Solar Energy for Bridgestone Nature Reserve at Chestnut Moutain

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Introduction

The Bridgestone Nature Reserve, a 5,763-acre property near Sparta, TN, was gifted to The Nature Conservancy (TNC) by Bridgestone Americas, Inc., in 2018. Since then, TNC has been pursuing the goal of carbon neutrality on the property. The property managers at Bridgestone Nature Preserve have tasked the 2021-2022 Society and the Environment Capstone class with creating a proposal for installing a renewable energy generation system on the property to provide electricity for the buildings and equipment. To accomplish this, the Solar Group researched carbon neutrality, solar panel systems, energy usage on the property, and commercially available solar panel manufacturers and installers. The final proposal was completed as a reference sheet for TNC to use moving forward to select an installer and system for the property.

Carbon Neutrality

To aid in the fight against climate change, The Nature Conservancy has pledged to achieve a goal of net zero carbon emissions by balancing their emissions with carbon sequestration. There are two primary methods to achieve this goal: reducing emissions and increasing carbon sequestration. (For more information on the global net-zero initiative and the political and societal necessities for achieving such, scan the QR code below to view the Princeton Net-Zero America Project.) Carbon sinks, such as old forests, absorb large amounts of carbon and are a major contributor to carbon sequestration. Although the Reserve is heavily wooded, The Nature Conservancy has sold the carbon credits for most of the property to other companies to help contribute to their carbon neutrality; therefore, TNC must take other measures to achieve carbon neutrality. At the suggestion of the 2020-2021 Society and the Environment Capstone class, the property managers for the Bridgestone Nature Reserve have begun upgrading equipment and office appliances to electric and energy efficient models. To further reduce carbon emissions, TNC hopes to switch to a renewable form of electricity generation for the facilities at the Reserve. The three main types of small-scale renewable energy are geothermal, wind, and solar energy. This proposal focuses on solar energy, which was previously determined by the current and prior Capstone classes to be the only feasible option for on-site electricity generation.

Solar

So, what is a photovoltaic system? It is the use of sunlight through the 'photovoltaic effect' to generate direct electric current (DC) in a direct electricity production process. The DC is then converted to AC, usually with the use of inverters, in order to be distributed on the power network. These systems have been shown to be easier to install, at lower cost and in a shorter time frame. A portion of building a PV system includes choosing the best fit panels. Listed below are the types of panels that we did research on and see best fit for the conservancy.

Panel Type	Efficiency
PERC	25%
Copper indium gallium selenide (CIGS)	13-15%
Cadmium telluride (CdTe)	9-11%
Amorphous silicon (a-Si)	6-8%

Panel (Module) Type	Average Cost per Watt	Estimated Cost for 6kWh System
PERC	$0.32 - 0.65	$1,920 – 3,900
Copper indium gallium selenide (CIGS)	$0.60 – 0.70	$3,600 – 4,200
Cadmium telluride (CdTe)	$0.50 – 0.60	$3,000 – 3,600
Amorphous silicon (a-Si)	$0.43 – 0.50	$2,580 – 3,000

Not only do you have to consider these things when looking at panel types you also have to consider temperature, fire rating, hail rating, hurricane rating, and Light-Induced Degradation.

Lastly after choosing which type of panel to go with, we needed to consider our storage options. The first option is lithium-ion batteries, and the positive aspects are that they require almost no regular maintenance. They also have a higher battery energy density, meaning they can hold more energy in a smaller space than a lead acid battery. They have a longer life cycle, or lifespan, most have a guaranteed warranty of at least 10 years, and the price has decreased by 65 % since 2010. Lastly, you can use more of the energy stored within the battery before it has to be recharged. Some downfalls to lithium are that they can be expensive to buy and install. If they are not installed properly, they have the chance to catch on fire, but this is very rare. Overall, lithium-ion batteries are best for residential solar installations because they hold more power in a limited space and allow for greater use of the energy stored within the battery. The second option is sealed lead acid batteries, and they are the cheapest energy storage option which makes them the most cost effective. Plus, because the technology has been around for years, they can be easily disposed of and recycled. They require ventilation and regular maintenance to operate correctly, which increases the chances of the battery leaking. Due to the leaking, they cannot be placed on their sides and do require charging more often. Finally, having a low depth of discharge also means they have a shorter lifespan of five to ten years. Overall, the reliability of lead-acid batteries is great for off-grid solar systems, or for emergency backup storage in case of a power outage.

Energy Audit

An energy audit was performed by the Tennessee Valley Authority to determine the energy requirements for the office. The energy use between the calendar year of 2018 and 2019 shows an average use of 6,951 kWh for the year. They determined that the electrical consumption was higher during the months of November to April, and this was due to heating.

More information that was gathered:

- Average energy requirement per day: 19kWh
- November – April: 24.17 kWh
- May – October: 13.5 kWh
- Month of highest use – January (968 kWh)
- Month of lowest use – August (310 kWh)

Fact Sheet for TNC

Cost Analysis

After using the energy audit to determine the amount of energy required to run the facility, sizing for the solar system could be determined. To produce all the energy requirements, the PV system would have to be a 6kWh system. This could produce an average of 400 to 900 kWh per month and thirteen to thirty kWh per day depending on the solar radiation. The range of production is due to the variation in panel number and panel efficiency.

With this in mind, a 6kWh PV system in Tennessee will cost on average $14,000. This cost does include all products used as well as the installation costs. It should also be noted that two-thirds of the total cost is comprised of the installation and permit costs. Other cost considerations include environmental costs. The production of the components used in creating PV systems do require hazardous chemicals which must be disposed correctly. Solar panel components can be recycled with e-waste, and there are new studies being conducted that focus on extracting any hazardous and valuable materials from the panels to then be reused within production.

Overall, the specific pricing and sizing requirement could not be obtained during this study due to legal circumstances with the solar companies and the team members not having speaking rights for this piece of property.

Recommendations

Our recommendation for solar energy at Bridgestone Nature Reserve based on research of the components of a PV system is to have PERC panels installed on the ground area with the most sun due to the lack of sun that hits the buildings in the area. However, this should be discussed with the solar company chosen due to the product availability. The top panel manufacturers are LG, Panasonic, and SunPower. LG would be the top choice due to their warranty, reviews, and the affordability of their products; however, LG has announced they will be exiting the solar market. This could affect the current product warranties or manufacturer reliability. The other two manufacturers with the second highest ratings are: SunPower which is the most efficient and Panasonic which has the best temperature coefficient. We recommend contacting GES Solar and Light Wave Solar for installation. They are within the vicinity of the Bridgestone Nature Reserve and hold the highest ratings of the installation companies that service the area. Moving forward, TNC should contact these companies for quotes and base their next steps on the best option available.

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