

Living Off the Grid with Renewable Energy: A Case Study

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The trend towards green, sustainable living is on the rise and the benefits are continuing to make noise in the world of homeowners. In this project, the benefits of renewable energy and consumer preferences were analyzed and applied to off-grid living in the form of a case study. It was found that the majority of homebuyers are concerned about the environment and wanted an environmentally friendly home but are not willing to pay more in order to achieve these desires. This information spurred the need for a detailed assessment of the feasibility of sustainable off-grid living. After conducting extensive research, overview guidelines for living off the grid were provided which include expert experience and cost data. These guidelines were exemplified in the real-life success story of the Auerbach's off-grid home on Lasqueti Island in Canada. They were successful in creating an off-grid home which showcased several of the components discussed in the research-based guidelines. Their system was based on strategically placed solar panels and a well thought out lithium-ion battery system. This research paper benefits the reader with a general outlook into the feasibility of off-grid living and/or ideas for implementing renewable energy sources into one's home.

Key Words: Off-Grid, Solar, Power Generation, Renewable Energy, Sustainability

Introduction

Renewable energy consists of using sources of energy that are sustainable and replenishable, such as from the sun or wind. Taking advantage of this form of energy is overwhelmingly beneficial to not only the individual user but to the environment and society as a whole. The general benefits focus on the minimized impact on the environment that we create as we fuel our everyday needs. By lessening our reliance on fossil fuels, we are able to reduce harmful greenhouse gas emissions while diversifying our energy supply. Those who make the decision to implement renewable energy in their individual house will also reap many benefits. These benefits include reliability in their own sourced energy that is safe from price surges and blackouts, as well as serious financial gains. As written (Shinn 2018), energy-efficient appliances can bring in savings from utility bills of about \$500 every year. This number can be increased through more drastic steps being taken to maximize the total energy used in a home to consist of mainly renewable sources. These benefits combined with the

personal satisfaction of saving the environment have sparked interest in homeowners to adapt their homes to use more renewable energy or even live off the grid completely.

There are some cases where individuals are able to apply renewable energy to their own homes to the extreme marks of living off the grid, independent of managed utilities. Living off the grid essentially provides all of the benefits discussed for renewable energy and takes it to a new level of independence. That is exactly what two individuals, Melinda and Ezra Auerbach, were able to accomplish in their home on an island in British Columbia. Whether you follow their whole process or just one component, this paper will provide the information necessary to implement renewable energy into your home or even go off the grid completely.

Methodology

In order to obtain the best results, secondary quantitative research was used for this project in order to provide key insights into renewable energy savings and off-grid equipment selection. The primary source of information comes from the use of the case study approach to data collection. More specifically, the case study I will be using as my primary source is titled: "Case Study: Living off the Grid." This case study details the success story of Melinda and Ezra Auerbach in their attempt to live off the grid in their home on Lasqueti Island, BC, Canada.

Literature Review

It can be difficult to make the first steps of implementing renewable energy in one's home, let alone to consider living off the grid completely. This is largely due to the intimidating up front costs. This is understandable, as just installing solar panels costs an average of \$14,100 (Richardson 2022). With the goal of expanding the use of renewable energy in homes, it is important to analyze consumer data to fully understand what factors drive homeowners to make the decision to improve their energy efficiency. The National Association of Home Builders (NAHB) questioned recent and prospective homebuyers on if they would be willing to spend more money based on their concern for the environment. As shown in Figure 1, only 14% of respondents would pay more and the most common response was that the individual does want an environmentally friendly home but is not willing to pay more.

Buyers' Concern about Impact of Their Homes on the Environment

(Percent of Respondents)

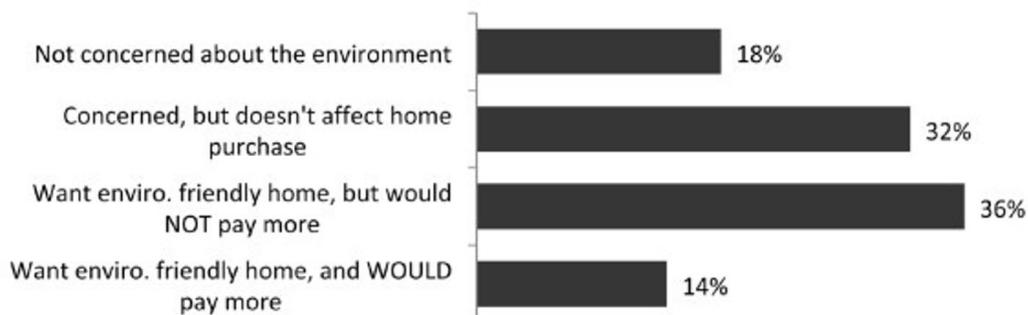


Figure 1 (NAHB 2019)

Once the decision is made to begin using renewable energy or even making strides to live off the grid, it is crucial to spend a lot of time on equipment selection. The main sources of energy needed to live off the grid are devices that maximize energy from wind and the sun, as well as a strong battery system when aiming to live off the grid completely. The following steps serve as the general guidelines to consider for living off the grid but are not mandatory nor fully comprehensive. It is important to note that partial implementation of the following suggestions can greatly improve the energy efficiency within a home without the accomplishment of living off the grid completely.

Land Selection

When preparing to live off the grid, land selection is one of the most important components to consider. It is common for the residents to construct a new home when making this decision, so there is an opportunity to choose the most effective environment. Finding land in a remote area will ensure fewer permitting regulations and building codes as well as lower taxes and an overall less expensive purchase of land (Black 2008). It is crucial that the chosen area has the resources needed to meet energy and comfort needs. Most importantly, there needs to be a dependable and clean natural water source nearby. In a later step, we will go further into the details of obtaining and storing water but that is not possible without close access to a natural supply. Since energy will most likely be gathered from solar panels or wind turbines, it is essential that the environment is conducive to the energy system that is chosen. For example, solar panels require adequate direct sunlight and turbines are powered by wind ideally in a non-obstructive area. It is also beneficial to choose the land to be in a climate that fits well with the resident's desires. It is a simple consideration but can be massively important so that the dweller maximizes comfort and is able to adhere to the off-grid lifestyle. Lastly, adequate research is a major requirement as specific restrictions and zoning laws are important to consider.

Power Generation System

After deciding on a piece of land for your off-grid home, finding a method of generating power is the next step to maximizing efficiency. The two most effective and most popular methods are using solar panels or a wind turbine, or a combination of the two. According to the U.S. Energy Information Administration, the average American household consumes about 11,000 kWh per year which simplifies to roughly 30 kWh per day (EIA 2021). Having an understanding of your energy needs is essential when considering power generation options.

Solar panels will serve as the primary source of generating energy, as land selection was analyzed earlier to include a sunny environment. Having assessed your energy needs, the amount and size of solar panels can be calculated. Based on the household average, this will require about twenty 350-watt panels. In the U.S., the cost of a full off-grid solar powered home ranges between \$30,000 and \$60,000 (Askari 2015). This cost is before applicable rebates and tax credits, and also includes the panels, battery system, inverter, and installation. The battery system will be covered in detail in the following step. Solar panels are also a very effective option for those not living fully off-grid, as it can be used in a hybrid system with the utility company's main grid acting as a backup.

Wind turbines can also be utilized as a primary energy source but more commonly as a supplement to solar energy. Similar to solar, site selection is crucial for optimizing energy from wind as was

discussed in the first step. Based on the U.S. household average of 11,000 kWh per year, a wind turbine that meets the rating range of 5-15 kilowatts would make a significant contribution to the energy demand (Pierce 2020). According to the American Wind Energy Association, small residential turbines of this size cost between \$3,000 and \$5,000 (2022). Based on the 5-15 kWh capacity, this means you can expect to pay between \$15,000 and \$75,000 for a wind turbine for your off-grid home. Like solar power implementation, wind turbines can be beneficial for those living on-grid. They too have a significant up-front investment but are virtually free after installation and they reduce energy expenses in the long run.

The usage of solar panels and wind turbines are the two most effective methods of generating power for an off-grid home and require serious research and consideration. The average American household kWh was used for the purpose of demonstrating quantity and cost effectiveness of the mentioned systems. However, when considering real life application, one should carefully analyze their individual energy expending habits. Energy Saver (energy.gov) provides a useful tool that estimates annual energy use and cost to run specific products:

<https://www.energy.gov/energysaver/estimating-appliance-and-home-electronic-energy-use>

Power Storage System

Since the sun doesn't shine all day long nor does the wind constantly blow, you will need a method of storing the energy generated from your environment. An effective battery system is able to collect and store excess energy gathered from sources such as solar and allows for usage at a later time. Specifically, lithium-ion battery cells are popular among off-grid households and are one of the most efficient methods of storing solar power. Lithium batteries typically come with higher cycle guarantees and degrade longer in their life cycle, making them a better option for off-grid homes (Pickereel 2021). Battery storage allows you to stay connected to power in times of emergency, so it is essential. Lithium-ion batteries of this caliber cost between \$12,000 and \$14,000 for each installation (Few 2018).

Water System

Access to a clean and dependable water source is crucial for off-grid living taken to this extent. One of the more common ways to address the need for water is by using a well system. After having a drilled well installed, the water system functions just as it does on the grid. The cost of drilling a residential well varies due to the required depth and size of the well itself. Drilling costs \$25 to \$65 per foot which comes out to \$3,750 to \$15,300 for a complete system installation (Tsai 2018). Other methods involve collecting from natural sources such as a nearby lake or rainwater which require a primary filter and a purification system. A well thought out water system can be expensive and complex, but it is one of the most important aspects of an off-grid home as it is essential for human life.

Case Study



Figure 2 (Auerbach 2018)

Melinda and Ezra Auerbach were able to accomplish many of the steps that were discussed in order to achieve a functioning off-grid home in Canada. They began their off-grid journey on Lasqueti Island in the 1970's. Their lifestyle at this time was very simple and their home was centered around elementary components such as kerosene and candles. Utilizing today's renewable energy technology, they now have a fully modern house that runs internet all day long and they even help power some neighbors' appliances. As their success has inspired others, the Auerbachs have become very active in the solar industry and have even started their own solar company. Their applications make for a great success story of off-grid living and using renewable energy.

Power Generation System

As you can see in Figure 2, their home is located on an island and is able to catch a lot of direct sunlight which makes solar panels a great option for their primary source of power. This is exactly what the Auerbachs did, along with a generator for back up power. For their panels, they use 2 kW Phonos modules on their shop and 2 kW Sharp modules on the house itself. They also use 1.2 kW Mitsubishi modules which are pole mounted on the roof as you can see above. Their backup generator covers the PV deficit in the Winter months, supplementing a 6-10 kWh daily load. The generator that they elected for is the 8 kW Kubota (1800 rpm). With their sunny environment and backup generator, they are able to live very comfortably with this relatively simple power generation system.

Power Storage System



Figure 3 (Auerbach 2018)

The power storage system is the focus of the Auerbach's Off-Grid home and it is something they have researched extensively through trial and error. They recently installed a 390 A/h Discover AES Battery bank which replaced their 750 A/h flooded lead acid battery. After making the switch to a lithium-ion battery system, they noticed drastic improvements in charging efficiency and a more stable operating voltage range. This preference for lithium batteries in off-grid applications was highlighted in the *Power Storage System* section. The system is also serviced by Sunny Boy 2000 inverters and MS MPPT 60/600TR(150) charge controllers.

Conclusions

This paper detailed renewable energy options, consumer cost preferences, and guidelines for living off the grid which were brought to life in a case study. The Auerbachs provided a well executed example of how to live off the grid using renewable energy. They even showcased specific topics discussed in the guidelines such as the preference for lithium-ion batteries. My only complaint with the case study is the usage of a diesel generator as a backup source rather than a cleaner source. In the guidelines I discussed the potential for wind turbines to be used in combination with solar panels. When properly stored in an efficient battery system, this combination is very effective and does not require other sources such as a generator that derails from sustainability efforts. Overall, the case study was certainly a success story and it was effective in exemplifying the methods discussed.

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