**University of South Florida**
**Patel College of Global Sustainability**

# Renewable Energy
# at
# Rosebud Continuum Education Center

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**IDS6233 Concepts of Sustainability**
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**Executive Summary**

This paper will touch on how solar and wind are great options for renewable resources for Rosebud Continuum Education Center. It will present the current situation at Rosebud and the recommendations for improvements. Solar and wind are not limitless though as they are affected by sources out of our control. Depending on your location, sun or wind can be abundant or scarce but usually one option can work in most places. Due to life's dependency on the sun, it has become a part of cultures and religions throughout time, from ancient Aztec, Greek, and Chinese civilizations to present day where humans are able to capture solar energy to utilize it as a renewable resource (Turgeon and Morse, 2012). Florida is nicknamed the sunshine state and has some of the highest number of days for sunshine in the country which helps provide a good outlook for solar energy. Meanwhile, wind is less efficient in Florida with low number of windy days in the area. The aim of study for this paper is to improve the current system for solar and wind for Rosebud Continuum. Currently the wind energy production is null, but the solar energy output is efficient. The main reason for improving current energy infrastructure is to decease dependency on Duke Energy, the current utility provider. We propose various wind energy technologies and expansion on the current solar system for Rosebud to adapt.

**Introduction**

Theis and company mention it in their book ''*Sustainability: A Comprehensive Foundation*'' that sustainability is a long-term environmental-socio economic strategy for achieving sustainable development that meets the needs of the present without compromising the ability of future generations to meet their own needs. We have already degraded 60% of the ecosystem because of unsustainable usage and that damage we have caused is mostly irreversible (Theis et al. 2012). We can still adapt and mitigate global warming by capturing or sequestering some greenhouse gases. Rosebud uses renewable sources solar and wind that are environmentally less carbon intensive thus, less contaminated than fossil fuels. For the good of the environment, liberty and justice for all, Rosebud is evolving into more renewable projects.

Rosebud Continuum Education Center is a great example of a closed system sustainable farm that utilizes solar and wind energy, as well as biofuel from organic waste. Rosebud Continuum is named after the Indian Reservation that the owner, Sonny Bishop, grew up on. Rosebud is a place where people from all walks of life can come to gain knowledge about sustainability and off-grid living. Rosebud is a nonprofit organization (501c3) that was started when Sonny and his wife Maryann became aware that their property was full of invasive plant species (Smith, 2021). A student from University of South Florida began research on the site and the Patel College of Global Sustainability (PCGS) began to cultivate this farm by implementing sustainable methods and technologies.

Rosebud Continuum has aquaponic systems, biodigesters, a solar panel photovoltaic (PV) system, beehives, farm livestock and a small wind turbine. Students from PCGS help manage the property and conduct projects. Current projects include recycling plastic to use as 3D printing filaments and retrofitting a caravan to be solar powered. One of the professors, Dr. T.H. Culhane lives on site in a sustainable RV, living completely off the grid. Solar energy and biofuel help to power Rosebud Continuum and the rest of the energy is imported from Duke Energy.

Solar Power is the conversion of the sunlight energy into electricity, it can be either direct using solar photovoltaic panels (Abdali et al. 2019). Wind power is the use of airflow (kinetic energy) converted into electrical energy through wind turbines. This is converted in the generator, while the anemometer collects data of the wind speed which controls well the wind turbine is turned on or off because it onlys operates between the wind speeds of 16-55 mph (*U.S. Department of Energy*). Solar and wind energy production varies depending on the location.

Florida is the second largest state producing and consuming electricity, and 4% of its electric power comes from renewable energy. Solar and biomass are the main renewable sources, but a small power is generated from hydroelectric, there are no significant wind power resources in Florida (US Energy information, 2020). Florida is one of the leaders in solar energy with 908,181 homes powered and 3.74% of the state's power coming from solar (Solar Energy Industries Association, 2021).

**Review of Literature (solar)**

The sun is at the center of the solar system and is roughly 93 million miles away from earth. Despite the astronomical distance the radiation from the sun heavily influences earth's weather, season, climate, ocean currents, and is essential for the process of photosynthesis. Due to life's dependency on the sun, it has become a part of cultures and religions throughout time, from ancient Aztec, Greek, and Chinese civilizations to present day where humans are able to capture solar energy to utilize it as a renewable resource (Turgeon and Morse, 2012).

the various processes and technologies in which solar modules are constructed and operate. These next few paragraphs will discuss environmental factors that affect efficiency, photovoltaic tracking (PV) systems, determining appropriate use of materials, and types of solar cells, and the use of multi-junction cells in concentrated photovoltaic (CPV) systems.

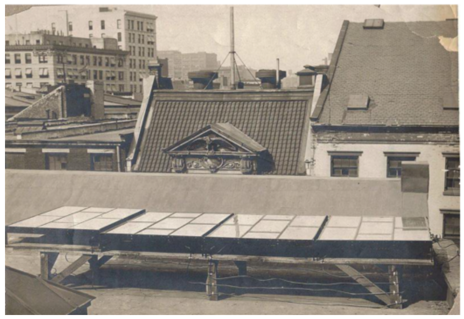

*Figure 1 First solar panels installed by Charles Fritts in New York City in 1884 (Chu and Tarazano, n.d.)*

Environmental factors can affect solar system efficiency, therefore it's important to identify, understand, and mitigate or enhance the effects of these environmental factors. These factors include solar panel orientation, solar panel pitch, shading, albedo effect, temperature, and humidity. Solar panel orientation and pitch are important considerations in constructing a solar PV system because if you optimize the time of direct sunlight exposure it also increases solar radiation absorption and energy conversion rate. Shading on the other hand blocks direct and indirect sunlight reducing solar radiation absorption, therefore decreasing energy produced. The albedo effect is the process when light is reflected off any given surface. Higher albedo effect is better for capturing solar waves (Rickards, 2020). Temperature refers to the intensity of heat. Solar panels are most effective in temperatures that range from 59 degrees Fahrenheit to 95 degrees Fahrenheit (Sullivan Solar Power, 2020). Humidity refers to the amount of water vapor in the atmosphere. Water vapor reflects or absorbs solar energy. Ideally, it's best if there is a low or a lack of humidity for the sake of the efficiency of the solar PV system (Panjwani, 2014).

Solar photovoltaic tracking systems enable solar panels to move accordingly with the sun. The two main types of solar tracking systems are single axis and dual axis. Single axis tracking allows the panels to move up and down, while dual axis tracking allows the solar panel to move up and down, as well side to side. The goal of these trackers is to angle the solar panels in a way that the sun rays hit the solar panels at a perpendicular angle, which has been determined to be the most efficient way to capture solar energy. Moreover, a solar tracker can be active or passive. An active tracker is powered by an electrical mechanical device, while passive trackers move as the sun heats up the gas within a mechanical device, which causes the gas to expand that causes the tracker to move. Active trackers are more efficient than passive trackers (Marsh, 2021).

Today the standard solar cell is typically made up of monocrystalline, polycrystalline, or amorphous. They vary in regard to composition and structure, efficiency, cost, temperature coefficient, and life span. All the aforementioned types of solar cells utilize the photovoltaic effect. Monocrystalline and polycrystalline are both made up of silicon crystalline. The crystalline structure in monocrystalline is uniform since is from a singular silicon crystal, while the polycrystalline structure is made up multiple silicon crystals, which leads to a mosaic like structure. Due to this difference monocrystalline solar cells appear black, while polycrystalline is a mosaic of various hues of blue. Amorphous on the other hand is not derived from silicon crystal but a silicon lightweight film that is flexible. Amorphous film is usually uniform in color but can be partially transparent (Xu, n.d.; David, 2021). Monocrystalline efficiency rate ranges from 15-20%. Polycrystalline efficiency rate ranges from 13-16%. Amorphous efficiency rate is around 7%. (American Solar, 2021.; Xu, n.d.). The cost of monocrystalline panels costs $1-$1.50 per watt, therefore the cost of a 6 kW solar panel system could range from $6,000 to $9,000. Polycrystalline costs $0.90-$1 per watt, therefore the cost of a 6kW solar panel system could cost from $5,400 to $6,000. Amorphous film panels cost $0.5 to $1.00 and is usually not for residential application and not likely feasible for a 6 kW solar panel system (Garrison, 2021; Xu, n.d.). Monocrystalline has lower temperature coefficient from -0.3% to -0.5% on the Celsius scale. Polycrystalline has high temperature coefficient from -0.3 to -1% on the Celsius scale. Therefore, monocrystalline solar cells are more resistant to heat in regards to efficiency (American Solar, 2021; David, 2021). Amorphous works best in indirect light, but cannot be described by temperature coefficients (Carlson et al., 2000; Xu, n.d.). The lifespan of monocrystalline solar panels ranges from 25 to 40 years. The lifespan of polycrystalline solar panels ranges from 20-35 years (David, 2021).

*Figure 2 Monocrystalline (right), polycrystalline (middle), amorphous (right) solar panels (Lane, 2021)*

Other aspects that can be analyzed is the utilization of multi-junction (MJ) solar cells in concentrated photovoltaic (CPV) systems. Multi junction cells also referred to as tandem solar cells are capable of absorbing a wider range of the electromagnetic spectrum, which can increase the efficiency of the solar cell. The way in which multi-junction solar cells are able to absorb more wavelengths of electromagnetic radiation is that there are multiple layers of semiconductors that are usually made up of gallium indium phosphide (GaInP), indium gallium arsenide (InGaAs), and germanium (Ge). These various layers of semiconductors are able to absorb different wavelengths that leads to less energy being lost as heat. Multi-junction cells are an important element of concentrated photovoltaic (CPV) cells (Chukwuka & Folly, 2014). The purpose of CPV is to concentrate the sunlight's energy onto the highly efficient multi-junction cells, therefore significantly increasing the efficiency of array absorption and energy conversion. The type of optics that are used for this are transmissive and reflective optics. Transmissive optics can use a standard or Fresnel lens that magnifies solar radiation. Reflective optics magnifies solar radiation through the use of mirrors with a simple reflection design or Cassegrain design (Honrubia, 2019).

**Applied Sustainability Strategies**

Rosebud Continuum's solar panel system features roof, pole, and ground mount modules, and 4 inverters. The solar modules and inverters are located by the carport, pavilion, pole mounts, and ground mount. The total capacity of this solar photovoltaic system is 26.4 kW. The carport inverter has a 6.5 kW capacity that consists of 18 modules and each module can produce 365 watts. However, due to shading the carport inverter's capacity is reduced to 5 kW. The pavilion inverter has a 17 kW capacity that consists of 48 modules in which each module can produce 365 watts. Optimizers are utilized in the pavilion solar panel so that one bad module does not reduce the entire electric current in the string. Due to the location, high inverter capacity, and optimizers the pavilion often experiences clipping. Clipping is when there is more DC power than an inverter has the capacity to convert to AC power. Therefore, when clipping occurs a plateau in energy can be observed around solar noon or around 1 o'clock during daylight savings. The pole mount inverter has a 3.8 kW capacity that consists of 10 modules in which 6 can produce 365 watts, while the remaining 4 modules can produce 380 watts. The reason for installing the 4 stronger modules is to increase shade tolerance due to the shade that is cast by nearby trees. The separate ground mount SMA inverter has a 6.4 kW capacity that consists of 16 modules that can produce 400 watts. The reason that the ground mount inverter is separate from the system of the other three inverters is because of clipping of the nearby pavilion inverter. The carport, pole, and pavilion inverters are all on the same system that communicate through original equipment manufacturer (OEM) software. In this case the OEM software is mySolarEdge. This software collects data from the inverters that allows system owners to track production and consumption of energy. Since, the ground mount inverter does not relay data to a communication device the energy produced and consumed cannot be tracked. This absence of data skews energy import and export data of the site as it does not account for energy produced and consumed by the ground mount inverter.

The following data is from mySolarEdge OEM software, moreover it excludes any data from the ground mount inverter. However, it should be noted there is a lack of data during multiple periods of time, which has skewed the data to a certain degree. The total energy produced by the three inverters aforementioned inverters is 61.7 MWh, which has saved the owners $9,850 thus far. The total annual production of energy was 35.3 MWh in 2020. In 2020, 31% (11.1 MWh) of the energy produced was exported to Duke Energy. In 2020, 61% (17.5 MWh) of the energy produced was imported from Duke Energy and the remaining 39% (11.3 MWh) of energy was produced and consumed on site. The total annual production of energy is estimated to be 35 MWh by the end of 2021. In 2021, 56% (19.9 MWh) of the energy produced so far has been exported to Duke Energy. In 2021, 66% (30.1 MWh) of the energy so far has been imported from Duke Energy and the remaining 34% (15.2 MWh) of energy was produced and consumed on site. Additionally, mySolarEdge has calculated that 95,546 lbs of carbon dioxide ($CO_2$) emissions have been mitigated by using this solar panel system instead of nonrenewable energy (i.e. fossil fuels).

*Figure 3 (left) carport solar panel; (right) carport inverter*

**Proposed Recommendation**

The solar panel system at Rosebud Continuum has proved to be a great sustainable source of energy. Inverter efficiency and module efficiency are good indicators to the overall efficiency of the solar PV system. With ideal conditions on a clear day the inverters should be able to convert 26 Kw of AC power into DC power and each module should reach maximum full wattage output. However, the energy output by the solar panel system could be improved upon. The following recommendations are ways to increase efficiency and energy output; installing PV tracking systems, use of multi-junction cells in CPV systems, increasing the amount of solar modules, and retrofitting the current Solar PV system. PV tracking systems are more efficient than fixed ground mounts and can save an owner $1,430-$1540 annually on energy savings depending on if the owner chooses to install a 4 Kw single or double axis tracker. However, PV tracking systems are more costly. For a 4 Kw single axis tracker PV system it costs $22,125 and for a 4 Kw double axis tracker PV system it costs $29,625. The increase in cost also increases the time of return of investments (ROI) by 3-6 years, which depends on whether a single or double axis tracker is installed. Therefore, while feasible PV tracking systems are not worth the investment for small scale agricultural or residential use (Lane, 2021).

CPV systems that utilize multi-junction cells cost $16.5 million USD and require a 100 megawatt system, therefore this method is only feasible for commercial use (USA DOE, n.d.; Yellowlite, 2018). Installing more solar modules is feasible both in terms of cost and increased efficiency. This is the most feasible solution as it is the only recommendation that improves the overall system efficiency and energy production that is economically feasible and doesn't require vast amounts of land. Currently, the owners are planning to install a new solar ground mount PV module system. One way to retrofit the current PV system to be more efficient is to include optimizers that track maximum power points (MPP) of each module that mitigates the issue of mismatch loss between modules. Moreover, increasing the number of optimizers increases efficiency and energy production. Another recommendation would be to attach the ground mounts to a communication device via ethernet cable to a router so that import and export data can be accounted for.

"The installed cost of ground mounting systems, particularly ones that are elevated and provide shelter/shade vary widely. The additional engineering/permitting/structural modification costs for PV structures add approximately 30% to the cost. The original system was designed to offset up to 35,000 kWh of annual electricity purchase. In the first expansion [of the solar system], the Bishop family wanted to increase the capacity of the carport system as there was ample roof space remaining and inverter capacity to do so without any modifications to the AC service entrance at the site. In the second expansion, the ground mount, the Bishop's wanted to close the gap between actual energy consumption and site performance. A goal of 50,000 kWh of annual production was established. The most recent system installed was a repurposed commercial ground mount system using a used 5 kW SMA inverter and an existing 20-degree pitch commercial ground mount system. The array capacity of this system is 6 kWp and using the same energy potential we have an expected output of 8,424 to 9,180 kWh. All of the modules on the site are monocrystalline.

Current costs in the US are being lifted by high import tariffs, covid related scarcity of supply, shipping, and supply chain profit taking, and the continuous cost reduction associated with OEM facility technology and manufacturing improvements. Here's an example of the retail price for a high quality residential module with a capacity of 395 watts that I pulled off the web just now. This would equate to $324 / 395 watts = $0.82 per watt. The installer (trade) would have bought these for approximately $0.50 to $0.60 per watt. And the cost of manufacture by the original equipment manufacturer (OEM) is approximately $0.20 per watt. The difference between $0.60/watt and the $0.20/watt cost of the manufacturer are the related expenses and profits taken by everyone in the supply chain including the exporting country, the importing country, importer, the distributor, the wholesaler and the trade. Please note that over 90% of all global solar manufacture is outside of North America" (Mike Kozdras, personal communication, November 29, 2021).

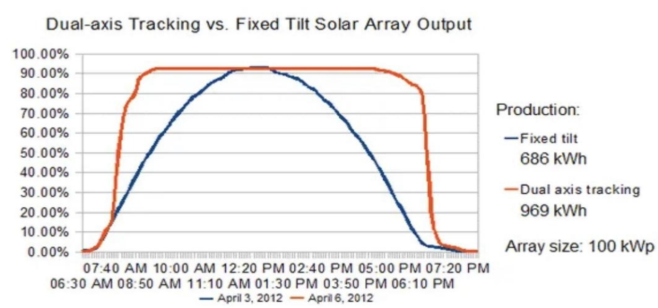


*Figure 3 Solar PV tracking system VS fixed Solar PV System (Bruce, March 2021)*

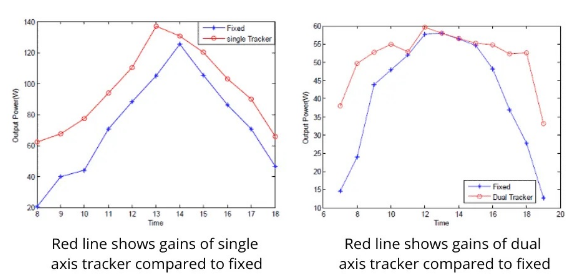


*Figure 5 Output Energy between fixed PV system, single axis tracker, & double axis tracker (Bruce January, 2021)*

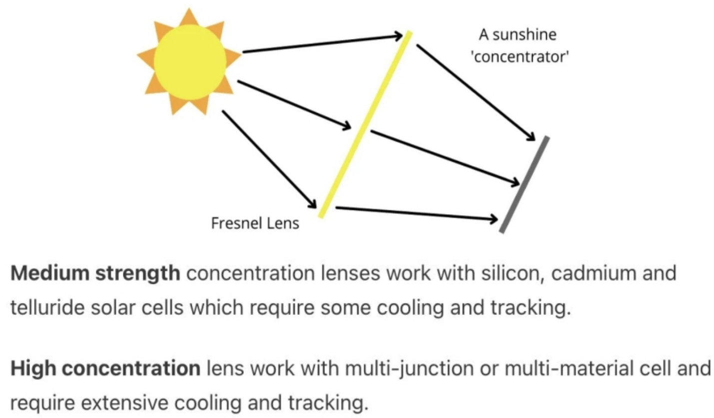


*Figure 4 Medium vs High Concentration Photovoltaic Systems (Bruce, January 2021)*

**Review of Literature (wind)**

Wind energy has been cultivated by humankind for thousands of years. In the early stages wind energy was utilized for water extraction, the making of grain and flour, as well as other agricultural applications. Nowadays wind turbines are mostly used for generating electricity, where the wind's kinetic energy is converted into electrical energy. Due to the shortage of oil during the energy crisis in the 1970s, alternative energy bloomed within the developed countries, which include the USA, Denmark, and Germany. Renewable energy resources are a great alternative to the burning of fossil fuels. Wind turbines mitigate the accumulation of carbon dioxide in the world. To be exact, Matt Farrell signals that annually wind turbines prevent over 1.1 billion tons of CO2 being emitted into the atmosphere (Brilliant, 2021). Due to f the cost-efficiency of wind energy this technology continues flourishing and is the best option for developing countries like China and India to generate a substantial amount of power. Wind energy can be produced all year long since it can be produced day and night. Wind is the second most utilized renewable source of renewable energy preceded by solar, which is the fastest growing renewable energy resource in the world. It was reported that in 2018 wind turbines were provided 600 gigawatts (GW) worldwide and by May 2021 the global capacity of wind power was up to 743 GW, and International Energy Agency (IEA) roadmap predict that by 2050 could provide 18% of the global energy demand (Kumar et al. 2019 and Brilliant, 2021).

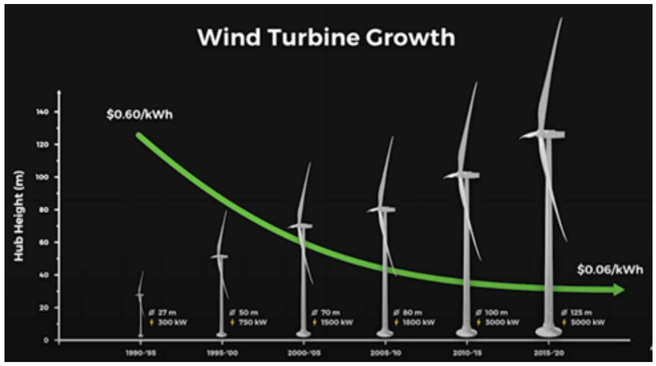


*Figure 8 Real Engineering, 2020. Video youtube: 13m49s.(Real Enginering, 2020)*

Seeking higher efficiency and energy output, wind turbines have become bigger in size over time to accommodate for market expectations. From 1990 to 2020, the efficiency of the standard wind turbine has increased from 300 kW to 5000 kW, which is 16 times the power capacity than 30 years ago. This tremendous increase in productivity is due the fact that standard wind turbines have increased 4.63 times in size within those 30 years. The increase in efficiency of wind turbines has led to a drop in production cost of the kWh that has passed from $0.60/kW to $0.06/kWh according to *Real Engineering 2020,* which makes wind energy the cheapest renewable energy option among the variety that exist yet.

The efficiency of a wind turbine can be affected by the wind's velocity, which means that the conventional large-scale wind turbines work in a wide range of wind velocities. Any high-speed wind can damage the blades and make the turbine dysfunctional. To mitigate this problem most wind turbines are generally equipped with an anemometer that usually signals the system to shut off when registering a wind speed higher than 55 mph. Low wind speed does not contribute to the function of a conventional turbine, therefore wind speeds lower than 6 mph are not categorized in the operational range for large-scale wind turbines. The wind's velocity determines how much electricity a wind turbine can produce. Therefore, wind speed is positively correlated to the amount of electricity generated (Nguyen et al. 2018 and NREL, 2021).

Wind energy sounds like an easy technology to handle and it could be, but the conventional large-scale or horizontal-axis wind turbines are too advanced to be operated by most qualified technicians. Large scale horizontal-axis turbines are not currently financially feasible technology that the public can readily access. Other factors that compound the issues of feasibility is that facilities with conventional large-scale wind turbines are capital intensive in terms of material and labor. Conventional wind turbines are massive devices that can measure up to 200 meters tall that are made of sophisticated pieces, which makes for a complex mechanism. This makes the tasks to assemble, maintain, and move them to their designated location more difficult. (Jin et al. 2019).

Wind energy is usually considered clean energy as they do not emit greenhouse emissions or produce toxic or radioactive waste. However, like any other device, wind turbines are far from perfect even when they provide clean energy. One issue with wind turbines is that when they are located near residential areas, they tend to bother people living nearby due to the noise pollution produced when the wind turbine's motor is running or when the wind shocks with the blades. Wind turbines are responsible for killing birds and bats, frequency disturbances and shadow nuisances. These inconveniences lead to wind farms being installed far away from the human population. Wind farms are then designated to be placed offshore, near-shore (near or in the ocean), in deserted or unused land where wind speed is sometimes not optimum for turbines to works properly, which leads to reduced efficiency and energy lost during transportation, due to the development of wind farms in remote locations that easily accessible (Dong et al. 2010 and Jaber ,2013). Scientists and businessmen that observe and are concerned about these issues have designated more affordable and less disruptive smaller scale, bladeless (vortex) and portable wind turbines that are more readily available to the public, for residential and commercial use. This way, residential homes and small businesses can also benefit from wind power in addition to big enterprises.The power capacity generation of a wind turbine is determined by its size. Smaller wind turbines are mainly divided into three categories; medium-wind turbines with an energy output from 50-500 kW, small-wind turbines that generate equal to or less than 50 kW and have a blade radius inferior to 8 m, and micro-wind turbines that have rated power below or about 50 W (Wood, 2011).

## Vertical Blade Turbines

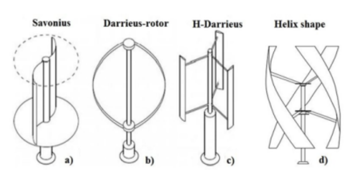


*Figure 9 Types of vertical blade wind turbines (Castellani et al. 2019)*

## Bladeless and portable wind turbine

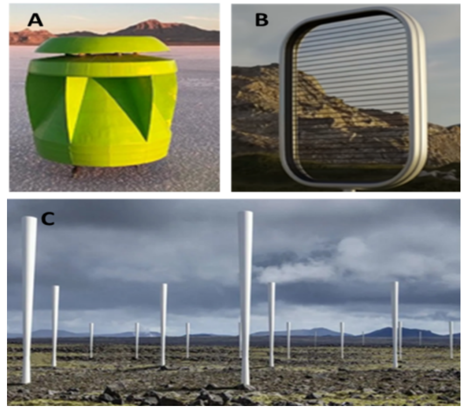


*Figure 10: A. Powerpod ; B: Electrostatic w.energy converter (EWICON) , C: Vortex bladeless (google images, 2021)*

Small-scale wind turbines are called vertical wind turbines because of the perpendicular to the wind direction, and they are contributing a lot in the decentralization in traditional power generation. They are suitable for remote areas where the grid has not yet reached, moreover small-scale wind turbines are more affordable, and they are easier to maintain and require less space than conventional large scale wind turbines (Bukala et al. 2015). Furthermore, small wind turbines perform well with low wind speed about 3m/s (Wood, 2011). It should be acknowledged that medium, and small wind turbines will still affect the well-being of birds and bats to some degree, but significantly lower compared to large-scale wind turbines as stated by Simon James Strong, 2008.


*Figure 11 Small urban wind turbines (Duffy, 2010)*

Regardless of size a wind turbine needs to be placed in an open windy area in order to work properly and efficiently. Additionally, with function and efficiency in mind small wind turbines in urban areas are better suited at higher altitudes and examples are as shown below.

**Rosebud Continuum Case study**

Currently the singular wind turbine at Rosebud made for marine vessels is not in use and produces no energy. In this report we will try to gain a deeper understanding into the reasons why the turbine is not working. Additionally, recommendations will be proposed to repair the current wind turbine and/or replace it with a more efficient or manageable small or portable wind turbine that is more feasible for the site.

*Figure 12 Rosebud wind turbine*

Here is the wind speed record for the Land O' Lakes area where Rosebud is located, based on the monthly wind speed mean we will analyze if any small wind generator can properly function in that area.

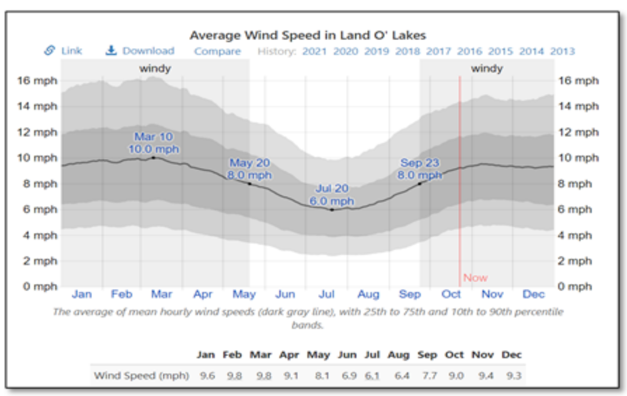


*Figure 13 Wind speed record of Land O' Lakes (Weather Spark 2021)*

If we base on Wood, 2011 observation that states most small wind turbine cut-in speed or start operating in at 3m/s (6.67 mph- miles per hour), we will conclude that a small wind turbine placed in Land O'Lakes area should works pretty well most of the months of the year except for July and August that present a very low speed wind below the proper range.

But instead, if we base on the U.S Department of Energy which stipulate that cut-in- speed for small turbine is 3.5 m/s (7.78 mph) then we could say that a small wind can work in in Land O' Lakes are 9 months over 12 yearly, set aside: June, July and August.

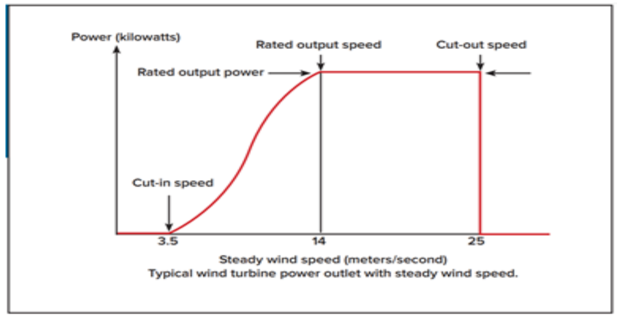


*Figure 14 Wind speed range operation of small wind turbine (US Department of Energy, 2021)*

Now we touch the end of October, based on Tampa's wind speed registration 4.04 m/s (9.0 mph), the wind turbine in Rosebud should work if the problem was the wind speed. And analyzing the height of the turbine tower (fig 14) it is clear that the turbine is not obstructed by any tall tree or building at all. The only remaining conclusion is assumed that the turbine has a mechanical problem that could be fixed by a qualified technician. The position of the turbine regarding the wind direction could be the issue but the wind turbine at Rosebud is equipped with a triangular tail that helps them ubicated the wind direction (Raikar *et al.* 2015).

**Recommendations**

Based on David Wood's results in *Small wind turbine* 500 W 1.94 m of diameter and the wind speed record for Land o' Lakes by the national weather center it is rise to conclude that wind turbine capacity 500 Watts dimension 1.94 m of diameter is not suitable for Rosebud use because this turbine in that area can only produce 50-90 watts at maximum according to the yearly registered wind speed of Land O' Lakes.

However, wind energy can still be profitable at Rosebud if more efficient and adapted urban area wind devices are installed, Powerpod or Freya model for instance. PowerPod (fig 10) is a small and bladeless wind turbine created recently by Halcium a small company in Salt Lake in Utah, claims to have the capacity to produce 1 kW of electricity, and what makes it more efficient than any other type of wind turbine is that it can increase the incoming wind by 40% on average which means it can increase the power 3X versus regular turbine. With that special capacity it can work well with very low speed 2-3 m/s. Furthermore, the wind direction is not a problem for the Powerpod because it has wind inlets in all directions. The PowerPod is the environmentally friendliest wind turbine ever made, no birds or bats will ever kill by it, besides children and pets won't get injured by it either since the PowerPod has no external moving parts. The PowerPod can be installed anywhere, on top a woof or directly in the courtyard, it can be associated with installed solar system to complete the system since wind is disponible even at sunset. There is no price attributed to a Powerpod yet because it is still under design and experimental phase but by the end of 2021 it will be available for sale states its inventors.

The Freya CW100 is another small or micro turbine made by Icewind. This small turbine measures only 1.5 m and has been claimed to be very efficient (Fig 11). It is an adapted urban area turbine. Freya CW100 works as well on slow speed, it's cut-in speed is 2.5 m/s or 4.5 mph and can support till 60m/s, it can generate up to 600 Watts. It can be placed on a wood top or in the yard on a clear pathway. A Freya model costs $ 3,200.

**Conclusion**

Renewable energy is the key to a sustainable future. Rosebud Continuum is a shining example of a closed sustainable system that utilizes solar energy and biofuel. These renewable resources help to mitigate greenhouse gas (GHG) emissions. While the current wind turbines make no contribution to energy output it has potential to at Rosebud if more modern small wind turbines are chosen because they are more efficient working with very low wind speed and pose less of a risk to wildlife. Solar energy has substantially reduced Rosebud's dependence on fossil fuels and Duke Energy Company. The most feasible way to improve the efficiency of energy production is to expand the amount of solar PV modules, retrofit the current solar modules with optimizers, and connect the ground mount solar panel to communicating device to account for energy input and output so that the combined data from the SMA inverter and mySolarEdge software is accurate. The combination of solar and wind energy Rosebud should be able to cover a good amount of energy consumption.

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