Do you stay connected or do you disconnect?

Author: Sergio A Lozada Figueroa
Advisor: Rafael A Nieves-Castro, PharmD
Master of Engineering in Mechanical Engineering

Problem Statement

As the title states “Do you stay connected or do you disconnect?”. What we are referring is to the energy source that is provided to a household or business. Three main sources of energy exist, nuclear, fossil fuels and solar. This project will only concentrate on two, solar and fossil fuels. In 2021 fossil fuels provided about 97% of Puerto Rico’s electricity. In the recent years many clients have moved to a more stable source of energy, solar. The current power grid is not stable due to lack of maintenance and lack of upgrades. Another issue is the forces of nature. Puerto Rico is constantly experiencing heavy rains or worse, hurricanes. This causes for the grid to degrade or fail.

Research Description

The importance of this project is to allow the general population or business owners to select the different options when it comes to a stable source of energy. We will look into companies operating in Puerto Rico that provide solar power options and the only fossil fuel company in Puerto Rico, Luma. Also, we are going to compare two households. One of them is a regular home and the other one has a special case where the AC has to be on due to a skin condition.

Objectives

Decipher and create a guide to configure a system that provides a sustainable source of energy to a household or operating business. The research will also allow to select solar products from different suppliers allowing us to keep the price low and maintain a high return on investment. One additional objective is to calculate the average of electricity per occupant independent of the age.

Research Contributions

Provide the general population or business owners the needed information in order to select the most beneficial source of energy configuration based on need, efficiency, cost and productivity. Other major contributions are that solar power is pollution-free, produces renewable clean power, provides a return on investment, creates jobs, and solar panels a virtually maintenance free and can last up to 30 years.

Methodology

For this part we will calculate the energy consumption in the household in order to design the solar system. First, we need to identify the electrical device and pull out the specs in Watts*hour (Wh). Second, with the Wh we multiply it the number of hours use during the day, that give us the Watts*hour per Day (Wh/day), if we dived it by one thousand, we get kilo*Watt*hour per day (kWh/day). Third, we multiply by the times used during the week and we get kilo*Watt*hour per week (kWh/week). Fourth, we multiply it by four and get kilo*Watt*hour per month (kWh/month).

Next, we have one of the monthly bills with the reading of the use of electricity. The month shown there was a consumption of 755.00 kWh.

Methodology Cont.

This gives us an idea of what to design for. We need a system capable of generating this amount or to cover the bill. This is the most important part of the project, the analysis of the yearly consumption. We have to use all the values from all months and find the average. With this average we design our system. This way we cover the yearly consumption. Covering all the low consumption and high consumption months.

Once we have our average, we can design the system accordingly. We need to calculate how many solar panels we need and how many batteries we require. First, we calculate our average. We add all the monthly consumption and dived it by 12. Also, we will annotate our max and lowest consumption for comparison. Once we have that average, we compare it to all of our monthly consumption and make sure that we cover more than 75% of all readings. A detail new to the analysis is the consumption per house occupant. This is calculate using the yearly average divided by the house occupants.

To calculate the amount solar panels, we need a few details. We require the number of hours daily of sun, we are going to use 5 hours daily of sun. That gives us 1800 hours of sun per year. We need to know the capacity of generating electricity depending on our solar panel. Our design uses a 415 Wh per hour solar panel. With this we can calculate our number of solar panels:

$$\frac{16{,}500\left(\frac{kWh}{Yr}\right)\times 1{,}000\left(\frac{W}{kW}\right)\times\frac{1}{1{,}800}\left(\frac{Yr}{h}\right)\times\frac{1}{415}\left(\frac{h}{Wh}\right)=22\ panels}{(Yearly\ house\ required\ power)\times(kWtoW\ conversion)\times (Yearly\ hrs\ of\ Sun\ Power)\times(Solar\ panel\ power\ generation)\times}$$

Next, we move to the option of how many batteries we require. We have to be based on how much consumption is needed. One battery is 13 kWh, but the use of the battery is not to power everything in the house, it’s only for the essentials during an emergency or local grid outage. In an emergency the only devices used may be tv, fans and lights. A TV only consumes around 75W, a fan consumes around 100W and lights consume around 10W. From the table “Average power consumption use of electrical devices table” we can calculate how much a battery will last.

$$\frac{Battery\ Power\ Capaity}{The\ Sum\ of\ Electrical\ Devices\ Used}$$

$$\frac{1\ Battery}{1\ TV+3\ Fans+10\ Lights}$$

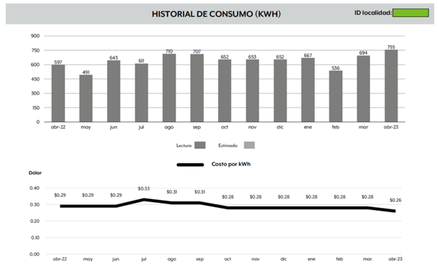
$$\frac{13{,}000\ Wh}{75\ W+300\ W+100\ W}=\frac{13{,}000\ Wh}{475\ W}=27\ h\ 20\ \text{min}\ on\ one\ battery\ only$$

$$\frac{2\ Battery}{1\ TV+4\ Fans+10\ Lights}$$

$$\frac{26{,}000\ Wh}{75\ W+400\ W+100\ W}=\frac{26{,}000\ Wh}{575\ W}=45\ h\ 12\ \text{min}\ on\ two\ battery\ only$$

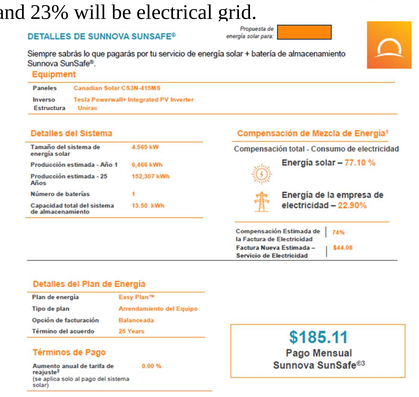
Results and Discussion

The first house analyzed is 4 occupants house hold, three adults and one child. Per the electrical bill we have an average of 697kWh per month and yearly consumption of 8,368kWh per year. It is clear that the highest consumption will always be June and July or if a weather pattern present itself, for example, a heat wave.

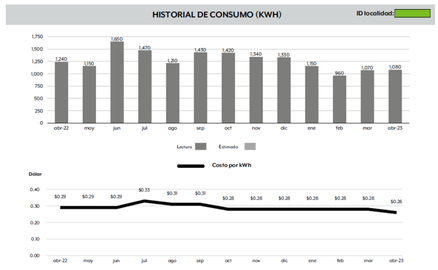


Now we can calculate the Max, Average and Minimum consumption, and most important the average use of electricity per occupant. Using the formula to calculate the number of solar panels is eleven and one battery is required. With that calculated we can take our information to a company that sells, installs and maintain solar system. We got a quote of $200.11 per month.

The quote provides a very important detail, how much energy you will consume from both source, solar and electrical grid. For house 1 we can se that 77% of the energy will be solar power and 23% will be electrical grid.



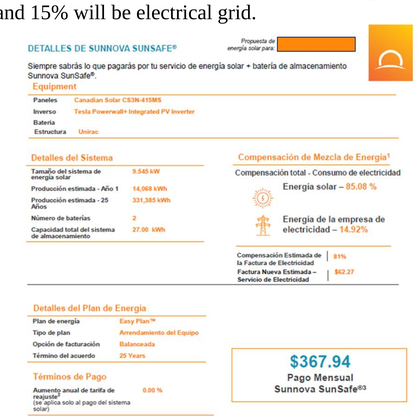
The second house analyzed is 5 occupants house hold, three adults and two child. Per the electrical bill we have an average of 960kWh per month and yearly consumption of 16,500kWh per year. It is clear that the highest consumption will always be June and July or if a weather pattern present itself, for example, a heat wave.



Results and Discussion Cont.

Now we can calculate the Max, Average and Minimum consumption, and most important the average use of electricity per occupant. Using the formula to calculate the number of solar panels is eleven and one battery is required. With that calculated we can take our information to a company that sells, installs and maintain solar system. We got a quote of $367.94 per month.

The quote provides a very important detail, how much energy you will consume from both source, solar and electrical grid. For house 1 we can see that 85% of the energy will be solar power and 15% will be electrical grid.



Average consumption per ocupant. The second house has a special medical situation. We can find an average between a special case and a regular house.

Cosumption History (kWh)	Cost per kWh	Monthly Bill	Average per occupant
225	$ 0.29	$ 64.95	

Conclusions

Per the analysis of both house hold we can clearly identify that both solar systems cost less than the average monthly payment. Currently in Puerto Rico the current electric company is Luma. The average cost of electricity in Puerto Rico between 2014 and 2021, is $0.21 per kWh. It is clear that the current average cost between 2022 and 2023 is $0.29. That shows that Luma is charging higher prices than the last 7 years. Luma continues to announce that there will be a raise in the cost of electricity.

By converting to solar you eliminate all fluctuation of the cost and stop it from getting a higher bill. If we dived our monthly payment for the solar system and our energy consumption, we get an electricity cost of $0.26 proving that it is cheaper to run on solar power. By switching to solar power we achieve all our objectives.

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