Autonomous desalination systems: A potential solution for fresh water supplies in rural areas.

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The majority of remote rural areas in Morocco, and particularly in the Tensift-Alhaouz and Essaouira regions, are characterized by scattered villages with populations of less than 100 households per village. These regions are also well known for their abundant solar and/or wind energies which makes them attractive for decentralized renewable energy generation and use. Regarding drinking water (for population and livestock), the populations usually rely on hand-operated traditional means to supply water from wells or the transport water from remote sources. Furthermore, in some zones existing water points have salinities beyond the accepted levels and require an adequate treatment. The Marrakech 21 Foundation has undertaken steps towards alleviating the scarcity of fresh water supplies in rural areas by participating in the ADIRA project which aims at:

- Overcoming drinking water problems in rural areas using autonomous desalination units operating with renewable energies,
- Developing optimum concepts for fresh water supplies which are adapted to the features of rural areas of the south Mediterranean, particularly Morocco.

The activities carried out in the framework of this project include the identification and quantification of potential regions and sites for Autonomous Desalination Systems (ADS) using renewable energies, the development of sustainable ADS concepts and the planning, implementation and monitoring of pilot installation in selected sites. These and other activities aimed at promoting ADS as a solution to the fresh water supply problems in rural areas will be presented and discussed.

1. Introduction

Morocco is classified as a water-poor country since the annual water availability is less than 1000 m^3/inhab and it is projected to be as low as 585 m^3/ inhab. per year in 2050. Regarding drinking water, the partnership between the state, the local collectivities, NGOs and the communes made it possible to satisfy the needs of several localities and villages. Despites

these great efforts, the deficit in securing an adequate drinking water supply for rural populations still remains very remarkable. This is mainly due to 1) the dispersed nature of the villages, which calls for decentralized production; and 2) the availability of brackish or sea water as the only water resource for rural communities in many regions. The populations usually commute daily for more that 3 to 5 km to get their daily needs of water. Furthermore, this task is widely performed by women and children at the expense of income generation activities or education. Adequate decentralized autonomous desalination units may greatly alleviate this deficit in such regions. The ADIRA project (Autonomous Desalination system concepts for sea and brackish water In Rural Areas with renewable energies) was launched in order to overcome the freshwater shortage in the Middle East and North Africa (MENA) countries.

The main objective of the project is to develop optimum concepts for fresh water supplies for rural areas derived from brackish or sea water. Only decentralized autonomous renewable energy powered systems with outputs varying from 100 liters /day to 10 m^3/day are considered. Commercially available desalination technologies (RO, ED, distillation, ..) will be matched to different renewable energy sources (solar PV, solar thermal and wind energies) under various boundary conditions. This will be achieved through the installation and monitoring of Pilot desalination units in Morocco, Egypt, Jordan, Turkey and Cyprus. The technical, economical, environmental, organizational, socio-economic and socio-technical aspects will be taken into account.

2. The ADIRA approach

The main activities undertaken for this purpose are:

- Identification and quantification of potential regions and sites for ADS.
- Survey of market available technologies and development of technical concepts for the installation of the units.
- Planning, implementation and monitoring of pilot installations.
- Actor and stakeholder analysis in the water and energy sector and identification of barriers to boost ADS units.
- Preparation of tools, data bases, training and awareness raising materials.
- Dissemination of the results and experiences among stakeholders at the national and international levels.

3. Preliminary activities carried out in Morocco

3.1. Proposed system.

In the frame work of the ADIRA project, the Marrakech 21 Foundation (FM21) is in charge of the installation in two different sites of two autonomous Reverse Osmosis desalination units powered respectively by photovoltaic and wind energies. The capacity of the units will range from 2– 2,5 m^3/day and are destined to supply drinking water for population and possibly bottled water to cover parts of the operation and maintenance costs. The schematic diagram of PV-powered RO system is shown in figure 1.

3.2 Site survey and selection:

The investigations carried out by FM21 to identify suitable sites for ADS units in Morocco were based on the following sources of information:

- Salinity maps of the ground waters of the regions
- The available data on the drinking water needs in rural areas (PAGER program, National Office of Potable Water ONEP)
- Solar and Wind energy resources data (Renewable energy development center, CDER Marrakech Morocco)
- Various data pertinent to the project (demography, accessibility, …)
- On-site investigations which also enabled us :
    - to establish contact with populations and to know their real needs and problems
    - to see the existing water infrastructure
    - to take some preliminary measurements of the quality of water (salinity), depths of the water point…
    - to sample the water for detailed analysis

Furthermore, the criteria used in the selection of the village are as follows:

- The availability of the water point and the absence of drinking water source within reasonable distance of the site.
- The remoteness of the site and the absence of grid-connection
- The availability of suitable solar and/or wind energy resources.
- The existence of potential uses of the desalted water in the site,
- The readiness of the targeted population to participate and to assist the project team in the operation, the maintenance and the monitoring of the system.
- The technical and financial feasibility of the installation

- Distance of the site from Marrakech (headquarters of FM21)

The proximity criterion, lead us to limit our research to the Marrakech-Tensift-Alhaouz which is known for its solar energy potential with an average daily full sun hours of 5 hours. This makes this inland region very attractive power PV-powered autonomous desalination unit. The factor related to wind energy potential has been considered. The ESSAOUIRA region located along the ATLANTIC COAST is the most favorable region to conduct the investigations since it is well known for its wind energy potential and is therefore considered for wind energy powered RO unit.

3.2 Preliminary results

Throughout its multiple field visits, FM21 has identified several potential sites and their characteristics were compiled (demography, water infrastructure,) The population range from 400 to 500 inhabitants per village. Typical sites that were visited are shown in figure 2 and 3. The TDS in the majority of the open wells and boreholes that were screened varied form 2.5 to 5 g/liter for the brackish water. To our surprise, some of these sources were used for drinking despite the fact that their salinity and their other contents are beyond the accepted limits. For example the Tazitount site in the Essaouira region with a TDS=3800 μS/cm, the AZLA site with conductivity =4300 μS/cm, …). When the salt content is high, water from the well is usually used for hygiene and for livestock. In most other cases, rain water collection and storage in ground-built reservoirs is used to secure the needs of the populations.

Other sites are equipped with water pumping, storage (reservoirs) and distribution (fountains) infrastructure. However, most of the pumping systems in the surveyed sites are shutdown most of the time because of the lack funds to buy fuel. This is usually done by usually collecting money from the inhabitants (not an easy task). Most of these water points have been realized either in the framework of the PAGER or MEDA programs.

It should be noted that the unit price (on the order of 1 EURO/m^3) of desalinated water (investment & operation included) is considerably higher than the usual 0,4 – 0,6 EURO/m^3 of municipal water. However, this price is considerably lower than the daily price that is paid by women and children or the health problems that originate from the use of the brackish water.

4. Conclusions

The work performed in the framework of the ADIRA project by FM21 enable the identification of several suitable sites for ADS units. The desalination unit may be installed either at the water point, the water reservoir site or near the fountains. The possible choice will be a function of other parameters such maintenance and monitoring, and security of the installation… Negotiations with the local populations (associations) and the communes need to be deepened in order to make the final choice of the site.

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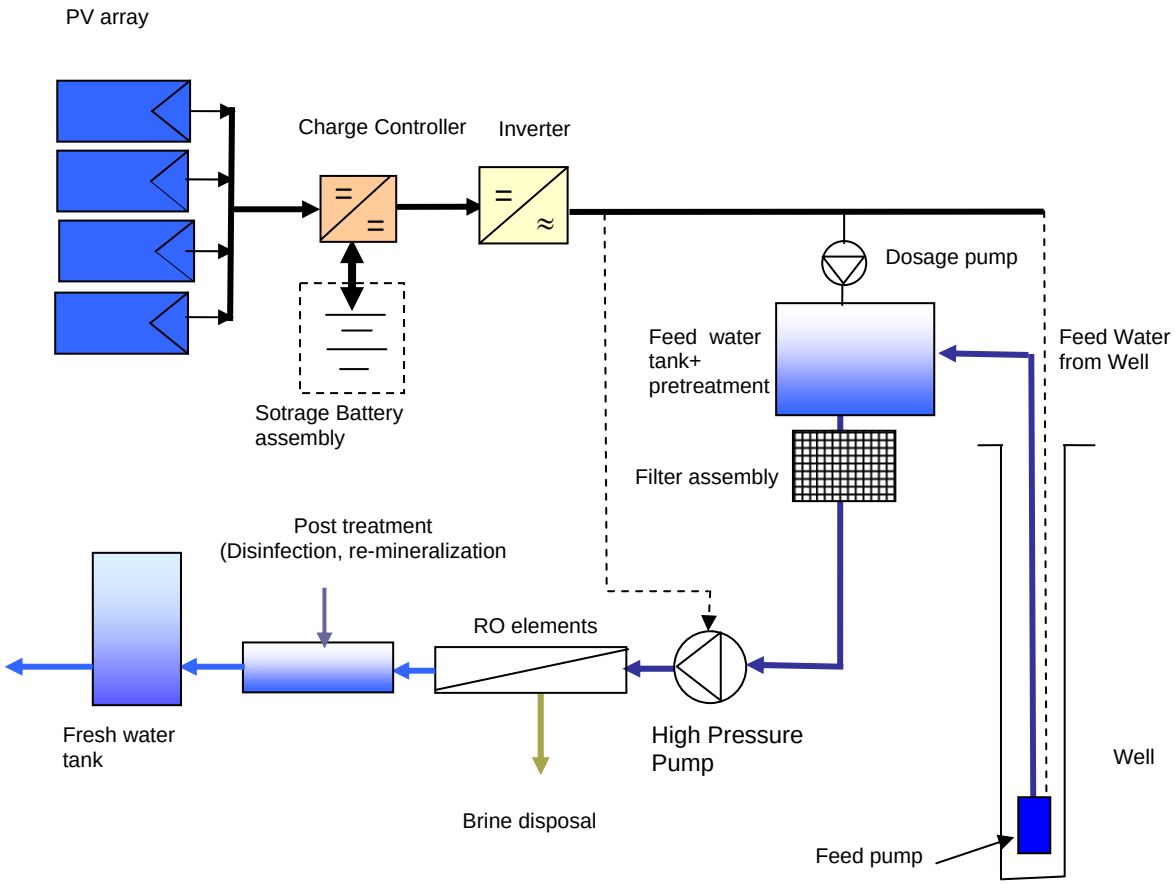

Figure 1 : schematic diagram of an autonomous desalination system powered by photovoltaic energy

Figure 2. Photograph of the Ait Tamellal site in the Essaouira region

(a)

(b)

Figure 3: Photographs of a) the Idberbniz site in the Essaouira region showing the water storage thank on the hill top; b) the Tazitount site in the Essaouira region showing a non operational wind mill in the site.