Case Study: Solar Powered Atmospheric Water Systems as a Sustainable and Reliable Solution for Isolated Communities in Scarce Fresh Water Countries.

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Abstract

Access to safe drinking water is a priority concern for populations around the globe. The World Health Organization stated in its report *"The Progress on Drinking Water and Sanitation"* that in 2012 the share of global population using an improved source of drinking water and improved source of sanitation facility has considerable increased worldwide. Although progress was made, it remains highly unequal between urban and rural populations. Access to drinking water and sanitation is nearly always better for urban than for rural populations. On the other hand, the atmosphere contains 12.900 km^3 of freshwater-98 % water vapor and 2 % condensed water (Beysens and Milimouk, 2000). At a given location, the amount of water vapor and its ability to condense depend on air temperature and partial pressure (Beysens and Milimouk, 2000). To address current global water problems, many companies and individuals are developing technologies that capture water vapor in the air and produce water. In October 2014, Tonamix Renovables (Mexico) together with Eole Water (France) installed the first atmospheric water system in Mexico in an isolated community on the Zacatecas' Sierra mountains. Due to the fact that this equipment is very often installed in isolated communities, energy reliability is a challenge which, for this case was met by sizing and configuring a photovoltaic system. The technology was acquired by the Zacatecas State government through the water management facility and was set up as a pilot project. During the first months of 2015, three more devices were purchased due to the outstanding results, representative savings and direct community benefits. This paper contains a detailed explanation of the project installation, management, energy provision and operation of the equipment. It is shown that this technology leads to revolutionary way of water drinking provision since it copes with hard challenges in relation to water issues.

Keywords: water, renewable energy, photovoltaics, sustainable solution, atmospheric water, innovation, isolated communities, water scarcity

1 Introduction

Atmospheric water producing companies are developing rapidly, with varying technologies to extract and treat water from the air. Thus far, many technologies have emerged from the United States and Europe. One of the leading companies is Eole Water technology, which combines sources of renewable energy to power a system that produces water from air.

Eole Water, a French company, focuses on design and development of solar and wind powered atmospheric water producing systems. Eole Water's mission is to provide drinking water everywhere in the world, including the most isolated remote areas, in a socially, environmentally and economically sustainable way.

Proyecto MEDRA is a Mexican company dedicated to the development and engineering of sustainable energy. Since 2008, the focus has been on innovative projects and sustainable technologies for energy generation and water uptake for human consumption. In 2014 MEDRA and EOLE Water created a joint venture for such projects in Mexico.

Tonámix Renovables, an energy and renewable energy consultancy company, acted as partner of MEDRA to manage the procurement, installation, operation & maintenance of EOLE's water system, in this case, a NERIOS S3 plant operated with photovoltaic energy.

The first of its kind in Mexico and within Latin America, it was installed in the isolated mountains of Zacatecas State (Fig. 1.1) in North-central Mexico, in a location called Palos Colorados. This is a rural community with a population of only 20 living in the surroundings.

Fig. 1.1: Palos Colorados, Zacatecas
Source: Self prepared based on Google maps

Given the conditions of isolation and lack of access to water, this site was selected for the pilot project.

2 Nerios S3 - Technology

Eole Water's Nerios consists of a selection of best technologies for producing drinkable water from the atmosphere. The key technology is based on the condensation phenomena with the exclusive use of photovoltaic energy (Fig. 2.1). In principle, Nerios can also be connected to the grid, allowing for more flexibility. With the energy source, a chiller, freezes water in a tank during peak sun hours. This cold reserve is set to work at night to cool down a stainless steel heat exchanger on which air is cooled down to its dew point. Once the dew point is reached, the condensation starts and the saturated air creates water droplets on the cold surfaces of the cooling coil. These droplets are then stored in a raw water tank after a first mineralization stage in order to raise the pH.

In a second stage, recirculation and sterilization of water are carried out by a pump, a filter set and a UV lamp in order to stabilize the raw water prior to storage. In the final stage, the water flows through an ultrafiltration cartridge, a second stage of mineralization and second UV lamp in order to purify the water outflow according to World Health Organization (WHO) standards.

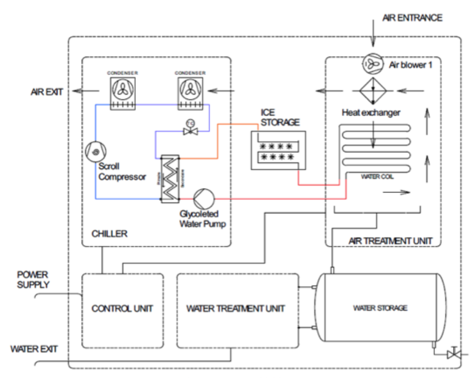


Fig. 2.1: Schematic representation of the process

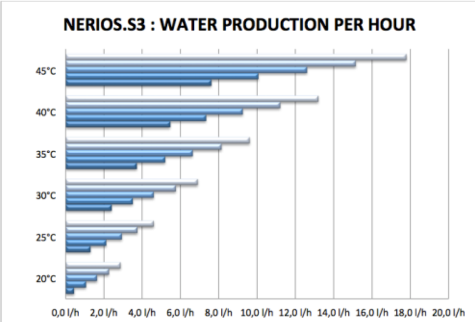
Source: NERIOS S3 Operation Manual

The working cycle of the process comprises six modules starting with the energy production (through photovoltaic modules), intake of the air, condensation, water production, purification and distribution of clean, reliable and drinkable water (Fig. 2.2).

Fig. 2.2: Working cycle Nerios

Source: NERIOS S3 Operation Manual

The output in terms of drinking water depends on the humidity on the air at the given location and the *in situ* configuration (Fig. 2.3).



	20°C	25°C	30°C	35°C	40°C	45°C
80 % RH	2,9 l/h	4,6 l/h	6,9 l/h	9,6 l/h	13,2 l/h	17,8 l/h
70 % RH	2,3 l/h	3,8 l/h	5,8 l/h	8,2 l/h	11,2 l/h	15,2 l/h
60 % RH	1,6 l/h	2,9 l/h	4,6 l/h	6,6 l/h	9,3 l/h	12,6 l/h
50 % RH	1,1 l/h	2,1 l/h	3,5 l/h	5,2 l/h	7,3 l/h	10,1 l/h
40 % RH	0,5 l/h	1,3 l/h	2,4 l/h	3,7 l/h	5,5 l/h	7,6 l/h

Fig. 2.3: Eole's Water production estimates according to climate conditions

Source: NERIOS S3 Operation Manual

It can be stated that the Nerios technology is state of the art and appears as a market leader (Fig. 2.4). The technology has been patented in 43 countries. Since its conceptualization in 1997 up to the installation in Palos Colorados in October 2014 all plants perform in an outstanding manner. Currently, the fifth generation of Nerios plants is operating. This shows that Eole Water has the ambition to stay at the forefront of technological development. Among its customers, the company counts *Danfoss, Siemens, Emerson* and many less-well known users.

The outstanding characteristics of Nerios are determined by its technological concept, its ability to be combined with energy from renewable sources or its grid connection and, not in the least, the quality of the drinking water which minimally complies with WHO standards, as mentioned. In more detail, the characteristics can be summarized as follows:

- Portability (due to its design)
- Operational autonomy
- Low maintenance
- Innovative state of the art technology
- Secure water distribution source
- Utilization of alternative sources of energy
- Strategic drinkable water provision

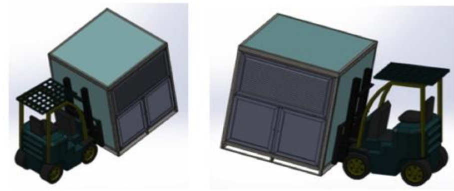


Fig. 2.4: Portability of the Nerios S3

Source: NERIOS S3 Installation Manual

3 Short description of the pilot project tion

By the end of September 2014, the first Nerios S3 arrived in Mexico City and was transported to Zacatecas city and, from there, together with other equipment (PV modules, accessories and structures) was taken to Palos Colorados by the local Water and Environment Secretary (SAMA). The complete time from Zacatecas city to the site required more than 5 hours, including two hours of off-road trail through the mountains.

Upon arrival, the machine was settled down (Fig. 3.1) according to the orientation suggested by the manufacturer. The orientation is very important for the water production. The entire operation of installation required only a few days. It included the installation of Nerios and of the photovoltaic structures as shown in Figures 3.1, 3.2, 3.3. and 3.4.

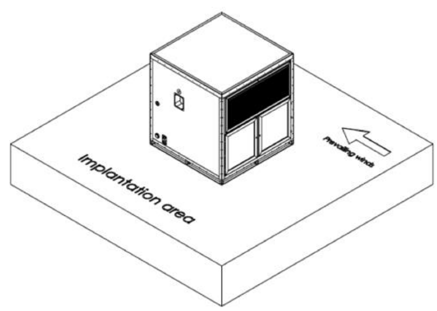


Fig. 3.1: Suggested orientation of the machine

Source: NERIOS S3 Operation Manual

Fig. 3.2: Completion of the structure

Source: Self prepared

The energy system part has the following characteristics:

- 20 x 250Wp PV modules (5KW system)
- SMA 5KW inverter
- DC protection accessories
- Cabling and coupling accessories

Fig. 3.3: PV modules installed (20 units)

Source: Self Prepared

Fig. 3.4: Inverter and DC protections

Source: Self prepared

4 Operation and Maintenance

Since its installation and upstart, two regular visits for inspection and maintenance, one in January and another one in June 2015 were made. One unexceptional visit was made in March 2015 for a re-start due to misuse of the emergency stop button. According to Eole Water's specifications, a visit will be needed for maintenance of the filers after the first year of operation (Fig. 4.1).

Fig. 4.1: Maintenance visit 2015

Source: Self prepared

It is also worth to mention that some problems have arisen during the operation period mainly as a cause of the water provision which stopped for some time periods. Such periods, occurring during the rainy season (June-September), occur when a high concentration of clouds prevents the machine to produce water due to lack of enough solar power. However, a general overview of the system has been very positive and the local community has adopted the technology in a very thankful manner (Fig. 4.2; Fig. 4.3).

Fig. 4.2: Water production

Source: Self prepared

Fig. 4.3: Overview of the system

Source: Self prepared

From its installation in October 2014 up to the last visit to the community in June 2015 (a timeframe of 9 months) the machine produced 412 lts of water. This production considers the timeframe of circa two months during which the machine did not function due to the misuse in March 2015.

Conclusions

The installation of the first machine NERIOS from Eole Water Company in Mexico has been a very challenging project due to the location, installation and other weather details since its installation.

However, this pilot project has allowed MEDRA and Tonámix renovables to set an improvement path for the following machines installation procedure as well as a complement for the learning curve of a technology that has as vast potential in this country and the region.

Additionally, since April 2015 three new machines were bought by the Zacatecas government and the machines have arrived in Mexico in October 2015.

This technology is coping with a deep problematic of the country and its demonstrating its reliability and replicability.

This first machine has been a pilot project and it is still under evaluation to proceed with further orders and settlement of priority criteria for the following locations to be installed at.

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