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Oman, Renewable Energy
Oman: A Solution for an Approaching Crisis

Oman is the oldest country in the Arab world with rocky mountains and a sprawling coastline. Oman is known for its beauty and its history and has a population of 5.107 million. Oman has a majority of its citizens living in an urban environment (86.285%) (Trading Economics) with the remaining population living in a rural setting. Oman has a family-focused culture with an average of seven people per household (Expat Arrivals) due to multiple generations living under one roof. You would find a typical family eating rice and wheat (NPR). Mealtime is a very important time in Omani culture with it serving as the typical time for social gatherings. (Britannica). Wages average approximately $4,631/month (Destination Scanner). Mud-brick homes are still common (Culture Trip) and a majority of the citizens have access to clean water (Macro Trends) and electricity (World Data Info). Education (Expat Arrivals) is free not including college/universities. Free Universal Healthcare is offered (PHCPI). Oman is a very hot country and it is hard to get around and this is highlighted with the fact that major cities in Oman are not very walkable (Expat Arrivals). Oman being hard to travel may be one of the reasons 8.2% of Oman citizens face undernourishment (FAO). Not everything is perfect in Oman because Oman is facing an upcoming energy crisis. Oman's oil and gas reserves are lower than originally estimated. Potentially, there are two-three decades of these energy sources remaining(Spglobal). As of 2019, Oman draws 100% of its energy through fossil fuels (World Data Info). This means that in the upcoming years Oman must commit to a renewable energy solution or solutions in order to remain a landmark country in western Asia.

Taking a closer look at Oman's climate it's strange that more progress hasn't been made towards renewable energy goals. Oman receives a lot of solar radiation making it a prime location for solar energy (EcoMENA). However, there are no current government operated solar energy plants in Oman (ICLG). This is an issue because Oman faces a great threat with climate change, according to the World Bank Group *"Oman is vulnerable to the impact of climate change due to sea level rise, temperature, and precipitation variability/extremes, effecting urban infrastructure, population health, and its water resources, which is critical as Oman is a water-stressed country."* The World Bank Group also states that *"Increase in sea level and floods might increase coastal erosion, affecting people and marine ecosystems along the coast… Increase in temperatures along with a decrease in rainfall might lead to more severe droughts."* With more unstable weather leading to more droughts and more coastal erosion it makes it very hard for the Omanis to produce their own food. Also, an increase in carbon dioxide can lead to the food having less levels of zinc, protein, and iron content (Concern Worldwide US). This means the food that is produced is less fulfilling of its needs meaning more of it is required. It's important to implement renewable energy in order to combat these issues. But that doesn't mean Oman doesn't have a strong outlook for the future.

From the *Oman Vision 2040*, we learn that Oman has a goal of obtaining 30% of all energy from renewable sources. I believe in order for this goal to be reached there needs to be a plan in place. Through utilizing the latest technology and bringing Oman's energy resources to the future, this country can potentially find its place connected to renewable energies within the Arab world.

One possible solution is utilizing Oman's natural high amount of solar radiation through the use of solar energy. People, from newborns to elderly, in both rural and urban populations can benefit from this type

of renewable energy. Oman can climb to their 30% energy goal. They can achieve results by harvesting solar energy through a unique setting identified as a solar farm.

Solar farms can increase food production, create new jobs, and are cheaper to produce than fossil-fuel based energy. But with these solar farms comes some minor drawbacks. These solar farms take up a lot more land space than other energy production facilities and can lead to habitat degradation of plant and animal species. Another disadvantage I found in my research is these types of solar farms may not be aesthetically pleasing. While this isn't a huge factor in deciding on a renewable energy solution, it is still important to consider because of how many people it will impact. If the people of Oman react to these changes in a positive way, it will help Oman reach the 30% goal towards renewable energy. We need to keep in mind that new information about solar power is growing everyday and research, combined with technology, increases the solar power advantages.

In a study published by *Nature Sustainability,* the researchers placed solar panels over various plants and tested light levels, air temperature, soil surface temperature and soil moisture. Through this study it was learned that none of the plants tested grew less when under the solar panels, but some they tested did better. The plants which grew better were related to the solar panels providing shade for the plants. In Oman's climate, solar panels can become overheated. However, there is an important point made by one of the lead researchers, Greg Barron-Gafford, who stated, "*Those overheating solar panels are actually cooled down by the fact that the crops underneath are emitting water through their natural process of transpiration – just like misters on the patio of your favorite restaurant,*". (interestingengineering). Another major advantage of solar energy is job growth. A typical solar farm can employ around 500 new jobs. While jobs would be lost from the declining use of fossil fuels those jobs would be replaced by these new solar farms. Plus, solar farms are cheaper than energy produced by fossil fuels. It costs $0.10 per kWh for solar panels to produce energy while it costs $0.17 to produce energy through fossil fuels. (greencoast).

As previously mentioned, in order to draw energy to help meet energy needs from a solar farm, there is a substantial amount of land area required. While solar panels placed over plants in these farms are possible, additional research is going to be required to see if adequate amounts of food can be grown in Oman through this type of setting. It is necessary, additionally, to think about how native plants and animals can be directed for new habitats.(greencoast)

Solar farms are not the only solution to energy problems. In order for Oman to reach and surpass its goal, Oman needs to implement multiple forms of renewable energy. Another energy form that Oman can use is Geothermal energy which is steam from the reservoirs of hot water underneath the earth's surface. (nrel)

Geothermal energy has multiple advantages including reliability and is described as a rapidly evolving energy form with huge potential. But the disadvantages of geothermal energy is that it can be difficult to work with. Geothermal energy is very *"location specific" (TWI-Global)* due to the nature of utilizing pools of water under the earth's surface. Gasses such as carbon dioxide, methane, and hydrogen sulfide can be released from inside the earth, through geothermal energy, which can damage the environment (Lafayette College). Another major problem is geothermal energy can be expensive.

The energy output for geothermal energy can be considered to be reliable. This makes it a much safer option because nations can know about how much energy will be produced. Geothermal steam produced by water is easier to control than other methods of renewable energy such as wind or solar. It does require very strict management because more energy fluid needs to be pumped in faster than the water being depleted. This problem can lead to more advantages for geothermal energy and that means more jobs becoming available. (Twi-Global). Geothermal energy is changing rapidly. Everyday more projects and studies are being used to find out more about geothermal energy. This indicates that geothermal energy

has huge potential to be a leader in renewable energy. Currently, the world uses 15 terawatts of energy and scientists estimate geothermal energy can provide up to 2 terawatts of energy. If Oman utilizes geothermal energy they could have a major push towards their 30% goal of renewable energy (Twi-Global).

It is concerning that most geothermal reservoirs can't be currently used. This is due to the lack of research funding available on geothermal energy. This form of energy production is very *"location specific" (TWI-Global)* and if those locations are not available for use then that can greatly limit the usability of geothermal energy. But through a study detailed in the *Proceedings of the institution of Civil Engineers-Energy* it was found that Oman has great potential for geothermal energy so this problem is lessened. It is important to mention how expensive geothermal energy is. It can cost $2-$7 million for a megawatt capacity plant. But that is the initial setup of the plant, the cost will eventually even out with fossil fuel energy (Twi-Global).

It is important to recognize that Oman is limited in the production of hydropower based energy. This is because according to Frontiers *"In Oman, hydropower technology is limited because it is a semiarid country having very few permanent water resources due to its location in the desert region."* Oman needs renewable energy sources that can be relied upon and that the natural land has an abundance of.

In order for Oman to reach and surpass their 30% renewable energy goal they need to utilize multiple forms of renewable energy. But Oman is not able to implement these programs immediately. Additional solutions need to be studied and implemented to work towards the 30% renewable energy goal.

I recommend that the first step Oman needs to take is to create organizations to focus on implementing renewable energy. Oman can do this by holding elections so the people can have input in who leads the initiative for renewable energy and form a groundwork for how many. These leaders would then select professionals from within Oman and from around the world to work with these organizations. Oman could hold press meetings in its 11 governorates (an area controlled by a governor) (Cambridge Dictionary) to spread information about the different projects, this would lead to voters being informed on who/what they are voting for.

These organizations would have different areas of focus, but everyone would have the ultimate goal of making Oman a leader in renewable energy. These focuses would include research towards cheaper and better sources of renewable energy, finding the optimal location for implementation of these energy sources, installation of renewable energies, raising awareness and promoting information of the renewable energy projects, and raising additional funds. There could be separate organizations formed by the citizens of Oman with these specific missions in mind that I previously mentioned. The leaders of each organization could be trained for strong communication between other organizations to ensure a smooth process.

Funding may be a challenge but through researching helpful resources, discoveries can be made that can help with the challenge of funding renewable energies. Through my research I found two organizations that could possibly help with the concerns of a renewable energy budget. The first being the *Organization for Economic Cooperation and Development* (OECD). It was interesting to find this statement,within the OECD website which stated, "*Together with governments, policy makers and citizens, we work on establishing evidence-based international standards and finding solutions to a range of social, economic and environmental challenges."* (OECD) I believe that renewable energies match up to the goals of the OECD and could benefit the country of Oman through a reliable partnership."

The second organization is the *International Renewable Energy Agency* (IRENA). On the IRENA website it states that it is

"an intergovernmental organization that supports countries in their transition to a sustainable energy future, and serves as the principal platform for international cooperation, a center of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy." (IRENA)

In 2009 Oman joined IRENA (IRENA) and has been working with them. Through IRENA, Oman can work with other countries which can cut time and cost off of research towards improved renewable energy sources.

The organization that raises awareness for the renewable energy projects could be in charge of promoting renewable energy to families and businesses. Proceeds collected from this promotion could then go towards more research and more implementation. This would help Oman get closer to the 30% renewable energy goal.

During my research I did not find any star-point organizations where there was a complete focus on renewable energy. However, I did find a number of resources connected to renewable energy projects tied to Oman. This includes Oman signing the Strategic Framework Agreement and a Renewables Data Collection Agreement with *BP*, which according to *BP "will support the potential development of a multiple gigawatt, world-class renewable energy and green hydrogen development in Oman, by 2030."* That is not Oman's only project related to renewable energy. There are over 15 projects related to renewable energy that include solar and wind-based energy. Title names of these projects connected commonly to Oman Power and Water Procurement Company (OPWPC) along with others include the following:

OPWP - Solar PV IPP at Ibri 2-Execution Stage
Raysut Cement - Waste Heat Recovery Project-Execution Stage
OPWP - 200MW Dhofar III Wind Power Plant (IPP)-Study Stage
OPWP - 500 MW Solar 2022 Independent Power Plant (IPP)-Study Stage
OPWP - Manah Solar 2 IPP-Bid Evaluation
Beeah - Integrated Industrial Waste Treatment Facility in Sohar Freezone-Bid Evaluation
OPWP - Dhofar Wind Farm IPP-Main Contract Pq Stage
SSDC - Biomethane and Solar PV Power Generation Plant-Main Contract Bid Stage

These projects are in different stages from study level, bid evaluation, and execution stage as examples. In my determination, this spells out hope for Oman because of the number of projects tied to renewable energy for this country. They are in different stages because each type of project requires research, information and study to determine the best process and system for each project that will benefit Oman sustainably in regard to energy needs.

Overall, Oman needs to implement renewable energy systems promptly. Without renewable energy Oman potentially faces an energy crisis. By considering and utilizing the suggested solutions detailed in this paper, Oman can adopt new ideas and strengthen current ideas, make the 30% goal and perhaps surpass it.

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