ADU-RES Project

Co-ordination Action for Autonomous Desalination Units based on Renewable Energy Systems

Dear friends,

spring comes into all parts of Mediterranean and so it is time to evaluate this winter's water yield. According to the Jordan Ministry of Water and Irrigation, the winter precipitation in the country has been only 62% of the long-term average. A similar shortage of rain is reported from Morocco, Egypt and other Mediterranean regions. It is obvious that the water crises caused through overexploitation of the natural resources finds a dramatic add-on in the declining natural precipitation. It is the rural population that is hit hardest by the growing water scarcity.
They suffer directly from the shrinking surface water and the deterioration of groundwater reservoirs. Outside the cities the public water supply networks are often unreliable and not able to compensate the loss of local resources. In this respect the EC funded Coordination Action "ADU- RES" works in a field of vital importance promoting small scale and autonomous desalination units for the rural and arid areas of the Mediterranean.
The ADU-RES seminar in Hammamet, Tunisia in September 2005 has brought together cutting edge developments in the very dynamic field of solar desalination. Some of the contributions to this seminar have been compiled in this newsletter. The discussions in the last months clearly showed that for the moment it is most important to install well working demonstration units in the rural environment. In this respect it is worth mentioning the article of Dr. Stefan Thiesen who reports about mature solar desalination units manufactured for sailing yachts which could be easily installed in any Mediterranean village.
One of the required Best Practice designs will be installed in the village Ksar Ghilène in Southern Tunisia by the ADU- RES partner ITC. Ksar Gilène with 300 inhabitants is 60 km away from the nearest water well and 150 km away from the electricity grid. In future a RO desalination unit powered by a 10 kWp PV array will provide the water for the population. Additional information on this important project can be found in the contribution of Mr. Fernando Castellano. Furthermore, Mr. Papapetrou reports on the EC funded programme ADIRA that will install additional demonstration units in 2007 in the countries of Egypt, Jordan, Morocco and Turkey.
All these activities allow us to be confident that in the near future solar desalination will be able to play an important role in ensuring livelihood in the rural areas of the Mediterranean, an environment threatened by a water crisis of so far unknown dimensions.

Munich, March 2006

Dr. Christian Epp
Senior Project Manager WIP

Policies and Market opportunities for Desalination Systems powered by Renewable Energy
Workshop in the framework of the ADU-RES project

The seminar will take place on the 19th of September as a parallel session to the "Global Conference on Renewable Energy Approaches for Desert Regions" in the Le Royal Hotel in Amman, Jordan. At this event the results of the ADU-RES project will be presented, international experts will give presentations and round-table discussions will be organised on policy-making issues.
The workshop is organised jointly by WIP and RSS.
More information is available from the workshop coordinator Dr Mohammed Saidam: m.saidam@emarcu.gov.jo

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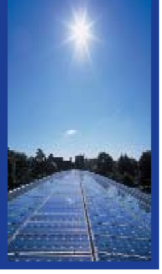

International Seminar on Desalination Units powered by Renewable Energy Systems - Opportunities and Challenges

M.T. Chaibi*, Institut National de Recherche en Génie Rural, Eaux et Forets

An international seminar on the opportunities and challenges of desalination units powered by renewable energy sources was held in Hammamet, Tunisia on the 26th of September 2005. The seminar was organised in the framework of the project Autonomous Desalination Units based on Renewable Energy Systems (ADU-RES), by the National Institute of Rural Engineering Water and Forestry INRGREF Tunisia and co-organised by WIP-Renewable Energies, Germany. The seminar has attracted a large and diverse collection of actors from the desalination and renewable energy scene from Tunisia and other Mediterranean and European countries specialised in the field of water desalination - a total of 125 participants from 15 countries who assembled to attend 15 presentations over one day. This event brought together politicians, decision makers, researchers, lectures, engineers, students, commercial companies of water desalination systems and related equipment, water suppliers, NGOs and consumers, to discuss and analyse the different issues related to development of autonomous desalination based on renewable energies. The sessions of this seminar focussed on four main topics:

1) the water supply situation in Tunisia where there is growing awareness of the increasing demand for water while the natural supply is limited;

2) the presentation of the successful pilot desalination plants based on renewable energies in Tunisia and all over the world;

3) the research aspects involved in the development of desalination technologies using renewable energies;

4) in the last session, international companies presented the technical and economical performance of the latest technologies of autonomous desalination units available on the market.

A full spectrum of information relevant to the topic of the seminar has been covered, and interesting discussions and debates about the opportunities and challenges of the technology applications in Tunisia and elsewhere took place. Additionally, the event offered the platform for extensive networking and information exchange which stimulated the formation of consortia for further research as well as for concrete implementation plans. This represents a remarkable achievement for the ADU-RES project demonstrating the great interest in introducing autonomous desalination units to satisfy fresh water demand, mainly in remote rural areas, presenting the research activities undergone in the world, and providing a forum for discussion on market penetration of these units in regions confronted with the problem of water shortage.

The presentations from the event as well as the proceedings with the abstracts in English and French are available on the project website (www.adu-res.org). Many thanks are due to the European Community, within the 6th Framework Programme, for their financial support and sponsorship of this meeting, also thanks to the presenters and to all participants for their contributions to the discussions.

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Using Geothermal and Solar Energy for Autonomous Water Desalination Units

K. Bourouni*, Laboratoire d'Energie Solaire, Département de Génie Industriel Ecole Nationale d'Ingénieurs de Tunis, **M.T. Chaibi****, Institut National de Recherche en Génie Rural, Eaux et Forets

The present study was dictated by the need to solve the problems of water desalination in arid and semi-arid regions that have important resources of brackish water, sometimes deep and at a high temperature. In arid areas it is necessary, generally in very hard conditions, to uphold the lives of groups of people whose presence is linked to a specific economic activity, for example extraction of petrol. On the other hand, in semi-arid areas a minimum of economic activities, such as agriculture, must be maintained.

Some common methods of abstracting freshwater from sea water or brackish water such as abstracting by distillation, reverse osmosis and electrolysis are not adapted to this situation. The requirements of drinking water in these regions do not exceed a few cubic meters per day. However, these desalination techniques are competitive only for large-scale production of a few thousand cubic meters per day.

These methods, used in affluent countries, are too expensive to be used in poor countries. They require large quantities of expensive power and the capital cost and maintenance costs involved in the use of necessary apparatus are high. The climatic conditions in arid and semi-arid regions, for example temperature, humidity, sandstorms, and rainfall, are very difficult for installations to withstand, especially if they are not designed to operate in this environment.

For all these reasons, we have implemented a little prototype, with minimum maintenance, for water desalination in arid regions. This prototype was patented and experimented in the south of Tunisia (Kebili city).

The aim of this study is to provide a desalination unit, with a capacity of producing a few cubic meters per day, allowing the use of geothermal or solar energy and minimising the capital cost. The present prototype includes two cross flow heat exchangers, a horizontal falling film evaporator and a horizontal falling film condenser. The two exchangers are made of polypropylene and operate by the humidification-dehumidification of the air.

The prototype was designed to use low temperature energy and in particular geothermal energy.

The brackish water is at a temperature between 75 °C and 90 °C, which is less than the maximum operational temperature of the polypropylene, which is limited to 100 °C.

Heat exchangers made of plastic have the following advantages: they are light weight, inexpensive, technologically suitable, easy to clean, only slightly polluting, corrosion-resistant and resistant to aggressive media. The use of plastic material is money-saving since the price of the exchange surface is much cheaper than other common exchange surfaces (metallic surfaces, etc.).

The use of plastic as the material allows the heat exchangers to be used for heat recovery from process gases, which are sometimes corrosive.

Condensable components in the gas, such as water-vapour, sulphur oxides and nitrogen oxides, may form condensate films along the

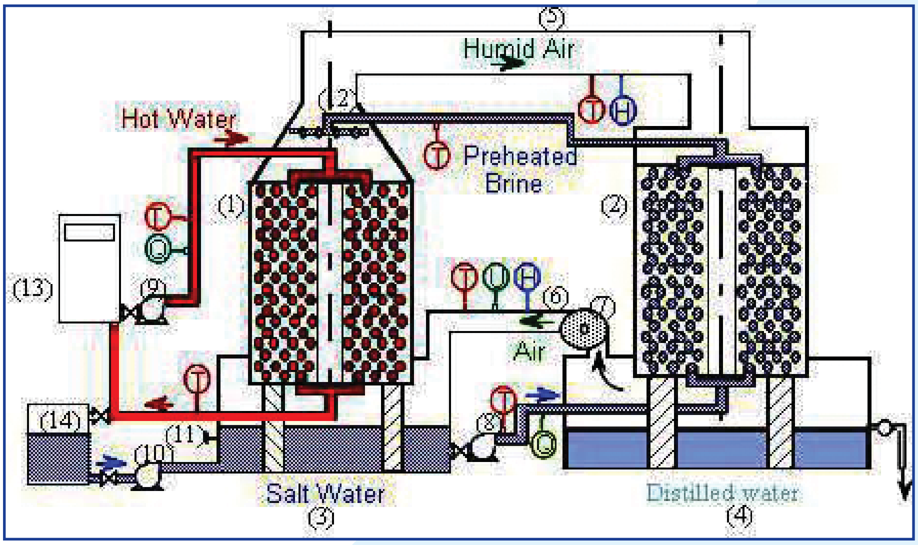

Figure 1: Presentation of the desalination prototype functioning by the aero-evaporo-condesation process (A.E.C.P).
(1) evaporator, (2) condenser, (3) sat water tank, (4) distilled water tank, (5) and (6) pipes, (7) blower, (8), (9) and (10) pumps, (11) purge sluice, (12) liquid distribution systems, (13) brackish water.

corrosion-resistant walls.
The prototype is presented in Figure 1. It includes an evaporator (1) and a condenser (2). Each heat exchanger consists of circular plastic tubes and a cylindrical insulated envelope. Heat recuperation in a low-temperature process requires an important exchange surface. The evaporator which is 1.4-in diameter and 2.5 m in length includes 2’000 m of tubes. On the other hand, the condenser which is 1.6 m in diameter and 2.2 m in length involves 3’000 m of tubes. Two tanks (3), under the evaporator, and (4) under the condenser contain salt and distilled water. The two exchangers are linked by two pipes (5) and (6), of a diameter of 0.2 m, allowing the circulation of humid air, maintained by a blower (7). Three pumps (8), (9) and (10) permit the circulation of salt water. In order to avoid an excess in salt water concentration, the distilled water tank (4) level is held constant by a continuous supply of salt water. The salt concentration is controlled by a purge sluice (11). Furthermore, the level in the salt water tank (3) is held constant by distilled water levy.
The cooled hot brackish water (13) moves down the tubes. Its temperature at the entrance is about 80 °C. The cooling air moves up in the space between the tubes. The cold salt water in the tank (3) at ambient temperature is sucked up by the pump (8), to the condenser (2). In this exchanger the water moves up inside the tubes. At the condenser outlet, salt water is preheated to 50 °C. The liquid is introduced through spray nozzles (12) into the top of the evaporator and falls from tube to tube. Liquid films flow and evaporate on the outside surfaces of the tubes.The vapour is carried by the air flow to the condenser. At the top of the condenser, the air is hot (55 °C) and humid (35%).
In the condenser (2), the humid air moves down through the space between the tubes. On contact with the cold tube walls, film condensation occurs. At the same time latent heat applies to the salt water circulating inside the tubes. Finally, the distilled water is recovered in the tank (4). The characteristics of the film flowing around horizontal tubes is visualised during the tests through two Plexiglas windows, placed on each exchanger.
A prototype has been built and tested in the south of Tunisia. A geothermal brackish water source, with an input water temperature of 65 °C, has been used to feed the unit. The capacity of this unit was about 3 m^3/day, which is sufficient to cover potable water needs in remote villages due to the dispersed population that characterize the south Mediterranean and Gulf coast areas.
Energy cost is one of the most important elements in determining water costs where the water is produced from desalination plants. In some cases it can represent more than 80% of the total desalinated water cost. Since the use of direct geothermal energy in the AEC process is almost free, an interesting cost is obtained, as low as 1.2 \$/m^3 of fresh water. A numerical study has shown that when solar collectors are coupled to the AEC pilot, the water cost can reach 1.58 \$/m^3 of fresh water produced. The direct use of solar energy was analyzed and evaluated. In fact, simulations are done for different surface collectors to evaluate the monthly capacity of the unit, as figure 2 shows.
The experimental and numerical investigations showed that the use of the humidification and dehumidification process is very interesting for producing potable water from brackish sources in the Tunisian context. This process is simple, economic and does not require any specific technical knowledge to be maintained. For all these reasons it could be very promising in the southern regions of the Mediterranean countries.

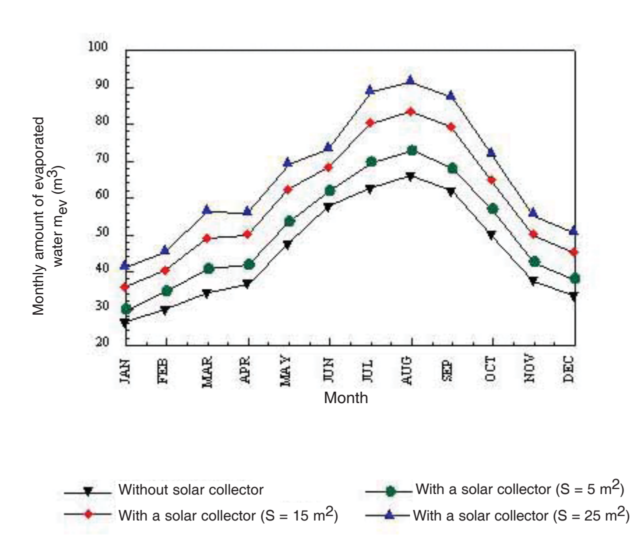

Figure 2: Variation of the montly amount of evaporated produced by AECP for different solar collector surfaces (m_{air} = 0.3 kg/s), Bourouni et al 2003.

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Marine Reverse Osmosis for Rural Communities in Developing Countries - the Search for Immediate Solutions

Stefan Thiesen*, Ph.D.

Although it can hardly be called news, it cannot be stressed often enough that the water supply situation for many millions of people is critical, often immediately life threatening. At the same time we do live on the blue planet and water in principle is abundant. All that is required are proper water treatment and desalination technologies. For me, being a science consultant looking for applicable solutions, the question is if technologies exist that can be immediately dispatched and installed, especially to solve pressing drinking water problems in remote locations.

Portable seawater RO system Aquifer from Spectra Watermakers with daily production up to 680l of freshwater.

The technology in question should ideally meet a set of criteria. It should:

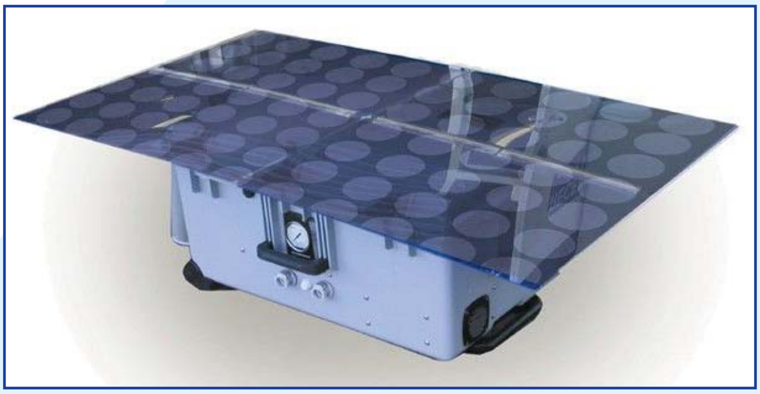
- be rugged and reliable
- be tried and tested
- be easy to operate
- be easy to maintain
- have spare parts readily available

It should also be possible to operate the technology in question with a wide range of energy options, including renewable energy.

As a consultant, I am not interested in developing a new technology or optimizing available systems, therefore the logical option is to scout for existing options fulfilling all or most of these needs. An overview of different sectors reveals that in the marine and boating sector the development of small scale off grid desalination systems based upon the reverse osmosis principle have been in development since at least 1975. Since then several major manufacturers have sprung up providing the marine and yachting community with small, lightweight and energy optimized systems that have proven their reliability in countless operation hours in remote locations at sea. It is surprising therefore, that to date these systems are relatively rarely utilized for aid projects or rural water supply in the developing world.

The renewable energy pioneer, Peter de Vries, CEO of the company "Contained Energy" in Jakarta, routinely offers Photovoltaic powered Reverse Osmosis freshwater systems for boating applications. He remarked that the only difference between installations on boats and installations on land is that those on land are a lot simpler. The installations are also surprisingly economical: a standard set including Spectra yacht RO watermaker, Mitsubishi solar panels, appropriate battery bank and electronics as required is available at a price of currently approximately 8'250 Euro. The production capacity is up to 1'000 litres per day, making the system a highly economic option for small scale communities drinking water supply (especially where bottled water is the main competitor).

Recently Spectra watermakers introduced "Aquifer". It is a portable all-purpose small scale desalination system that can be operated with a variety of energy sources and produces up to almost 700 litres of freshwater daily at very low energy consumption.



Aquifer by Spectra with mounted Photovoltaic Panel.

The German marine outfitting company Ferropilot kindly provided me with technical information about the Yachting RO systems they distribute in Europe and worldwide (including recently 8 systems for aid projects in the Tsunami struck Aceh province of Indonesia). The systems are produced by the Italian manufacturer Schenker, and technical data of the Schenker Modular electron 60 marine Reverse Osmosis System are given below as a reference:

Watermaker Group Dimensions:

- Length: 67 cm
- Width: 30 cm
- Height: 30 cm
- Weight: 29 kg

Pumping-Group Dimensions:

- Length: 34 cm
- Width: 9 cm
- Height: 35 cm
- Net weight: 12 kg

Power supply: 12 VDC +/- 20 % (version 60M12); power consumption: 250 Watt average, including pumps and installed pre-filters, leading to a standardized energy requirement of ca. 4.2 kW/h per cubic meter product water. Different power supply options (120 or 230 V AC) are available.

The production rate is in the range of 60 l/h +/- 20 % with salt water at 25 °C and a salt content of 35’000 ppm. The average continuous quality of the product water is in the range of 300 ppm TDS. Typical limits are temperatures of 40 °C and TDS above 50’000 ppm.

Some of the latest systems operate without anti-scalants and anti-foulants, using physical solutions instead, so the need for an ongoing and costly supply of chemical components will no longer be a major issue. Progress has also been made regarding the membrane lifecycles. In continuous operation, the membrane lifetimes range between two and five years, with suggested cleaning intervals of one to two years.
Systems like the one described here are shipped ready to install with all plumbing and repair kits included. The capacity is already sufficient to supply a small village with drinking water, and Ferropilot assured me that it would be possible to provide maintenance training for local technicians. Global distribution and service networks are already in place and the systems themselves could be integrated into existing plans for rural solar and wind power solutions for rural communities, as for example devised by the UNIDO rural energy programme. The available capacities range from small systems like those described here, to commercial grade transportable modular water factories with production rates of up to 166 tons of water per day.

The Schenker portable RO system.

In my view the technological side is not the main problem for solving the world's water supply problems. The issues that need to be addressed mainly are financial, social and political in nature, and it is in these fields where major efforts are required.

For further information you can visit following web sites:

- www.mindquest.info
- www.containedenergy.com
- www.ferropilot.de
- www.spectrawatermakers.com

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The ADIRA Project

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ADIRA is a project funded by the European Commission "EU - MEDA Water Initiative". It focuses on the supply of drinking water in rural areas by autonomously operating desalination systems powered by renewable energy units. ADIRA develops concepts and tools that are applicable to the whole MENA region and will

establish demonstration plants in Jordan, Turkey, Cyprus, Egypt and Morocco. Within ADIRA existing concepts and technologies are being adapted for use with renewable energy. Their potential for the areas and countries involved is being evaluated by taking into account the technical, economic, environmental, organisational, and social aspects.

The project consortium has analysed the conditions in rural areas of the target countries, with regard to their suitability to accommodate autonomous desalination units as a solution to the water supply problem. Specific sites have been selected for the installation of project demonstration units. In order to identify barriers and opportunities for the development of Autonomous Desalination Systems applications, an analysis of the institutional situation of the water sector in the target countries has been carried out. Additionally, a survey has been undertaken of entities that could play the important role of ADS operators. A technical study has collected all the relevant information for the design and construction of such units, while a comprehensive list of suppliers has been elaborated. Software tools, data bases, training and awareness-raising materials for supporting the systems designers, installers, operators and final water users are being prepared and disseminated on all levels in order to facilitate the application and raise awareness of the local, national and international communities. Now the project is entering the phase where more than 10 systems will be installed in involved MENA countries.

This will demonstrate the reliability of the technology and will be used to obtain detailed results on technical, social and environmental issues. In the last phase of the project, extended training of operators will take place and local authorities or other stakeholders will be assisted to develop concrete plans ensuring the viability and safe operation of the installations after the completion of the project. This will give to local stakeholders the opportunity to replicate the experience gained in other sites with similar characteristics.

ADIRA is being coordinated by the Agricultural University of Athens (Greece) and the cooperating institutions are: Foundation Marrakech 21 (Morocco), Egyptian Water and Energy Association (Egypt), Canary Islands Institute of Technology (Spain), Jordan University of Science and Technology (Jordan), Istanbul Technical University (Turkey) and WIP-Renewable Energies (Germany), while the Middle East Desalination Centre (Oman) contributes as an additional sponsor.

More detailed information is available in the project website: www.adira.info

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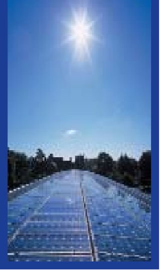

Spanish Cooperation Project in Southern Tunisia: PV-RO Desalination Unit in the Village of Ksar Ghilène

Fernando Castellano*, **Penélope Ramírez**, **Baltasar Peñate**,
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Ksar Ghilène is an isolated village in southern Tunisia, located in the Sahara desert, 150 km away from the nearest electrical grid and 60 km away from the nearest drinking water well. The village has a population of 300 inhabitants whose main activities are cattle raising and agriculture in the nearby oasis, irrigated by a brackish water well. In the framework of the Spanish -Tunisian cooperation, a project for the supply of drinking water through a desalination unit driven by solar photovoltaic energy has been approved. The partners of this project are the Spanish International Cooperation Agency (AECI), the National Agency for the control of energy consumption (ANME), the Regional Directorate for Agricultural Development of Kèbili (CRDA), and the Government of the Canary Islands through the Canary Islands Institute of Technology (ITC).

The project aim is to desalinate water from the existing brackish water well through a RO desalination unit with a mean water production of 15 m^3/day. This unit will be an autonomous system driven by a 10 kWp PV solar generator, which includes a 10 kW inverter and a battery capacity of 600 Ah at 120 VDC. Produced drinking water will be distributed from an existing 50 m^3 elevated storage tank through a hydraulic grid to several water taps inside the village.

The Ksar Ghilène village in southern Tunisia where the PV-RO unit will be installed.

The project is structured in the following phases:

- design of the desalination unit and the solar PV generator;
- study of infrastructures;
- hydraulic and civil engineering works;
- installation and starting-up of the whole system;
- complemented by the practical training of local technicians who will be in charge of its future operation.

At the present moment, both, the solar PV generator and the RO desalination unit have been designed and are in process of being manufactured. At the time, the civil and hydraulic works have been carried out. The start-up of the system is expected for the beginning of May 2006, while the final delivery after the testing period will be in December 2006.

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ADU-RES Consortium

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CRES, Centre for Renewable Energy Sources, Greece	INRGREF, Institut National de Recherche en Génie Rural, Eaux et Forets, Tunisia
CREST, Centre for Renewable Energy Systems Technology, Loughborough University, UK	ISE, Fraunhofer Institute for Solar Energy Systems, Germany
E.C. DG-JRC, Institute for Environment and Sustainability, Renewable Energies Unit, EU	ITC, Instituto Tecnológico de Canarias, Spain
ELARD, Earth Link and Advanced Resources Development, Lebanon	PHG, Palestinian Hydrology Group, Palestinian Authority
ETA–Renewable Energies, Italy	RSS, Royal Scientific Society, Environment Monitoring & Research Central Unit (EMARCU), Jordan
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