculture systems in Africa to increase carbon sequestration in soils, to boost profits for farmers, and to develop greater resilience to a changing climate. Particularly organic fertilizers provide a wide range of benefits. These include improved soil health, reduced GHG emissions, carbon sequestration, biodiversity increase, reduced ground and water pollution and increased smallholder incomes.

What is an organic fertilizer?

Organic fertilizers are made from natural materials and provide nutrients for an enhanced plant growth. They can be produced based on plant residues, bone meal, manure, animal waste from food processing plants or others. By upcycling organic wastes into a useful product, organic fertilizers are a perfect circular economy solution.

What are the main features?

The source material of organic fertilizers consists of residues or by-products from agricultural production. These can include rice husks, the peel of fruits or animal manure. The preparation usually includes processes like drying, crushing, composting, pyrolising, pressing or pelletizing, depending on source material and final form. Once applied on the field, the organic fertilizers bring many advantages, ultimately increasing the yield. Some fertilizer types contribute to improving soil structure, texture and aeration, thus increasing the soil water retention capacity. Some organic fertilizers are even carbon negative. Their application stores carbon in the soil, making them a climate-change mitigation measure.

What are common uses?

WE4F's partners sell their products to a wide range of farmers, including small scale and export-market farmers in their respective countries. The fertilizers are available as biochar, top dressing and foliar and can be used for growing fruits, vegetables, food crops and commercial flowers.

Market development

The market potential for organic fertilizers in East Africa is huge due to its economic viability and environmental sustainability, especially in light of recent price-increases of inorganic fertilizers. Organic fertilizers provide a suitable alternative. However, awareness needs to be created for farmers to understand the benefits of the product and its application. Facilities should also be set up across the region for local production of the fertilizers, to improve access by farmers, support local value addition and to further manage agricultural waste.

INNOVATIONS FOR AGRICULTURE

Biomass Briquettes - From agricultural waste to eco-friendly biofuel

What are biomass briquettes?

Biomass briquettes are made from organic waste. Biomass is collected, crushed, dried and then pressed together under high pressure. The briquettes can be burned for cooking, heating or for thermal and electricity generation. They are an environmentally friendly alternative to charcoal or firewood.

What are the main features?

The briquettes can be of two types; carbonized and non-carbonized to substitute charcoal and firewood respectively. They are mainly made from sawdust, groundnut husks, sugarcane bagasse, charcoal dust, rice husks or other agricultural waste, depending on the seasonality and availability of by-products. Biomass briquettes are technically a renewable form of energy, which only release the same amount of carbon that they had previously sequestered from the atmosphere. Being an alternative fuel to charcoal and firewood, biomass briquettes help to reduce deforestation and emission of CO_2.

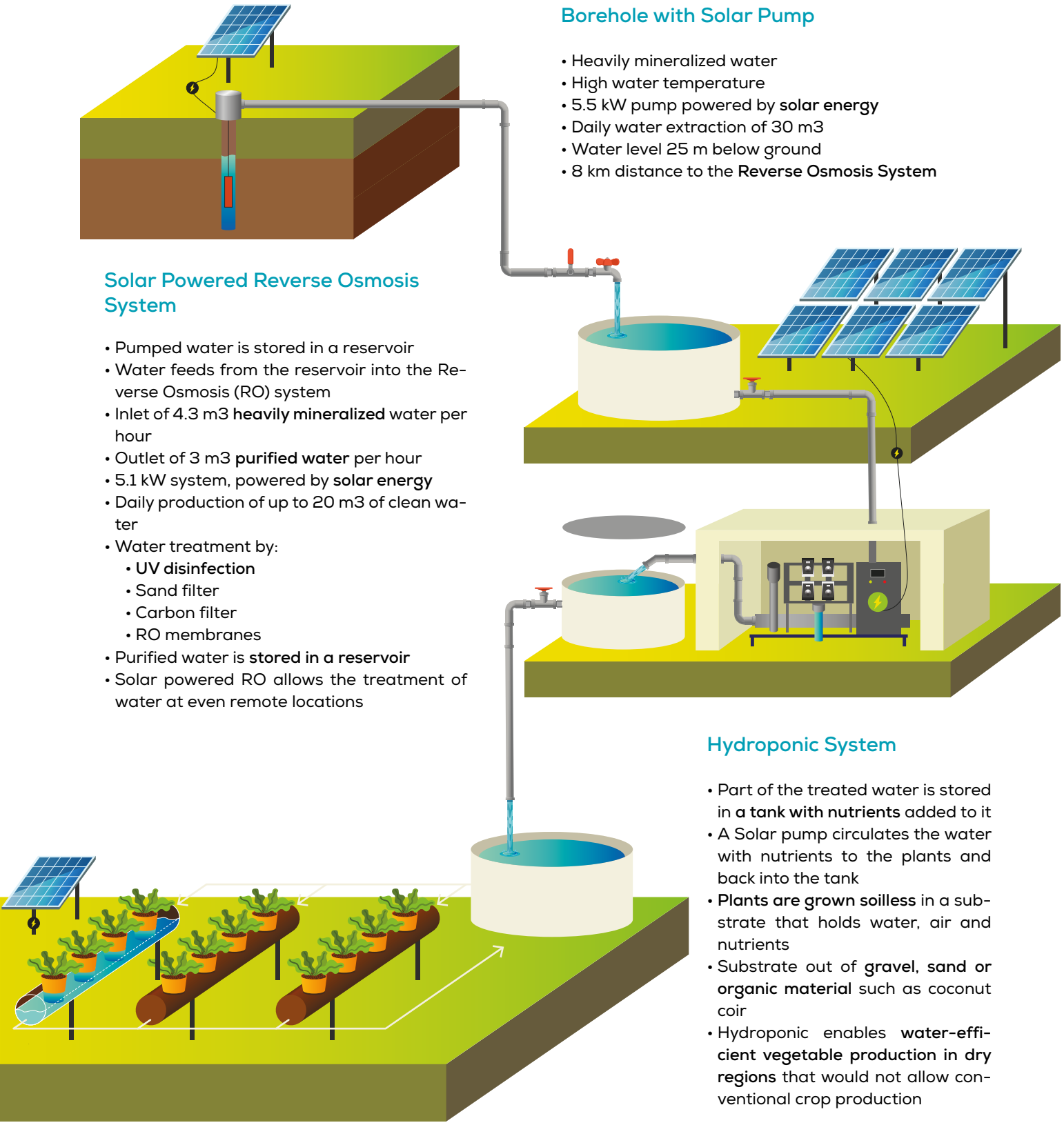
What are common uses?

Biomass briquettes are used for industrial and domestic consumption, but also in schools, hospitals or hotels. In households they are mostly used for the purpose of cooking, while in schools, hospitals and hotels they are also burned for heating or hot water. In industries, e.g. driers in the tea sector can be powered by the briquettes.

Market development

Increasing populations, expanding economies and a lack of regulation have led to increasing fuel prices and shortages. This often hits vulnerable businesses and households hardest. As a consequence, the demand in alternative fuels has risen. Governmental programmes and laws aiming to decrease deforestation have also pushed the demand for alternative fuels for heating and cooking, With the source material being agricultural waste, the prices per calorific value are cheaper than charcoal or firewood, presenting a good business case. However, the limited knowledge about the product and consumer preferences are still hampering a large-scale application of biomass briquettes.

Solar Powered Reverse Osmosis and Hydroponic Farming



Borehole with Solar Pump

- Heavily mineralized water
- High water temperature
- 5.5 kW pump powered by **solar energy**
- Daily water extraction of 30 m3
- Water level 25 m below ground
- 8 km distance to the **Reverse Osmosis System**

Solar Powered Reverse Osmosis System

- Pumped water is stored in a reservoir
- Water feeds from the reservoir into the Reverse Osmosis (RO) system
- Inlet of 4.3 m3 **heavily mineralized** water per hour
- Outlet of 3 m3 **purified water** per hour
- 5.1 kW system, powered by **solar energy**
- Daily production of up to 20 m3 of clean water
- Water treatment by:
  - **UV disinfection**
  - Sand filter
  - Carbon filter
  - RO membranes
- Purified water is **stored in a reservoir**
- Solar powered RO allows the treatment of water at even remote locations

Hydroponic System

- Part of the treated water is stored in **a tank with nutrients** added to it
- A Solar pump circulates the water with nutrients to the plants and back into the tank
- **Plants are grown soilless** in a substrate that holds water, air and nutrients
- Substrate out of **gravel, sand or organic material** such as coconut coir
- Hydroponic enables **water-efficient vegetable production in dry regions** that would not allow conventional crop production

Desalinization for water and food security

What is a Solar Powered Reverse Osmosis?

Reverse Osmosis (RO) is a water purification process that filters out unwanted molecules and particles such as chlorine, salt, dirt or microorganisms. The technology uses a partially permeable membrane and applied pressure to purify water. Energy is needed to operate the system, mainly to power the different pumps and electronics. Conventional systems that operate off the grid, need a diesel generator to power the RO, causing high CO2-emissions, noise and operating costs. In Solar Powered Reverse Osmosis, the energy is generated by solar panels - a clean alternative to diesel.

What are the main features?

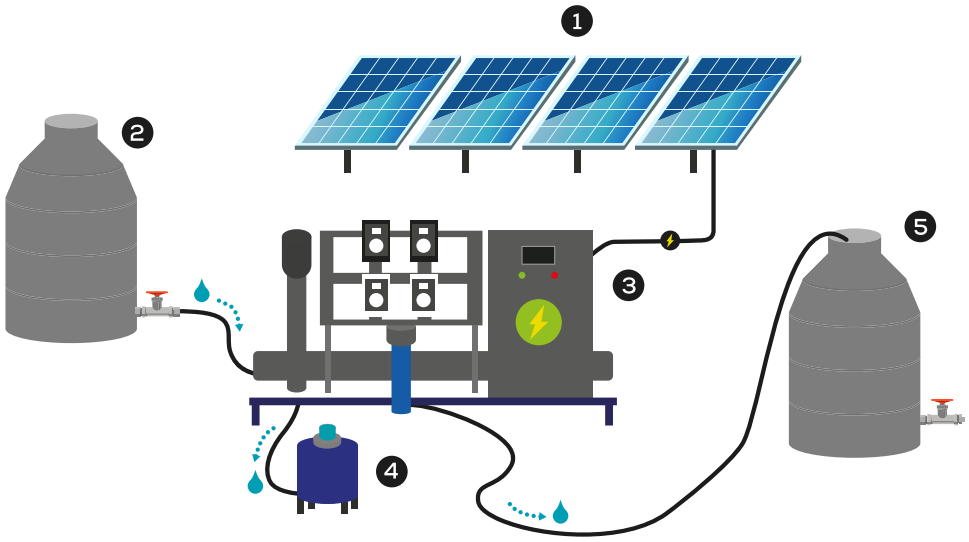
Water from the sea, brackish water or groundwater with high salinity levels cannot be used directly for agriculture or human consumption due to their high content of minerals. Other water sources, such as rivers or lakes might be polluted and unsafe to use. RO can purify water from such sources and bring the quality up to drinking water standards recommended by the World Health Organization. The system installed in Northern Kenya can produce up to 20 m^3 of clean water per day, consuming 1.5 kWh per m^3. The energy is provided by 32 panels (7.4 kWp).

What are common uses?

Besides treating water for human consumption, RO can be used for agricultural purposes. This includes production of fresh water for irrigation in highly efficient farming systems, like hydroponics, or the use of cleaned water for the production of ice, that can be used for the cooling of agricultural products.

Market development

The Solar Powered Reverse Osmosis Technology is technically proven, reliable and suitable especially for remote off-grid areas that only have water of minor quality. There are several established manufacturers, while a number of startups are innovating the market. Solar Powered Reverse Osmosis Systems are adapted to different types of raw water and amount of daily treated water.



1. Solar generator
2. Raw water
3. Reverse Osmosis System
4. Concentrate
5. Fresh water

INNOVATIONS FOR AGRICULTURE

Biodigesters – Transforming organic waste into biogas and slurry

What are Biodigesters?

Biodigesters are technologies designed to manage organic waste, transforming it into biogas and nutrient-rich bio-slurry. This process involves breaking down organic materials, such as animal manure, food waste, and agricultural residues, in an oxygen-free environment. Biodigesters provide a sustainable solution for waste management, energy production, and soil enrichment, making them highly beneficial for small to medium-scale operations, among others in Sub-Saharan Africa.

What are the main features?

Biodigesters work through a biological process called anaerobic digestion, where microorganisms break down organic material in the absence of oxygen. Organic materials get into an oxygen-free chamber where the processes take place. The biogas produced rises to the top of the biodigester and is collected in a storage chamber. The biogas typically consists of about 50-70% methane, 30-40% carbon dioxide, and trace amounts of other gases. The solid and liquid residue left after digestion is known as bio-slurry. This by-product is rich in nutrients like nitrogen, phosphorus, and potassium, making it a good organic fertilizer. Biodigesters come in various sizes and designs, from small household units to larger systems suitable for farms or communities. They can be constructed using locally available materials such as bricks, concrete, or plastic. Once installed, biodigesters have low operational costs, making them an affordable and sustainable technology for rural communities.

What are common uses?

In rural households, biogas produced by small-scale digesters is used as a clean and efficient fuel for cooking, reducing reliance on traditional biomass fuels like firewood and charcoal. Medium-scale biodigesters can produce sufficient biogas for combustion to generate heat or electricity, which can power homes, schools, or small businesses. The bio-slurry that is produced as a by-product by biodigesters is a valuable organic fertilizer that enhances soil health and improves crop productivity.

Besides providing different outputs as listed above, biodigesters also help manage and reduce organic waste, contributing to cleaner and healthier living environments.

Market development

The market potential for biodigesters in Sub-Saharan Africa is high, particularly in areas with significant agricultural activity and limited access to other sources of energy. While the adoption of biodigesters is growing, challenges such as initial investment costs, need for technical knowledge and maintenance must be addressed to ensure broader uptake and long-term sustainability.

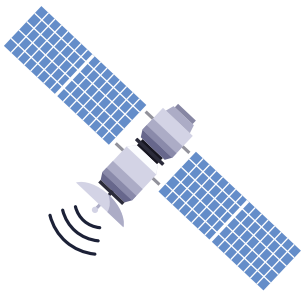
DIGITAL INNOVATIONS

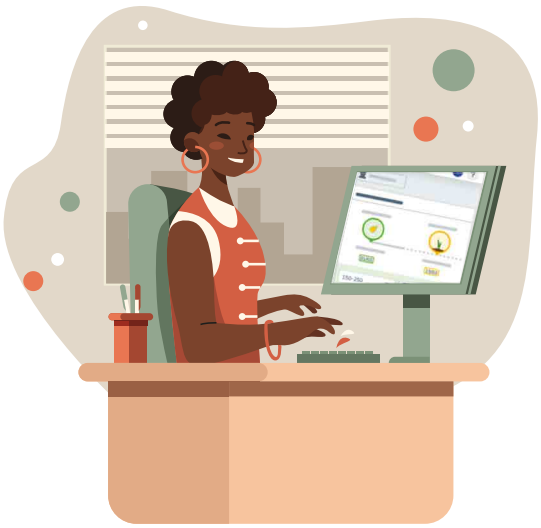
In a world that is more interconnected than ever, digital tools have become indispensable when navigating daily life, managing complex processes, and building connections across boundaries. In agriculture, digitalization plays a pivotal role in ensuring sustainable food production and security amidst global challenges. Digital innovations – from IoT-enabled irrigation to digital weather forecasting – are not only enhancing the productivity of smallholder farmers, but are also reshaping entire communities. This chapter delves into the groundbreaking digital solutions supported by WE4F, highlighting their impact on sustainable agriculture and food systems.

Mobile application for accurate weather forecasts

Ignitia has developed a highly accurate **weather forecast model** that helps farmers plan their farming activities such as **sowing, fertilizer application, spraying, and harvesting** at the best possible time.

- A **48 hour forecast message**, specific to the subscriber's location, is **delivered daily via SMS.**
- Information on weather parameters such as **rain, timing of rainfall, intensity of precipitation, temperature, humidity, wind speed,** among others precisely for locations within a 9 km radius, is provided.
- The forecast messages use key words which are **user-friendly** and constructed in a way so that low-literacy subscribers can extract the information with little or no training.
- The forecast also features **monthly and seasonal predictions** including details surrounding the likelihood, timing and intensity of weather phenomena. These messages are sent via sms, WhatsApp, mobile apps, and APIs.
- Ignitia has three main products: "**Iska**" (rainfall forecast), "**CSA**" (climate smart advisories), which is designed for smallholder farmers and "**Ojo**" (mobile and web intelligence platform), which is aimed at actors in agricultural food systems.





The digital platforms "Porc'Ivoire" and "Pharmanimal"

Veterinary services have access to conclusive data to improve knowledge of the animal's health, monitor the spread of diseases and plan emergency interventions.

In 2023, the Ivorian company Grainotech launched two digital platforms (also accessible on apps via smartphones) that provide inclusive access to profitable markets and veterinary services.

Porc'Ivoire offers online sales of pork meat, connecting pig breeders and farmers in Côte d'Ivoire to buyers and consumers without going through intermediaries. A transport service is integrated to ensure delivery. There are 3 tabs:

1) **The store:** which is the e-commerce portal for sales.

2) **A forum:** which enables farmers to share best practices, formulate the pigs' diet and access advice on emergency precautions.

3) **FarmersPay:** to manage mobile payment for livestock product purchases.

Pharmanimal offers an online remote veterinary consultation service. The platform also aggregates all the information needed to provide the most relevant solutions for optimizing the performance of livestock farms. There are 4 tabs:

- **Online consultation:** make an appointment and consult a veterinarian.
- Issue **digital prescriptions** and **treatment protocols remotely.**
- **E-pharmacy:** antibiotic delivery by drone.
- **Knowledge** of general the **animal health situation** in the locality.

Smart metering and process monitoring - Optimization of water and energy consumption in tea factories

What is smart metering and process monitoring (IOT)?

Smart metering helps to capture data on a real-time basis to document resource utilization at factory and process scale. Process monitoring on an Internet of Things (IoT) platform enables the monitoring, verification and optimization of efficient water and energy use. The integrated system is used in tea factories as well as other agro-processing facilities to improve resource use efficiencies.

What are the main features?

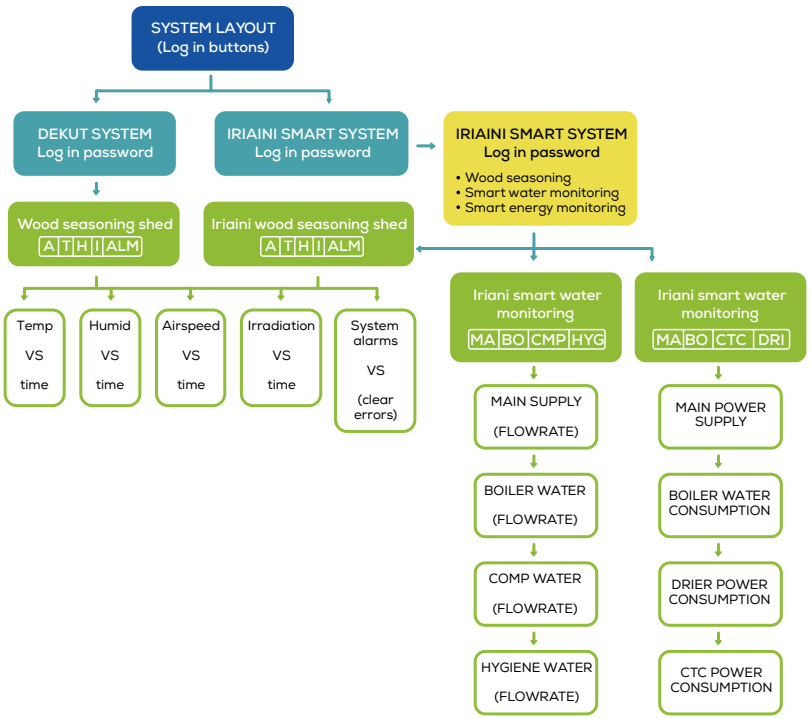
The IoT-based energy and water management system for factories helps to control different equipment wirelessly. Process data is collected by sensors and processed to regulate use by machinery. In tea factories, fans are controlled according to the humidity level in the withering house. Lamps are switched on/off based on light intensity. The water distribution is based on real-time demand. With learning capability through integration of Artificial intelligence (AI) the system will have both predictive and prescriptive capabilities.

What are common uses?

The IoT platform is the central data repository and decision-making engine and driver for wood seasoning shades and smart metering systems installed at tea factories. The system optimizes the water and energy-resource utilization efficiencies of different processes in tea production.

Market development

The Internet of Things is a field that has evolved due to the convergence of multiple technologies, including ubiquitous computing, commodity sensors, increasingly powerful embedded systems and machine learning. Developing customized IoT solutions for tea factories is expected to introduce technical, economical and environmental benefits to the overall production processes. In the tea factories, it has helped to save on costs and reduce the demand for fuel wood.



Eagles energy management portal- Energy management for improved energy efficiency in agrifood processors

What is the Eagles Energy Management Portal?

Energy and water resources are critical for food security and agricultural productivity. However, the agricultural sector is lacking proper systems and skilled labour to oversee the management of these resources. The Eagles Energy Management Portal is a Python-based energy data analytics platform for energy management and energy audits. It offers real-time monitoring of energy data to reveal and predict trends and performance allowing the customer to make informed decisions and to achieve savings.

What are the main features?

The data gathering and analytics engine collects energy use raw data of clients, and applies powerful analytics. Energy experts can then identify opportunities for increased efficiency. Additionally, it offers comprehensive real time monitoring, granular power quality analytics, machine-learning powered reports and automated audit process tracking among other features.

What are common uses?

The portal closely monitors energy consumption and analyses the data to help energy engineers provide crucial insights on the energy usage of processors. This helps to identify potential issues and opportunities for sustainable solutions towards increased energy efficiency and savings. It is also an audit management tool through which clients can track the audit process and provide the required information for an efficient and comprehensive energy audit exercise.

Market development

A number of processing companies are now investing in energy management platforms for various reasons including high cost of energy and water and lack of awareness on energy and water consumption. The desire to achieve savings on these two resources has increased the demand for energy management programs to monitor consumption and advise on approaches & technologies to reduce energy and water utilization.

1. Data inputs from water and energy consumer
2. Eagles data analytics platform
3. Energy and water saving measures (EWSMs)

LINKS AND PUBLICATIONS

WE4F GIZ Worldwide

Innovation Compendium

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WE4F Publications

Most QR codes may become invalid after the end of the international initiative in summer 2025. However, the WE4F GIZ Worldwide QR Code will remain with relevant information about the program as well as links, factsheets, publications and more.

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