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Concentrating Solar Power to Be Used in Seawater Desalination within the Gulf Cooperation Council

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Abstract

The research discussed in this paper is intended to shed some light on the potential that exists when concentrating technology of solar thermal energy for use in Gulf Cooperation Council Countries, or most commonly referred to as GCC. The research provides the opportunity to study the technologies related to the concentration of solar power technologies along with water desalination demands and fresh water availability, which in turn leads to the jeoparadization of water resources that are derived from the ground. Desalination plants that are solar powered, within the Gulf Cooperation Council countries comprise of Qatar, Saudi Arabia, Kuwait, Oman, UAE, and Bahrain. The study recognizes that a political structure is required for introducing the premier foundation of solar power and desalination as well as ensuring comprehension of the proposal.

The study evaluates solar energy accessible resources and the costs of integrating this alternative energy source, desalination of water, long standing scenarios of integrating power production technologies into the water sectors, and quantifying the socio-economic and environmental impacts of this alternative energy notion.

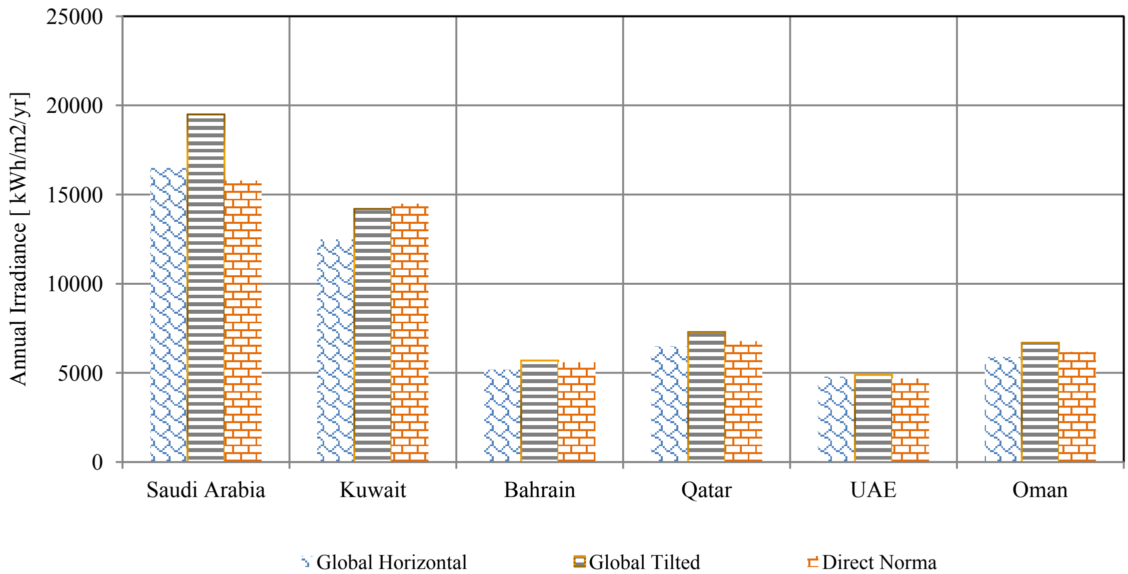
Keywords: Concentrating Solar Power (CSP), Gulf Cooperation Council (GCC), power, water, desalination plants

1. Introduction

The practice of solar desalination has received a massive amount of attention from the engineers that operate within small scales supplying water resources to remote areas of the world, specifically, those areas that are considered to be rural, based on their distance away from other sectors of society. Desalination is best described as expansive technologies whose sole intent is to produce energy intensive technologies and fresh water resources. Desalination has environmental consequences that are rendered in various forms, pollutant emissions that are derived from energy consumption contributes to the dangers associated with global warming along with brine additive discharges and chemicals from outfall culverts into the seas (Rubin ES, 2007). Concentrating solar power, commonly referred to by its acronym term CSP, is a specific technology that supplies energy for seawater desalinations within ranges of an expected solution. The increasing world population steadily helps with the increasing demand for water resources depletion of naturally attainable groundwater sources within the arid global regions needing remedies that are affordable, secure, and match the surroundings, creating a sense of sustainability. The remedies should have the capabilities of dealing with the magnitude of demand with the foundation being accessible along the establishment of expertise, as further approaches avail to remove the vagueness from methodological advances-in case further solutions are not ascertained in time-endangering entire areas (Rubin ES, 2007).

2. Global Horizontal Irradiance within GCC Countries

According to recent studies, there is enough solar irradiance meeting the specifications of green based electrical needs within multiple GCC countries. According to Rubin, ES, R & D is a requirement for developing technological needs (Rubin ES, 2007). There are plethora of motivations for large-scale implementation of CSP desalination systems, known as the basis of energy storage and bio-fuel hybrid operations. Concentrating solar power plants will avail continuous firm capacities that are fitting for scale desalination through thermal processes or membrane processes. Desalination plants that integrate technologies with regards to CSP will be recognized by their ability to produce large units that reaches to 1000000 m^3/ per day. The energy produced by the solar based thermal power stations will be more to economically priced electrical production cost. Efficiency is another factor that is yielded with the perception of managing water use, improving distribution and irrigation systems, reusing wastewater responsibly keeping sustainability measures in mind, should avert 50% of the long term GHC region deficits. Solar desalination and proficient amounts of water use in large scales, forces groundwater over-exploitation within the GCC regions to be forced to come to an end. Figure 1 shows The annual global horizontal irradiance, global irradiance in GCC countries.



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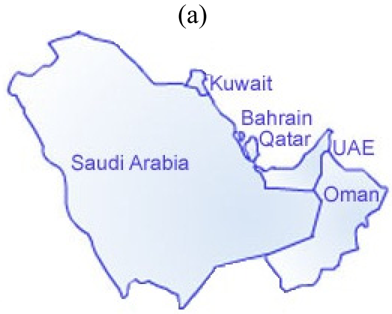


Bahrain	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	711 1,323,535 5500
Saudi Arabia	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	2,149,690 28,082,541 20000
Kuwait	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	17,820 2,818,042 14000
UAE	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	83,600 7,890,924 5000
Oman	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	309,500 2,846,145 6000
Qatar	Area (Km^2) Population horizontal irradiance (kwhr/m^2/yr)	11,440 1,870,041 6100

(b)

Figure 1. (a) The annual global horizontal irradiance, global irradiance in GCC countries; (b) Map of GCC countries (Kingdom of Saudi Arabia, Kingdom of Bahrain, State of Kuwait, State of Qatar, United Arab Emirates and Sultanates of Oman with the Area of the country and population 2010 and horizontal irradiance yearly

Recent developments suggest that utilizing superior solar powered desalination techniques through the utilization of horizontal drains seabed intakes and nano-filtration shall avert the majority of environmental consequences that are a direct result of desalination. With the support of Europe, the countries included in the GCC nations should commence to establish constructive political conditions and legal frames for introducing the market of solar power technology concentration for electricity and seawater desalination (Rubin ES, 2007). For this reason, this paper is composed to shed additional light on indicates that move towards a sustainable remedy to the threatening water crisis within the GCC region, illustrating a means to attain balanced, affordable, and safe framework for water supply to coming generations that are typically overlooked in modern strategic evaluations.

The scope is to locate adequate combinations for technologies in regards to concentrating solar power (CSP) and seawater desalination when used as an energy source. The desalination of brackish water that uses the high total dissolved solid ground water is another choice, but because its resources are limited in comparison to seawater, utilizing groundwater has many adverse impacts on the environment. Brackish groundwater as an alternative energy source is not an option that should be ignored entirely, but it is taken to be non-major contribution to sustainable fresh water supply systems. Seawater desalination is the most important of the desalination technologies, defining and evaluating several combinations of desalination technologies and combinations of CSP under diverse environmental and climatic situations within GCC countries. The main intent is to evaluate GHG as COseq whenever CSP has an involvement.

3. GHG Abatement Costs in GCC Regions

The cost of GHG was calculated, finding the importance of its environmentally friendly technology to be worth noting. When the cost of GHG abatement is referred to per ton of CO_2eq, there is a five percent cost reduction that applies to the behavior on the operation, following a trend to move negatively, but saving the yield. When CSP along with the optimization of the cost of GHG abatement is integrated, a good output for technology can be recognized. Both the CSP and GHG abatement optimization when integrated, move to an R^2 that is above ninety eight percent.

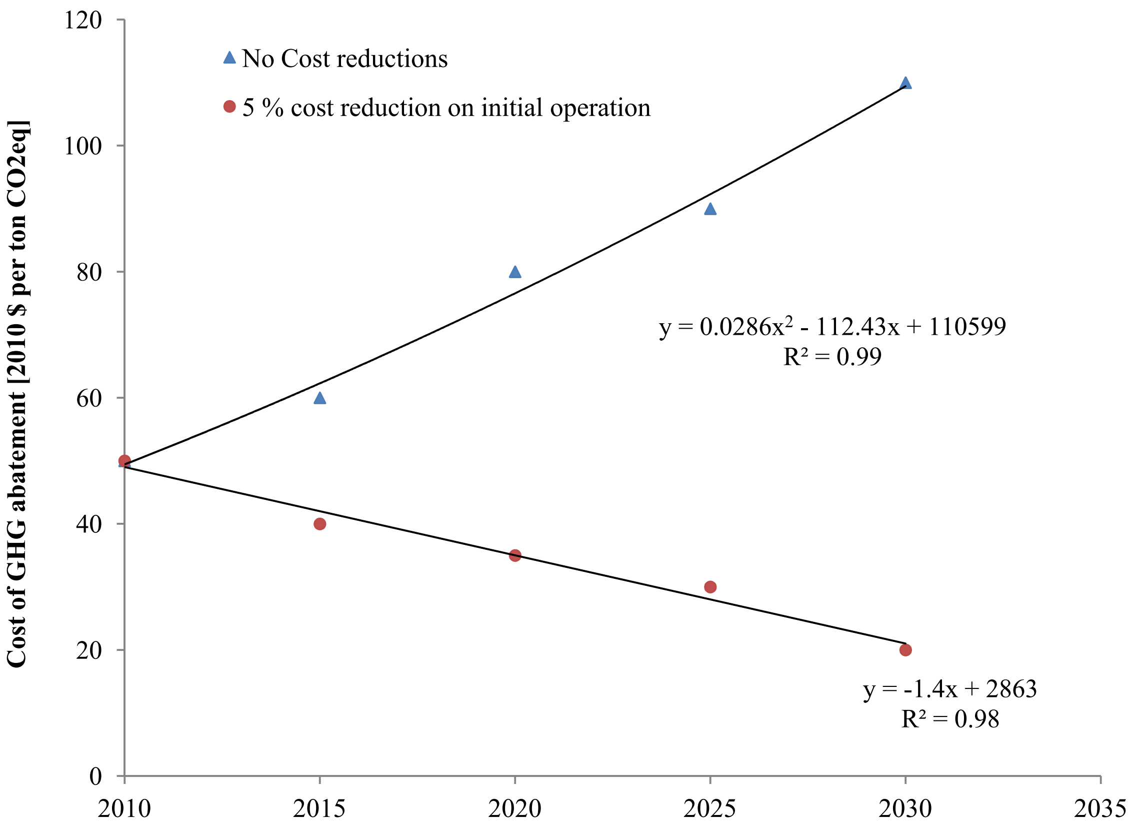


Figure 2. Cost of GHG abatment in GCC

Utilizing a five percent reduction on the initial costs would help benefit GHG abatement by twenty percent, if the policies were fixed towards utilizing CSP technologies by the year 2030 as per Figure 2 that shows the cost of GHG abatement in GCC. The implementation of one type of renewable energy source would have an influential output on the cost of this technological solution, which in turn would also benefit the environment.

4. The Pre-Selection Process of Desalination Technologies in Regards to Seawater Implementation

There are many different types of desalination technologies that are available and utilized within GCC regions. The GCC countries are respectively located in an area where seventy three percent of the world's desalination plants are housed. Some of these plants are applied in large scales, specifically for this region.

Thermal desalination techniques are used to evaporate seawater by utilizing heat that is produced from surrounding power plants. Other desalination techniques use a mechanical approach where filtration is done through membranes. Compression technologies that utilize vaporization are done in conjunction with thermal distillation to increase the productivity of desalination processes.

Multi-Stage Flash Desalination, commonly referred to by its acronym term MSF, is a specific type of thermal desalination unit that comprises of condensing and evaporating product water. The condensation and evaporation phenomena's take place when they are coupled with each other during various stages where latent heat is recovered to be reused for preheating seawater when its concentration levels exceed 48000 ppm. Within what is referred to as a brine heater, incoming feeds of water are heated to their maximum temperatures, through condensing steam that is saturated from the cold ends of steam cycled power plants from other heat sources. The heated seawater will then flow into the initial evaporation stage, where pressures will be set to a lower standard. The abrupt introduction of the heated water within the chamber combined with low pressures forces the water to boil at a quick rate, forcing an explosion, or flashing of steam. During this process, there is only a minute percentage of water that is converted into vapours, based on the amount of pressure that has managed to remain maintained during this stage. Further boiling will persist until the water has the chance to cool down to an equal boiling state, supplying the required heat for vaporization.

Vapours that are generated through flashing will become condensed within tubes of heat exchange that run throughout the upper section of the stage. The tubes will be cooled by the feed water as it comes in and then transferred into the brine heaters, which will preheat the water as well as recover part of the energy released, used for the evaporation within the first stage. The process gets repeated until forty different stages are done, but twenty stages are normally the most that are employed. To ensure that energy recovery and maximization of water is employed, every stage within the MSF unit should operate at lower pressurizations.

Another system, known as the Multi-Effect Desalination, or MED for short, is another type of thermal desalination process, but it utilizes different configurations. During this process, feed water is dispersed onto the tubes that are located in the evaporator, shortly after the evaporator has gone through a preheating session that takes place along the top section of each of its chambers.

When applied to the cold ends of steam cycled power plants, MED plants that do not contain TVC will have a heat consumption that comprises of 0.2-0.4 MJ/kg that comes in the form of steam process that is less than 0.35 -0.38 bars when it is withdrawn from steam turbines.

Reverse Osmosis, or RO for short, is a desalination unit that utilizes membrane separation processes to recover water that has been permeated from pressurized seawater to points that are greater than the osmotic pressures of the seawater, and can reach up to eighty bar pressure. The way that this process works is actually considerably straight forward. The membrane filter will hold all of the salt ions that are present in the pressurized solution back; this allows the additional water to pass through. The RO membranes do have sensitivities when it comes to oxidizers, pH, algae, organics, bacteria, and fouling depositions.

Pre-treatments of the water feeds is a vital processing step that can have an impact on energy costs and consumption in RO processes. This is especially true due to the fact that every portion of feed water that is utilized, even if the water will later be discharged at the end of the process, will need to be treated before it is able to pass through the membranes. Micro, nano, and ultra filtration processes have been proposed as alternative methods to avoid chemical pre-treatments of raw water, avoiding contamination of the additives within the seawater from affecting any plants surrounding. The pre-treatment of reverse osmosis involves the removal of all dissolved gases as well as ensuring that the pH has been stabilized in addition the salts and other dangerous substances must be removed from the brine as well.

MSF and MED are two primary contenders in terms of electricity consumption and energy consumption. MSF has a lower cost, but MED showcases better performance whenever primary energy is the topic of debate. The temperature that MED operates at is lower when steam at lower pressures within steam cycle thermal power plants hydrides with co-generation. Due to this fact, the combination of MED desalination with CSP is more productive and effective than a MSF and CSP combination, whenever the raw feed water being used is seawater.

5. Thermal Vapour Compressions

Vapor compressions have an added effect on distillers to help improve their efficiency. Compression processes that utilize vapors rely on reusing vapours that are produced by distillers for heating steam after the second stage of compression has commenced. Vapours that are produced during the first stage will be recompressed partially again inside of a compressor, and utilized to apply heat onto the initial cell. Vapors are compressed in two different fashions. They can be compressed by utilizing mechanical compressors, or they can be compressed with steam ejectors. In regards to thermal vapor compressions, steam is used at high pressures and then withdrawn from other processes to produce industrialized processed steam.

Thermal vapour compression can be used to help increase the efficiency of the MED desalination process; however it does require steam to be saturated or wet steam at higher pressures if it is being connected to steam powered cycle. Reverse osmosis requires lower consumptions of electrical energy and the costs are done per units product in terms of brackish water being consumed, this of course, is in comparison to the mechanical vapour compression method. Whenever low grade energy is being used as a type of useful energy, thermal technologies for desalination would positively move towards an adoption of MED and MSF. CSP, otherwise known by its extended name, concentrating solar power technologies has grown to become the hub whenever concentrating solar thermal power generation is being discussed or applied, because this method is the most reliable and abundant renewable energy resource within the GCC region. Additional desalination concepts that are based on geothermal energy, wind energy, plus biomass and other sources are additional promising sources that contribute to the supply of freshwater from seawater. Due to the fundamental properties of CSP, it is believed, this technology will provide large scale desalination seawater plants for individuals residing within the GCC countries.

The energy harvesting that is taking place each year on GCC land is producing a massive amount of solar energy that is equal to 1.5-1.8 million barrels of crude oil, per each km^2. One CSP plant that covers square kilometer of the desert land can deliver power and energy to desalinate 6.9 km^3/hr; this is equivalent to the consumption of one enormous desalination plant. The parameters of design for solar power in regards to renewable energy will construct CSP, a key technological source that is required in the future of the renewable energy circuit. CSP is also a key resource of energy in regards to desalination of seawater in GCC countries. CSP has the ability to satisfy the demand for power capacity; its natural resources are easily obtainable and never show obvious signs of restraint. Economically, CSP requirements will be governed by the demand of the market, within electrical sectors of GCC countries that possess high to moderate solar irradiance.

6. Concentration on Solar Power Used for Thermal Turbines

The time series of parabolic plant design utilizes synthetic oils to transfer energy into steam generators within the cycle of a power plant. The shade that is provided by the Fresnel segments are a valuable additional service that is granted by the plant. The plants provide cover for stores, buildings, common lots, and protecting certain crops from an extensive amount of sunshine, as well as reducing water consumption that is required for irrigation. The series of time that is represented in the following figure, reaches a point of over 110000 m^2, which equates to a total of 48 MW from solar heat, along with 1245 W/m^2 of normal direct irradiance. This is all transported from linear Fresnals from parabolic trough collector fields located over the areas mentioned above. To positively generate electricity, fluids flowing throughout the absorber tubes-using either synthetic oils or steamed water-will transfer the heat to conventional steam powered turbines (Tamme et al., 2005).

The storage of heat can consist of either the utilization of two large style tanks, each that contain a mixture of molten salt nitrate as a medium for stage with the ability to sustain heat capacities for hours when full load operations are being performed on the turbine. The heat will then be transferred either from or to the transfer fluids that collect via an additional heat exchanger mechanism. The liquid salt will be pumped directly through the heat exchanger within the cold tanks into a hot that during the charging periods and the opposite will occur during the periods of discharge. The concentration of solar thermal powered generation is the most abundantly utilized and reliable sources of renewable energy within the GCC countries. But, other types of desalination should not be dismissed, simply because this method is seen to be more favorable.

The concentration of technologies that are solar thermal powered is based on the existing concept that when solar radiation is concentrated at higher temperatures to produce heat that electricity can be generated without the need for conventional power cycles. For this to occur, a lot of the systems will employ the use of glass mirrors that will help to track the position that the sun is presently at. Contradictory to most common beliefs, annual sums of solar irradiance that is delivered directly along the tracking surface of the sun within desert regions is typically higher than those globally, that are located along fixed surfaces that possess either a tilt southward or horizontally.

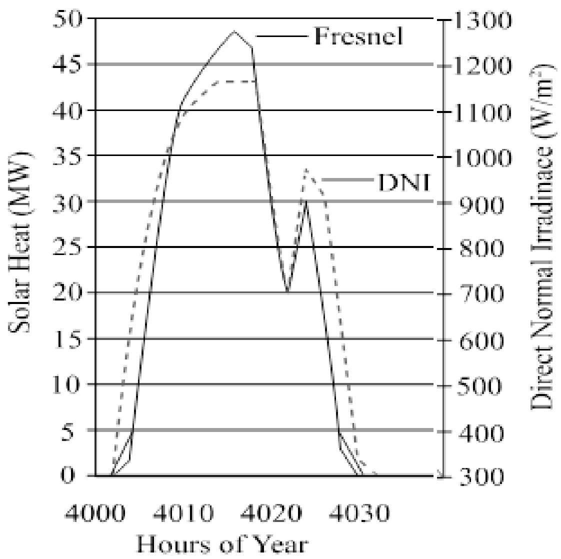


Figure 3. Time Series of solar heat as MW and Direct Normal Irradiance as W/m^2

In instances where CSP is being brought further into the picture, sunlight will be focused on receivers that are designed to help reduce the amount of heat that is lost during its capture. Fluids flowing throughout the receivers will help take the heat that is being emitted from the sun away, forcing it to set along the thermal power cycles; this is where high pressures and steam that is of high temperatures can be generated to help the turbine drive. Additional transfer fluids such as water, air, oil, as well as molten salt can be utilized during the transfer.

7. CSP for GAS Powered Turbines

Before the year 2030, GCC countries should anticipate that the amount of ground water will be depleted, therefore, all efforts to use waste water that has been treated should be integrated as a cost saving technology. Engineering and economically based technologies make water consumption utilizing CSP technologies the main target for GCC countries. Solar towards utilize large fields of two-axis tracking mirrors known as heliostats to reflect sunlight to central receives located along the top sections of a tower. The CSP is then converted into high temperatures of heat. The optical emblematic concentration factors range from 200 to 1000. Plant sizes range from five to one hundred fifty MW or electrical production, with these figures being feasible. High solar fluxes impose the receive, permitting work at elevated temps exceeding 1000 degrees Celsius, combining thermal energies into steam cycles then into gas powered turbines and combining cycles. Solar towers that possess central receiving systems are also compromised, which integrate fossil plants for hybrid operations in wide varieties of options, possessing the potential to proactively generate electricity with increased annual capacity factors when thermal storage is used. Higher efficiencies can be reached when gas turbines that are solar-heated are used. This adoption has the possibility of increasing supplementary within cycle processes that are combined. The quota of persons residing in Arab and GCC countries averages 320 m3 per person per year and the Arab nation is 1000 m^3 capita. These figures are stressed by water consumption areas that are lacking renewable resources for agricultural output; this could in turn lead to a food threat in regards to harvests within the area. There is a gap between supply and demand within the area; desalination is the only way that this gap can be filled sufficiently.

Solar towers can be utilized to help achieve extremely high operating temperatures that can exceed 1000-1200 ^{o}C, this helps to enable them to produce heated air that can be utilized for the operations performed by gas turbines. These gas powered turbines can be combined with additional cycles that will yield extremely high efficiencies of conversion within the thermal cycles that equate to more than fifty percent.

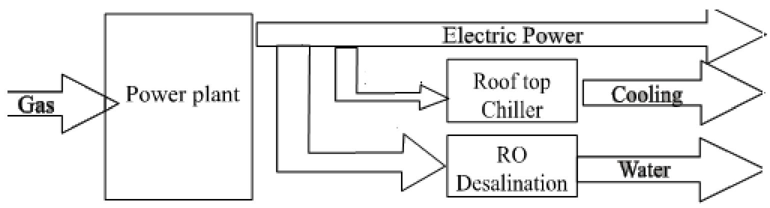
Concentrated solar energy that is high temperature can be used for generating electricity and also assisting with processing heat. In this type of scenario, the amounts of energy inputs can be used with an efficiency that totals eighty five percent; Additional applications that combine production of industrialized heat, direct cooling measures, along with seawater desalination.

All of the CSP desalination concepts that exist, aside from one have the same exact perspective to further expand the amount of time that solar operation base loads need, by utilizing a thermal energy storage source and also larger collection fields. To be able to generate what equates to one megawatt hour of solar powered electricity, a land space of 4 to 13 m^2 is a requirement.

The primary characteristics that will make the concentration of solar power a primary technological future advance will require that key energy resources for GCC countries are able to: deliver enough power capacity as demand requires, ensure that the natural resources can easily be accessible and that the amounts of them are unlimited, can be combined with additional power and heat for cooling along with desalination.

8. Concentration of Solar Power for Combined Heat and Electricity

With price fluctuations in fossil fuels, a requirement for a feasibility study of different alternative power plant concepts for producing on-site combined generation of electricity along with thermal for MED desalination units and absorption cooling became apparent. Further worth mentioning is that absorption chillers have been exploited for base load operations, while compression chillers are primarily used for intermittent demands of desalination and electricity. Cold water district cooling grids will be used to distribute cooling power from the plant to the end users. This integrated process makes less than a 35% fuel input, because of the enhanced efficiency of solar fuel and the combined generation of it.



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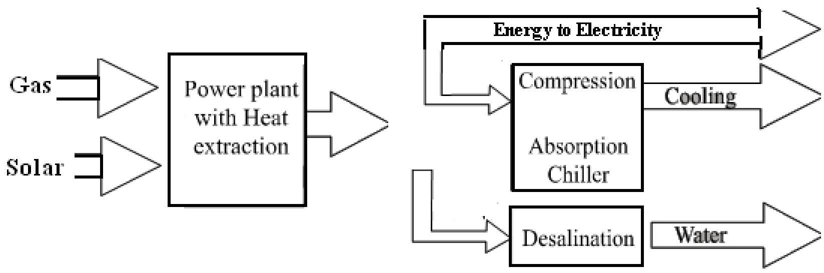

(b)

Figure 4. (a) Conventional arrangement for power, cooling and water; (b) Integrated Power & Cooling and Water Units

An obvious advantage of onsite production of certain commodities such as power, cooling, and water is production cost is able to compete with purchase price, instead of production cost of larger power plants. There is coincidence that solar energy along with cooling demand is primarily caused by air-conditioning, which is due to the intense heat of radiation emitting from the sun; this allows efficient utilization of solar energy, saving fuel for peak load times.

9. Concentration of Solar Power for Large Seawater Desalination

Concentrating solar power plants, CSP, can generate energy that can be used in membrane desalination, which takes place during reverse osmosis or RO either with seawater or brackish. The challenge that arises is ensuring smooth operations of seawater RO, which can guarantee continuous production of desalinated or permeated water; Thermal desalination methods, such as MSF or MED are potential hybrids powered by CSP that are directly connected with co-generating power and electricity.

In order to supply constant energy and power, desalination plants that use PV electricity or wind would need to be coupled with an electricity grid for added backup. Discontinuous operations that are allowed for high power capacities of win and PV energy would need to be installed and allowed to produce the same amounts of water and electricity. Renewable shares provided by CSP are 91%, PV renewable shares are 25% and wind powers renewable shares are 37%. Based on the conditions within different GCC locations, these numbers are considered to be the average performance for said systems.

CSP plants are able to save fuel when they are installed to run at capacity, in comparison to other types of renewable sources of energy, such as wind and PV for desalination. Instead of utilizing a backup power technology, the electricity that is generated by these systems can be stored in the form of batteries, hydrogen energy storage, or hydro-pumps, thus providing a continuous flow of power to desalination. If this is the case, additional electrical storage capacity that is required by CSP would be minor, the additional storage that is required for wind and PV power, would steadily increase system costs.

Further concentration will be given to CSP technology in regards to membrane desalination and thermal technologies, descriptions of economic and technical performance of larger scaled systems of this caliber combined with generated power from seawater that has been desalted will be further described in comparing the technical performance.

10. Comparing Technical Performance of Desalination Technologies

In order to be able to correctly compare MED and RO in combination with CSP in regards to different sites, both of the systems were designed to request an identical demand of water and electricity. By calculating the required amount of thermal energy input and the size that the solar collector field would need to respectively be, evaluations of the differences that exist in the systems performance can be further documented.

The vital design parameters are different for each site, due in part by the different nominal performances produced by the solar field, this varies based on the solar incidence angle, which is defined by the fields latitude, the different salinity found in the desalted seawater strongly influences how RO performs. Additional parameters such as the relative humidity and ambient temperature are also core influences of plant performance, having a specific effect on internal energy requirements and efficiency that are required for plant operation. The influence introduced by relative humidity and ambient temperatures do not have as much influence on the systems performance as that of the salinity of seawater and solar irradiance.

Both of the systems should deliver the product water while satisfying the WHO standards, allowing the salinity maximums of 200 ppm. This will require a reverse osmosis plant that utilizes a multi-pass approach, due to the fact that the single stage reverse osmosis process does not produce adequate final salinity figures. However, typical MED plants deliver water that is 10 ppm. The end product is not potable, requiring adequate proportioning of salts and minerals for human consumption. Electrical energy is considered to be a necessary by-product. Plants are designed identically, where the water output and the net power are the same, but the size of collector fields and fuel consumption will vary according to other requirements.

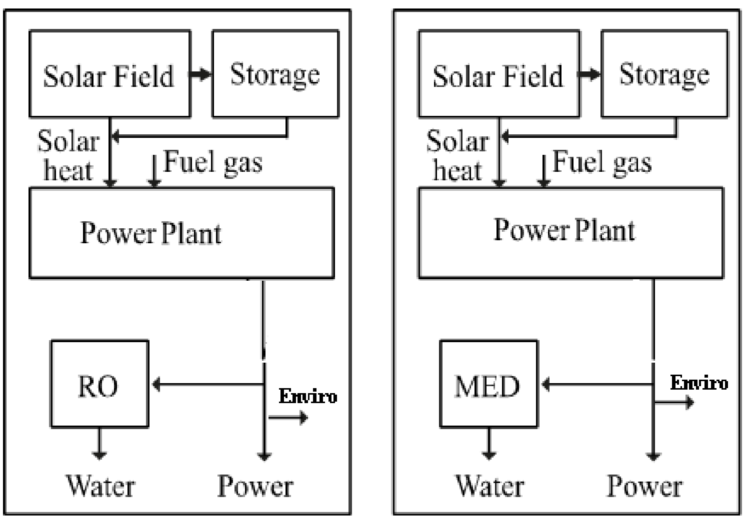

Figure 5. Different arrangements for desalination powered by CSP

There has been a massive amount of literature composed that compares thermal desalination and Reverse Osmosis, commonly referred to as RO. Most of the compositions come to the same conclusion that the thermal desalination process is not as energy efficient as the RO process. A further evaluation performed on this principal study brings up an opposing conclusion in regards to combining full scale CSP plants. In seven different cases performed on the GCC region, when CSP and MED processes are combined, four and eleven percent less input energy is required in comparison to when CSP and RO processes are combined.

The reason why there is a contradiction in the studies is due to the fundamental differences of the design target of solar power and conventional systems: with reliability being given to finite, polluting and expensive fossil energy sources, the conventional system is designed to yield optimal energy conversion from fuels into energy that can be used, which maximizes the electrical output of plants with their given fuel inputs (El-Nashar, 2002). Systems that are powered by the sun are made to maximize solar shares of given energy services. The efficiency of conversion is secondary; competiveness and economic performance are equivalent when both systems are concerned. Considerable reductions of global fuel consumption-a primary target of sustainability- is minimally achieved by increasing the efficiency of conversion, but is fully achieved when the shares of renewable energy sources are increased to 100%; The efficiency of the combined generation, producing two products that are extremely valuable, such as water and power-is extremely high.

Desalination plants are normally operated at constant loads. Part loads can cause problems in regards to fouling and scale performance, this also reduces economic attractiveness of respective projects. Solar energy can only be captured during the daytime and is reduced significantly on days that clouds are present in the sky. Directly coupling MED plants with CSP will require storing thermal energy that is taken from solar inputs or hybrid operations with bio or fossil fuels to allow continuous operations to commence. A reverse osmosis plant that is connected to grids can help compensate for the fluctuations of solar input levels by pulling electricity from other sources that are accessible on the grid.

Electrical transfers from remote CSP plants to RO plants located along the shore can produce a loss in electricity. Putting the CSP plants in hot desert climates will require dry cooling procedures to be carried out, this could lead to colder end temperatures along the steam cycles, which would emulate MED and CSP combined processes. In this type of case, heat would be dispersed into the desert, instead of being reused for desalination. Instead of losing the efficiency of processes by ineffectively cooling, its favorable to place CSP plants near the shores even though lower solar irradiance can occur.

Directly coupling MED with CSP has specific benefits: primary energy consumption will be drastically reduced, with this reduction, environmental impacts caused by the plant decrease. Integrating plants in this fashion is extremely attractive to large consumers, due to the fact that onsite operations are extremely competitive amongst water and power purchase prices of external sources.

RO and MED process design are currently in phases of dynamic development in regards to efficiency gains, cost reduction, reduction of environmental impact, and material enhancement (Alarcon et al., 2007). Combining desalination technologies along with CSP is in a premature stage within the feasibility analysis; there are no plants that fit this description that are presently operable at the time.

All of the desalination technologies showcase a lot of technical learning effects, considerable reduction being given to investment costs within the past years are anticipated to pursue, solar collectors prices will decrease overtime, thus compensating the increased cost of additional measures that are required for controlling population which will be indispensable for implementing these technologies in the large scale within GCC countries.

11. Demand for Desalination Plants in GCC

The GCC area will continue to be the largest segmented market for desalination technologies, where combinations of the increasing population, polluted groundwater sources and capacity of retirement that was built during the booms of oil production in the 1970s and early 1980s will cause a doubling in the capacity requirements.

Growth within the region is moving forward with added emphasis being given to Saudi Arabia's financial stability to help maintain capacity within the timeframe. Desalination is an environmental issue that involves brine discharges and energy consumption. This technology must be reasonable against other types of environmental alternatives and impacts. The desalination industry is not string, with a large portion of small and medium sized players governing operations in different places. It appears that desalination growth worldwide will escalate to 25%, in GCC countries demands for desalination increase by 35%. Saudi Arabia is a primary shareholder within the desalination market, receiving the highest amount of solar irradiance per square meter per year.

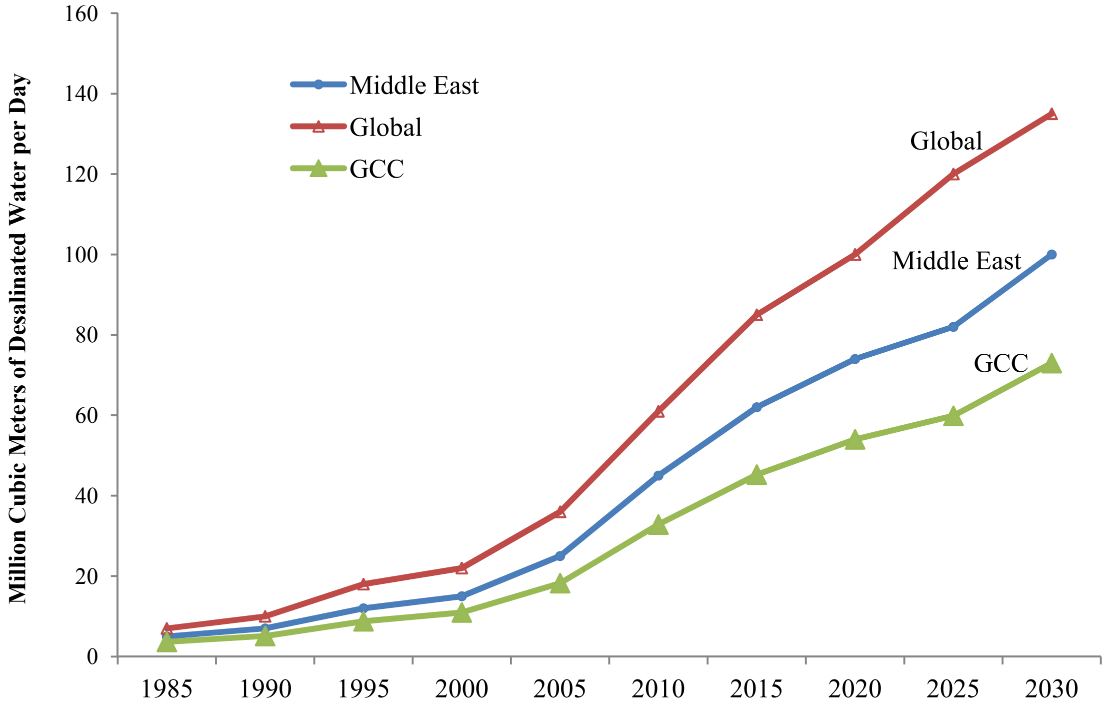

Figure 6. The demand for desalination plants Global, Middle East and GCC

CSP will be required to contend with wind-powered PV systems plus RO-systems and solar thermal collector non-concentrating systems. Aside from these contenders, linear Fresnel and parabolic trough systems are also likely to be competitive within this market segment. These two options offer low costs and probability of energy storage with hot water temperatures falling below 100 degrees Celsius.

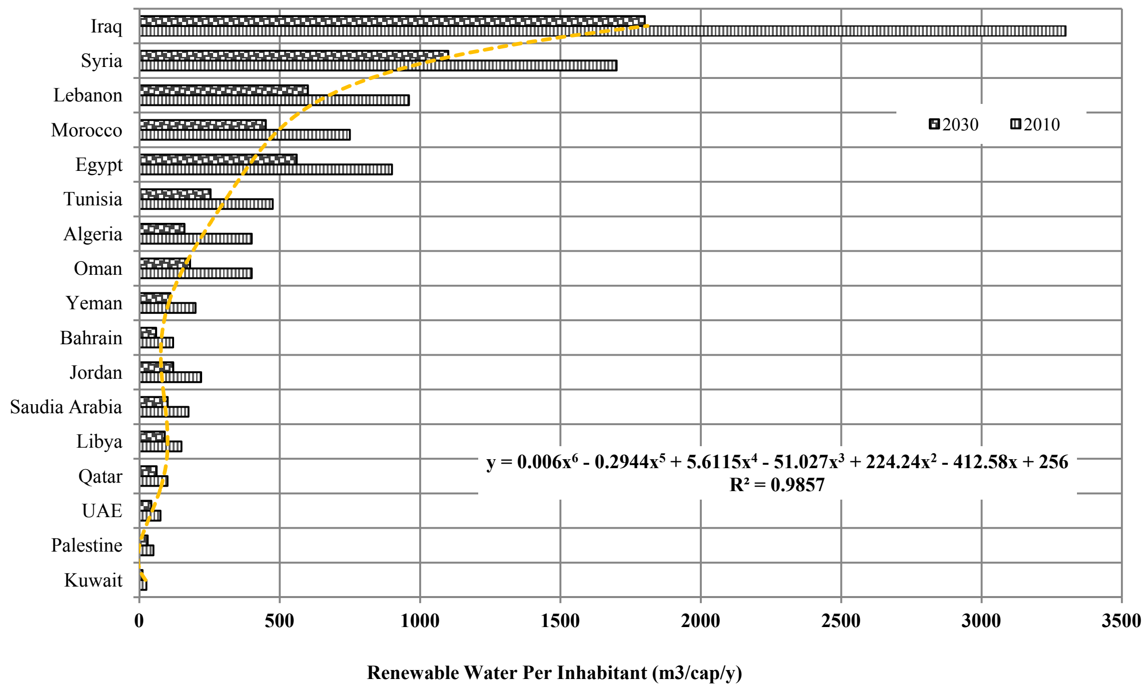

Figure 7. Total available renewable freshwater sources available per capita in the region of the year 2030

12. Socio-economic Impacts of Desalination on GCC

The economic performance of the referenced plants have been done for a site that has solar irradiance that measures 2400 kWh/y and salinity seawater of 40,000 ppm. Taking these conditions into consideration, both plants achieve a yearly solar share of 19% utilizing solar fiends that are designed to provide a nominal power capacity without engaging in thermal energy storing.

The yearly cost on capital is calculated from reviewing the discount rate of five percent, and taking economic plant life of twenty five years, this equates to annually fixed charged rates of 7.1%.

Additional costs related items are maintenance cost and operational costs, which are assumed to be 2% of investments along with annual insurance costs that are equivalent to one percent of investments made per year for both types of plants.

Plants will be operated in fossil modes/hybrid solar modes additional fuel inputs of natural gas will be emitted. Average life cycle costs of fuel is assumed being 25 €/MWH. Related yearly costs and fuel consumption will depend on the total amount of solar share yearly, which will vary with investment and size of the solar field and amount of thermal energy that is stored.

Replacements of membranes required for reverse osmosis will be required to take place once every five years, thus adding twenty percent additionally to the initial investments made on membranes to the yearly cost of operation when a CSP/RO process system is used.

Economic performance of desalted water and combined generated electricity is compared to the fixed sales price for electricity, which equates to 0.07-0.084 €/kWh this would equate to the production costs of cycle powered stations utilizing gas-powered cycles subtracting annual electrical revenue from the yearly expenditure figures. Remaining yearly cost is charged to the yearly production of desalted water, which yields an average cost done on per cubic meter of desalted water.

The CSP/MED process configuration reflects lower costs in water in comparison to the CSP/RO processes. Because CSP/MED systems have increased technical performance abilities, average fuel consumption is ten percent lower than the amount of fuel consumed in CSP/RO processes. An addition in regards to replacing the RO membranes every five years also brings added costs. The cost of these items makes the CSP/MED system appear economically better, even though the initial investment cost is slightly higher than with CSP/RO process systems.

This result is contradictory to the presumed assumption that RO systems are cheaper than MED systems. Even though this assumption is true in regards to initial investments, when both processes are combined with CSP/ desalination plants, the end result is opposite, even though the differences amongst the systems is not large. In-depth, project wise evaluations of the economical performance and technical performance will lead to well-founded decisions for one of the technical configurations that are appropriate CSP-desalination systems; competition will further define the shares that the different options within the future desalination market generate.

The considerably high lifetime costs of fuel and the costs of solar collector fields have been taken into consideration. Considerations in the high initial investment costs of MED plants, because of the rising costs associated with raw materials required to build the plants such as steel and copper have also been given considerable thought.

The cost of water is high in comparison to the costs associated with desalted water, which was taken from literary works, even though it still is within the range of values reported. The cost of water from RO and MED is reportedly in the range of 0.40-2.00 €/m3., representing large varieties of sites, product and sea water qualities as well as economic frame conditions (Abu Arabi, 2005).

The cost analysis appears fairly different when considering the learning curve in regards to CSP until the year 2020. Figuratively, during that time, collector costs will have decreased, power blocks will be well-adapted for solar fields, increased enhancements for environmental protection pursuits will be taken, costs of MED will have changes because of the increasing production of commodities such as steel and copper. The efficiency gains that will take place within the solar field will increase solar shares of reference plants to twenty five percent without the requirement for thermal storage to ninety five percent utilizing full scales of storage capacities. The cost for fuel will increase respectively. The revenue for electrical sales are assumed to remain constant, this may be a conservative estimation. Under these proceeding conditions, associated costs of water will decrease for CSP desalination processes that do not require thermal storage.

13. Available Freshwater Renewable Sources per Capita in the Gcc Region Circa Year 2030

Non-renewable resources such as the large fossilized groundwater reservoirs that are located beneath the Sahara desert can partially be utilized, if acceptable time-spans to be able to supply several generations with the valuable resource can be guaranteed. Additional measures, allowing the reutilization of waste water that has been treated and managed with respects given to accountability towards moving forward the distribution systems along with new unconventional water sources are imperative to help avoid the probability of disintegrate water supplies within the region (Gueymard, 2011).

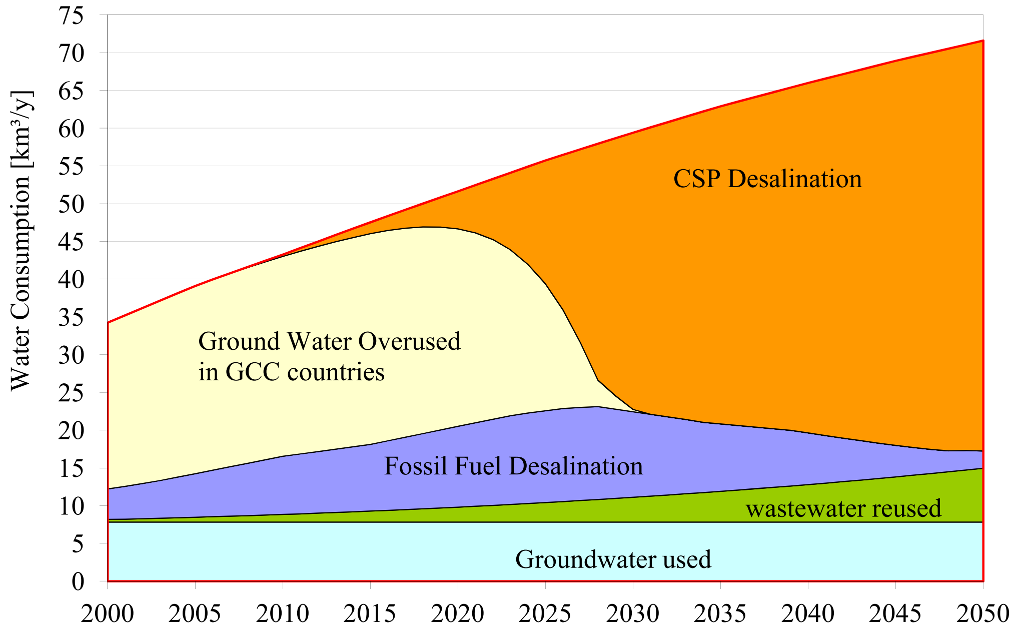

Figure 8. Concentrating Solar Power for Gas Turbines

From Figure 8, GCC countries should anticipate ground water depletion before 2030, so integration of all efforts to be collectively to use both treated waste water and any cost saving technology. Economical and engineering make water consumption using CSP became one of lthe target in Figure 4. Solar towers use a large field of two-axis tracking mirrors (heliostats) that reflect the sunlight to a central receiver on top of a tower. The concentrated solar energy is converted to high temperature heat. The emblematic optical concentration factor ranges from 200 to 1000. The plant sizes ranges from 5 to 150 MW of electricity production and these are feasible. The high solar fluxes imposing on the receiver (average values between 300 and 1MW/m²) permit working at elevated temperatures over 1000 ºC and to combine thermal energy into steam cycles into gas turbines and combined cycles. It is also comprises solar towers with central receiver systems which can be integrated in fossil plants for hybrid operation in a wide variety of options and have the potential to generate electricity with high annual capacity factors by using thermal storage. High efficiencies may be reached with solar-heated gas turbines. This may increased supplementary in combined cycle processes. The quota of the person in GCC and Arab countries were averaged to come with 320 m^3 per head per year and for Arab nation's 1000 m^3/capita/annum. Those figures are still with the stressed water consumption areas that the lack of renewable resources and accordingly agricultural output which eventually means the food strategically is a threat to yield and harvest in the area. There is a big gap between demand and supply in the area and desalination must fill this gap.

14. Probable Environmental Impacts

The primary impacts in regards to desalination of seawater will depend on the idea that taking seawater for desalination processes and cooling the system may result in entertainment and impingement of airborne pollutant emissions and organisms. Carbon dioxide that is caused by the generated electricity and heat that is required to power the desalination plants, biological control agents and chemical additives can be used to help avoid foaming of the raw water resources, biological fouling, corrosion of the systems and scale precipitation of desalination plants can appear finally in brine, and discharges of the hot brine along with highly concentrated salt from the sea can affect the local species of the region (Gueymard, 2011).

The impacts on the environment that are due to emissions from power plants and plume rise regarding life-cycle fundamentals combined with constructing the plant, maintenance and operation as well as de-commissioning of CSP/RO orientation and CSP/MED process plants, and the impact of the said locations have been analyzed in conventional desalination schemes. Because of the direct impacts that desalination plants have on the costal environment, performing impact analysis should be taken into account for accurate evaluations and every prior case up to the erection of large scaled desalination plants to further avoid deterioration of sensitive species that could vanish due to the plants erection. The only sites that should be chosen for erection should allow proper and effective quick dilution tactics of concentrated brine disposal to the seawater to avoid overheating local areas and high concentrated amounts of salinization long with low demands of oxygen (Gueymard, 2011).

15. Greenhouse Gas Emissions Produced by Desalination Types

Greenhouse gas emissions emitted from hybrids within desalination plants are taking origin for lifecycle assessments combining of the GCC regions will increase renewable carve ups within the system. It appears that MSF is amongst the highest within its share in regards to GHG, while the CSP/MED process is in competition and could very well be a contender to hybrid combinations in the near future. Extra efforts are put on R&D within this field. MED is a setback, that most are recovering from, with manufacturers deciding to take a more conventional approach toward implementing MSF processes.

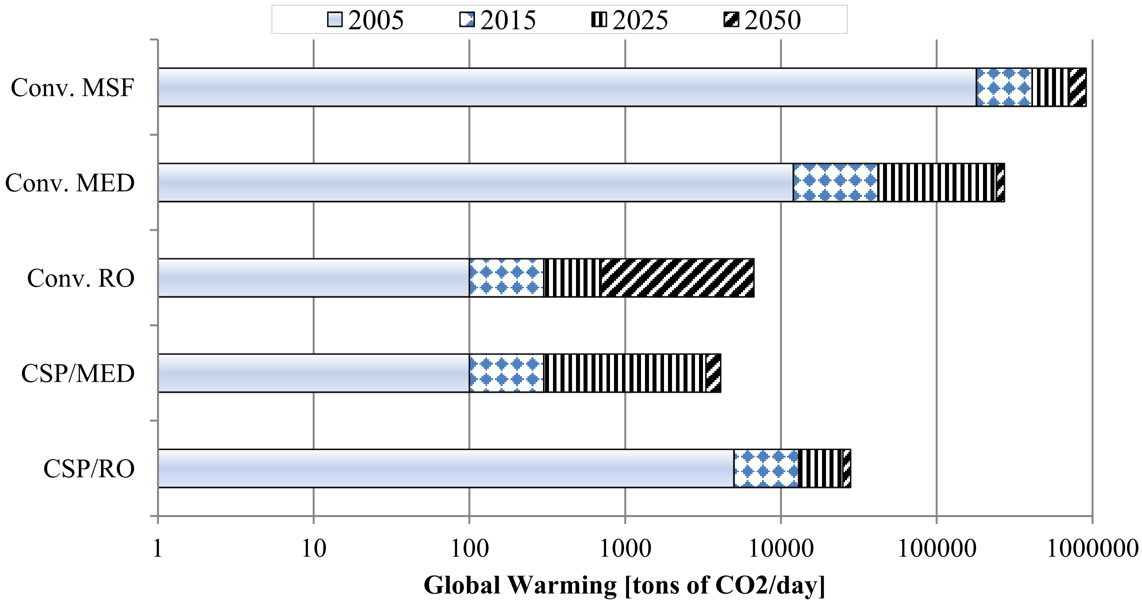

Figure 9. Greenhouse Gas Emissions (GHG) from different type of desalination

Figure 9 suggest that the greenhouse gas emission from hybrids of desalination plant taking as origin for lifecycle assessment the power combine of the GCC countries with increasing renewable carve ups of the system. It looks that MSF is the highest in its share to the GHG while CSP/MED is competing and could be contender to any hybrid combination in the future. Here it could be suggested to run extra efforts on R&D in this field. It came a setback for MED in the past and now is recovering when most manufacturer started to move towards conventional MSF.

16. Conclusion

Apart from the conclusions that other strategic evaluations of the GCC water sectors have proposed, desalination plants that utilize seawater have a quota on the supply of freshwater that is priced reasonably for GCC countries, support is given to domestic energy sources and will propose extreme impacts on the environment if CSP/ concentrating solar power is taken as the primary base of energy supply. Sterilized and clean desalination plants are imperative to help rectify the water dilemma that is taking place in GCC countries. If chemical additives are to be substituted within proper design intakes and the filtration of seawater on the opposing side would need to have its own reflections on energy. Concentrating solar power/ CSP is to be emission-free and the GCC region means will need to be large enough to deal with the added strain on demand. Based on the current available technology, and economics within a fifteen to twenty five year time frame, CSP will be a great solution that will be a contender amongst fossil fuel desalination services.

CSP will increase the way that the water distribution system is practiced in an efficient manner, market introduction for incorporating CSP for seawater desalination and power should start soon and adequate economic and political frameworks will need to sustain GCC countries to help implement initial pilot plants that will pledge to quickly expand this impressive technology in GCC countries that require its implementation. Any setbacks for the strategies will heavily jeopardize the further depletion of groundwater resources and have an adverse effect on social and economic development.

Looking at the concept of GHG abatement along with cost reductions of five percent of initial operations, utilizing solar irradiance will reach the average of 10 MWhr/ per year in GCC countries. The high demand for desalination plants within GCC countries is equal to seventy three percent of the total amounts of desalination plants, putting the extremely high costs of fossil fuels into consideration, all give proper support that CSP/MED processes will be successful, perform highly, and ascertain economically reasonable yields in favor of such technologies.

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