

Everyone's Smart University

Project (Spring 2021)

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Section	Date	Course Code
Master	Saturday 08 / 05 / 2021.	(PMG506)

Advanced project Management

Solar Powered Cattle Watering System

Contents

Introduction	2
Literature Review	3
Methodology	5
Result & Discussion	5
References	6

Project Description

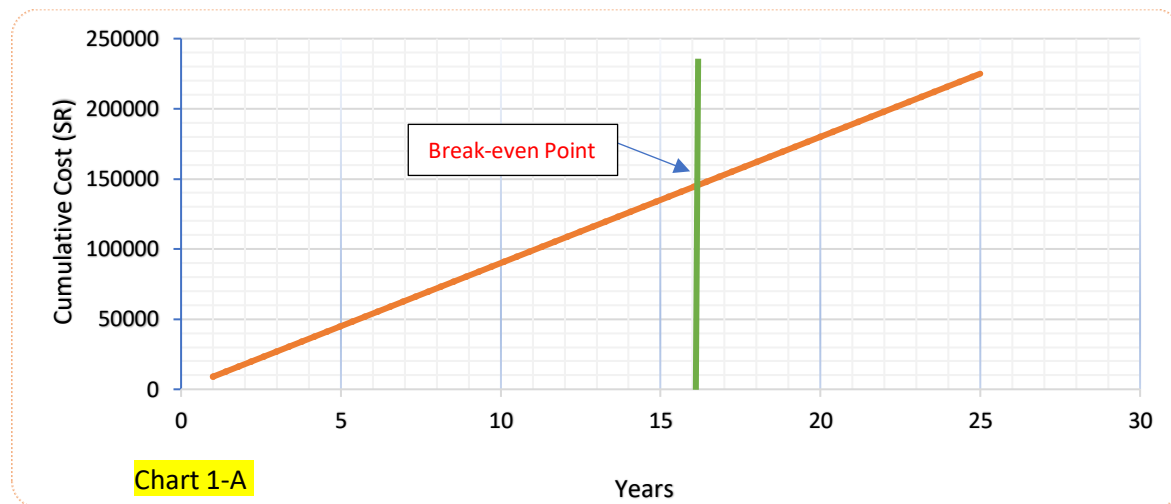
Effective ranch land management is difficult under ideal circumstances, but it's particularly challenging in Wadi Ad-dwasir where average rainfall of around 75 mm per year makes two key resources, strong grass especially in the Winter and Spring, and a little Water swamps, precious for cattle grazing. A lush piece of land without accessible surface water is virtually worthless for ranching due to water consumption requirements for cattle (107 heads of camels). However, the grid-connected electric pumps are cost prohibitive due to the expense of running electrical lines to remote locations.

Contemporary technologies like electric pumps, solar panels, and rechargeable batteries present an opportunity for a reliable, low-maintenance solution.

In our rancher's problem scenario, we have to meet the following criteria:

- The pasture is 13 kilometers from the nearest power source so it needs to be locally driven by solar power.
- There is a well on another part of the property that was drilled 90 meters deep. Because this
- Camels drink approximately 10 liters per watering in two sessions a day, once mid-morning and again in mid-afternoon. There are 107 heads of cattle on the ranch, so they consume some 2140 liters of water per day.
- Because the cattle must be consistently watered so they stay healthy and remain on the pasture, the main watering tank supplying a day's worth of water and a reserve tank containing at least another day's worth of water is required in case of pump failure.
- The storage tank(s) must have an automatic shutoff switch to prevent overflow, and the reserve tank must have a master switch to control the pump.
- Reliability is key. Because the well is on the far end of the ranch, it can not be inspected daily, and a garage full of tools can not be easily moved on-site if a repair is required. If it could somehow report when watering tanks/troughs are low, this would be ideal.

Anyways, the owner of the farm brings the water trucks three times a month with a total cost of 750 Saudi Riyal per month. On the other hand, the completely solar-powered watering system will cost 140,000 Saudi Riyal. In the below chart, we calculate the cost of bringing a truck for 25 years which is the period that can solar energy last without losing efficiency.



The goal of this project is to produce a detailed design for the above requirements, but practicality and our budget prohibit the fabrication of a full-scale solution. Based on the full-scale mathematical models, we will size and build a 1/10th scale model as proof of concept.

Literature Search

The first part of our research consisted of familiarizing ourselves with water wells and their construction. For this, we turned to reference material from the National Groundwater Association, their related web resource WellOwner.org, and websites from a variety of well-drilling companies to understand the anatomy of a water well and the types of pumps typically used in wells.

We turned to the reference The Handbook of Pumps and Pumping for information related to the various types of pumps and their appropriate applications. Additionally, the same handbook was our go-to reference for developing the system resistance curve, calculating the pump head, and for advice on other details involved in choosing the correct size pump for our application. The Working Guide to Pumps and

Pumping Stations and The Pump Handbook provided additional information on pump sizing.

To get the most from solar panels, it is critical to set the panels at the correct angle to maximize sun exposure based on the season of the year. The tilt of a solar panel impacts how much sunlight you capture. There are four ways that solar panels can be placed. They can be at a fixed angle for the whole year, a fixed angle that can be adjusted two seasons of the year, a fixed angle that is adjusted all four seasons, and a 2-axis tracker that tracks the sun automatically. Fixed solar panels are convenient because they do not require regular readjustment. The disadvantage to a fixed solar panel is less power because it does not follow the sun. Adjusting solar panels, a couple of times a year gives more solar energy than panels at a fixed angle. A 2-axis solar tracker gives maximum solar energy, plus you would not need as many solar panels. The disadvantage of a 2-axis solar tracker is they are more costly, and an extra budget is needed for regular maintenance. The angle that the solar panels are based on the latitude of the location of the solar panels.

There are different types of solar panels: monocrystalline, polycrystalline, and thin-film. Monocrystalline solar panels have the highest efficiency of 15-20% and they are space-efficient. The disadvantage to monocrystalline is they are the most expensive compared to other solar panels and tend to be more efficient in warm weather. The advantage to polycrystalline solar panels is they are cheaper as they are simpler to make. They also have a somewhat lower heat tolerance than monocrystalline solar panels. This means that they function slightly worse than monocrystalline solar panels in high temperatures. The disadvantage of polycrystalline solar panels is they have an efficiency of 13-16% due to the lower silicon purity. Thin-film solar panels have an efficiency between 7-13%. Based on the advantages and disadvantages of the different types of solar panels, the best choice for this project is polycrystalline solar panels ("Wuham, China, 2010").

Building a solar panel frame structure that can withstand various conditions, we should study the natural and unnatural environmental factors that our project is likely to face and how to handle them. National Council of Structural Engineers Associations

gave us an overview of the most important factors like wind load, sandstorm, and humidity that threaten outdoor applications and may affect their continuation for a longer period. Knowing the characteristics of some mechanical and manufacturing properties of materials always leads to a better selection of material, the process for making it is the most critical decision for the designer. Aluminum is the best choice, but costly so for this kind of project iron is better to use (Nisbeth and Budynas 2014)

Methodology

We built the 10th scale model which consists of two parts electrical part and a mechanical one. So, the prototype must meet the followings:

- Electrical aspects:

- 1- The 150 W solar panel produced excessive voltage (12V required, ~ 20V)
- 2- Found a 12V, 60W DC-DC converter(Input 9- 36V and Output 12V, max current 5A)

- Frame aspects:

1. Support one 100 cm x 100 cm, 12 kg panel weight
2. Category 1 (80km/h) Wind
3. Spring and fall inclinations (17° and 55°)
4. The factor of Safety of 2 - 3

Results and Discussion

The prototype that we built, was tested in three different weather conditions (sunny, partly cloudy, cloudy). We got an average flow rate of 6.25 liter per minute which is equivalent to 25 liters per minute in full-scale. I think this kind of project will be really useful for people who live in remote areas. As it is shown in (chart 1-A), the break-even is in the year 16th, and that means some money will be saved in the next nine years. Finally, sandstorm is a common natural phenomenon that may lead to sand creeping, and that is the biggest issue that our project will face.

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