Cal Maritime Siting and Project Development Report

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Site Description

For the 2018 competition, our team developed a wind farm siting plan rated to 80 MW in the northeast San Francisco Bay Area, southeast of Travis Air Force Base in Solano County, California (pictured at right). A large portion of the siting location is either grazing ranges for animals or farmland. A number of roads bisect the region with homes and businesses scattered throughout, both of which caused complexities when siting the turbines. To reach 80 MW, a total of thirty 2.5 MW GE 127 Wind Turbines were used. This particular model was chosen because multiple local wind projects already using it thus providing local expertise for maintenance. Due to the lack of familiarity with the program OpenWind, the majority of the wind turbines were sited in two long, vertical rows. This arrangement had decent array efficiency but the backwash from each turbine affected another down the line. This siting plan also did not take into account local city zoning regulations regarding noise levels. In addition, multiple turbines were placed on or near major roads and substantial structures. Lastly, the 80 MW wind farm did not meet the guidelines of the competition for a minimum 100 MW farm. Therefore, there were numerous improvements that needed to be made this year based on the original layout.

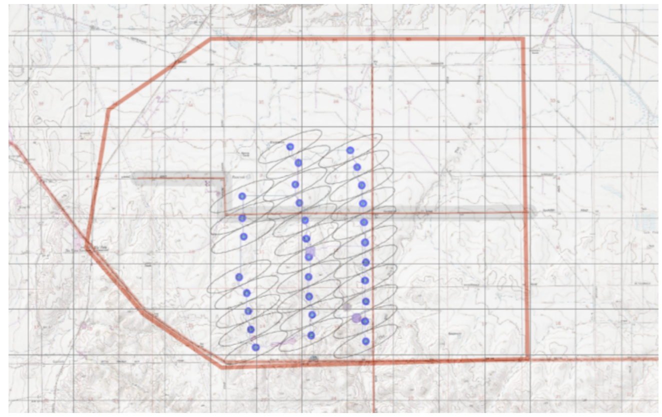


Figure 1

Site Design Changes

For the 2019 competition, the same land space was used for siting the wind turbines. However, major changes were made to meet local city zoning regulations and to increase the output to 100 MW (pictured at bottom left). First, ten additional GE wind turbines were added to the original thirty. The same model from last year's competition was used due to familiarity with its operation. The addition of these ten turbines provided the necessary energy output to meet the minimum guidelines of 100 MW. Next, the actual placement of the wind turbines was greatly altered. As previously stated, numerous wind turbines from the 2018 plan were placed on or near roads and substantial structures. The Solano County Land Ordinance specifically states that all wind turbines must be a minimum of 300 meters from the nearest road or structure for safety and noise control.

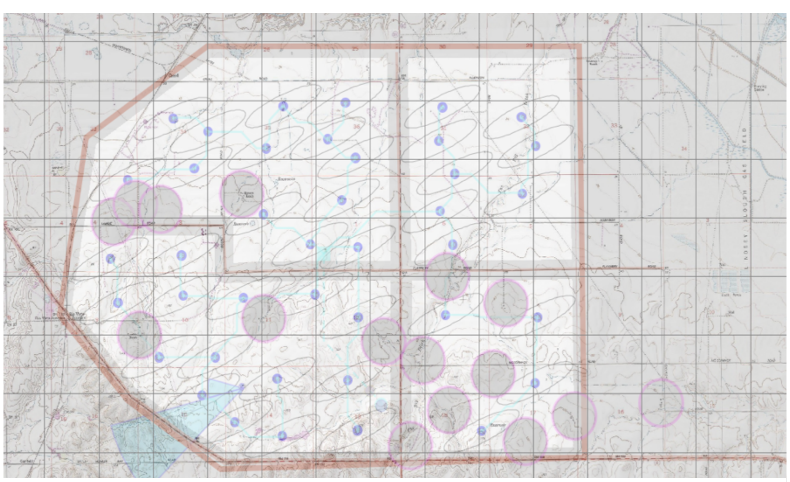


Figure 2

To meet this minimum requirement and to provide a gap for safety, a distance of 400 meters was used for siting the wind turbines in this farm. The shadow flicker is currently an issue for identified property buildings, but a conscious effort has been made to reduce the overall probability of shadow flicker on properties. During the physical site walk, potential residential sites identified on OpenWind were nonresidential, such as barns, sheds, or storage facilities, which allowed for greater flexibility in our siting plan, acknowledging the reduced impact of shadow flicker on residents. In order to provide this distance, nearly all of the locations of the wind turbines were changed from the previous plan. The two original rows were broken up with the turbines being scattered all over the region which reduced the backwash of the turbines on nearby units. Thus, the array efficiency was increased by about two to three percent.

As aforementioned, major roads and structures were identified and marked appropriately in order to further build on the accuracy of the chosen turbine locations. Additionally, an in-person visit to the physical site was undertaken to better pinpoint smaller buildings that did not necessarily show up on mapping websites. These smaller buildings were subsequently marked in the program OpenWind. Power lines from the already existing wind farms to the south were located in order to avoid them. Due to the proximity of Travis Air Force Base, airspace was another significant issue that impacted turbine location. Fighter jets and other planes continually use the airspace around the wind farm for both their approach and takeoff. Furthermore, there was the possibility of the wind turbines affecting the operation of radar from the air base. The impact reports and mitigation efforts employed by neighboring windfarms served as the basis and inspiration for any turbines proposed near Travis Air Force Base. The wind turbines from such farms stayed a minimum of six miles from the outskirts of the air base, so this same strategy was employed in the placement of our turbines. In addition, proper lighting was installed on the turbine structures to warn all aircraft of their physical location and proximity.

Financial Analysis

Breakdown of basic financials

It can only be assumed that a project of this size will require substantial amounts of capital. While this is a given, our team needed to conduct a thorough cost analysis of the materials and services required to complete the project. For much of the information necessary to conduct this analysis, we found conflicting information from a variety of reputable sources. In situations where the costs figures varied widely between sources, we chose to work with the largest of the options in an attempt to create as realistic of a simulation as possible.

We began the analysis with the metaphorical foundation of our whole project, the GE 2.5-127 turbines, of which we will need 40 units. Getting precise cost numbers for these machines proved exceedingly difficult, so we were forced to use the best sources we had accessible and determined a per-unit cost of $2.457 million (Bloomberg, 2018). Following this, we moved to pricing the literal foundation of our turbines, which we found to be priced at a cost of $114,001.36 per foundation, in total occupying roughly 3.5% of capital (Orrell and Poehlman, 2017). Our road and cabling costs are figures that normally would have taken extensive research to get near-exact costs, but the OpenWind software utilized in the optimization of our farm accommodated the implementation of cabling and road costs. Using the topographic layers and terrain files in the program, OpenWind was able to generate a total cost of $11,983,783 for the necessary 4.5-meter width roads required by our facility. The total cost of our new cabling was generated as $11,466,106. Our site access and staging cost was another difficult figure, so we stuck to our strategy and went with the highest quote we could find for a site of similar characteristics, totaling in at $3,727.245.69. To secure engineering management services for our site's development, we found the figure of $1,464,275.09 to be the most accurate (Orrell and Poehlman, 2017). For the expense of hiring a developer, we referenced the NREL 2017 Wind Energy Finance Report to determine we would pay 5% of capital costs, in this case totaling at

$6,314,497.17. Our final figure to determine capital costs is that of the land lease rates. This was one of the most complicated figures we generated, with its total coming to $9,584,041.82.
The remaining costs in our analysis are in the form of Operations and Maintenance costs. We were lucky to find our figures via Windustry.org, which features a comprehensive cost section which provided extensive insight into the administrative operations of a wind farm. Though many of the figures quoted are accurate to the fiscal year 2007, we used an inflation calculator model to bring our figures to modern standards. The first of these figures is our annual general Operations & Management budget, which we have set at $3.2 million, a figure found in the Lazard Levelized Cost of Energy Analysis (Lazard, 2010). We find this budget to be appropriate in addressing the projected necessary operations and maintenance functions found in the following section. The first *windustry.org* figure we utilize is the per-turbine insurance rate, which accounts for $569,194.80 annually. After that, our administrative costs total at $296,971.20 annually, or $7,424.28 per turbine (Daniels, 2007).

O&M, Balance of Power

Cabling to Substation*:* The power generated by each wind turbine will either be exported wholly back to the national grid or consumed locally with a small amount of export through an underground trenched cable network. The cable network will connect the turbine with the substation at either a low voltage (LV) or high voltage (HV) and the overall length of the cables will vary depending on the distance from the turbines to the substation and the network layout.

Table 1

Items	Capital costs
Cost per turbine	$ 2,457,000.00
Total Turbine Cost	**$ 98,280,000.00**
Total road cost	**$ 11,983,783.00**
site access, staging	**$ 3,727,245.69**
engineering management	**$ 1,464,275.09**
Total Cable cost	**$ 11,466,106.00**
Installation, assembly	**$ 3,327,897.93**
Cost per foundation	$ 114,001.36
Total Foundation	**$ 4,560,054.40**
Developer fee %	5%
Total Developer fee	**$ 6,314,497.17**
Land Lease	**$ 9,584,041.82**
Total Capital Cost	$ 134,809,362.11
Total Amount Financed	$ 149,243,626.01

Cabling to Grid: The cabling to the grid that connects the wind turbine substation to the closest distribution or transmission line will be underground to reduce visual impact (Spectrum Energy Systems). The length of the line will depend on the amount of distance between the wind turbine and the point of connection to the main grid. The cable characteristics are dependent on the total wind turbine rated power and the voltage of the wind turbine substation. We expect losses of less than 2% voltage drop over distance (Spectrum Energy Systems).

Transformers and transmission: Each wind turbine is equipped with a transformer to reduce electrical transmission losses by stepping up the voltage. The transformers will be located close to the generator in the nacelle in order to reduce losses (Orrell and Poehlman, 2017).

Foundations: The foundation costs vary significantly based on the geological site and manufacturer's recommended foundations. In order to get a more definitive quality of the geological site, surveys such as soil samples will need to be taken, pressure calculations completed, and trial pits. The surveys will be conducted at the exact wind turbine location before a definitive BOP cost is given for contracts. If a non-standard condition is identified, the foundation may need to be redesigned to carry designated loads. The foundation is a critical part of a wind turbine installation due to the intense load bearing activities and the innate difficulties of pouring concrete according to specifications (Orrell and Poehlman, 2017).

Transportation and Logistics: The costs required to ship the turbine from manufacturer to customer site are dependent on site location and manufacturer agreement, and the turbine may be shipped to local warehouses or indirectly to the customer site, incurring costs (Spectrum Energy Systems).

Access roads: Access roads need to be constructed to support cranes, delivery vehicles, and various diggers and allow for ease of accessibility for operators, contractors, and other necessary personnel. Such roads will be designed for the duration of the wind farm lifespan. Service roads will be made up of layers of crushed rocks and gravel and site access roads will be built off of the highway roads to allow entry to windfarm network roads. The networks roads will be 4.5 meters in width (WE Energies).

Operation and Maintenance: The engineer's responsibilities are to maintain overall operation and maintenance of BOP activities, complete preventative and maintenance actions, complete administrative reports, confirm site safety and health, check productivity and environmental compliance, monitor the Supervisory Control and Data Acquisition (SCADA) system, and maintain spare parts and consumables. The GE 2.5 MW turbine has a gearbox requiring annual maintenance, such as oil sampling, vibration analysis, and IR inspection. Conditionally, in the designated siting area, there are several nearby wind farms utilizing GE wind turbines which allows for accessible GE turbine representatives and engineers at the sited location (Siemens, 2013).

Crane: Crane pads are prepared for each turbine location to instigate the lifting of tower, turbine, and installation of the blades. Crane pads are designed for approximately 200kN/m^2 to 500kn/m^2 depending on size of turbine and the generator. The pads will be unpaved, compacted layers of rock (Orrell and Poehlman, 2017).

SCADA: Supervisory Control and Data Acquisition (SCADA) is an industrial control system that enables real time monitoring and control over remote operations of wind turbines and other associated systems. Users are able to access accurate real time data including live weather and meteorological updates and fully configurable Key Performance Indicators (KPIs). The ability to compare past production patterns with historical, current, and live information assists in fine tuning equipment for optimal efficiency. Some SCADA systems provide wind farms with rich 2D and 3D visualizations and reports that are integrated with real time and historical geographical terrain maps. SCADA also allows real time access to turbine information such as wind speed, wind direction, power blade position, temperature, and vibration. The cost of the SCADA system will depend on the complexity of the package chosen (University of Strathclyde, 2012).

Project-Specific Risks & Respective Mitigation Strategies

One of the first risks detected with our project came when using the county assessor's map to distinguish property lines and land uses for the plot of land that we have designated as our site. To be specific, we determined that the land affected by our usage was spread across nine different land usage types and forty-eight different plots in total. On top of this, the values of these plots of land varied from $50,000 to $3,000,000. With the severe variance of land use, property owners, and total plots as a whole, we found it better to approach each land use segment separately and develop lease rates for them based off of the average values of the land. When averaged out by usage, we determined we would pay land owners up to 14% of state-declared property value per acre. In some categories there were severe outliers and we were forced to shed the average figures in the name of retaining realistic figures with which to approach the property owners for lease negotiations. We settled on a 14% figure to provide substantial financial benefit to property owners over the 20-year life cycle of our project. The easy rationalization on the financial side of negotiations along with our accommodations for turbine noise generation will provide smooth lease agreements with land owners.

Even with landowner-biased lease rates (14%), we still found our LCOE calculation to be healthy. To further assist in mitigating lease-associated risk over the life of the project, we made a decision to pay the entirety of these lease agreements at the beginning of the project life cycle.

The next issue we encountered was the environmental impact of our development plans on the existing ecosystem. Given the proximity of our designated land to the existing Shiloh wind farms, we were able to utilize the extensive environmental impact studies that were conducted in the implementation of those farms.

There are many environmental impacts related to the construction of our windfarm, most of which concern habitat degradation. Many species will potentially be affected by the wind farm including a variety of birds, bats, frogs, and salamanders, but the local and migratory species that are likely to be most impacted are the Swainson's Hawk, Golden Eagle, Red-Tailed Hawk, and American Kestrel (ICF International, 2010). The consequences of construction include destruction of habitat and nesting areas, but there are a number of on site and off site mitigation measures that will compensate for the damage.

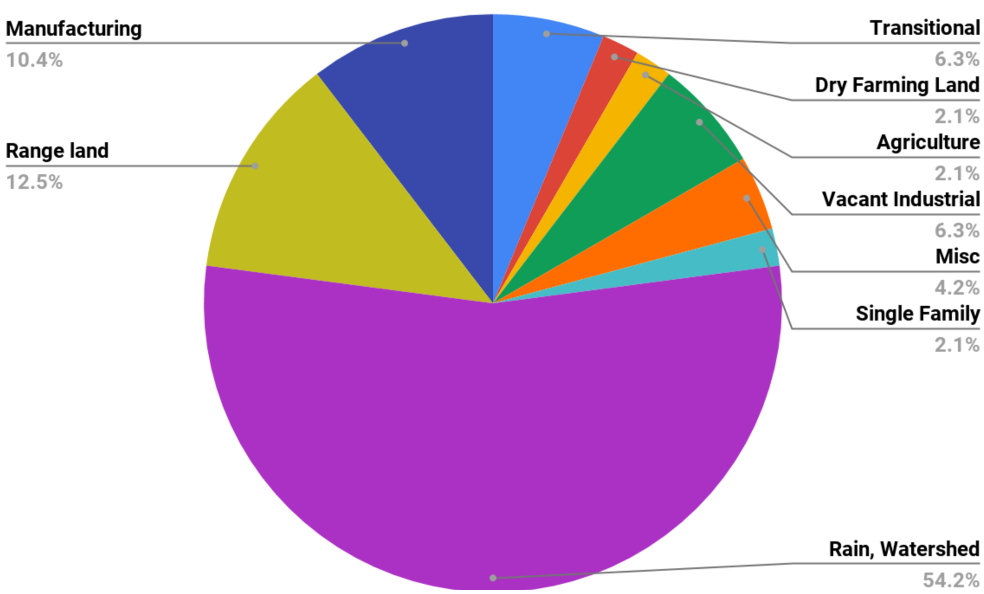


Figure 3

On site mitigation includes avian strike data collection and a raptor mitigation plan which involves weekly canvassing of the site for bird carcasses in order to keep track of fatalities. Yearly impact reports will be conducted for a minimum of three years post construction and will be sent to the state and federal departments of fish and wildlife to determine if the turbines generate disproportionately high levels of avian strikes.

Offsite mitigation consists of purchasing a replacement mitigation habitat that accounts for a 1:1 ratio of the total rotor swept area of each turbine. The area must consist of any combination of open oak woodland, mixed grain or cropland, grazing land, or non-native grasslands. The land must have sufficient nesting areas for species such as the Swainson's Hawk, and if not tree planting must be incorporated. In the years post construction, if the site proves to be the cause of disproportionately high numbers of fatalities, other deterrence options include sonar, radar, and UV light.

Additionally, we will be coordinating with the Friends of the Swainson's Hawk and the Napa-Solano Audubon Society to ensure compliance with local ordinances and to obtain more information on the migration patterns and habits of local species. Most of the information we gathered for our environmental impact assessment comes from data from Travis Air Force Base and the neighboring Shiloh Project, both of which track and monitor bird fatalities and practice deterrence.

Project Funding

Understanding the scope of funding in the wind energy industry and exploring funding strategies was crucial to our team in determining the best route to go about securing funding. For this reason, our team conducted funding simulations from two different perspectives. The first of these analyses puts us in the perspective of a developer seeking to receive a loan from a major bank for all of the necessary capital to fund the project through its life. We understand that this perspective is not likely to be taken in the wind industry, but pursuing this route allowed us to utilize PTC and a standard loan structure to compare against our primary funding strategy structure. To keep the analysis honest, we have standard baseline figures we used for both analyses. The first of these is annual energy production income- with a PPA of $53/MWh and an annual production of 440,244.08 MWh, both scenarios receive $23,332,935.95 from energy production annually. In addition to this, both scenarios receive $900,000 annually from the sale of 60% of our farm's produced carbon credits. This figure is based upon a $15/ton market rate for carbon credits ("California Carbon Dashboard", 2019) and gracious expected transaction fees of roughly 10%. Seeing as both funding scenarios are for the development of the same proposed wind farm, both will be subject to the same annual Operations & Maintenance expense of $4,066,166. We also subjected both scenarios to an income tax level of 20%, this was used Beyond the aforementioned figures, the income, debt, and incentive structures vary between the two scenarios.

Funding Analysis 1

As previously mentioned, this analysis operates from the perspective of a single developer, in this case the California State University (later referred to as "CSU") system, seeking a debt equity loan from a large financial institution in the sum of all necessary capital to fund the project. For our wind farm, a total of $149,243,626.01 will need to be financed. Seeing as this project has a 20-year life cycle, we assume the lender will consider this a higher-risk investment, so we have conducted the analysis using an 8% annual interest rate. An incentive enjoyed by this financing strategy is the utilization of the PTC. Even with the reduced PTC payout percentage, our production amount would net a substantial $4,015,025.96 annually until fiscal year 10 when the program finishes. After all expenses, we found this approach's effectiveness to be largely hindered by its lack of loan portfolio diversification, which results in its high interest rate. This sees the CSU paying a substantial amount of interest over the life of the loan, delaying its payoff to fiscal year 12.

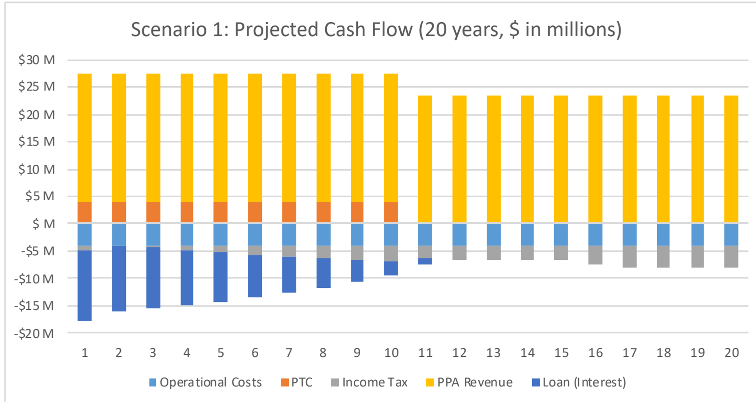


Figure 4

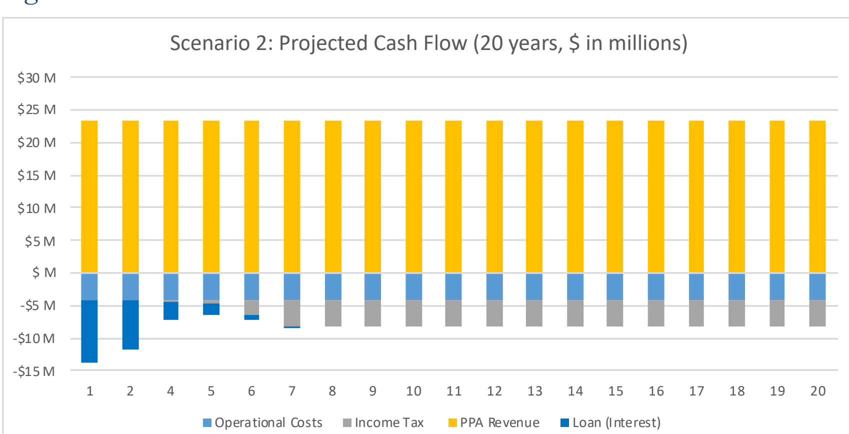
Funding Analysis 2

The funding strategy our team found to best suit current market conditions is that which spreads the project's capital sourcing across 3 different funding sources. The first of these sources is a policy that would require approaching the State of California's Energy Commission. This loan incentive proposal would be rationalized using the provisions of CA PON-13-401 (CEC, 2019), a widely-used 1% interest loan program implemented by the California Energy Commission to incentivize the development of renewable energy projects such as this. This would be a loan which accounts for 20% of our total loan portfolio, or roughly $30 million. The reasoning for financing such a slim portion of our project in this manor lies in the belief that the low-risk nature of the smaller investment will all but guarantee the loan's approval.

The second funding source would be that of a traditional bank loan for the next 30% of our loan portfolio, which equates to roughly $45 million. Seeing as this is a higher-risk traditional loan which will be paid back in a window exceeding ten years, we are anticipating a relatively high interest rate; for the sake of our analysis we settled on a rate of 6.25%.

For the remaining 50% of the loan portfolio, our team decided to utilize a traditional tactic with securing of a tax equity investor to fund the remaining ~$75 million necessary to complete the project. Due to the high-risk nature of this loan, we see it as fair that the interest be higher than average. For this analysis we decided to use an 8% interest rate through the life of the loan. This financing strategy provides a distinct advantage in the fact that we have elected to capitalize on our wind farm's eligibility for the MACRS depreciation program ("Modified Accelerated Cost-Recovery System (MACRS)", 2019). Given the size and nature of our project, we are qualified to use the MACRS 5-year total depreciation model ("MACRS Depreciation and Renewable Energy Finance", 2019).

Figure 5



With the utilization of the MACRS 5-year model, our project sees our tax equity loan paid entirely in year 4, our debt equity paid off in year 7, and the state loan paid off in year 8.

Finance Conclusion

Through the comparison of our first and second analyses, it is clear that our second funding strategy is far superior in its creative usage of current market loan conditions and existing financing incentives, paying off all debts and generating profit by fiscal year 8, as opposed to year 12 in analysis 1. In addition to generating faster return to investors and higher overall profit by the end of the 20-year life cycle, analysis 2 pays over $40,000,000 less in combined interest and tax expenses over the life of the project. As observed in the table below, Scenario 2 pays substantially less interest due to its aggressive repayment tactics, though it is subjected to paying more income tax over the life of the project. We see this this increased tax payment as a double-edged sword, on which we expand in the "*Triple Bottom Line Benefits*" section below.

Table 2

Interest & taxes	20-year period	total
scenario 1 interest	$ 83,261,852.90	
scenario 1 taxes	$ 45,220,792.29	$ 128,482,645.19
scenario 2 interest	$ 27,015,979.38	
scenario 2 taxes	$ 59,794,504.62	$ 86,810,484.00

The push for a clean California State University

In the 2018 fiscal year, the California State University system as a whole consumed 777,000,000 KWh of power, paying an average rate of $0.11/kWh across the entire university system. Sadly, our own Cal Maritime paid an egregious $.27/kWh for power that what was more than likely not clean energy sources. Our project, after all expenses are taken into account, breaks even at a rate $0.033/kWh. Taking all of this information into consideration, we found it to be advantageous for us to offer the CSU an extremely competitive PPA of $.053/kWh to purchase our farm's entire annual capacity of 440,244,074.5 kWh. Not only would this give the CSU an incredible opportunity to convert more than half of its consumed power to clean, renewable energy, it would reduce its energy expenditures by a whopping $311,076,463.04 over the life of the 20-year agreement.

To generate such a figure, we first began by multiplying our plant's annual power output by the aforementioned PPA rate, which produces a bill of $23,332,935.95. In addition to the PPA rate, these utilities are subject to PG&E transmission and distribution taxes specified in the E-20 tariff, which sit at a rate of $.02267/kWh (PG&E, 2018). When combined with the remaining energy being paid for at their existing average rate of $0.11/kWh, the CSU's total annual energy bill is $70,702,500.85, as opposed to the their $86,256,324.00 in energy costs under current agreements.

Triple Bottom Line Benefits

In addition to the environmental benefits that come naturally from our PPA established with the California State University system, we have developed a figure to measure the exact carbon emissions offset provided to the California State University through the remaining 40% of our farm's carbon credits. Annually, the CSU produces 194,271 tons of carbon emissions. With the remaining 40% of our carbon credit production, its emissions will be offset by over 65%.

Table 3

$/ton CO2	15.1
lb CO2/kwh	0.5
project kWh production	440244074.5
lb CO2	220122037.3
tons CO2/year offset	110061.0186
CSU tons/tear	194271
Total $/year worth of carbon	1661921.381
Selling Credit $/year with some CSU offset	1000000
	0.60171318
CSU carbon - 40% of project tons	128045.8344
Using 40% of credit reduces CSU footprint	0.65910936

Our team has also decided to set aside an annual budget of $125,000, distributed locally at the River Delta Unified School District, the school district for the nearest town to our site, Rio Vista, which also happens to consistently be one of the lowest-funded school districts in the state of California. Taking this into account, our team thought it would be great for us to sponsor wind energy programs in the local elementary, middle, and high schools. The schools would receive $25,000, $50,000, and $50,000 annually to fund wind energy programs such as those that have competed in our Kid Wind event in years past.

As displayed in the "*Finance Conclusion"* section above, one of the benefits we see of pursuing our Scenario 2 funding strategy is the sum of taxes paid over the life of the project. Though the project overall is much more financially feasible than Scenario 1, it pays substantially more taxes, benefiting the local, state, and federal governments through the life of the project.

A final team goal was to address the opportunities that arise when approaching the end of the 20-year life cycle of the wind farm. At the end of the project's life cycle, we see an opportunity to generate a snowballing effect by coordinating the sale of our GE 2.5 turbines with a firm such as Zola, which seeks to democratize sustainable energy generation in sub-Saharan Africa. By the end of year 2039, our turbines will more than likely be seen as too inefficient for our domestic wind industry and will be in need of severe reconditioning. For that reason, we would coordinate with local turbine reconditioning firm Halus Power to conduct hardware refreshes and necessary maintenance to prepare the turbines for extended usage after their sale. Not only does this further the vision of global sustainability, it also frees up last remaining bits of capital tied into the aged turbines. From that point, depending on the state of the energy industry, we are free to use the profit generated from our plant to re-power the plant with current wind technology, or to begin the process of restoration back to the land's natural state.

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