Zero Energy Desalination System Based on High Concentration Photovoltaics and Metal-Organic Framework Membranes

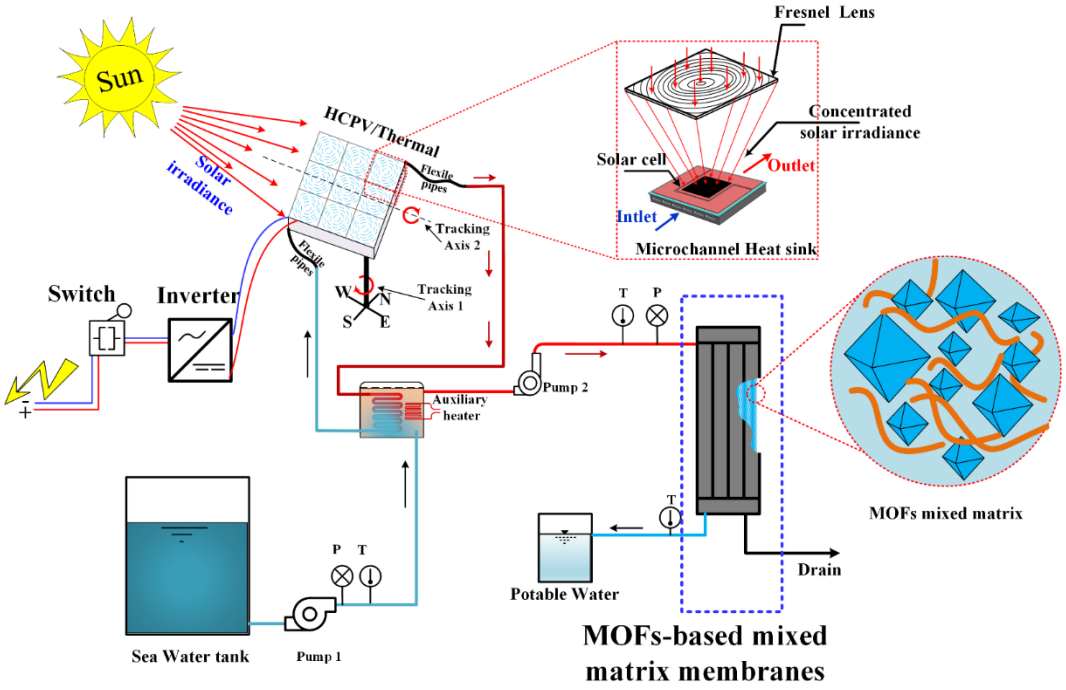
1.1 Abstract

The fulfillment of energetic needs through solar energy and supply of clean-and-safe potable water are very high priorities and supported lines of development of the Egyptian government. Solar energy, in the form of high concentration photovoltaic (HCPV), is one of the most promising sources of energy to fulfill these concerns and desalinate water in hot climate zones.

The current proposal aims at developing zero energy desalination plants combining two promising technologies. Firstly, high concentration photovoltaic (HCPV), which is state-of-the-art solar technology with the potential to replace existing expensive photovoltaic materials with lower-cost optical components with an augmented overall yield. Secondly, metal-organic framework (MOFs) desalination membranes, which are innovative micro-porous materials for seawater desalination and will be powered by the HCPV subsystem.

In parallelism with these technologies, the proposal offers the expertise of the academic partners in simulations and experiments to overcome the challenge of HCPV cooling to produce reliable electricity to desalinate water (See next figure). In particular, accurate simulations and experimental work will be carried out to design a new cooling mechanism of the HPCV based on multiphase flows, and to predict cycle outputs in a wide range of operating conditions. Besides, the proposal aims at implementing innovative MOF membranes in a broad spectrum of desalination and seawater treatments.

By the end of the project, a final prototype for near-zero energy desalination of water will be available for commercial consideration. The economic and environmental considerations will be pondered to encourage and stimulate the attention of the proposed system.



The proposed prototype for a HCPV combined with a MOF membrane desalination system

1.2 Partners and collaborators

I. Egypt-Japan university of science and technology (EJUST) – www.ejust.edu.eg

EJUST is a research-oriented university created recently in partnership with the most highly ranked Japanese engineering universities and has a track record of research and innovative output in different projects related to this project.

II. Alexandria Fertilizers Co (AlexFert) - www.alexfert.com

AlexFerts Company will support the installation and experimentation of the HCPV/MOF unit in its facilities. Also, it can provide extended support with their experienced engineers in the research area.

III. Universidad politécnica de Madrid (UPM)- www.upm.es

The UPM is the first Spanish university on return to R&D investments and the third institution in Spain most involved within the H2020 and is among the best European universities in R&D. Also, it holds double recognition as a Campus of International Excellence, a distinction that refers to the quality of its research and teaching activity

IV. Spanish company (TBA)-

1.3 Work Packages and Reporting Scheme

In this project, we have six tentative work packages (WP) to achieve within 24 months.

The final number of packages and specific tasks will be addressed with the Spanish Company.

- **WP1: Statistics of the local weather and terrestrial conditions**
- **WP2: Design and optimization of a new multiphase cooling system for HCPV**
- **WP3: Laboratory scale fabrication and testing of the optimized cooling system**
- **WP4: Fabrication of the MOFs based membrane and investigation of the main parameters affecting membrane performance in desalination**
- **WP5: Pilot-scale fabrication of a complete HCPV/MOF desalination system and evaluation of its performance**
- **WP6: Dissemination, communications, and studies of commercial exploitation**

No.	Partner	Country	Main Task
1.	Ejust	Egypt	WP1, WP3,WP4,WP5,WP6
2.	AlexFert	Egypt	WP1, WP3,WP4,WP5
3.	UPM (to be subcontracted by the Spanish Company)	Spain	WP2
4.	Spanish Company	Spain	WP3, WP5, others to discuss

WP Number	1	
WP Title	Statistics of the local weather and terrestrial conditions	
Lead Beneficiary	EJUST and Alex Fert.	
Objectives: The main objective of this WP is to collect and analyze meteorological and environmental data, such as average solar irradiance, ambient temperature, wind speed, solar angle, etc., at different locations in Egypt suitable to deploy the HCPV/MOF prototype.		
Task 1.1 Daily data recording during the four seasons. **Task 1.2** Data reduction and analysis.		
Description of Deliverables **D1.1** Complete map of the infield operation conditions. **D1.2** Determination of the optimal placement for final prototype installation.		

WP Number	2	
WP Title	Design and optimization of a new multiphase cooling system for HCPV.	
Lead Beneficiary	UPM	
Objectives: The main objective of this WP is to design a multiphase cooling system for solar cells that able to cool down the ultra-high heat flux of a typical HCPV.		
Task 2.1 Implement an appropriate model for the heat transfer of boiling flow in microchannels. **Task 2.2** Validate the model from experimental laboratory data. **Task 2.3** Computational simulations at a vast range of geometrical and physical parameters to optimize the cooling of solar cells under the conditions obtained in WP1.		
Description of Deliverables **D2.1** Multiphase flow algorithm for cooling. **D2.2** Formation of personal in state-of-the-art CFD and Conjugate Heat Transfer simulations. **D2.3** Identification of parameters to optimize electric output from the HCPV subsystem.		

WP Number	3	
WP Title	Laboratory scale fabrication and testing of the optimized cooling system	
Lead Beneficiary	EJUST, AlexFert, Spanish Company	
Objectives: The main objective of this WP is the fabrication of a cooling system for solar cells at a laboratory scale and the evaluation of its performance based on the WP2.		
Task 3.1 Fabrication of a cooling system based on multiphase flow through microchannels. **Task 3.2** Experiments of different configurations and data logging.		
Description of Deliverables **D3.1** Validation of computational fluid dynamics and conjugate heat transfer models of WP2 through experimental results. **D3.2** Optimize the cooling subsystem through the feedback of experiments and modeling results. **D3.1** Optimized design of microchannel heat sink.		

WP Number	4	
WP Title	Fabrication of the MOFs based membrane and investigation of the main parameters affecting membrane performance in desalination	
Lead Beneficiary	EJUST and Alex Fert.	
Objectives: The main objective of this WP is to develop a new MOFs based membrane		
Task 4.1 Fabrication of a novel MOF based membrane at laboratory-scale. **Task 4.2** Lab-scale experiments with the MOF membrane and data logging. **Task 4.2** Evaluation of the performance of the MOF based desalination subsystem at indoor conditions.		
Description of Deliverables **D4.1** Completion of desalination subsystem based on MOF membranes. **D4.2** Experimental data and optimum operating conditions of MOFs.		

WP Number	5	
WP Title	**Pilot scale fabrication of a complete HCPV/MOF desalination system and evaluation of its performance**	
Lead Beneficiary	**EJUST, Alex Fert, Spanish Company**	
Objectives: The main objective of this WP is the fabrication of a full prototype of a HCPV/MOF desalination unit and the evaluation of its performance under field conditions based on the outcomes of WP1-WP4.		
Task 5.1 Implement an appropriate design for a complete system based on the WP1-WP4. **Task 5.2** Fabrication of a prototype through the assembling the HCPV and MOF subsystems. **Task 5.3** Evaluation of the performance in energy production and desalination capability in outdoor conditions.		
Description of Deliverables **D5.1** Complete prototype of the HCPV/MOF desalination system after the integration of the HCPV and MOF subsystems. **D5.2** Experimental results for outdoor conditions. **D5.3** Comparison of the output of the working prototype with modeling and simulations.		

WP Number	6	
WP Title	**Dissemination, communications and exploitation**	
Lead Beneficiary	**EJUST**	
Objectives: The main objective of this WP is to provide a robust and transparent communications strategy aiming to reach broad range dissemination of results.		
Task 6.1 Roadmap and timeline for dissemination and communication tasks as well as present relevant results to improve the developed strategies. **Task 6.2** Manage a site and server to advertise the results of the project and share data between the partners. **Task 6.3** Explore commercial exploitation strategies.		
Description of Deliverables **D6.1** Deployment of website and server. **D6.2** Reports on diffusion activities across events and online channels. **D6.3** Reports on exploitation activities.		

1.4 Budget

The final budget will be defined after the definition of all the activities with the Spanish company. The Spanish budget won't be less thatn 200.000 euros. This budget includes the R&I tasks to carry on within the Spanish company (including personnel expenses, materials, overheads, etc.) and also the cost of subcontracting the UPM.

1.5 Contact details:

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