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Water-Energy Nexus
Evaluation of different renewable energy in Desalination of Brackish groundwater

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Abstract: Water resource management and water requirements have increased with exceeding populations on the globe. This calls for innovations in research for water management and desalination as an alternate source of fresh water. Energy projects worldwide need water source, May it be treated water or direct source; hence the relationship exists between water and energy. This paper aims at using renewable energy for desalination of water and using water as a resource. This hold good for a specific area like Texas as a case study. This also makes it easier for managing water in areas with less of water.
Of late many sources of energy have been incorporated to generate power within USA, ranging from solar, to wind and water. The drawback in the wind related energy is lack of storage capacity hence it has limitations for grids. However, the intermittency associated with wind-generated electricity without storage has limited the amounts sold on the grid. System need to be developed which can be source of wind energy occasionally during off peak periods. Power generated through wind for desalination can also be a low carbon, sustainable energy an source of drinking water in areas of brackish groundwater.
Keywords: Water-Energy Nexus, Brackish Water, Renewable Energy, Desalination,

1. Introduction

Water and natural resource crises are on the rise with increasing population and demand of drinking water. Natural reserves are continuously showing decline and available water is not of the quality to be used as renewable energy resource due to non-sustainable usage. Human society and urban development today face various challenges in terms of water, energy, environment and economy.

The consideration of the water-energy relationship in the optimization of water supply systems not only ensures the sustainability of the water supply with increasing water requirements, but also reduces water-related energy and environmental concerns. Studies reported in the literature are categorized and systematically analyses for different energy sources, central / decentralized approaches, and system parameter uncertainties. Several major gaps have been identified. The lack of models that take into account uncertainties regarding water demand and renewable energy supply. The main gap, however, is the lack of models to optimize the long-term planning of the water supply system, taking into account renewable energy in the urban context. Based on this review, we have therefore suggested for future studies on the water supply side of the Nexus.

Texas contains more than 2.7 billion acre-feet of brackish groundwater in 26 of the 30 major and minor aquifers. Brackish groundwater is defined as groundwater with a total dissolved solids content of between 1,000 and 10,000 parts per million. To overcome the demands of population in Texas fresh water sources are needed and converting brackish water into usable water. But to do this energy is needed and renewable energy is recommended for sustenance of environment.

In many parts of the world, due to increasing population demand the issue of fresh water supplies is an uphill task and managing it. Municipal water desalination issues are on the rise. The estimated volume of brackish groundwater in the state of Texas is greater than 2.7 billion acre-ft. Currently, there are more than 46 municipal water desalination facilities in Texas; 34 use brackish groundwater as the source supply with a total design capacity of 73 million gallons per day. Money required in desalination is high and operational costs also increase.

Reverse Osmosis is a very effective approach in treating water but it needs high powered energy and hence increased costs and it has repercussions on cost for brackish water in Texas. RO separates fresh water from saline. Renewable energies commonly being used in desalination processes include wind, solar thermal, photovoltaic and wave energy. The two methods can be classified as :- the first category consists of distillation processes driven by heat coming the renewable energy plans, while the second includes reverse osmosis or multistage flash distillation that need electricity or mechanical energy produced by Renewable energy system.

2. Research Objectives

- Ways to maximize benefits from the country potential resources :(Brackish water, Wind power, Solar power, Sea wave power)
- Water Treatment and Energy availability.
- Potential earnings or revenue from solar, wind and water (Evaluation)
- Futuristic cost effect of technologies needed.

3. Research Motivation

Most water resources in Algeria are polluted by uncontrolled and untreated municipal wastewater. Water resources have become increasingly limited, difficult to exploit. Approximately, 87% of the Algerian population in the cities has access to clean drinking water, not including the 13 million living in the rural areas. My country need to improve the water sector. Desalination of seawater and brackish water is an important choice that can help Algeria to manage the crises of water supply. In addition, we can apply our potential naturel resources as solar and wind power even sea wave power, since the desalination of water is considered as one from the expensive treatment. Which need a big amount of energy that we can solve with energy water nexus with sustainable power.

4. Literature review

4.1 Water Issues in Texas

With an increase of 82 % in the Texas population from 2010 to 2060, the usage of water may rise by 22%. The demand in municipal water is also expected to rise from 4.9 million acre-feet in 2010 to 8.4 million acre-feet in 2060 while natural fresh water supplies are estimated to decrease 10% over this period. Hence alternative sources need to be tapped to cope up with increasing demands.

4.2 Energy and water – The Nexus

Natural resources are being limited primarily due to industrial and population growth, as these rapid advancements are part of well being of humans. With increasing population the depletion in natural resources and water is evident factor. In addition to this, over 1.3 billion people worldwide still lack access to electricity; most of them live in sub-Saharan region or East-Asia. About 2.8 billion people live in areas of high water scarcity and 1.2 billion live in areas of water deficiency. Despite all these factors, electricity production requires large amount of water reservoirs and water treatment also needs energy and hence the linkage between them is far deep. This linkage is called as “energy-water nexus”.2 Energy–water nexus analysis aims to find pathways to increase energy output and reduce energy and water cost [3].

- Water is necessary to produce all forms of energy and energy is needed to be used in water treatment, bio fuels, plants and fuels extraction and transportation . For primary fuels, water is used in resource extraction, irrigation of biofuels feedstock crops, fuel refining and processing, and transport. In power generation, water provides cooling and other process-related needs at thermal power plants; hydropower facilities harness its movement for electricity production [2].
- So what is the water and energy nexus and how much water is required to generate a 1 kWh of wind power and how much energy may be needed to drive the water extraction, utilization and desalination treatment in the wind power generation system. This would reveal the water requirements and energy generation and usage in wind power systems. Also, the quantification of direct and indirect energy and water inputs may provide the basic energy and water flows for constructing the energy–water nexus network via pathway analysis [3].
- Water for energy: Water consumption of the wind power generation system consists of two parts, i.e., direct water consumption from the natural environment and embodied water consumed in upstream processes of the wind power generation system. Direct water consumption can be acknowledged by field investigation. Embodied water consumption in the supply chain was calculated using LCA, which considers the total water invested into the whole. chain of processes from the extraction and processing of raw materials and resources to the final product (electricity) [3].
- Energy for water: The energy used for water extraction, for water extraction, the energy used to lift water from underground, lakes or rivers was considered. Because the extracted water is manually used for construction and blade cleaning, the energy consumed in the water utilization stage is very minor and was ignored in this paper [3].

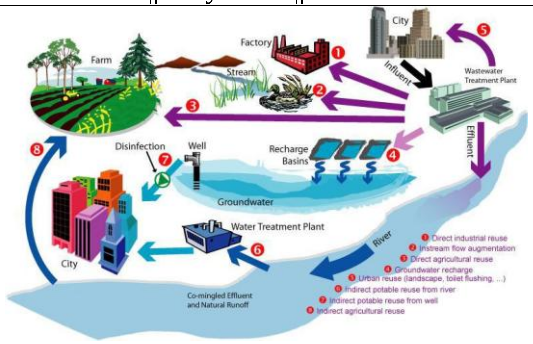

Figure1: Urban water

4.3 Desalination*:*

Desalination is an important choice for water supply in chronic water related areas. In the literature, desalination is defined as a process in which salt water is generally purified to remove salt from seawater or generally salt water. Their disadvantage is the high salt content of the ocean. The energy cost of treating low salinity seawater is many times higher than that of a typical freshwater source. Desalination is therefore only a suitable option if there are no other sources or if the energy costs for water transport are very high [2].

- So desalination represents one the most case of water and energy interconnections and in particular, the principal aim of this work is its application using renewable energy. As above mentioned, desalination is the most energy intensive water treatment technology but it could be solution for many problems in water supply for areas with chronic debt of water. [2]
- In general, we could identify different technologies adopted as multistage flash distillation (MSF), multieffect distillation (MED) and vapour compression (VC), reverse osmosis (RE) and electrodialysis (ED) [2].
- Fresh water is needed for Texas with increasing population and treatment of brackish water requires desalination which needs more energy. The Texas Water Development Board projects a need of 8 billion m3 per year in new water supplies by 2060 for the state to meet the 22% growth in demand and 10% decrease in existing water supply. The state water planners have identified water management strategies to meet these significant water needs, including increasing groundwater desalination to over 220 million m3 per year for the state. Brackish groundwater is prevalent in much of Texas, as there are approximately 10,000 wells with a range in TDS of 1000 to 10,000 mg/L and in depth of zero to 2225 m. The total estimated volume of brackish groundwater in Texas aquifers is over 3.1 trillion m3 .There are 44 brackish water desalination facilities in Texas with a total capacity of 166 million m3 per year (120 million gallons per day) [4].
- Established and reliable desalination technologies include reverse osmosis (RO), multi stage flash, multi effect distillation, and electrodialysis. Of the 44 brackish water desalination facilities in Texas, 42 use a reverse osmosis (RO) process. RO is considered for this analysis, as it is the most common, energy-efficient, and economical process. The RO desalination process involves separating the saline water (feed) into two streams: low-salinity product water (permeate) and very saline reject water (brine or concentrate). Recovery from RO treatment of brackish water ranges from 50% to 90%, depending on water quality and operating parameters [4].
- Special infrastructure is needed along with energy power to execute desalination. But it has another problem of disposing off the concentrate. Current options for concentrate disposal include sewer or surface water discharge after wastewater treatment processes, land application, deep well injection, evaporation ponds, and zero liquid discharge. But it all depends on specific site conditions. Disposal of concentrate need to be specially monitored to avoid contamination of land and water sources and environmental effects [4].

4.4 Desalination of Brackish Groundwater

- Texas has an abundance of brackish groundwater, thought to be more than 2.7 billion acre-feet, which can be desalinated and used to meet public needs. Brackish groundwater is defined as water with a total dissolved solids (TDS) concentration of 1,000 – 10,000 mg/L. For comparison, seawater has a TDS concentration of 35,000 mg/L. The Texas Commission on Environmental Quality (TCEQ) has set a primary standard concentration for TDS of 500 mg/L and a secondary standard of 1,000 mg/L for public use. Reverse osmosis (RO) and electrodialysis (ED) are the most common types of desalination systems [1].

- Reverse osmosis applies pressure to a solution on one side of a selective membrane to reverse the natural flow of solvent to the side with higher solute concentration. The solute remains while the pure solvent passes to the other side, thereby producing freshwater. Electrodialysis uses electromotive forces applied to electrodes that are adjacent to both sides of a membrane to 3 purposely move salt ions through the membrane leaving behind freshwater. ED is best applied to treatment of brackish-water with TDS up to 5,000 mg/L and is not economical for higher concentrations. Both methods are used coupled with PV systems. In Texas, RO accounts for 80% of desalination systems in operation [1].
- Desalination of brackish and saline water is becoming an increasingly popular means for municipalities to meet water demand. Water with total dissolved solids (TDS) between 1000 and 10,000 mg/L is considered “brackish”, while water with TDS greater than 10,000 mg/L is considered “saline”. In these TDS ranges, water is not useful for most purposes without treatment. However, desalination provides a means to reduce the salt content so that the water may be used for municipal, agricultural, or industrial purposes. There are a multitude of desalination technologies and methodologies including multistage flash distillation, multi effect distillation, vapor compression, electrodialysis, and reverse osmosis (RO) [5].

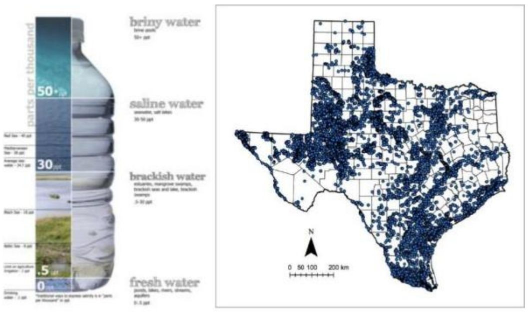

Figure 2: Brackish water

4.5 Solar-Powered Desalination

- Photovoltaic reverse osmosis contribute towards 31% of the processes for desalination and renewable energy. If solar energy can be located near the desalination plant, using solar panels directly for desalination eliminates the need to incorporate solar energy into the grid, although grid interconnectedness provides support for the system [1].
- The energy intensity of desalinating brackish groundwater has been estimated to be 0.5-3 kWh/m3 while other sources estimate this value to be 1-2.5 kWh/m3. The energy requirement is proportional to the TDS concentration as well as the depth to the groundwater source. There are currently 44 brackish water desalination plants in Texas, 12 of which use surface water and 32 of which use groundwater [1].
- This research will focus on reverse osmosis desalination since the majority of desalination facilities in Texas already utilize this technology. Photovoltaic cells will be the primary focus of solar power generation because PV technology can produce energy from both direct and diffuse radiation as opposed to other concentrating solar power (CSP) technologies which can only make use of the direct radiation. Diffuse radiation is the radiation that is scattered from the direct beam by the atmosphere. The synergistic effects of integrating PV with desalination and using water storage as a proxy for energy storage can advance the implementation of these two technologies. Given existing strain on freshwater along with a wealth of solar and brackish water resources, this research will focus on Texas as a testbed; however, the research methodology and results will be broadly applicable to areas with similar resources and prevailing conditions [1].
- Solar energy also faces numerous problems like wind power. Due to fluctuations the operators need to balance the solar power with electrical power grid. Specifically, solar insolation captured during off-peak morning hours is often of low value due to limited energy demands in the early morning. A possible solution to this challenge is to use low-valued solar power for a time-flexible process such as water treatment by integrating solar power with desalination. During off-peak hours, solar-generated electricity can power the desalination process, enabling the treated water to act as a storage proxy for solar energy. When energy demand and electricity prices rise, the higher-valued electricity generated from the solar farm can be sold to the grid. Coupling solar power with desalination can advance the implementation of solar-power technology by providing a use for electricity generated during off-peak hours [5].
- For desalination applications, electricity generated from a solar farm can be used to power pumps that develop the high pressure needed to force feed water through the semi-permeable membrane used in

the desalination process. Investigation into solar-powered desalination has been conducted since the 1970s and demonstration projects were developed as early at 1978. Since this time, there have been a number of demonstration units and small-scale plants implemented. However, projects have been limited to supplying relatively modest amounts of product water, with the largest plant producing approximately 75.7 cubic meters per day, a small fraction of the product water supplied by municipal desalination plants in the United States [5].

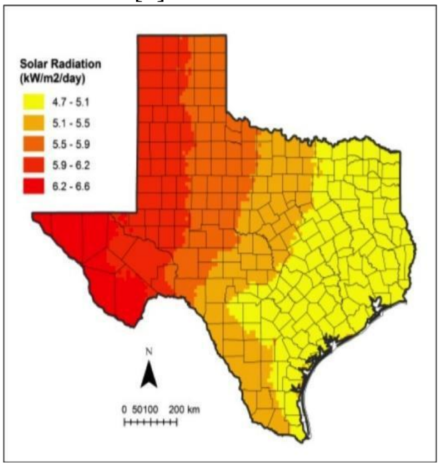

Figure 3: Annual average solar insolation in Texas

4.6 Wind-Powered Desalination

- With a push toward renewable electricity standards and existing production tax credits for wind-generated electricity, the last decade has witnessed substantial growth in wind power. Wind power comprised 43% of the electricity generating capacity additions in the United States in 2012. Of the 60,000 MW of installed wind generation capacity in the United States at the end of 2012, Texas currently leads the nation with 12,200 MW. Texas is also the lowest-cost region for installed projects. Typically, a wind class of 3 or greater is considered to be profitable for generating energy with large wind turbines at utility scale. Wind resources are prevalent in the panhandle region of Texas. Furthermore, if electricity prices rise, or if costs for wind turbines fall, the wind power classification considered profitable could decrease and more areas of Texas could be considered suitable for wind power generation [4].
- Energy storage technologies provide opportunities to shift electricity from periods of low demand to those of higher demand or damp out fluctuations in output. Beyond direct energy storage, one option to mitigate grid-wide challenges is to dedicate wind power to energy-intensive, high-value processes that can be operated intermittently, such as wind-powered desalination. Thus, desalination coupled with wind might serve as an alternative for storage [4].
- Due to the inherent variability of wind-power production, the majority of wind-driven desalination projects and operations include battery storage or backup power by alternative sources such as a diesel generator. Studies exist that have investigated the possibility of combining wind-power with grid-electricity to drive the desalination process. This possibility offers a potential solution to the intermittent nature of wind power. Recently, studies have investigated a configuration in which a desalination facility and wind farm are grid connected. Electricity purchased from the grid can potentially drive desalination during hours when wind-power is not available. Additionally, including an on-grid wind farm enables the facility to sell electricity to the grid during times when it is economically attractive to sell wind-generated electricity rather than use it for desalination. Grid-connected wind desalination was determined to be economically feasible in a study by Clayton, Stillwell, and Webber that investigated integration of desalination with wind-power in a grid-connected configuration. One of the goals of this investigation is to expand on work conducted in that analysis by adding an investigation of integrating both wind and solar power with RO desalination [5].
- Wind-powered desalination combines RO with wind power with the intent of producing a high-value product (drinking water) from a previously unusable source (brackish groundwater) using energy that cannot be dispatched on demand and produces no air emissions (wind-generated electricity without storage). While this approach seems promising, to the authors' knowledge, no methodology has been published that allows for the rigorous calculation of economic tradeoffs as a function of different technical factors. This paper seeks to fill that knowledge gap by analyzing the economic feasibility of

this integration with the intent of aiding planners and decision-makers who might contemplate this configuration to solve electricity and water challenges. For this analysis, the wind power and desalination systems are integrated and co-located but are considered to operate as separate facilities [4].

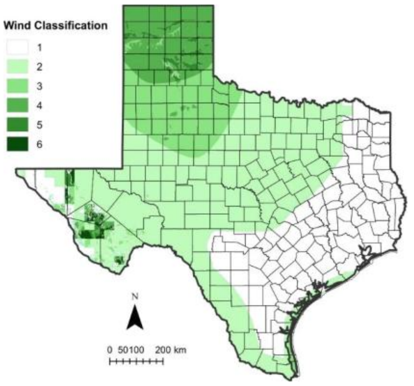

Figure 4: Geographic variability of wind classification across Texas

- Desalination facilities directly connected to a renewable energy power supply must also consider the inherent intermittency of the energy resources. Membranes are designed to operate under constant pressure to maintain performance and avoid damage. Operation of wind-powered membrane systems under pressure fluctuations has been documented and pilot studies have demonstrated that, over short periods of time, membranes can be operated in a variable manner without deteriorating. The long term consequences of cycling membrane systems on and off have not been determined, yet some facilities have successfully operated using variable flow desalination equipment tied to wind turbines without batteries and wind-photovoltaic hybrid power supplies [4].

4.7 Photovoltaic Thermal Desalination

In recent years, there have been substantial research developments regarding photovoltaic thermal (PVT) solar technologies as a way to improve the efficiency of harnessing solar energy. These systems are a combination of photovoltaic and thermal solar components that can produce both electricity and heat for useful purposes. Though many collector types have been investigated, air or water is often used a heat collector in these panels. These systems include an enclosed PV model that is cooled by a working fluid entering one end of the panel and leaving through the opposite end. For the analysis discussed in this investigation, brackish groundwater is considered as the PVT module coolant [5].

4.8 Wind/Solar-Powered RO Desalination

Hybrid systems in which wind and PV solar energy are used to power desalination have been investigated for quite some time. Providing a combination of wind and solar energy can be advantageous because power availability from these sources often occurs during different times of day. As discussed previously, solar power typically peaks in the afternoon while the highest wind speeds occur during the night in many regions. Additionally, solar insolation is strongest during summer months, while more wind power is typically generated during the winter than during summer. Hence, power generated from wind and solar technologies do not match one another on a daily or seasonal basis. Power from wind can be used during certain times when solar power is not available and vice versa. The diurnal and seasonal variability of wind and solar power is conducive to combining these renewable energy technologies [5].

4.9 Sea wave energy desalination

- Recent studies defined exploitation from sea wave as one of the most talent among the renewable energy. It is approximated that in the imminent period it will have one huge increase because these electrical devices used become more complete. In general, these generators are called Wave Energy Converters (WECs). Wave energy devices need large investment of money throughout the process of producing a valid device: overcoming successive steps that can lead them to validate their concepts, build and test prototypes and optimize parameters with the final outcome of a successful product that can be deployed in arrays and sold [2].
- The current panorama with many concepts being patented in every country can be confusing; some technologies have the potential of being successful, whereas many others will not pass the concept

phase. An interesting research on wave energy conversion is excellent in countries near oceans, where the wave energy potential is a big resource. In Europe, most of the pilot plants are located along the Atlantic coast in countries such as Ireland, Portugal, Spain, Norway and the UK [2].

Energy accessibility is one of the most important aspect to determine a wave energy production, but high energy potential usually includes uncommon wave during extreme events. In flat opposition, other characteristics or physical aspects regard semi closed sea as Mediterranean where is possible a minor availability, but interesting researches are addressed to optimize wave energy extraction. For example, some studies demonstrated a wave energy production along Italian coasts. As mentioned before, sea wave information, about fundamental features as its temporal and spatial variability and of its distribution or different sea states, is necessary to WECs' realization2.

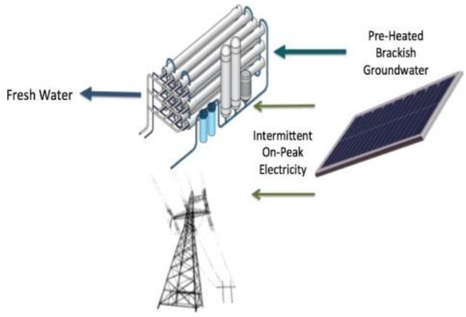

Figure 5: Possible layout and array of Sea Wave energy farm

5. Methodology

The methodology in this investigation is using these models, four different scenarios are analyzed in this investigation to compare desalination powered by different energy sources and a combination of these sources.

The following sections describe the models used to analyze Scenarios A, B, and C of desalination powered by renewable energy, and Scenario D of desalination powered by the electricity grid.

Scenario A: analyzes a desalination plant that can be powered by electricity generated at an integrated solar farm or by grid-purchased electricity. Correspondingly, power from the modeled solar farm can be either used for desalination or sold to the electricity grid, as shown in Figure

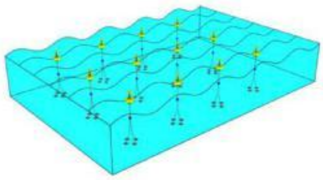

Figure 6: Scenario A models a desalination facility integrated with solar power that can either use solar-generated electricity for water treatment or sell solar-generated electricity to the grid.

Scenario B: assumes the same circumstances, except incorporating a modeled wind farm rather than a solar farm, similar to work by Clayton, Stillwell, and Webber. Desalination in this scenario can either be powered by the wind turbines or by electricity purchased from the grid; similarly, wind power can be either used for desalination or sold to the grid, as shown in Figure 7.

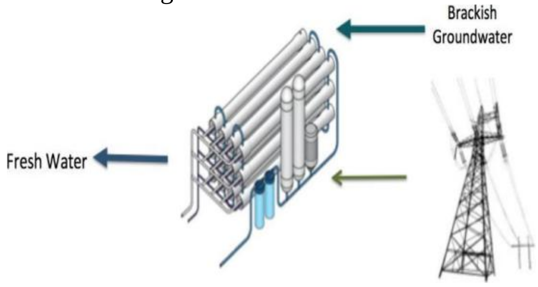

Figure 7: Scenario B models a desalination facility integrated with wind power that can either use wind-generated electricity for water treatment or sell wind-generated electricity to the grid.

Scenario C: analyzes a desalination facility integrated with a wind farm and co-located with a solar farm. In Scenario C, wind-generated energy can be sold to the grid or used for desalination; similarly, desalination can be powered by either wind-generated electricity or by electricity purchased from the grid. Solar-generated electricity from the co-located solar farm is assumed to be sold to grid. In addition to the opportunity to sell solar power, the purpose of the co-located solar farm is to provide heat exchange between the solar panels and the pretreated brackish groundwater using PVT modules. The brackish groundwater is assumed to be preheated before water treatment to reduce the energy intensity of desalination while the solar panels are assumed to be cooled using brackish groundwater to improve the efficiency of solar power production. In Scenario C, the solar farm and desalination facility are co-located for the purpose of yielding these mutual benefits and it is therefore assumed that all solar-generated electricity is sold to the grid. Revenue generated from the co-located solar farm can also be an important source of revenue from this facility to make desalination integrated with renewable power more attractive. This scenario is shown in Figure 8.

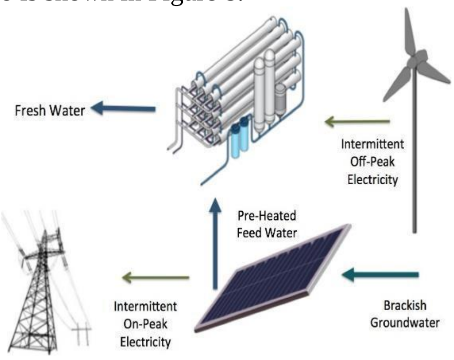

Figure 8: Scenario C models a desalination facility integrated with a wind farm and co-located with a solar farm. Wind-generated electricity is used to power the water treatment process while the solar panels are used to reduce the energetic intensity of desalination.

Finally, Scenarios A, B, and C are compared to Scenario D in which desalination is powered solely by electricity purchased from the grid. Electricity from the grid is assumed to be purchased at an industrial price, as discussed in the section regarding the integrated this model. This final scenario is shown in Figure 9.

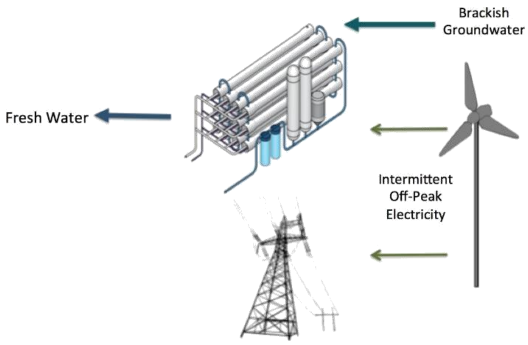

Figure 9: Scenario D models the traditional approach of a desalination facility that is powered by electricity purchased from the grid.

6. Conclusion

Many options and variations are available on analysis of nexus of water and energy. The foregoing analysis contributed towards daily targeted revenue from three sources i.e, solar power, wind power, and water production. In scenario C, it is concluded that wind-generated electricity is enough to meet the energetic requirement of desalination for a majority of the day while solar-generated energy can be sent over to the grid during high energy requirements period. The operational profile for this configuration indicates that electricity purchased from the grid is limited. Having power from the wind farm available during night and early morning limits the amount of electricity purchased from the grid by the integrated facility. The configuration is therefore not heavily reliant on carbon-emitting fossil fuels and offers a suitable use for intermittent wind resources.

Once the solar or wind resources are weak and lack of electricity the facility can be befitted from water production. By providing two sources of revenue, a desalination facility integrated with wind power and co-located with a solar farm can reduce the risk of investing in stand-alone desalination or renewable energy.

7. Recommendations

The energy and water sectors have a chance to collaborate for the benefit of both parties. Meeting water needs can have adverse consequences on the energy sector's goal of reducing reliance on carbon-emitting fuels. Integrating desalination with renewable power is a unique opportunity to advance the implementation and uses of wind and solar power. Results from this investigation indicate that collaboration can unite the water and energy sectors for the benefit of both parties.

References

[1] Viola, A.; Franzitta, V.; Trapanese, M.; Curto, D., Nexus Water & Energy: A Case Study of Wave Energy Converters (WECs) to Desalination Applications in Sicily. International Journal of Heat and Technology 2016, 34 (Special Issue 2), S379-S386.

[2] Yang, J.; Chen, B., Energy–water nexus of wind power generation systems. Applied Energy 2016, 169, 1-13.

[3] Clayton, M.; Stillwell, A.; Webber, M., Implementation of Brackish Groundwater Desalination Using Wind-Generated Electricity: A Case Study of the Energy-Water Nexus in Texas. Sustainability 2014, 6 (2), 758-778.

[4] Gold, G.; Webber, M., The Energy-Water Nexus: An Analysis and Comparison of Various Configurations Integrating Desalination with Renewable Power. Resources 2015, 4 (2), 227-276.

[5] Arroyo, J.; Shirazi, S.; Texas Water Development Board, Innovative Water Technologies. Cost of Brackish Groundwater Desalination in Texas; Texas Water Development Board, Innovative Water Technologies: Austin, TX, USA, 2012.

[6] V. Franzitta, A. Milone, D. Milone, S. Pitruzzella, M. Trapanese and A. Viola, "Experimental evidence on the thermal performance of opaque surfaces in mediterranean climate," Adv. Mater. Res., vol. 860–863, pp. 1227–1231, Dec. 2013. DOI.

[7] Committee on Advancing Desalination Technology, National Research Council. Desalination: A National Perspective; National Academies Press: Washington, DC, USA, 2008.

[8] U.S. Department of Energy, National Renewable Energy Laboratory. Installed Wind Capacity. Available online: http://www.windpoweringamerica.gov/wind_installed_capacity.asp (accessed on 18 November 2013).

[9] 10.Texas Water Development Board. Water for Texas, 2012 State Water Plan. Available online:http://www.twdb.state.tx.us/publications/state_water_plan/2012/2012_SWP.pdf (accessed on 18 November 2013).

[10] Desalination Plant Database; Texas Water Development Board: Austin, TX, USA, 2014.

[11] 2012 State Water Plan; Texas Water Development Board: Austin, TX, USA, 2012.

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