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RENEWABLE ENERGY

Canisteo Wind Energy Center Decommissioning Assessment

Prepared for:

The Towns of Cameron, Canisteo, Greenwood, Jasper, Troupsburg, and West Union

Prepared by:

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Introduction

Energy Ventures Analysis Inc. ("EVA") has been contracted to provide an independent cost assessment for the decommissioning of Canisteo Wind Energy Center ("CWE"), a proposed 290.7-MW wind project to be located across the Towns of Cameron, Canisteo, Greenwood, Jasper, Troupsburg, and West Union in western New York State. The project will constitute up to 117 wind turbines—all to be sited on private property leased from landowners. Invenergy LLC is the developer of the Canisteo Wind Energy Center project. Invenergy LLC is a private company with power generation assets in 18 states.

Wind decommissioning is a relatively new challenge for the wind industry because the vast majority of wind capacity in the United States has not yet reached retirement age. To that end, there is insufficient data and industry expertise for stakeholders to easily identify what cost decommissioning might have on the community after the useful life of the project has passed. The purpose of this study is to review the project, perform an assessment of the decommissioning cost, and draw general conclusions on the likely cost of decommissioning the CWE project.

Result

After performing an independent review, EVA concludes that decommissioning the Canisteo Wind Energy would cost $18.2 million, or approximately $156,000 per turbine. If the cost to decommission access roads, operations and maintenance building (O&M), and meteorological towers are excluded from the estimate, then it would cost a total of $15.9 million, or $135,700 per turbine.

Figure 1 – EVA Canisteo Wind Energy Decommissioning Estimate

Cost Category	Median Cost
Wind Turbine and Base	$ 106,639
Collection Lines and Substation	$ 9,784
O&M Building	$ 4,260
Access Road Reclamation	$ 11,999
Meteorological Towers	$ 600
Permitting	$ 2,137
BoP Subtotal	$ 28,780
Turbine + BoP	$ 135,418
Contingency (10%)	$ 13,542
Indirect Costs (5%)	$ 6,771
Total	$ 155,731
Use (Rounded)	$ 156,000

Project Overview

The Canisteo Wind Energy project is expected to consist of up to 117[1] wind turbines that will have a combined generating capacity of 290.7 megawatts (MW). This project is still in the design phase. Because Canisteo Wind Energy has not yet broken ground and the final turbine model type has not been selected, this analysis will assume that the project will utilize

[1] 117 is the number of assume turbines based on Canisteo Wind Energy LLC's filing "100.6 Exhibit 6 Wind Power Facilities Revision 2". If the number changes after EVA files its report, EVA will attempt to update analysis accordingly.

117 turbines with an approximate capacity of 2.5 MW each due to the fact that the project cannot exceed the proposed 290.7 MW.

EVA has not visited the project site as part of the study because the project is in a pre-construction phase. As a result, the contents of this evaluation, including any conclusions, are based upon desktop analysis.

Wind Farm Components

The CWE will be composed of the following main elements:

1. Wind turbines
2. Access Roads
3. The Electrical Collection System
4. Collection Substation
5. Meteorological Towers
6. Operations and Maintenance Building (O&M)

Decommissioning

Decommissioning would occur under two scenarios: if one or more turbines fail and are irreparable before the end of the useful life of the project, or after the useful life of the project. The wind industry points to two options for projects at the end of their life: 1) repowering turbines, and 2), utilizing scrap value to cover decommissioning costs. Repowering could prove to be an attractive option for projects, particularly in New York given its ambitious Clean Energy Standard. The Department of Energy notes that in 2017 more than 2 gigawatts (GW) of wind capacity were partially repowered[2]. However, it is not a certainty that repowering the assets will be feasible when Canisteo Wind is nearing retirement between 2040 and 2050. The future salvage value of the components of a wind farm is also uncertain. The value of the turbine after its useful life depends on the price of steel and other turbine components during the period that the wind farm is decommissioned. Without a proper agreement between the community and the developer, the community is burdened with commodity price risk.

Canisteo Wind Energy is proposing the following plan in the event of decommissioning. CWE will "remove wind turbines, pad-mount transformers, foundations to a depth of 3 feet below grade, and the project substation." CWE is proposing to leave the access roads and the O&M building under the assumption that the owners will find value in the residual roads and building. Additionally, CWE proposes leaving the majority of the electrical collection system in place—cutting cables near the pad-mount transformers "to a depth of 36'' or more." CWE's decommissioning plan does not include a provision to decommission the meteorological towers or a cost for removing the project substation.

CWE's decommissioning cost estimate is based on the following main assumptions:

1. Wind turbines can be resold at the end of their operational life
2. Turbine resale value of an approximate $900/MW depreciates at a rate of 50 percent in the first year and by 10 percent every year thereafter
3. Decommissioning cost is based on a project-adjusted decommissioning analysis conducted by LVI Environmental on Invenergy LLC's Stony Creek Wind Farm in 2010.
4. Decommissioning costs increase at a rate of 2.5 percent per year

CWE has noted that "the Towns should be able to complete such an operation for a net income… But to cover upfront costs the Town may encounter to arrange for and select a company to complete the decommissioning, CWE proposes posting security in the amount of $10,000 per wind turbine." CWE further states that it will "most likely… post and renew

[2] Wiser, Ryan. Bolinger, Mark. 2017 Wind Technologies Market Report. U.S. Department of Energy. Office of Energy Efficiency & Renewable Energy. https://www.energy.gov/sites/prod/files/2018/08/f54/2017_wind_technologies_market_report_8.15.18.v2.pdf

the security annually;" and goes on to make the stipulation that host Towns could "draw 50% of the funds if CWE does not renew the security instrument prior to its expiration date."

Herein lie the first significant problems with CWE's decommissioning analysis and proposal. First, as depicted in Figure 8 in the appendices, the net decommissioning cost (the claimed turbine resale value less the decommissioning cost plus the $10,000 bond) becomes negative in the 20th year—meaning that the Towns will not be able to "complete such an operation for a net income" as claimed by CWE if the project is decommissioned in its 20th year.

Second, CWE assumes that the project will likely run for 30 years, but performs its decommissioning analysis out only to the 20th year of operations. The cost burden on the Towns to decommission grows considerably by the 30th year. Figure 5 in the appendices demonstrates that the net income from decommissioning would reach more than -$166,000 per turbine by year thirty if CWE's assumptions hold.

Finally, the stipulation that the Town would only be able to draw 50% of the funds contingent on CWE's approval further increases the risk to the Townships.

EVA Decommissioning Cost Methodology

EVA has taken a multifaceted approach in estimating the cost of decommissioning CWE. First, EVA performed a sample decommissioning estimate based off the project details, available construction cost data from Craftsman Book's National Construction estimators, R.S. Means, previous decommissioning studies, and analyst judgement. An output table and the stated assumptions for the analysis is provided in Figure 11 in the appendices. Because of the high degree of variability between cost estimates and in the individual cost components of decommissioning a wind farm, EVA sought to undertake a "meta-analysis" type approach in assessing the value of the CWE project. EVA believes that the meta-analysis approach is superior to a one-off cost estimate because it incorporates multiple engineering and developer estimates, while utilizing the variability between estimates to create a distribution of cost outcomes. Stated another way, EVA's approach allows us to both estimate the cost of the project and to better understand the likelihood that those costs will exceed or fall below our estimated value.

EVA collected data on the decommissioning costs of proposed wind farms in the state of New York. Figure 9 in the appendices provides an overview of the various projects studied. Data was not obtained from all these projects for several reasons: first and foremost, several of the proposed projects have had decommissioning costs redacted or are not yet at a stage where it is necessary to file a decommissioning estimate. Other projects, such as the projects proposed for the Tug Hill region (where a number of wind projects are already located) or projects under 100 MW in scale were not included in this analysis. The remaining proposed projects are gathered in the southern portion of western New York. These projects are in similar communities, and because they are located in one geographic region, they theoretically have similar topography, infrastructure conditions, and construction costs. Although EVA reviewed other decommissioning estimates from projects around the country, we believe this sample is most appropriate for estimating the cost of the Canisteo Wind Energy Center project because of a range of factors including state regulatory affairs, demographics, infrastructure constraints, and geology.

- Alle-Catt Wind
- Baron Winds
- Eight Point Wind
- Cassadaga Wind
- Ball Hill Wind park
- Bluestone Wind Farm
- Canisteo Wind Energy

Many of the studied projects have multiple decommissioning estimates: one from the developer, one from an independent assessor, and in some cases specific numeric recommendations from the New York State Board of Electric Generation Siting and the Environment's Decommissioning Panel. EVA compiled the data from these various project estimates.

The next facet of EVA's method was to construct decommissioning cost scenarios based on the available data to better inform the Towns and other stakeholders of the potential range of costs they could face in the event that the CWE requires decommissioning. Those cost categories are:

1. Turbine and Turbine Base
2. Collection Lines and Substation
3. O&M Building
4. Access Roads
5. Meteorological Towers

Finally, EVA performed a Monte Carlo scenario analysis to better understand the likely range of cost outcomes for decommissioning the project. For each cost category EVA assumed that costs would be randomly distributed under a normal distribution around the median cost claimed by the various decommissioning estimates[3]. EVA then simulated the decommissioning cost for 5,000 wind projects to better understand how total cost would be distributed based on the fluctuation in factors. EVA believes this is an appropriate way to understand costs because many of the inputs are exposed to fluctuations in a wide range of factors. For instance, the cost to take down a turbine depends heavily on crane rental costs. Crane rental costs depend on supply, demand, and operating costs for cranes. When considering crane costs, EVA could imagine cases where crane costs increase significantly in the future based on higher demand, but also cases in which innovation in the industry or oversupply of large cranes leads to a dramatic decline in this substantial cost factor. By simulating many different turbine cost cases, EVA can both assess the decommissioning cost and provide a probability-based estimate of the likely range of costs—given normal variation in factors.

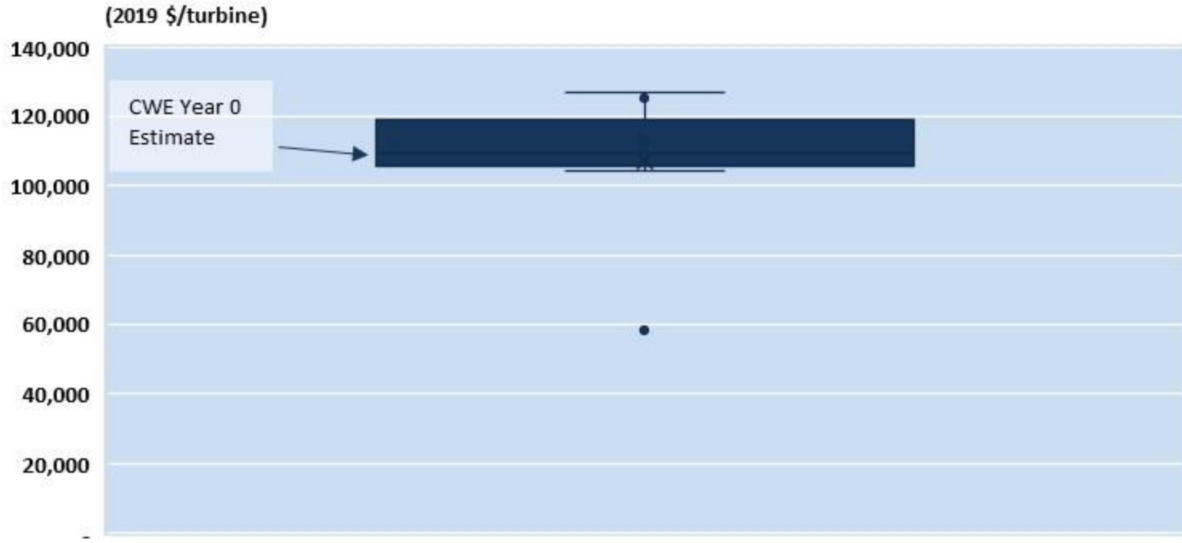
Primary Components

This study assumes that the CWE will consist of 117 GE 2.5-116's based on the current proposal's maximum capacity of 290.1 MW, but acknowledges that CWE has not yet finalized the turbine model and could use a mix of turbines. EVA assumes that a GE 2.5-116 will weigh a total of 378 tons, with the nacelle weighing 85 tons, the tower weighing 241 tons, and the rotor and hub combined weighing 52 tons. The turbines require significant manpower and machinery to take down.

Estimates for the cost to take down a turbine are relatively consistent. Figure 3 depicts that with the exception of an outlier at $54,951, the majority of estimates are grouped together between a range of approximately $120,000 and $105,000. CWE's estimate is within that range.

[3] Due to data limitations and because the O&M building and the meteorological towers are relatively simpler fixtures to deconstruct, EVA was forced to assume that the O&M building would cost $500,000 (or $4,274 per turbine) to remove and then assumed O&M costs would be randomly distributed between 30 percent more and 30 percent less than this value, and that the met towers would cost an average of $14,000 to remove with cost outcomes randomly distributed between 15 percent more and 15 percent less than this value.

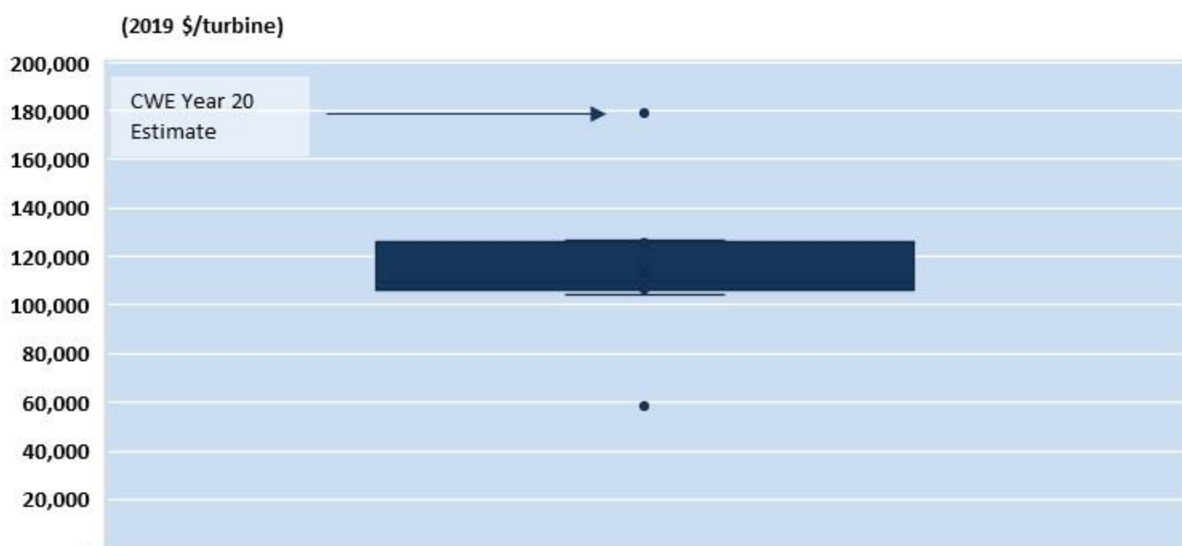
Figure 2 – Per Decommissioning Cost Estimate by Study



Note: Turbine Cost is inclusive of Turbine, Base, Pad Transformer Removal, and Site Remediation

Figure 3 depicts the range of costs proposed by the various parties for the various projects if CWE's estimate in year 20 is also included. The blue box represents the space between the 25th and 75th percentile. Stated another way, 50 percent of estimates lie in a tight band between roughly $106,000 and $126,000 per turbine. CWE's 20-year estimate of $178,983 per turbine is an outlier compared to estimates put forward by other developers and independent assessors—who did not, as a practice, extend the cost to the end of the respective projects.

Figure 3 – Per Turbine Decommissioning Cost Estimate by Study – Including Canisteo Wind Energy Year-20 Estimate



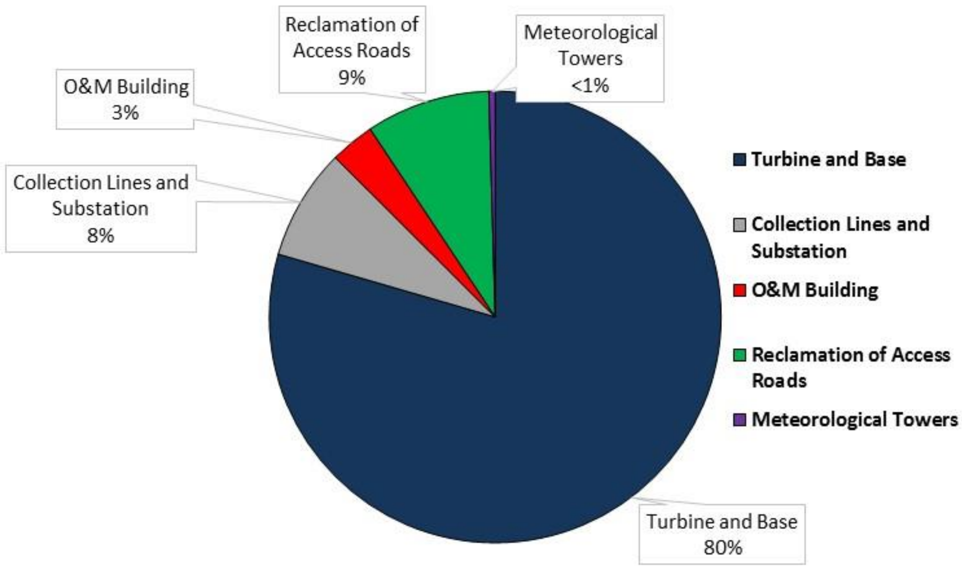
Note: Turbine Cost is inclusive of Turbine, Base, Pad Transformer Removal, and Site Remediation

By considering the impact of inflation on costs, CWE put forward a relatively conservative estimate for tower removal. However, as we move into secondary and other elements, CWE's overall estimate becomes less conservative.

Secondary Components

In addition to the turbine itself, decommissioning the other elements of the project could have a significant cost. Decommissioning of the support equipment and infrastructure is commonly referred to as the cost of balance of plant (BOP) decommissioning. EVA's cost data suggests that turbine decommissioning costs constitute about 80 percent of the total costs, while BOP decommissioning roughly makes up the remaining 20 percent. A breakdown of EVA's cost data by category is depicted in Figure 4. The blue "turbine and base" category represents the cost of tearing down the turbine and removing the base, while all other colors represent BOP costs.

Figure 4 Decommissioning Cost Breakdown by Category



Because CWE failed to include the costs of BOP in the decommissioning analysis, EVA is unable to meaningfully compare other project costs to those utilized by CWE. CWE's lack of estimates for BOP costs makes their cost analysis optimistic in nature.

Tertiary Components

In addition to the costs of the physical components of decommissioning the project, EVA's assessment also includes financial allotment for engineering/permitting costs, contingency and for owner indirect costs. Engineering/permitting costs were assumed to equal a lump sum of $250,000. The engineering/permitting cost estimate is based on verbal estimates from LaBella Associates—the environmental consultant to the Towns in the Article 10 process. Contingency costs, which mitigate risk by creating an allotment for various cost overruns, are assessed to be 10% of the final turbine and base plus BOP costs. Owner indirect costs, which would cover fluctuations in costs of things like insurance, storage, and maintenance during the decommissioning phase, are assessed at 5% of the final turbine and base plus BOP costs. EVA recommends that contingency and indirect cost allotments are included in the final per-turbine assessment. EVA does not recommend that contingency and indirect costs be counted as part of CWE's security or bonding contribution in order to further mitigate the Towns' risk.

EVA Decommissioning Estimate

Decommissioning Cost

Because of sample size limitations and to increase the robustness of our estimate, we then simulated project costs for 5,000 wind decommissioning projects to generate summary statistics and a firmer cost estimate.

EVA's "median" case estimate for decommissioning the CWE is $156,000 per wind turbine, or a total of $18.2 million for the whole project. The results of EVA's decommissioning study are portrayed in Figure 5.

Figure 5 – EVA Median Cost Scenario for the Canisteo Wind Energy (2019$)

Cost Category	Median Cost
Wind Turbine and Base	$ 106,639
Collection Lines and Substation	$ 9,784
O&M Building	$ 4,260
Access Road Reclamation	$ 11,999
Meteorological Towers	$ 600
Permitting	$ 2,137
BoP Subtotal	$ 28,780
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Indirect Costs (5%)	$ 6,771
Total	$ 155,731
Use (Rounded)	$ 156,000

Sensitivity Analysis

Because of the wide array of uncertainty, EVA simulated the likely cost range of the project with the aforementioned simulation methodology. The results of said simulation (not including contingency and indirect costs) is shown in Figure 6. EVA found that, although potential cost outcomes have a wide range, roughly 57 percent of projected project costs were within 1 standard deviation of the sample mean and 92 percent of simulated project costs were within two standard deviations of the sample mean. Stated another way, 56 percent of simulated projects cost between $129,312 and $182,400 and 92 percent of simulated projects cost between $102,768 and $208,943. Cost estimates did not include the contingency and indirect owner cost allotments, but the finding that 92 percent of simulated projects cost lie in a range of roughly $100,000 per turbine is evidence to support the inclusion of contingency and indirect cost allotments in the final cost estimate. The results of EVA's simulations are displayed in Figure 6.

Figure 6 – Decommissioning Cost Estimate Simulation (2019$)

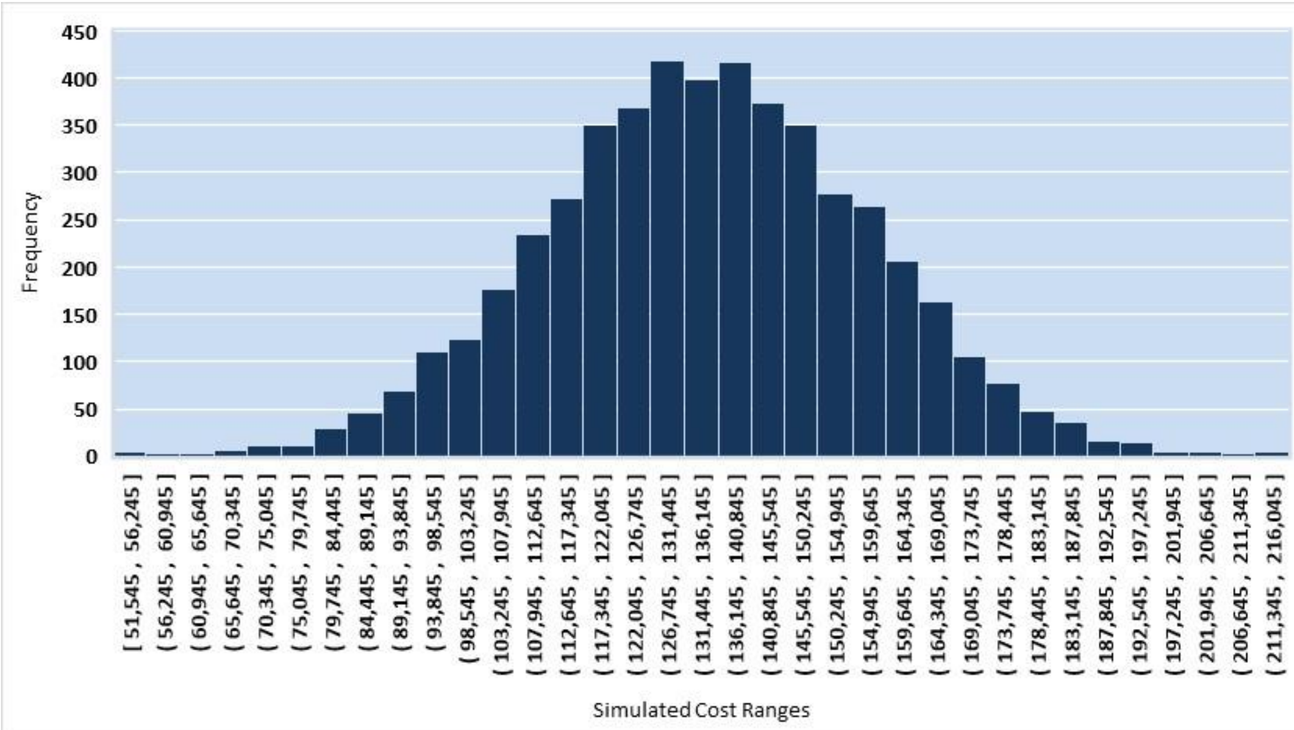
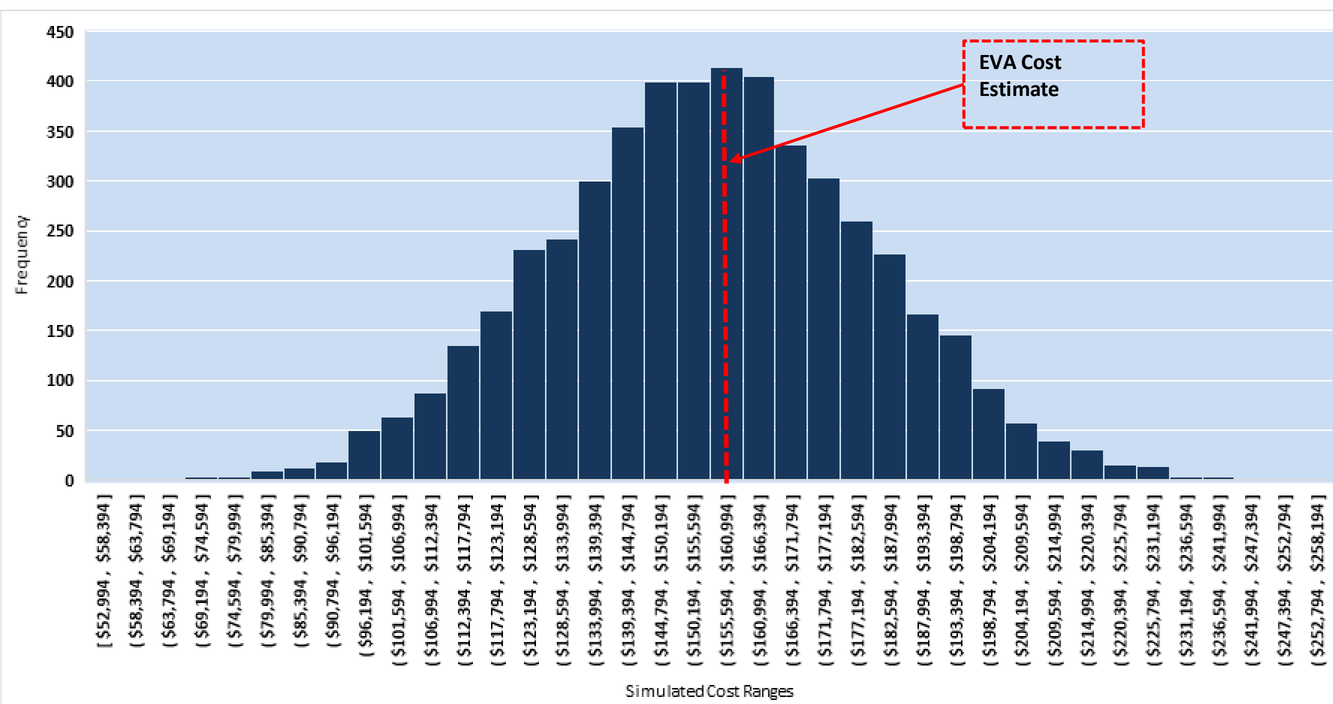


Figure 7 echoes the results of the analysis but includes the engineering/permitting costs, contingency, and indirect cost allotments. EVA's cost estimate of $154,245 falls within the range that that has the highest frequency of cost predictions. Moreover, half of the simulated estimates fall between a range of approximately $138,000 and $174,000.

Figure 7 – Decommissioning Cost Estimate Simulation Including Tertiary Costs (2019$)



Salvage Value

The New York State Board of Electric Generation Siting and the Environment's Decommissioning Panel has recommended that the project not be allowed to include any salvage or resale value in its final decommissioning estimate. EVA defers to the judgement of the New York Decommissioning Panel in this case, but puts forward a salvage estimate so that the Towns may better understand how to value the scrap metal in the turbines.

EVA's approach to calculating salvage value is simple. Because the future resale value of a turbine or substation components is uncertain, EVA focused on the raw commodities that would retain value. The project will have a certain amount of salvageable steel and copper. EVA made the following assumptions in constructing an estimate for salvage value:

1. Turbines will have an 85-ton nacelle of which 56 tons are salvageable steel
2. Turbine towers is 241 tons of which 217 tons are salvageable steel
3. Each turbine has 3.6 tons of copper
4. Future steel prices follow a normal distribution with a mean of $220 per ton[4] and a standard deviation of $80.
5. Future copper prices follow a normal distribution with a mean of $1.90[5] per pound and a standard deviation of $0.80.
6. Turbine salvage value is equal to price times quantity of steel plus price times quantity of copper discounted by 10 percent to account for possible transportation or processing costs.

Based on these assumptions, EVA estimates that the project salvage will be worth an average $74,008 per turbine, with a 95 percent chance that the residual scrap value falls in the range between $29,273 and $118,743. Figure 10 in the appendices provides a distribution of simulated salvage value outcomes.

Conclusion

EVA finds that the Canisteo Wind Energy project will cost $156,000 per turbine to decommission. This cost estimate is inclusive of engineering/permitting costs, a contingency, and indirect costs, as well as the cost of decommissioning the meteorological towers, the O&M building, and the roads. Based on this analysis, EVA concludes that CWE's current decommissioning cost estimate is insufficient. Moreover, the Townships are not adequately shielded from risk under the proposed bonding arrangement.

[4] A cost of $220 per ton is conservative in nature, given that over the past decade the average #1 HM Steel Scrap price has been roughly $299 with a sample price standard deviation of 76.9. Source: SteelBenchmarker Data

[5] Copper Costs are a low estimate based on analyzed decommissioning costs estimates for copper scrap resale. The standard deviation of copper costs is based on market reports and analyst judgement.

Appendices

Figure 8 – Modified CWE Schedule of Net Decommissioning Cost

Year	WTG Resale	Depreciation	Decommissioning Cost	Decommissioning Bond	Net Income from Decommissioning
0	$2,250,000		($109,228)	$0	$2,140,772
1	$1,125,000	-50%	($111,959)	$10,000	$1,023,041
2	$1,012,500	-10%	($114,758)	$10,000	$907,742
3	$911,250	-10%	($117,627)	$10,000	$803,623
4	$820,125	-10%	($120,567)	$10,000	$709,558
5	$738,113	-10%	($123,581)	$10,000	$624,531
6	$664,301	-10%	($126,671)	$10,000	$547,630
7	$597,871	-10%	($129,838)	$10,000	$478,033
8	$538,084	-10%	($133,084)	$10,000	$415,000
9	$484,276	-10%	($136,411)	$10,000	$357,865
10	$435,848	-10%	($139,821)	$10,000	$306,027
11	$392,263	-10%	($143,317)	$10,000	$258,947
12	$353,037	-10%	($146,900)	$10,000	$216,137
13	$317,733	-10%	($150,572)	$10,000	$177,161
14	$285,960	-10%	($154,336)	$10,000	$141,624
15	$257,364	-10%	($158,195)	$10,000	$109,169
16	$231,628	-10%	($162,150)	$10,000	$79,478
17	$208,465	-10%	($166,203)	$10,000	$52,261
18	$187,618	-10%	($170,358)	$10,000	$27,260
19	$168,856	-10%	($174,617)	$10,000	$4,239
20	$151,971	-10%	($178,983)	$10,000	($17,012)
21	$136,774	-10%	($183,457)	$10,000	($36,684)
22	$123,096	-10%	($188,044)	$10,000	($54,947)
23	$110,787	-10%	($192,745)	$10,000	($71,958)
24	$99,708	-10%	($197,564)	$10,000	($87,855)
25	$89,737	-10%	($202,503)	$10,000	($102,765)
26	$80,764	-10%	($207,565)	$10,000	($116,802)
27	$72,687	-10%	($212,754)	$10,000	($130,067)
28	$65,418	-10%	($218,073)	$10,000	($142,655)
29	$58,877	-10%	($223,525)	$10,000	($154,648)
30	$52,989	-10%	($229,113)	$10,000	($166,124)

Figure 9 — Wind Projects Studied by EVA

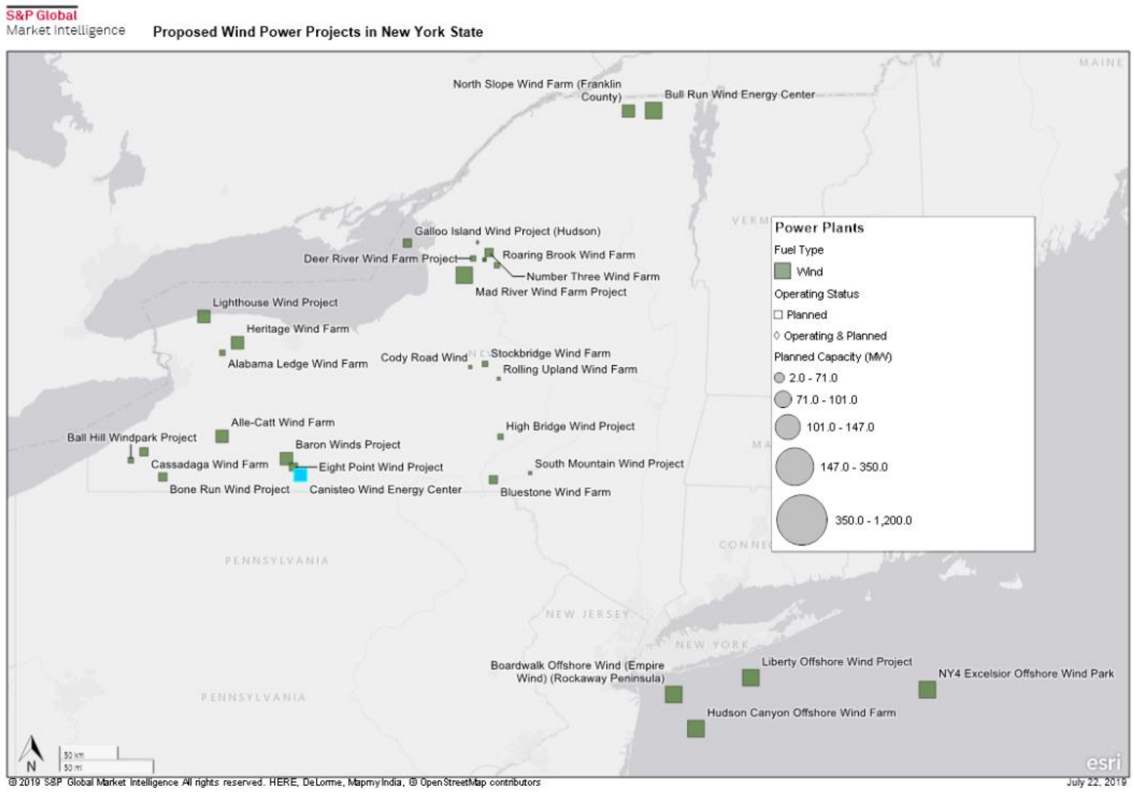


Figure 10 – Commodity Price Simulation Histogram (2019$)

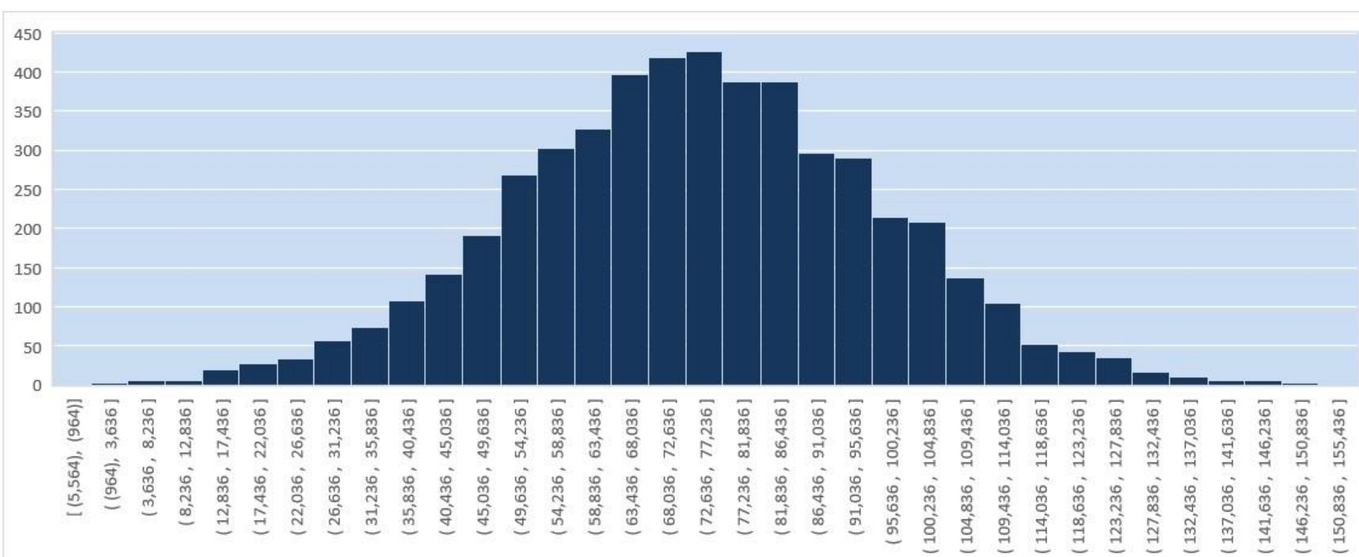


Figure 11— EVA Sample "One Off" Decommissioning Estimate (Not Including Contingency or Indirect Costs) (2019$)

Activity	Unit	Number	Cost Per Unit	Total
Mobilization and Demobilization	Lump Sum		$ 150,000	$ 150,000
Crane Rental, Operation, Deconstruction of Turbine	Per Turbine	117	$ 45,000	$ 5,265,000
Disassembly into Transportable Pieces	Per Turbine	117	$ 35,000	$ 4,095,000
Transportation to Recyler/ Buyer	Per Turbine	117	$ 10,000	$ 1,170,000
Demolition, Transport, and Dumping Fees for Non-Salvagable Pieces	Per Turbine	117	$ 3,000	$ 351,000
Transformer	Per Turbine	117	$ 1,200	$ 140,400
Turbine Foundation	Per Turbine	117	$ 14,456	$ 1,691,368
Subtotal	Per Turbine	117	$ 108,656	$ 12,712,768
Engineering and Permitting Costs	Lump Sum		$ 250,000	$ 250,000
Operations and Maintenance Building	Lump Sum		$ 500,000	$ 500,000
Meteorological Towers	Per Tower	5	$ 14,000	$ 70,000
Access Road Reclamation	Lump Sum		$ 1,573,000	$ 1,573,000
Site Reclamation	Lump Sum		$ 250,000	$ 250,000
Subtotal				$ 15,505,768
Contingency (15%)				$ 2,325,865
Indirect Costs (5%)				$ 775,288
Total				$ 18,606,922
Total Per Turbine				$ 159,034

Assumptions Utilized in Constructing EVA's One-off Estimate:

1. All costs are in 2019 dollars.
2. Mobilization and Demobilization of equipment costs $150,000. Estimate based on analyst judgement and review of decommissioning documents.
3. Crane Rental assessed at $400 dollars per hour for 4 days, site engineer at $42/ hour for 4 days, crew of 8 laborers at 30 dollars per hour, equipment and consumables cost assessed at $20,000.
4. Disassembly for transportation based off crew and equipment "s5" for Craftsman National Estimator operating with an 8-man crew and elevated crane costs due to larger crane and additional consumables.
5. Demolition, transport, and dumping fees based off EVA's 2012 decommissioning estimate for Green River Wind Farm.
6. Transformer estimate based off Craftsman National Estimator quote for pad mount transformer deconstruction and analyst judgement.
7. Turbine foundation cost based off Craftsman National Estimator quote for demolishing "thick, reinforced concrete" of $195/Cubic Yard and Craftsman National Estimator quote of $6.85/Cubic Yard to "spread topsoil with a wheel loader" to a depth of 15 cm. Assumed that foundation was 4.5 x 4.5 meters.
8. The permitting cost estimate provided by LaBella Associates was assumed to include all engineering, planning and permitting costs to take the decommissioning from conceptual design through the actual implementation of the decommissioning activities (demolition).
9. Metrological tower assumed to cost $14,000 to decommission completely.
10. Access road decommissioning assessed for 17 miles of roads. Utilized costs include Craftsman National Estimator of $35.28/MSY to remove road, $5.47/Cubic Yard to remove topsoil, and $1.8/square yard of 18-inch-deep road material for hauling and disposal.
11. Site reclamation assessed at $250,000 based on review of decommissioning estimates and analyst judgement.

Note: EVA is not an engineering firm, and thus believes that the "one-off" estimate is less accurate than the meta-analysis estimate. "Analyst judgement" refers to Figures where the analyst utilized other decommissioning estimates and industry Figures to construct a cost.

Figure 12 – Alternative Visualization of Distribution of Cost Scenarios in EVA's Simulated All in Cost Estimate (2019$)