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Doctorate Research Proposal**:'Control and Power Management of a Photovoltaic Reverse OsmosisDesalination System'**

Introduction:

Water and energy are facing current and future challenges caused by societal demands and environmental protection [**1**].
Obviously, the social and economichealth of the modern world depends on the sustainablesupply of energy andwater. However, nowadays about three billion people do not have access to asafesource of fresh water and about 1.76 billion people live in areas alreadyfacing a highdegree of freshwaterscarcityaccording to the 2015 United Nations World Report indicatingthat 75% of the Arab population livesbelow the level of water scarcity [**2**].
To deal withthisannounced water scarcity, emerging techniques as well as desalination have been widelydeployedthroughout the world howeveralmost of the desalination plants have been installednear the sea. Consequently, the remote areas which are generally not covered by the electricalgrid and in possession of large quantities of saline water did not benefit of theseprocesses. Using the renewableenergy sources, theseregionswillattain the twoprimordial conditions of the modern life: water and energy.
The combination of desalination technologies withrenewableenergy sources isnowaday issubject of severalresearchstudies [**3**]. The large number of possible combinationsbetweenthesetwo technologiesoffers to researchersseveral scenarios thatcanbeconsidered in terms of design, control, power management andtechno-economicanalysis [**4**].
The feasibility of RO desalinationsystemscombined to RE sources has been demonstrated in earlier papers [**5.6**]. Solar and windenergy sources are the mostpracticed in thisfield (19% wind-RO, 32% PV-RO). France and Spain wasamong the first countries in Europe to promote the Wind-RO desalination plants.
The design of PV-RO desalinationsystemsconsists in acombination of reverse osmosis membranes andphotovoltaic (PV) modules. The wide use of thiscombinationisprobably due to the factthatphotovoltaicenergytechnologyis the first to have conquered the markets, itconstitutes the mostdynamicmarket [**7,8,9**].
The PV-RO desalinationsystemscanbedesignedwith or without batteries [**10**]. The PVs are used to supply the pumpsthatgenerate the pressurerequired to supply the reverse osmosis membranes withgenerallybrackish water withlowsalinity. Over the last decade, reverse osmosissystemspowered by photovoltaic (PV) panels have been implemented in severalremote areas throughout the world.
The intermittency of the renewableenergy sources and theirunpredictablecharacter leads to the hybridization ofthe RES-Desalinationsystems. The interest of hybridization of the RE

drivendesalinationsystems has the main goal to satisfy the loaddemand in terms of water production . Indeed, photovoltaicenergy production alwaysfollows a parabola during the day and vanishesduring the night.The production isstronglyrelated to the weather conditions and wind speeds availableduring the yearwithoutneglecting moments of calmthat it willmay occur predictably. It isthere for necessaryto integratestorageunitswiththe power systems to act as a buffer between production and demand. Therefore, the use of a Power Management System (PMS) become an important key for optimal operation.

Scope of the research:

The presentDoctorateresearchaddresses the optimization, the control and the power management of aphotovoltaicbased Reverse osmosis desalination system, dedicated to an irrigation application.

The test bench contains:

-A photovoltaicgeneratorof (2.2 kW), associatedwitha DC–DC converter.

-Lithium-Ion Batteries of (100 AH, 48 V) associatedwithreversible DC–DC converter

-Athreephase inductionmotorof (2 kW), powered by a voltage source DC–AC converter used to drive a high-pressure pump (HP) of (1.8kW).

- A high pressure pump (1.8 kW).

- A module of reverse osmosis (RO).

-Measured instruments of electrical, mechanical and hydraulic quantities in real time.

Afterperformingthe sizing, the identificationand the modelling of the different parts, the control part includes in fact the following tasks:

1- The first goal focuses the optimization of the fresh water flowrate, under an acceptable salinity rate, through an adequate control of the feed pressure and the system valves. A costfunctionwillbeformulated, and optimizedthrough a candidate method.
2- The design of a smart power management strategy, based on either the control theory (sliding mode control, Extremumseekincontrol,….),artificial intelligence techniques (fuzzylogic, ANN), ensuring an adequate permutation between the various operating modes, according to both the solar insolation and the battery state of charge (SOC). As aconsequence, the power manager providesas aconsequencethe reference power amounts of each source (PV, battery).
3- The approaching control of eachstaticconverter. In thiscontext, the PV sideconverteristuned to performachosen maximum power point trackingalgorithm (MPPT), while the bi-directionalbatteryconverterisadjustedaccording to the power manager output. Finally, the control of the motion part (induction motor) willbedone via a robust power-FOC control method. All these control techniques willbeimplemented via DSP cards.
4- Finally, a smallscale prototype willbebuilt.

Outline of the Research:

1- A literatureReview on the themeisplanned, including the state of the art of PV desalinationsystems.
2- The parameter’s identification of eachsubsystemcanbeobtained via on line numericalalgorithms (such as Recursive least square method..).
3- The explicit modellingof the different system parts willbedone.
4- An adequatechoice of the various control and power management strategieswillbecheckedthrough intensive numerical tests.
5- Intensive real time tests willbecarried out on the smallscale PV-RO system, consideringvarious scenarios.

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