TUSKEGEE UNIVERSITY
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Collegiate Wind Competition (CWC)

Siting Report

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Contents

EXECUTIVE SUMMARY

The Tuskegee University Collegiate Wind Competition (CWC) Siting Team made the necessary investigations to find, within 23 counties in Eastern Colorado, a suitable location for building a 100MW wind farm. Through extensive research, which included finding wind conditions, permitting requirements, environmental concerns, and other salient factors, it was found that a location in Yuma County would make a very good choice for building a wind farm of the desired size. The factors that compelled us to choose a site in Yuma county were its proximity to existing transmission lines, smaller population size, absence of endangered species (specifically birds) in the vicinity, and sufficient distance from airports. These factors helped us ensure safety for the environment, aircraft operators, and lack of community disturbance.

Following the site selection, the Vestas V136-4.2MW turbine was chosen as the turbine model for the wind farm. The decision was made to use this equipment, because a higher turbine hub height would lead a higher rate of wind power and there are several Vestas wind manufacturing facilities nearby in the state of Colorado. The unit cost of the selected turbine model was in the range of $8.3 million USD. To accommodate a wind farm of the desired capacity a total of 25 turbines was needed for a total cost of $210 million USD. The turbines would be installed on 6,000 acres of land facing the direction of 60 degrees North-East (to achieve the best orientation since the normal wind direction at the selected site is South-West).

For implementation and financing of this project, we decided to begin by first constructing the wind farm to 50% total anticipated capacity and then incrementally ramping up to full capacity by the eleventh year; that is, capacity will be increased to the 75-percent level at Year 6 and to full capacity at Year 11. We adopted this strategy acknowledging the reality that it takes time to cultivate full customer base. We definitely wanted to avoid building to full generation capacity initially and having to deactivate some turbines while we wait to attract sufficient customers. The strategy also alleviates potential challenges regarding the availability and/or burden of initial capital costs. Our financial analysis indicated that the project is expected to reach its break-even point at the thirteenth year of operation. Our report includes a breakdown of capital costs, balance of system cost, total revenue, and total expenses including the loan principal and interest payments.

For our analysis, we are assuming a project lifespan of 20 years. Through our research, it was determined that the average cost of 1 MWh for the planned project would be equal to $20 USD. The wind farm has a capacity of 100,000 kW: it is comprised of twenty-five 4.2 MW turbines with each having a capacity of 4000 kW. We found through our Levelized Cost of Energy (LCOE) calculations that the LCOE value for our wind farm was $56.86/ MWh. As such, it was concluded that this project will be economically viable with a breakeven point occurring at the Year 13 mark of the planned 20-years project lifespan.

INTRODUCTION

The tasks of the wind project development of the Tuskegee University CWC Siting Team are documented in this report. The objective of the wind development work was three-fold: 1) To take a system approach and find an area within a prescribed Eastern Colorado region, a location that is suitable for installing a 100-MW wind farm. The prescribed region, shown in the darker shade green in Figure1 below, is comprised of 23 eligible counties. 2) Next, to collect the needed information and conduct the required research to perform a preliminary wind farm design. 3) Finally, to conduct a thorough financial analysis to assess the long-term economic viability of the project.

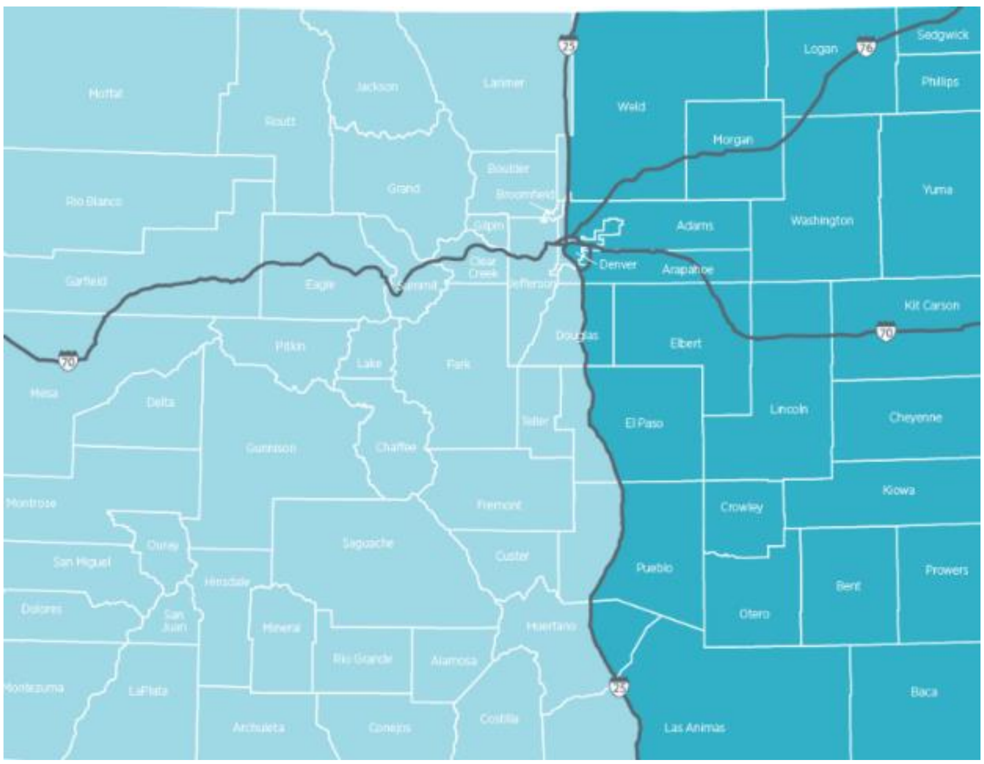

Figure 1: *Eastern Colorado (darker shade green region) for potential wind projects siting*

SITE DESCRIPTION AND ENERGY ESTIMATION

Site Selection

To proceed in a more systematic manner in pinpointing the most suitable/efficient location for a 100MW wind farm, we started by using the NREL's *Wind Prospector* [1] to find and tabulate, for each county, information on the selection factors that are typically considered in the evaluation of wind energy facilities. These selection factors include expected land-based wind speed at 100 meters height, land ownership, environmental concerns such as the presence of endangered species and the presence of suitable transmission lines. The transmission lines information for each county was obtained from the transmission line ownership map of Colorado (see Appendix A). The collected information on site selection factors for all the 23 counties in Eastern Colorado is presented in Table 1 below.

Table 1: **I**nformation on site selection factors for the 23 Counties. Following codes some of the column names: **EW**- number of existing wind farms, **WMS** - number of wind manufacturing sites, **AIRPT** - number of airports and **BRM -** number of Bromfield lands.

County	Wind Speed Range	Land Ownership	Transmission Lines	Land Cover	Endangered Species	AIRPT	EW	WMS	WREZ Hub	Population (2018)	BRM
Adams	5.0-7.0	FS	230 kV; 345 kV	Grassland	Yes (4)	19	1	2	None	517,421	1
Arapahoe	6.5-8.0	DOD	115 kV; 230 kV; 345 kV	Grassland	Yes (3)	18	0	0	None	656,590	5
Baca	7.5-9.0	None	115 kV	Grassland	None	3	0	0	1	3,585	0
Bent	5.5-8.5	DOD	115 kV	Grassland	Yes (1)	1	0	0	None	5,882	0
Cheyenne	7.5-8.5	BLM	none nearby	Grassland	None	1	0	0	1	1,831	1
Crowley	5.5-7.0	BLM	115 kV; 230 kV	Cultivated	Yes (1)	0	0	0	None	5,858	1
Denver	4.5-9.0	NSF & FS	115 kV; 230 kV	Shrubland	Yes (3)	14	2	1	None	716,492	1
El Paso	5.5-6.0	DOD, BLM & FS	115 kV; 230 kV; 345 kV	Cultivated	Yes (3)	26	0	0	None	720,403	6
Elbert	7.0-7.5	None	115 kV; 230 kV	Cultivated	Yes (3)	20	1	0	None	26,729	1
Kiowa	7.0-8.5	None	none nearby	Cultivated	Yes (1)	2	0	0	None	1,406	0
Kit Carson	7.0-8.5	None	115 kV; 230 kV	Grassland	None	4	1	0	None	7,097	0
Las Animas	6.5-8.5	DOD, BLM & FS	115 kV; 230 kV	Forest	None	6	0	0	None	14,503	1
Lincoln	6.5-7.5	None	115 kV; 230 kV; 345 kV	Cultivated	Yes (3)	4	2	0	None	5,610	0
Logan	6.0-7.0	None	115 kV; 230 kV	Cultivated	Yes (3)	3	5	0	1	22,409	0
Morgan	5.5-6.5	None	230 kV; 345 kV	Cultivated	Yes (3)	7	0	0	None	29,068	0
Otero	5.5-7.0	FS & NPS	115 kV	Grassland	Yes (1)	6	0	0	None	18,432	2
Phillips	7.0-8.5	None	115 kV	Grassland	None	2	0	0	None	4,265	0
Prowers	6.5-8.5	None	115 kV; 230 kV; 345 kV	Cultivated	Yes (1)	5	5	0	None	12,164	0
Pueblo	6.0-8.0	DOD, BLM, BOR, FS &	115 kV; 230 kV; 345 kV	Grassland	None	11	1	0	None	168,424	6
Sedgwick	7.5-9.0	None	none nearby	Cultivated	Yes (3)	1	0	0	None	2,248	0
Washington	7.5-8.5	BLM	115 kV	Cultivated	Yes (3)	2	0	0	None	4,908	0
Weld	4.5-7.0	FS	115 kV; 230 kV	Shrubland	Yes (4)	40	4	1	None	324,492	1
Yuma	7.0-8.5	BLM	115 kV; 230 kV	Grassland	None	9	1	0	None	10,019	0

This county-level tabular data allowed us to quickly eliminate from the list counties whose identified factors make them more unlikely to encompass areas where successful wind farm could be placed. According to Wind Exchange [2], a web portal maintained by the DOE Office of Energy Efficiency and Wind Energy, an area is considered to have wind resources adequate for wind site development if its annual average wind speeds is greater or equal to 6.5 m/s at an 80-m height. Guided by this information, we decided to disqualify any county whose range of wind speeds does not lie above 7 meters per seconds. After this step of our elimination process, all counties were disqualified from further consideration except for nine of them; namely, Baca, Cheyenne, Elbert, Kiowa, Kit Carson, Phillips, Sedgwick, Washington, and Yuma. Next, we used the requirement that, at minimum, a 230kV transmission line would be required to efficiently sustain a 100 MW wind site [10]. Since there is need to avoid the additional cost of transmission installation, the above criteria led to the elimination of additional counties due to their inadequate transmission line capabilities. These counties are Baca, Phillips, and Washington (since they only have 115 kV lines), and Cheyenne, Kiowa, and Sedgwick (since no transmission lines were available nearby).

Among the three remaining counties (i.e., Elbert, Kit Carson, and Yuma), Elbert appeared to have noticeably less attractive characteristics when compared to the other two. First, the range of wind speeds is from 7 to 7.5 m/s whereas Kit Carson and Yuma have a range of 7 to 8.5 m/s. Furthermore, environmental issues may arise in the development of site in Ebert county since three endangered species are present. Finally, since there are 20 airports in the county, there may be less options to easily find locations for wind site development. Due to the above considerations, Elbert county was removed from consideration. Based on the county-level information in Table 1, Kit Carson and Yuma appear to have equally attractive factors for finding adequate sites for wind development.

Toward our ultimate objective of finding a specific location to build a 100MW wind farm, we looked for additional differentiating information on the two remaining counties. We considered the following factors: number of cities, number of airports, population, proximity to transmission lines. We then decided to select a location within the county of Yuma, which has a population of approximately 10000, only 9 airports/heliport and readily available 230KV transmission lines. These airports/heliports can easily be avoided because Yuma has vast Grassland space with only three small cities. As such, finding an open 6,000-7,000 acres of land can be more likely achieved. From *Wind Prospector*, a wind farm at a location in Yuma (Power Class of 4) is expected to be more efficient than one in Kit Carson (Power Class of 3) because of higher wind power classification. Since Yuma is sparsely populated and mainly comprised of Grassland, selecting a site in Yuma would also remove concerns about visual impact, electromagnetic interference, and noise impact. An aerial view of the identified in Yuma County to develop the wind farm is shown Figure 1. The area is a squared-shaped patch of land with four corners located at the following latitude and longitude coordinates: [39.844918, -102.457812], [39.806060, -102.457106], [39.806533, -102.391299], and [39.806244, -102.391755].

However, potential risks exist. Lands in Yuma are primarily owned by the Bureau of Land Management (BLM). As result, we will need to purchase public land from the local BLM office. BLM does not usually sell land unless the land-use planning is deemed appropriate. Furthermore, there is no "average" cost per acre of lands sold by BLM. Each piece of land is evaluated separately and priced at a fair market value. Once the land is purchased, it is subject to state and local taxes, zoning ordinances and other expenses. Yuma County requires an administrative land use permit for the installation of a distributed wind energy system. The application for the permit includes a written description, site plan, detailed drawing or photograph, an FAA notice, and a notice of operation of communication links. The wind farm would also require additional standards with the land use permit. For example, the turbines must conform to all industry standards and state and federal requirements. The proposed turbine designated to be used in this project is the Vesta turbine model VS136-4.2 In addition, there must be no artificial lighting except to the extent required by the FAA.

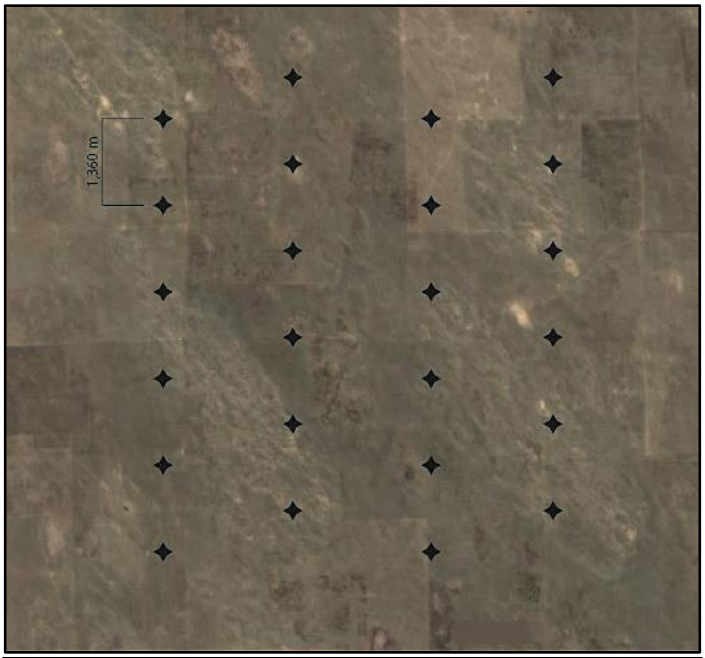

Figure 1: Aerial view of the identified site in Yuma County for wind farm development: a squared-shaped patch of land with four corners located at the following latitude and longitude coordinates[39.844918, -102.457812], [39.806060, -102.457106], [39.806533, -102.391299], and [39.806244, -102.391755].

Site Layout and wind resources

Through extensive research, it was concluded that Vestas would be the most suitable company for the procurements of the equipment needed for the project. This choice was guided by the fact that Vestas has several manufacturing facilities throughout the state of Colorado. The proximity of Vestas facilities to the planned wind farm site will reduce shipping costs and facilitate quick access to spare parts for maintenance over the 20-year life span of the project. Vestas turbines are manufactured for higher outputs to reduce the number of turbines needed. For our planned wind farm site, the Vestas V136-4.2MW turbine was selected. The key technical specifications of this Vestas model are presented below in Table 2.

Table 2: Characteristics of the selected Vestas turbine model

Turbine Model for Layout	IEC Wind Class	Diameter	Rated Capacity	Hub Height	Cut-In Wind Speed	Cut-Out Wind Speed	Number of Rotors Needed
(MW)	(I, II, III)	(m)	(kW)	(m)	(m/s)	(m/s)	(turbines)
V136-4.2	IIB	136	4,200	100	3	25	24

To obtain a 100 MW wind site, we plan for a site that is comprised of 25 Vestas V13-4.2 turbines. After collecting data on many existing wind farms in Eastern Colorado (See Table 3), we observed that, on the average, wind farms are typically in the range of 30-141 acres of land per megawatt. To stay consistent with existing wind farms, we designed our wind farm for a layout at of 63 acres of land per megawatt. For a 100 MW wind farm, the above choice coincides with approximately 6,300 acres (9.84 mi^2) of land. Since the team did not have access to the *OpenWind* software, the turbine layout configuration was done as follows. The turbines are arranged in four parallel lines of six elements, with every other column staggered. The turbines are evenly spaced by at least 1,360 meters (i.e., 10 rotor diameters) apart and are placed facing the direction of 60 degrees North-East (to achieve the best orientation since the normal wind direction at the selected site is South-West). This spacing is vital to the design of the wind farm because it ensures the highest level of efficiency considering the turbulence each individual turbine creates in its vicinity. The layout of turbine within the planned Yuma County wind turbine site is shown in Figure 1 above.

Table 3: Typical Acre/MW of Eastern Colorado wind farms

Wind Farm	Acres of land	Power output (MW)	Acre per MW
Carousel	34,000	150	227
Cedar Point	20,000	250	80
Colorado Green	11,000	162	68
Colorado Highlands	5,200	67	78
Golden West	37,000	250	148
Kit Carson	6,000	51	118
Limon I, II, III	90,000	600	150
Twin Buttes	9,000	75	120

Although industry estimates an annual output of 30-40% capacity, real-world data indicates that the typical annual output is in the range of 15-30% [9]. Using a 25% capacity factor, a 4.2 MW turbine produces 9,417,000 kWh/year per turbine [4.2 MW*365 days*24 hours*25%]. Therefore, for a site with 25 such turbines, the expected annual energy production would be equal to 229 GWh/year [9,198 MWh*25 turbines].

FINANCIAL ANALYSIS:

Included in the financial analysis below are equations, calculations, and results for the cost of energy, cash flow analysis and other cost/revenue information for the 20-year life-expectancy of the 100MW wind farm project. The first step of our financial analysis consisted of identifying individual costs of items considered in the Capital Expenditure (CapEx) and Balance of System Cost (BOS). The itemized costs for the CapEx and the BOS are presented below in Table 4.

Table 4. BOS and CapEx Individual Cost

Balance of System(BOS)				CapEx		
Access Roads		$15,000,000		Turbine Costs		$85,680,000
Wiring		$200,000		BOS		$56,325,000
Foundation		$250,000		Equity closing cost		$300,000
Warranty		$1,000,000		Debt closing cost		$450,000
Insurance		$375,000		Debt up-front fee		$137,500,000
Legal Cost		$250,000		Development Fee		$8,515,000
SCADA systems		$2,500,000				
Land leasing/Easements		$200,000			TOTAL	$355,770,000
Substation		$11,500,000				
Management		$1,250,000				
Permitting		$250,000				
Transmission Upgrade		$2,200,000				
Operation & Maintenan		$4,800,000				
Construction		$750,000				
Foundation		$750,000				
Erection		$15,000,000				
Site Assessment		$50,000				
	TOTAL	$56,325,000				

Table 4: Cash Flow Analysis

Cost Analysis

The equations used to compute revenues and expenses are discussed below.

Calculation of (cumulative revenue): To guarantee that all the electricity generated from the wind site can be sold to available customers, the project will be built in three phases. By Year 1 of the project lifespan 50% of the site will be operational. The site will be 75% operational by Year 6 and then fully operational by Year 11. Assuming that be the yearly revenue from the fully operational site is equal to R_T, the cumulative revenue $R[n]$ at Year n is given by

$$R[n] = \begin{cases} 0.5 \cdot UF \cdot R_T \cdot n, & 1 \le n \le 5 \\ R[5] + 0.75 \cdot UF \cdot R_T \cdot (n-5), & 6 \le n \le 10 \\ R[10] + R_T \cdot UF \cdot (n - 10), & 11 \le n \le 20 \end{cases}$$

Where $R[5]$ and $R[10]$ denote respectively the cumulative revenues at Year 5 and Year 10. Revenue computations considers the fact that Yuma County's highest wind speeds occur during the months of November to April. As such, we accounted for lower wind periods by adjusting the annual revenue by utilization factor UF = 65%. For our project, the yearly revenue from the fully operational site is equal to R_T = $105120000. At 65% utilization, the projected revenue at full operation= $68,328,000.

Expense costs (Bill cost plus O&M costs): Bill costs and O&M costs are considered as ongoing expenses proportional to the level of operation of the wind turbines. In consideration that the likelihood of equipment failure increases with equipment age, a 2% yearly increase is applied to O&M costs after Year 10.

- **Bill costs:** Assuming that be the yearly bill cost for the fully operational site is BC_T, the bill cost at Year n

$$BC[n] = \begin{cases} 0.5 \cdot BC_T, & 1 \le n \le 5 \\ 0.75 \cdot BC_T, & 6 \le n \le 10 \\ BC_T, & 11 \le n \le 20 \end{cases}$$

The yearly revenue from the fully operational site is equal to BC_T = $68,328,000.

- **O&M costs:** Assuming that be the yearly O&M cost for the fully operational site without taking into consideration equipment failures is OM_T, the O&M costs at Year n are thus

$$OM[n] = \begin{cases} 0.5 \cdot OM_T, & 1 \le n \le 5 \\ 0.75 \cdot OM_T, & 6 \le n \le 10 \\ OM_T \cdot \left(1 + \frac{2}{100}\right)^{(n-10)}, & 11 \le n \le 20 \end{cases}$$

The yearly O&M costs for the fully operational site without taking into consideration equipment failures are $OM_T = \$4{,}200{,}000$

Therefore, the expense cost $EC[n]$ at Year n is given by $EC[n] = BC[n] + OM[n]$

Yearly loan principal: The loan principal for a year (Year n) is equal to (1) the loan principal of the previous year (Year $n-1$) plus (2) the interest incurred for the previous year plus (3) new loan taken during the previous year minus (4) the loan payment made during the previous year. The four items are denoted as follows:

- Loan principal of the previous year: $LP[n-1]$
- Interest incurred for the previous year $LP[n-1] \cdot \left(\frac{r}{100}\right)$, where r is loan rate. We assume in our subsequent calculations a rate of $\left(\frac{r}{100}\right) =$ 6.5%, which is between the national average for wind turbines of 5 to 8% [10].
- Payment made during the previous is $P[n-1] = R^*[n-1] - EC[n-1]$ where $R^*[n-1]$ denotes the yearly revenue.
- Any additional loan taken during a previous is denoted by $NL[n-1]$. In our case, additional loans were taken at Year 5 and Year 10 to enable scaling of production to 75% level in Year 6 and 100% in Year 11.

Therefore, the loan principal at Year n is given by

$$LP[n] = LP[n-1] + LP[n-1] \cdot \left(\frac{r}{100}\right) - (R^{*}[n-1] - EC[n-1]) + NL[n-1]$$

The above equations were utilized to generate and show in Table 5 below a detailed cost analysis of the project over the 20-years expected lifespan of the project, where a break-even point is reach at Year 13. The project economic viability can also readily visible in Figure 2, where 20-years curves/profiles of revenues, expense costs (Bill+ O&M) and running balances are juxtaposed.

Table5: Cost Analysis

			Revenue	Bill Cost			Interest	O&M Cost		Capital	Prin. + Int		Rev-BC-O&M
		Base Value=>	68,328,000	6,914,777			6.5%	4,200,000		360,000,000			
YR	Capital	Cum. Revenue	Annual	Annual Cum	Bill Cost(Cum)	Annual	O&M Cost	O&M Annual	Expenses	Running Balance	Interest	Principal+Int	Profit
0	0	0	0	0	0	0	0	0	-	180,000,000	0	180,000,000	0
1	180,000,000	34,164,000	34,164,000	3,457,389	3,457,389	3,457,389	2,100,000	2,100,000	5,557,389	163,093,389	11,700,000	191,700,000	28,606,612
2		68,328,000	34,164,000	3,457,389	6,914,777	3,457,389	4,200,000	2,100,000	11,114,777	139,530,459	10,601,070	202,301,070	62,770,612
3		102,492,000	34,164,000	3,457,389	10,372,166	3,457,389	6,300,000	2,100,000	16,672,166	114,435,939	9,069,480	211,370,550	96,934,612
4		136,656,000	34,164,000	3,457,389	13,829,554	3,457,389	8,400,000	2,100,000	22,229,554	87,710,275	7,438,336	218,808,886	131,098,612
5		170,820,000	34,164,000	3,457,389	17,286,943	3,457,389	10,500,000	2,100,000	27,786,943	59,247,442	5,701,168	224,510,054	165,262,612
6	270,000,000	440,820,000	51,246,000	5,186,083	22,473,025	3,457,389	12,600,000	2,100,000	35,073,025	149,247,442	3,851,084	318,361,138	435,262,612
7		710,820,000	51,246,000	5,186,083	27,659,108	3,457,389	14,700,000	2,100,000	42,359,108	0	9,701,084	328,062,221	705,262,612
8		980,820,000	51,246,000	5,186,083	32,845,191	3,457,389	16,800,000	2,100,000	49,645,191	0	0	328,062,221	975,262,612
9		1,250,820,000	51,246,000	5,186,083	38,031,274	3,457,389	18,900,000	2,100,000	56,931,274	0	0	328,062,221	1,245,262,612
10		1,520,820,000	51,246,000	5,186,083	43,217,356	3,457,389	21,000,000	2,100,000	64,217,356	0	0	328,062,221	1,515,262,612
11	360,000,000	1,880,820,000	68,328,000	6,914,777	48,403,439	3,457,389	23,184,000	2,142,000	71,587,439	90,000,000	0	418,062,221	1,875,220,612
12		2,240,820,000	68,328,000	6,914,777	55,318,216	3,457,389	25,368,840	2,142,000	80,687,056		5,850,000	423,912,221	2,235,220,612
13		2,600,820,000	68,328,000	6,914,777	62,232,993	3,457,389	27,553,680	2,142,000	89,786,673		0	423,912,221	2,595,220,612
14		2,960,820,000	68,328,000	6,914,777	69,147,770	3,457,389	29,738,520	2,142,000	98,886,290		0	423,912,221	2,955,220,612
15		3,320,820,000	68,328,000	6,914,777	76,062,547	3,457,389	31,923,360	2,142,000	107,985,907		0	423,912,221	3,315,220,612
16		3,680,820,000	68,328,000	6,914,777	82,977,324	3,457,389	34,108,200	2,142,840	117,085,524		0	423,912,221	3,675,219,772
17		4,040,820,000	68,328,000	6,914,777	89,892,101	3,457,389	36,293,057	2,142,840	126,185,158		0	423,912,221	4,035,219,772
18		4,400,820,000	68,328,000	6,914,777	96,806,878	3,457,389	38,477,914	2,142,840	135,284,792		0	423,912,221	4,395,219,772
19		4,760,820,000	68,328,000	6,914,777	103,721,655	3,457,389	40,662,770	2,142,840	144,384,425		0	423,912,221	4,755,219,772
20		5,120,820,000	68,328,000	6,914,777	110,636,432	3,457,389	42,847,627	2,142,840	153,484,059		0	423,912,221	5,115,219,772

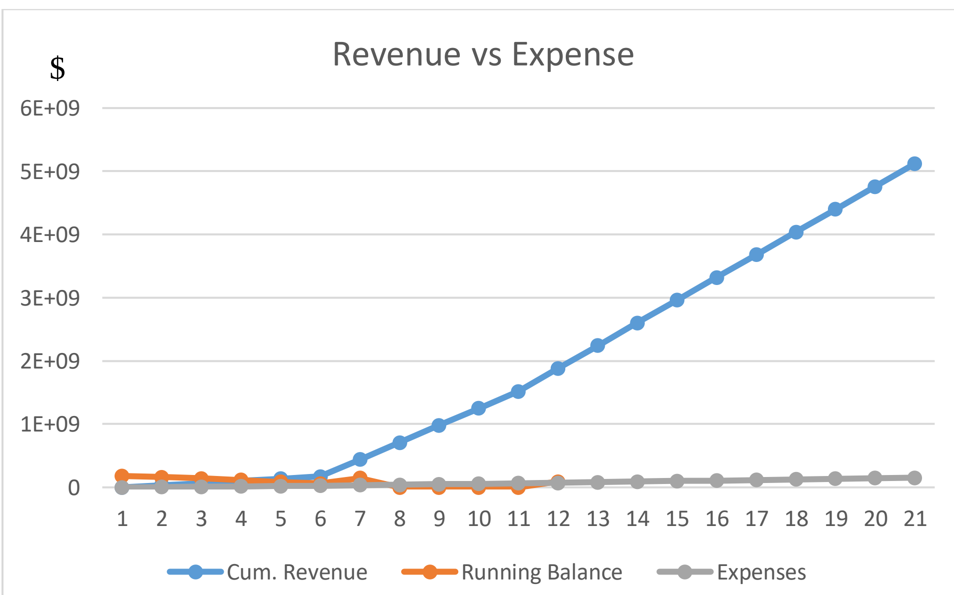

Figure 2: 20-years profiles of revenues, expense costs (Bill+ O&M) and running balances.

Levelized Cost of Energy (LCOE)

A simple levelized cost of energy gives an economic assessment of the cost of the energy-generating system including all the costs over its lifetime. In general, it is the minimum price energy must be sold for a 20-40-year project to break even. The following equation and calculations show how we arrived at the LCOE value of $56.86/ MWh. The TIC represents the price to build, which includes the Capital Expenditure and Operation and Maintenance costs. We are projecting a life expectancy of 20 years and found, through research, that the average cost of 1 MWh is $20 USD. The wind farm has a capacity of 100,000 kW: it consists of twenty-five 4.2 MW turbines that each have a capacity of 4000 kW. The LVC represents the average payment to cover per-unit operational cost, and Q represents the projected number of mega-watt hours the wind farm will produce per year. The LCOE value is computed using the equation below

$$LCOE = \left(\frac{\frac{TIC * r}{1-(1+r)^{-T}}}{Q} \right) + LVC$$

where,

- TIC: price to build
- T: life expectancy
- Cost of 1 MWh of electricity: $20
- Capacity: 100,000 kW
- r: interest rate= 6.5%
- LVC: avg payment to cover per-unit operational cost

The projected number of mega-watt hours the wind farm will produce each year, and the levelized cost of energy are calculated as follows.

$$Q = \frac{365\ days}{yr}\ x\ \frac{24hr}{day}\ x\ 100MW = 876{,}000\ MWh/yr$$

$$LCOE = (\frac{355{,}770{,}000 * 0.065}{1-(1+0.065)^{-20}}/876{,}000) + 20$$

$$= (\frac{23{,}125{,}050}{0.7162}/876{,}000) + 20$$

$$= (32{,}288{,}402.78/876{,}000) + 20$$

$$= 36.86 + 20$$

$$= \$56.86\ MWh$$

Taxes and Tax Incentives

The financing of this project will require the following sources of capital: equity, tax equity, and debt. The most likely and cost-effective option would be to finance this project through a partnership flip with a third-party equity partner. In a partnership flip transaction, the partnership allocates 99% of income, loss, and tax credits to the tax equity investor until it reaches a target yield. It is our hope that through a Power Purchase Agreement (PPA), we will be able to sell electricity to other utilities, corporations, and possibly trade power across state lines since Yuma County is at the border of Colorado. The Renewable Electricity Production Tax Credit (PTC) allows owners and developers of wind energy facilities to claim federal income tax on every kWh of electricity generated for the power grid for 10 years. The Business Energy Investment Tax Credit (ITC) is a federal income tax credit for capital investments in renewable energy projects. Since our wind farm is expected to be constructed after January 2020, we will not be eligible to claim PTC. We can however elect to claim the ITC in lieu of the PTC. The value of the credit depends on when construction begins. The credit we would receive (if construction begins before January 2021) is 18% of expenditures. The Rural Energy for America Program (REAP) provides guarantees on loans for renewable energy systems. REAP provides up to 75% of total eligible project costs. The Modified Accelerated Cost Recovery System (MACRS) is an accelerated federal depreciation tax offset that allows businesses to recover investments in certain properties through depreciation deductions. Through the MACRS, it is estimated that 100% of qualifying cost will be depreciated within the first six years of the wind farm's operation.

Risks and Alternatives

The design and construction of the teams 100 MW wind farm accounts for a few risks and setbacks. The first one is the voltage and capacity of existing transmission lines. Currently, transmission lines at the vicinity of the site are 115 kV-lines. From our research, it was found that a 230 kV transmission line would be most suitable for a wind farm of this capacity. To account for the potential that the existing 115 kV lines may not be able to handle such a large capacity, a budget of $2,200,000 USD was allotted in the Balance of System cost to account for an upgrade of transmission lines to 230 kV.We also took into account the proximity of Yuma County to the border of Colorado. This could benefit the revenue of this project by selling energy to utility companies located in the southern realm of Nebraska. Overall, this could increase our revenue and allow project debts to be paid off sooner than projected. As previously stated, the land proposed for this project is owned by the Bureau of Land Management. As a result, we will have to work with BLM to acquire the land. Although the BLM had not previously sold much land in this area, it is reasonable to assume that if the purpose of selling the land is deemed appropriate, the BLM would be more than happy to oblige. Another option would be to ask for a land exchange, where land that is not of particular importance to the BLM is exchanged to other land owners who can ensure improvement of land management.

CONCLUSION:

Through extensive research, on wind farms and the financial aspects of building and maintaining one of such high demand, it can be concluded that this project will in fact be feasible. Financial planning, and a partnership flip allows the project to come out with a reasonable break-even point despite the relative high cost of a project of this size.

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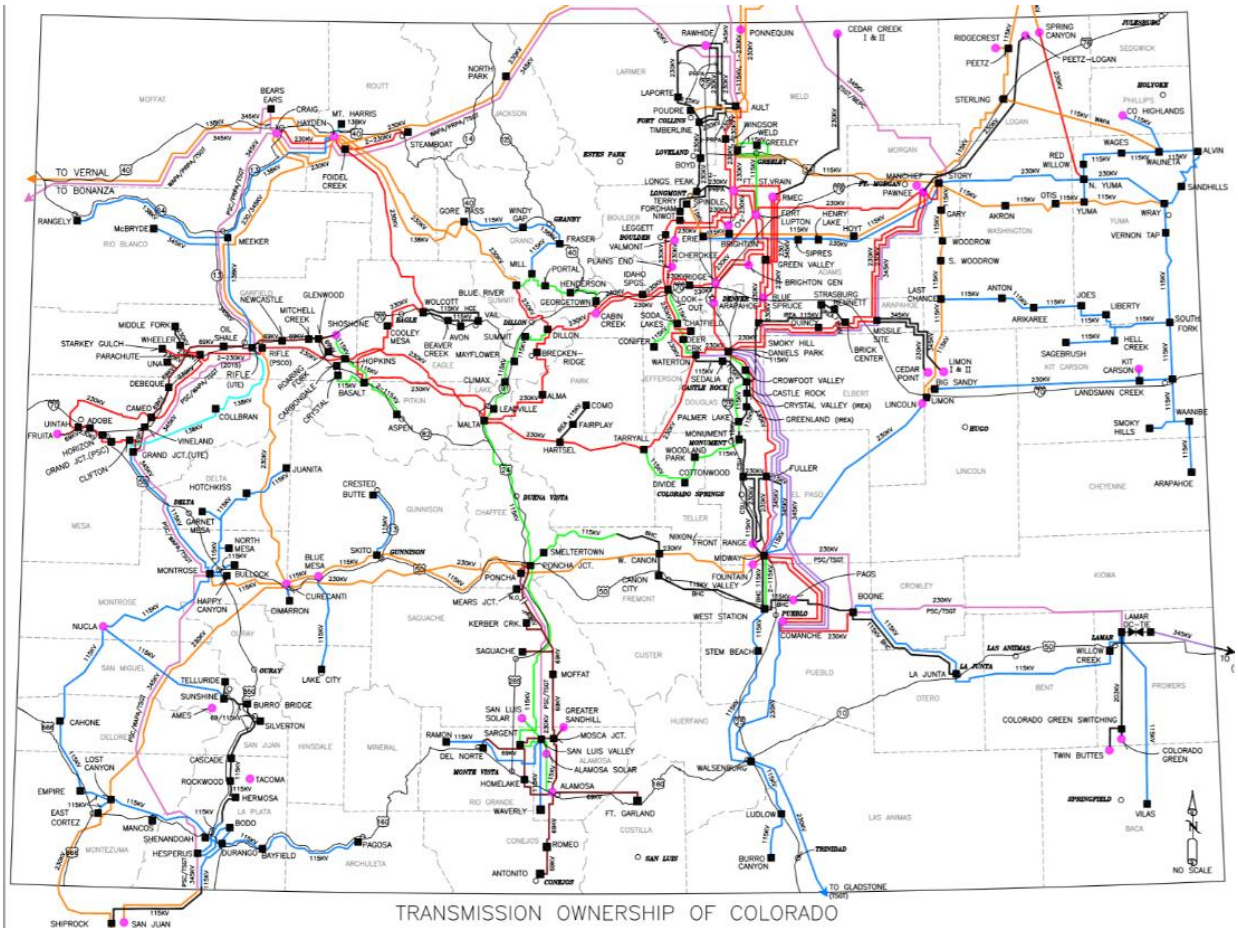
APPENDIX A: Transmission lines in Colorado



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