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Subject: Decommissioning Cost Analysis Update – Dakota Range Wind Project

1. INTRODUCTION

Apex Clean Energy Management, LLC ("Apex" or the "Customer") engaged Garrad Hassan America, Inc. ("DNV GL") to present an update to the previously prepared decommissioning plan for the Dakota Range wind project (the "Project") located in the Grant and Codington Counties, South Dakota. The purpose of this memo is to describe the additional decommissioning costs[1] associated with the collection line removal depth, Operations and Maintenance (O&M) building, local roads, crane costs, and inflation.

2. ORIGINAL DECOMMISSIONING CONCLUSIONS (2017 STUDY)

The Project will consist of 72 wind turbine generators (WTG) and associated infrastructure. It is assumed that decommissioning of the Project will take place 30 years after the start of commercial operations. Apex advised DNV GL that the required decommissioning includes the removal of all towers, WTGs, underground collection lines, ancillary equipment, and other physical material owned by and pertaining exclusively to the Project and restoration of the property, including the Project roads. Further details on the assumptions made can be found on the previously prepared decommissioning plan [1]. Table 2-1 shows a summary of the net decommissioning costs from the 2017 report.

The net decommissioning value is determined from the difference of 1) the sum of the disassembly and removal cost and 2) the sum of the salvage value and resale. The estimated net decommissioning gain or cost for the Project assuming no resale (Scenario 1), and with partial resale of the Project's major components (Scenario 2), are presented in the table below. Note, values in parenthesis are negative values representing positive returns to the Project.

[1] DNV GL has used the same cost assumptions for material and labor as in [1].

Table 2-1 2017 Dakota Range Wind Project net decommissioning costs

	Scenario 1 – No Resale	Scenario 2 – Partial Resale
Total per WTG	$38,900	($27,620)
Total for Project	$2,801,000	($1,988,500)

3. UPDATED ASSUMPTIONS

In addition to the removal of costs described in [1], Apex has requested DNV GL to estimate the additional costs related to:

1. Increasing the depth of removal of WTGs, electrical cabling, electrical components, roads and any other associated facilities from three to four feet (ft) below grade;
2. Decommissioning the O&M building; and
3. Increasing the Project roads length from 19.1 miles to 23 miles.

While it is impossible to predict the exact evolution of an industry 30 years into the future as well as the time value of money, DNV GL has at the request of Apex, estimated the decommissioning costs of the Project in 2051 using an annual inflation rate of 2% as agreed with Apex [2].

Results incorporating these updated assumptions and the inflation rate are presented in Table 3-1.

Table 3-1 Dakota Range wind project updated net decommissioning costs using Section 3 assumptions and including 2% annual inflation rate

	Scenario 1 – No Resale	Scenario 2 – Partial Resale
Total per WTG 2017 USD	$44,528	($21,993)
Total for Project 2017 USD	$3,206,000	$(1,583,500)
Total per WTG 2051 USD	$80,656	($39,837)
Total per WTG 2051 USD	$5,807,225	($2,868,291)

4. Crane cost sensitivity analysis

As mentioned in [1] the disassembly costs of WTGs are highly dependent on crane costs (which include crane plus crane crew). DNV GL estimated this cost based on experience from various projects in North America. Crane availability may greatly influence crane costs, and that it is not possible to accurately predict crane costs given the study horizon of 30 years. The results of a high-level sensitivity analysis are presented in Table 4-1 for crane costs varying ±20%. With the purpose of making the results in this memo comparable with those in [1], the results below are given in 2017 U.S. dollars, and incorporate the updated assumptions as described in Section 3.

Table 4-1 Project updated net costs for crane costs fluctuation

	Scenario 1 + 20% crane cost No Resale	Scenario 2 + 20% crane cost Partial Resale	Scenario 1 - 20% crane cost No Resale	Scenario 2 - 20% crane cost Partial Resale
Total per WTG	$64,930	($1,590)	$23,040	($43,480)
Total for Project	$4,675,000	($114,500)	$1,659,000	($3,130,500)

Sincerely,
For Garrad Hassan America, Inc.,

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Senior Project Manager, Engineering

Aren Nercessian
Project Engineer, Engineering

Kendra Kallevig-Childers
Team Leader, Environmental and Permitting Services

5. REFERENCES

[1] 10050292-HOU-R-03 Issue A, status FINAL, dated: 08 Dec 2017
[2] Email from B.Gunderson, Apex, to D.Pardo DNV GL, on 7 June 2018.

Exhibit A4-2

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DAKOTA RANGE WIND PROJECT

Decommissioning Cost Analysis

Apex Clean Energy Management, LLC

Document No.: 10050292-HOU-R-03
Issue: A**, Status:** FINAL
Date: 08 December 2017

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Task and objective: Wind power project decommissioning cost analysis

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A	08 December 2017	FINAL	D. Pardo	A. Nercessian	K. Kallevig-Childers
A	05 December 2017	FINAL	D. Pardo	A. Nercessian	J. Frye

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List of abbreviations

Abbreviation	Meaning
BOP	Balance of Plant
COD	Commercial Operation Date
DNV GL	Garrad Hassan America, Inc.
GRP	Glass Reinforced Plastic
O&M	Operations and Maintenance
WTG	Wind Turbine Generator

EXECUTIVE SUMMARY

At the request of Apex Clean Energy Management, LLC ("Apex" or the "Sponsor"), Garrad Hassan America, Inc. ("DNV GL") performed a decommissioning analysis of the Dakota Range Wind Project (the "Project") located in Grant and Codington Counties, South Dakota. The study estimates the costs associated with the dismantling, removal, and salvage or disposal of the Project equipment; all costs in this study are given in U.S. dollars.

The Dakota Range Wind Project is intended to consist of 72 Vestas V136-4.2 MW wind turbine generators (WTG), with an aggregate rated output of 302.4 MW, and associated infrastructure, and will be located in Grant and Codington Counties, South Dakota. The turbines will be mounted on 82 m tubular steel towers. The Project is anticipated to commence commercial operations in 2021. Per the Sponsor's request, it is assumed that decommissioning of the Project will take place 30 years after the start of commercial operations [1].

DNV GL assumes that there are strong parallels between wind power project construction and decommissioning programs and consequently bases the estimates for decommissioning costs on its broad experience of wind power project construction programs and the associated costs of labor, plant, and materials. The complete decommissioning cost is calculated as the sum of the cost of disassembly, removal, and disposal of the turbines and balance of plant (BOP), as may be offset by gains from salvage or resale of materials and components. It is noted that crane costs are the most dominant cost item in disassembly while transportation of the large turbine components dominates the costs of removal.

Assessments of salvage opportunities are based on the bill of quantities identified in this report. The average material weights and ratios for turbine components are derived from previous DNV GL studies, Sponsor documentation [2], and/or turbine supplier technical specification sheets. Although DNV GL assumes certain commodity prices and disposal service rates based on present day estimates, it does not forecast such future values. The salvage value is calculated as the difference between the sum of parts resale and scrap revenue, less the landfill cost of the remaining material. Two salvage/disposal scenarios are presented: Scenario 1 considers that all equipment is sold as scrap, while Scenario 2 assumes partial resale of some of the Project's major components.

The net decommissioning value is determined from the difference of 1) the sum of the disassembly and removal cost and 2) the sum of the salvage value and resale. The estimated net decommissioning gain or cost for the Project assuming no resale (Scenario 1), and with partial resale of the Project's major components (Scenario 2), are presented in the table below. Note, values in parenthesis are negative values representing positive returns to the Project.

	Scenario 1 No Resale	Scenario 2 Partial Resale
Total per WTG	$38,900	($27,620)
Total for Project (72 WTGs)	$2,801,000	($1,988,500)

As it is considered to be the more likely option, a detailed breakdown of Scenario 2 is shown below.

Project net decommissioning cost with partial resale (Scenario 2)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage/Resale (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(15,568,500)	$(4,206,500)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
High voltage substation	$157,000	$72,000	$9,000	$238,000	$(1,787,000)	$(1,549,000)
Transmission Line	$114,000	$12,000	$0	$126,000	$(70,000)	$56,000
Access roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,469,000	$0	$0	$2,469,000	$0	$2,469,000
Project Totals	$10,525,000	$5,414,000	$1,009,400	$16,948,400	$(18,936,900)	$(1,988,500)
Total per WTG						**$ (27,620)**
Total Project (72 WTGs)						**$ (1,988,500)**

Note: negative values, those in parenthesis, are positive returns to the Project.

It is stressed that this report is based on broad assumptions regarding the Project, including the approach to the decommissioning task and the market conditions for contracting costs, scrap value, and resale options. It is recommended that the net costs of decommissioning be reviewed closer to the end of the operating period (e.g., 2 to 4 years prior to the end of operations). At that time it would also be prudent to take into consideration: 1) a scenario in which Project profitability and turbine conditions justify continued operation beyond the initially assumed Project operating life; and 2) a "re-powering" scenario, in which case the existing turbines would be removed in the interest of constructing a more valuable project with larger, more efficient turbines. In the first scenario, decommissioning costs could be paid for by allocations of Project revenues in future Project years, while in the latter scenario any decommissioning costs could be transferred to the capital budget of the new project.

1 INTRODUCTION

Apex Clean Energy Management, LLC ("Apex" or the "Sponsor") retained Garrad Hassan America, Inc. ("DNV GL") to perform a decommissioning analysis of the Dakota Range Wind Project (the "Project") to be located in Grant and Codington Counties, South Dakota. The Dakota Range Wind Project is intended to consist of 72 Vestas V136-4.2 MW wind turbine generators (WTG), with an aggregate rated output of 302.4 MW, and associated infrastructure.

The Sponsor has advised DNV GL that the required decommissioning tasks will include the removal of all towers, WTGs, substation, underground collection lines, ancillary equipment and other physical material owned by and pertaining exclusively to the Project, and restoration of the property, including the Project roads.

While no specific ordinance specifies how decommissioning of wind power projects should be performed in either of the above mentioned counties as of the writing of this report, the following assumptions have been applied:

- Decommissioning will start soon after the end of the Project's operating life (assumed to be 30 years for purposes of this study), and all decommissioning work is performed in generally conducive weather conditions;
- Decommissioning includes removal of WTGs, electrical cabling, electrical components, roads, and any other associated facilities down to 3 feet (ft) below grade in accordance with industry best practice. Additionally:
  - The WTG foundations will have only the pedestals and concrete transformer pads removed and the remainder of the spread footing is abandoned in place.
  - One Project substation with two main transformers is assumed, a 0.25-mile, 345 kV transmission line will be completely decommissioned, as will the approximately 53 miles of underground collection system cabling.
  - Approximately 19.1 miles of Project roads will be decommissioned. DNV GL considers this a conservative assumption as many land owners may find such roads a benefit to their land and request to keep them.
- Crane pads are assumed to have been remediated during initial construction.
- No decommissioning of the operations and maintenance (O&M) building has been estimated as per Sponsor request.

This report does not consider the time value of money; the results should therefore be adjusted to represent the inflated costs at the time of decommissioning (e.g., annual escalation). It should also be noted that commodity values are volatile and difficult to predict over the study horizon.

This report also does not consider the decommissioning scenarios from a legal, regulatory, or commercial perspective, which should be assessed by the Sponsor.

2 STUDY ASSUMPTIONS

DNV GL's decommissioning study methodology assumes there are strong parallels between wind power project construction and decommissioning programs. DNV GL has used an internal bottom-up decommissioning model developed from its experience in the wind industry to formulate these study results.

All costs are quoted in 2017 US dollars, and it should be noted that no specific quotes were obtained in relation to this study, although the Project's location has been considered in the modeling. The study is broken down into three sections: disassembly, removal, and salvage/disposal. Due to the uncertainty associated with the majority of cost categories assumed and modeled, DNV GL has rounded costs to the nearest $1,000, unless otherwise noted.

2.1 General assumptions

DNV GL has assumed that, on average, one main crane will dismantle one turbine every day (including time for crane movements from turbine to turbine, crane teardowns where necessary, and some minor weather delays). A base crane for lower tower sections, as well as to aid in loading the components onto transport trucks, will also be required. The number of main cranes used determines the approximate time to complete the job. The Project layout was also analyzed for crane walking impediments to estimate crane teardown requirements. While a detailed analysis in this regard was not performed, the Project was assumed to require the number of cranes and teardowns presented in Table 2-1.

2.2 Initiation and mobilization

Before executing any decommissioning works, it is necessary to plan the work carefully, secure the appropriate permits and insurance, and manage the program of work and associated health and safety risks in order to ensure successful completion of the work. It is assumed that mobilization and soft costs are overhead. Soft costs, for the purposes of this study, include costs not specifically accounted for in the derivations presented later in this Report, including environmental studies, obtaining permits, environmental protection plans, hazardous material disposal, onsite administrative infrastructure and staff, utilities, off-site project management and insurance/legal services. DNV GL assumed 5% of the total disassembly and removal cost will be required for soft costs.

In addition to soft costs, DNV GL assumed that an additional 1% of the total disassembly and removal costs will be needed for contractor mobilization. DNV GL separately accounted for a lay-down yard of 10,000 m^2 to house the office trailers, staff parking and facilities for mobilization and demobilization. Table 2-1 summarizes the crane, mobilization, and soft cost assumptions used in this report, as well as the total cost estimate for such activities.

Table 2-1 Mobilization and soft cost assumptions

Item	Quantity
Number of main cranes needed	3
Number of main crane tear-downs needed	6
Number of base cranes needed	6
Number of base crane tear-downs needed	0
Decommissioning contractor's lay-down yard size [m^2]	10,000
Additional mobilization as percent of total hard costs (1)	1%
Decommissioning soft costs as percent of total hard costs (2)	5%
Total Mobilization and Soft Costs	**$2,469,000**

(1) Represents the costs of contractor’s mob./demob.
(2) For soft costs, it is assumed that decommissioning would be completed for the entire Project at once.

2.3 Schedule

It is assumed that the decommissioning program would be 7 to 12 weeks in length. This timeline is based on the assumption that the dismantling rate of the WTGs is approximately one turbine per workday per main crane, and that 7 to 10 workdays of mobilization and demobilization are allowed before and after turbine dismantling. During construction of wind power projects, it is typical that the time for erection across the entire project schedule averages about one turbine per day per main crane on a simple site. While disassembly could in theory be done with slightly less care than during assembly (damage to turbines not as much of a concern), safety and resale considerations will likely dictate that disassembly be accomplished in much the same fashion as erection, although in reverse order.

It is also assumed that other works across the site such as foundation removal, underground collection systems disassembly, substation disassembly and reclaiming of roads will be done simultaneously and/or in concert with the turbine dismantling and crane progress.

3 DISASSEMBLY

The disassembly of the Project pertains to all work prior to physical transportation of the infrastructure from the site. In the case of the WTGs, it includes the dismantling and loading of the tower sections, nacelle, and blade scraps onto trucks for transport. In the case of concrete foundations and roads, it pertains to the tear down, aggregate stripping, excavation and backfilling, and all reclaiming as necessary. Reseeding of removed roads and turbine areas is included in these costs.

Although certain activities must be sequenced appropriately, based on DNV GL's knowledge of wind project construction considerations, it is assumed that many activities (e.g., turbine, collection system, and substation disassembly) may be undertaken in parallel, facilitating an efficient decommissioning process.

3.1 Turbines

Once the site is mobilized, it is assumed that the decommissioning of turbines would start immediately and sequentially. This typically entails the individual removal of the rotor assembly followed by the nacelle enclosure. The tower internals are stripped of lifts, cables, cabinets, lighting and other miscellanea and are then dismantled, section by section, down to the foundation surface.

For the Project, 72 turbines are to be removed, consisting of 4.2 MW nacelles, with three-section, 82-m steel towers, and 66.7-m blades. It is assumed that the scope of the disassembly works includes the cost of labor, machinery, and tools required to perform the tasks and the loading of the dismantled material onto transport vehicles for removal from site. The main cranes would be required on site for approximately 6 to 8 weeks during the turbine dismantlement activities. The base cranes may be required a slightly longer period in order to assist with transport loading activities and substation dismantling.

It is also assumed that aside from the possible removal of the drive train to aid lifting, the nacelle and its contents will remain fully intact for purposes of transport. All cooling, heating, and lubrication fluids will be drained, stored, and appropriately disposed of before the nacelle is removed from site. Blades, however, will be cut into sections for easier transport to a recycling or incineration plant.

The costs presented below include the cost of a main crane to handle the hub/rotor, nacelle and top tower section (or top sections, depending on base crane hired). They also include the cost of a base crane for lower tower sections, as well as to aid in loading the components onto transport trucks. The costs take into consideration the rental of special tools needed from the manufacturer.

In accordance with industry best practice it is assumed that the site will be remediated to 3 ft below grade. This assumes that the concrete structures are to be cut and crushed down to 3.5 ft below grade (to allow some margin). It is assumed that approximately 31 m^3 of crushed concrete will result from removing each turbine's foundation pedestal and pad-mount transformer foundation (essentially in their entirety) to achieve these criteria. Table 3-1 summarizes the turbine disassembly costs for Project.

Table 3-1 Summary of turbine disassembly costs

Cost item	Costs per WTG
Dismantle hub and blades (3 blades per turbine)	$26,000
Dismantle nacelle (drive train, generator and transformer included)	$26,000
Dismantle tower sections, internals included	$27,000
Remove turbine foundation (1)	$8,000
Total per WTG	**$87,000**
Total for Project (72 WTGs)	**$6,264,000**

(1) 1 m below grade. Does NOT consider concrete tower sections

DNV GL notes that the disassembly costs of WTGs are highly dependent on crane costs (which include crane plus crane crew): over 60% of the total per-WTG cost is associated with crane-related costs. DNV GL estimated this cost based on experience from various projects in North America. It is noted that crane availability may greatly influence crane costs, and that it is not possible to accurately predict crane costs given the long study horizon.

3.2 Collection system

The decommissioning of the collection system has been considered, as requested by the Sponsor. DNV GL notes that in many decommissioning study requests, the underground portion of the collection system does not need to be removed, since it is often below the required grade clearance. That said, due to the relatively high value of conductors, removal and resale of the underground cables may yield a positive return to the Project. If the Sponsor determines the removal and resale may not yield a positive return, the cabling will be left in place because it will be buried at 4 feet, which is below the required grade clearance of 3 feet.

3.2.1 Underground Collection System

According to the Sponsor [1], the Project collection system will be composed of 53 miles of three-phase buried lines along with bare copper grounding cable. Underground collection system disassembly includes trenching, winding triplex with ground wire, and reclaiming. The conductors would subsequently need to be re-reeled for transport.

It is assumed that the scope of the disassembly includes the cost of labor and the loading of the dismantled material onto transport vehicles for removal from site. It is assumed that the disconnection work at the terminals would be performed as part of turbine removal or substation removal. The results are reported in Table 3-3 below.

3.2.2 Overhead Collection System

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider any overhead lines in this decommissioning analysis.

3.3 High-voltage substation

The Sponsor has advised that the Project will be equipped with two 345/34.5 kV, 167 MVA transformers at one substation location. The remaining portions of the Project's high-voltage (HV) substation is assumed to include typical equipment seen in North American for wind projects of this size, including grounding transformers, bus bars, relay switches, circuit breakers, air disconnect switches, capacitor banks, reactor banks and a control building. It is assumed that a dead-end structure will also be present.

An interconnection switchyard for the Project has not been considered in this decommissioning analysis.

It is assumed that the scope of the disassembly work includes the cost of labor and machinery required to perform the disassembly tasks, including disconnection work at the terminals, and the loading of the dismantled material onto transport vehicles for removal from site. The following table summarizes the costs to disassemble the Project's HV substation.

Table 3-2 Costs to disassemble Project substation

Item	Cost
Preparation	$7,000
Dismantle HV equipment	$29,000
Dismantle and prep. main transformers for shipment	$38,000
Remove control building	$5,000
Remove foundations	$36,000
Large machinery hire	$15,000
Small machinery hire	$13,000
Reclaim and reseed	$14,000
Total for Project (one substation)	**$157,000**

3.4 Transmission line

According to the Sponsor, the Project will use a 0.25-mile 345 kV overhead transmission line. Transmission line disassembly includes pole teardown and reclaiming. The conductors would subsequently need to be re-reeled for transport.

It is assumed that the scope of the disassembly includes the cost of labor and the loading of the dismantled material onto transport vehicles for removal from site. The results are reported in Table 3-3 below.

3.5 Site access roads

In practice, it is probable that most of the roads could remain after the completion of the Project, with the exception of the dead-end access roads that lead to the turbines. However, for purposes of the study, DNV GL has assumed that the entirety of the approximately 19.1 miles of roads will be remediated. Based on Sponsor information, DNV GL has additionally assumed that 72 crane pads will be reseeded during decommissioning, but that removal of concrete would have occurred during initial construction activities. The lay-down yard reclamation is accounted for in the mobilization/demobilization costs. Decommissioning of the site access roads will typically include stripping back the road surface and replacing it with topsoil in keeping with the surrounding environment. In the case of the Project, this activity also includes stripping and piling geotextile material used in the road base. The costs include reseeding with native grasses. A secondary reseeding may be required if the initial work proves inadequate.

The results are reported in Table 3-3 below. Note the cost of aggregate transport off site is captured in removal costs.

3.6 Meteorological masts

A total of three permanent 82-m meteorological masts are to be installed on the Project site. It is assumed that these met masts will be disassembled at an appropriate time during the decommissioning activities so as not to interfere with the other ongoing work. This typically involves the use of a base crane to dismantle the masts, section by section, down to the foundation surface. The instrumentation and booms would be either removed before the sections are laid down, or removed from the sections once on the ground.

It is assumed that the scope of the disassembly works includes the cost of labor, machinery and tools to perform the dismantling tasks, including foundation removal to appropriate below grade level, and the loading of the dismantled material onto transport vehicles for removal from site. It is also assumed that only one crane is needed for removal. The results are reported in Table 3-3 below.

3.7 Disassembly conclusion

The total estimated cost for the disassembly of the Project is summarized in Table 3-3.

Table 3-3 Summary of Project disassembly costs

Cost item	Cost
WTG	$6,264,000
Collection system	$845,000
HV substation	$157,000
Transmission line	$114,000
Access roads	$642,000
Met Masts	$34,000
Mobilization & soft costs	$2,469,000
Total Project Disassembly Cost	**$10,525,000**

4 REMOVAL FROM SITE

Removal of the Project in this study refers strictly to the transporting of the equipment from the site to the appropriate landfill, aggregate rework facility, or scrap yard. Various distances and truck sizes are applied in DNV GL's decommissioning model, depending on which Project component is being considered. Removal costs also include the costs of unloading the material once it reaches its destination. DNV GL notes that appropriate landfills and scrap yards appear to be located in the general region of the Project.

4.1 Turbines

It is assumed that the scope of the removal of the WTGs includes the cost of labor and vehicles required to transport the dismantled material to an appropriate disposal, salvage or rework facility. It is assumed that the transport distances for general waste would be within a radius of 80 miles, whereas the more complex and valuable material is assumed to be transported within a radius of 300 to 450 miles (300 miles for the tower internals and 450 miles for the main turbine and substation components). These assumptions may be somewhat conservative considering there are a number of recycling or salvage facilities near the Project site. DNV GL additionally notes the presence of rail transport in the relative vicinity which could decrease costs for removal of turbine components. While most of the main turbine components are modeled to be removed much as they were initially transported to the site during construction, the turbine blades will be sectioned to limit oversize transport.

Table 4-1 summarizes the costs for the removal of each of the turbine components from the site.

Table 4-1 Turbine removal costs

Turbine component	Cost per WTG
Blades (cut up prior to loading)	$5,000
Hub (one per truck)	$10,000
Nacelle	$10,000
Tower sections	$30,000
Internals	$1,000
Transformer	$1,000
Crushed foundation (31 m^3)	$800
Total per WTG	**$57,800**
Total for Project (72 WTGs)	**$4,162,000**

4.2 Collection system

4.2.1 Underground collection system

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material to an appropriate salvage facility. The material will mainly include the wound reels and/or cut cables removed by trucks. The results are reported in Table 4-3 below.

4.2.2 Overhead collection system

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider the remove of overhead lines in this decommissioning analysis.

4.3 High-voltage substation

It is assumed that the transport distances for substation foundation rubble and general waste would be within a radius of 80 miles, whereas the more complex and valuable substation material is assumed to be transported within a radius of 300 to 450 miles. It is assumed that local dump truck loads are 10 yd^3 in capacity.

The following table summarizes removal costs for the Project substation. As previously mentioned, an interconnection switchyard has not been considered in the present study.

Table 4-2 Project substation removal costs

Substation component	Cost
HV equipment	$10,000
Main transformers	$20,000
Control building	$4,000
Dead-end structures	$10,000
Crushed foundations (local transport)	$22,000
Yard gravel (local transport)	$6,000
Total removal costs for HV substation(s)	**$72,000**

4.4 Transmission line

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material to an appropriate salvage or rework facility. The material will include the wound reels and/or cut cables as well as the dismantled poles (9 steel poles assumed). The results are reported in Table 4-3 below.

4.5 Site access roads

For the purpose of removal calculations and at the Sponsor's request, the Project's 19.1 miles of roads to be removed were assumed to be 16 ft wide and approximately 1 ft deep and underlain by geotextile in line with Project drawings. While this width attempts to capture any shoulder material as well, the assumption that all roads to be removed are 16 ft wide is likely conservative with respect to the Project design and is expected to therefore cover the cost of decompaction and reclamation of any additional width required due to crane walking. Dump truck capacity is assumed to be 10 yd^3 and all load trips are assumed to be local. The results are reported in Table 4-3.

4.6 Meteorological masts

It is assumed that the scope of the removal works includes the cost of labor and vehicles required to transport the dismantled material from the two meteorological masts to an appropriate disposal, salvage or rework facility. The results are reported in Table 4-3 below.

4.7 Removal conclusions

Table 4-3 summarizes the total anticipated costs for removing the turbines, electrical collection system, substation, roadways, and met masts from the Project site.

Table 4-3 Project removal conclusions

Item	Cost
WTG	$4,162,000
Collection system	$284,000
HV substations	$72,000
Transmission line	$12,000
Access roads	$853,000
Met Masts	$31,000
Total Project removal cost	**$5,414,000**

5 SALVAGE – DISPOSAL

While it is impossible to predict the exact evolution of an industry 30 years into the future, it is not unreasonable to assume that there may exist by that time consolidated centers that will fully recycle a wind turbine given that many project "decommissionings" or "repowerings" will have been undertaken prior to that time. For example, DNV GL notes that significant attention is being placed by industry and academia alike into possible uses or methods for recycling wind turbine blades.

DNV GL notes that in this section only, gains are shown as positive and costs to the Project are shown in parentheses

While it may become easier to recycle wind turbines in the future, DNV GL performed this study assuming only the application of present day means. Following the disassembly and removal of all materials from the Project site, four potential destinations for the remediated material are typically envisaged by DNV GL when performing decommissioning studies. These scenarios may add extra cost to the decommissioning budget or offer an opportunity to reclaim some value from the project components to offset the cost of decommissioning.

1. Low-grade material such as contaminated aggregate, concrete rubble, wood, non-recyclable materials and other mixed general waste will in all likelihood be sent to landfill or incineration at cost to the Project. DNV GL notes that there is a relatively large volume of waste associated with the glass reinforced plastic (GRP) which composes most turbine blades today. It is possible that in 30 years recycling blade GRP into cement fill, roofing shingles or other useful industrial raw materials may be a net positive for the Project, or at least an offset to the cost, but no such projections have been made in the present study. Thus, blade GRP has been considered waste.
2. Medium-grade materials such as small- and medium-gauge cabling, small motors, cabinets of mixed electronics, and lighting may be sent to salvage centers to be stripped for parts and sold for re-use or re-processing. This may be done at a nominal, neutral, or negative cost (positive return) to the Project. However, this material may also be sent to landfill if an appropriate third party cannot be found. DNV GL notes that it is difficult to predict future returns of salvage for such materials due to the unpredictability of commodity prices.
3. High-grade materials such as large steel components (tower sections, bedplates, hub castings, gearboxes, and steel cables), large-gauge copper and aluminum cabling, aluminum flooring and ladders will be sent to reprocessing centers at a net neutral cost or positive return to the Project. DNV GL notes that it is difficult to predict future returns of reprocessing for such materials due to the unpredictability of commodity prices.
4. Reusable components that are deemed to be undamaged, functional and have not fulfilled their design life could be sold back to the manufacturer or its supply chain for a modest second-hand price for refurbishment. Some electrical infrastructure equipment as well as recently replaced turbine components could fall into this category.

Applying a conservative approach, DNV GL only considered items 1, 3, and 4 in this study. No resale gains were assumed for item 2, only scrap/disposal value. Furthermore, item 4 was limited only to certain main components within a conservative age range.

5.1 Pricing assumptions

The following salvage assessment is based on DNV GL's decommissioning model which estimates bill of quantities, typical material weights, and ratios for turbine components derived from the manufacturer's technical specifications or from DNV GL experience. The DNV GL model uses commodity prices and disposal service rates as inputs.

For the Project's decommissioning study, the following scrap commodity prices are assumed:

- Steel and cast iron: $300/ton
- Copper: $5,000/ton
- Aluminum: $1,400/ton

Weights are in metric tons. It should be noted that the commodity price of metals is volatile and thus, assuming present day values will hold true is highly uncertain. The assumed prices are based on DNV GL's analysis of USGS historical scrap metal cost statistics [3].

Because landfill costs are expected to keep rising, DNV GL used a different cost variable for the incineration, recycling or disposal of GRP. Although it is possible that in 30 years technology will be available to extract the fibers from the epoxy laminate for high-grade industrial reuse at a net benefit, DNV GL assumed a net cost to incinerate or low-grade recycle the GRP as a separate cost to landfill. The following landfill costs are assumed:

- GRP disposal (incineration or recycling): $100/$m^3$
- Class 2 landfill, Industrial/toxic waste: $75/$m^3$
- Class 3 landfill, General waste: $35/$m^3$

5.2 Turbines

5.2.1 Salvage and disposal

There should be considerable opportunity to reclaim scrap value from the turbines from the copper in the low voltage cabling, transformer and generator; steel from the tower, hub, drive train and bedplate; and aluminum from the tower internals. The blades and nacelle housing are made from GRP and would have to be disposed of.

The following table summarizes the salvage and disposal costs per each turbine. Component weights have been estimated by DNV GL, and/or obtained directly from manufacturer's documentation.

Table 5-1 Turbine salvage values

Component	Net Scrap Value
Blades	$(8,000)
Hub + blade steel	$9,500
Nacelle/hub GRP	$(3,500)
Nacelle bedplate	$19,000
Main shaft	$3,000
Gearbox	$9,000
Generator	$16,500
Tower steel sections	$81,000
Internals	$21,500
Transformer	$6,500
Crushed foundation	$(1,000)
Total per WTG	**$154,000**
Total for Project (72 WTGs)	**$11,088,000**

Note: Negative values (those in parenthesis) are costs to the Project.

5.2.2 Partial resale of major components

DNV GL considers that at the end of the Project's assumed 30-year operating life, many of the components of the turbines will still be serviceable and have positive value in the secondary parts market. DNV GL considers that the towers and nacelle shells would still be sold as scrap as well as the rest of the major components that were not resold.

While wind turbines are structurally designed to meet a fatigue life of 20 years plus some margin, DNV GL expects a significant number of failures during the Project's operating life involving the major components such as gearboxes and generators. DNV GL continually tracks and models the various failure rates for each of the main components across all major wind turbine model types and has, for purposes of this study, modeled failure rate assumptions for the Project for the assumed 30-year life. DNV GL considers that a number of other considerations apply to the actual potential for the turbines to economically operate past their 20-year design life, but notes that such discussion is outside the scope of this report.

It is assumed that other North American wind power projects with Vestas wind turbines (either owned by the Sponsor or not) will be arriving or will have arrived at their 20-year design life at the time of decommissioning of the Project, and some will have chosen to operate beyond it. Therefore, a secondary parts market may be assumed to exist that would demand some of the major components being decommissioned from the Project. Using a conservative approach and with the exception of the transformer, major components that are five years or younger (i.e., replaced or refurbished during operational years 25 through 30) are considered candidates for resale. Only the gearbox, generator, blades, pitch system, main yaw system, hydraulic unit, power converter, main bearing, and transformer are considered. The transformer is assumed to have a higher design life and so, half of the Project's 72 are considered candidates for resale.

Table 5-2 summarizes the turbine partial resale valuations estimated for the Project. The calculations account for the lost scrap opportunities.

Table 5-2 WTG component resale valuations

Component	New Part Cost [$]	Estimated qty. Aged ≤ 5 years (1)	Qty. to Resale (2)	Value at 25% of New [$]	Scrap Loss [$] (3)
Gearbox	$350,000	18	18	$1,575,000	$162,000
Generator	$190,000	19	19	$903,000	$313,500
Blades	$330,000	4	4	$330,000	$(32,000)
Pitch system	$10,000	11	11	$28,000	$0
Main Yaw	$85,000	0	0	$0	$0
Hydraulic unit	$10,000	0	0	$0	$0
Power converter	$34,000	27	27	$230,000	$0
Main Bearing	$175,000	11	11	$481,000	$0
Transformer	$75,000	4	36	$675,000	$234,000
Gross Resale Total				**$4,222,000**	
Minus Loss of Scrap					**$(677,500)**
Net Resale Total					**$3,544,500**

(1) Component replaced within the last 5 years of operation according to DNV GL model.
(2) Component assumed to be resold based on DNV GL engineering judgment.
(3) Partial resale of turbine components means scrap opportunities need to be subtracted from previous calculations; this is taken into account in this column, and therefore the net resale value of turbine components includes this loss of scrap.

5.3 Collection system

5.3.1 Underground collection system

The underground three-phase conductor and ground cabling reels from the Project will likely be sold for scrap. Based on Project information, DNV GL has estimated at total of approximately 159 miles of conductor (3 phases) along with 53 miles of bare copper ground wire. The salvage – disposal results are reported in Table 5-3 below.

5.3.2 Overhead collection system

In accordance with the documentation provided by the Sponsor, which indicates that no overhead collection lines are being utilized, DNV GL did not consider the salvage value of overhead lines in this decommissioning analysis.

5.4 High-voltage substation

There should be opportunity to reclaim metal scrap value from substation electrical equipment. Equipment such as bus work, circuit breakers, grounding transformers, and main transformers contain a significant amount of conductive material such as copper and aluminum. Dead-end and other steel structures contain a significant amount of steel. The substation yards also contain aggregate fill that could be sold. Rubble from the foundation demolition and all other materials would be sent to landfill at cost. The scrap value of the substation is presented in Table 5-3 below.

DNV GL considers that there is a resale market for substation transformers. Therefore, the transformer could be sold as operational second-hand equipment instead of being scrapped. This scenario has been taken into account in Section 6.

5.5 Transmission line

The three-phase conductor cable can be sold for scrap and the steel poles from the overhead line could potentially be resold to an electric utility as second hand parts. Based on Project drawings and specifications, DNV GL has estimated at total of 9 steel transmission poles and approximately 0.75 miles of total conductor (3 phases). The salvage – disposal results are presented in Table 5-3 below.

5.6 Site access roads

For the purpose of removal and salvage calculations and at the Sponsor's request, the Project's 19.1 miles of roads to be removed were assumed to be 16 ft wide and 0.3 m (~1 ft) deep and underlain by geotextile, in line with Project drawings.

The salvage – disposal results are presented in Table 5-3 below.

5.7 Meteorological masts

Although it is possible that the met masts could be dismantled, resold and reused at a different location, a 30-year old mast may have limited reinstallation value (although it could very well be a candidate to remain installed onsite in a repowering scenario). For the purpose of conservatism in this study, DNV GL assumes a dismantling and removal scenario with the intent of scrapping the met towers.

The salvage – disposal results are presented in Table 5-3 below.

5.8 Salvage – disposal conclusions

The following table summarizes the opportunities from the salvage / disposal analysis. Please note that this table does not incorporate the turbine major component resale scenario presented in Table 5-2.

Table 5-3 Salvage/disposal value (without resale of turbine components)

Item	Disposal	Salvage
WTG	$(936,000)	$12,024,000
Collection System	$(26,000)	$1,083,000
HV Substation	$(9,000)	$542,000
Transmission Line	$0	$70,000
Access Roads	$(38,000)	$423,000
Met Masts	$(400)	$5,400
Total Project Salvage Return	**$(1,009,400)**	**$14,147,400**

Note: The value presented does not include the resale returns of turbine components; negative values, those in parenthesis, are costs to the Project.

6 NET DECOMMISSIONING COST

The estimated net decommissioning cost for the Project is calculated by subtracting the total salvage value from the total of the disassembly and removal costs. This report presents two net decommissioning cost breakdowns: Scenario 1 assumes no resale of Project components, and Scenario 2 assumes the partial resale of major turbine components noted in Section 5.2.2 and the substation's main power transformers.

6.1 Net decommissioning cost – no resale

Table 6-1 summarizes the Project's net decommissioning costs assuming no resale of any Project components other than for scrap value (Scenario 1).

Table 6-1 Project Net decommissioning cost – no resale (Scenario 1)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(12,024,000)	$(662,000)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
HV Substation	$157,000	$72,000	$9,000	$238,000	$(542,000)	$(304,000)
Transmission Line	$114,000	$12,000	$0	$126,000	$(70,000)	$56,000
Access Roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,469,000	$0	$0	$2,469,000	$0	$2,469,000
Project Totals	$10,525,000	$5,414,000	$1,009,400	$16,948,400	$(14,147,400)	$2,801,000
Total per WTG						**$38,900**
Total for Project (72 WTGs)						**$2,801,000**

Note: negative values, those in parenthesis, are positive returns to the Project.

6.2 Net Decommissioning Cost – Partial Resale of Selected Components

Table 6-2 summarizes the Project's net decommissioning costs for Scenario 2, which includes some plausible and conservative parts resale assumptions.

Table 6-2 Project Net decommissioning cost – partial resale of selected components (Scenario 2)

Item	Disassembly (A)	Removal (B)	Disposal (C)	Total Costs (D=A+B+C)	Salvage/Resale (E)	Net (D+E)
WTG	$6,264,000	$4,162,000	$936,000	$11,362,000	$(15,568,500)	$(4,206,500)
Collection System	$845,000	$284,000	$26,000	$1,155,000	$(1,083,000)	$72,000
HV substation	$157,000	$72,000	$9,000	$238,000	$(1,787,000)	$(1,549,000)
Transmission Line	$114,000	$12,000	$0	$126,000	$(70,000)	$56,000
Access roads & Crane Pads	$642,000	$853,000	$38,000	$1,533,000	$(423,000)	$1,110,000
Met Masts	$34,000	$31,000	$400	$65,400	$(5,400)	$60,000
Mobilization/Soft Costs	$2,469,000	$0	$0	$2,469,000	$0	$2,469,000
Project Totals	$10,525,000	$5,414,000	$1,009,400	$16,948,400	$(18,936,900)	$(1,988,500)
Total per WTG						**$ (27,620)**
Total Project (72 WTGs)						**$ (1,988,500)**

Note: negative values, those in parenthesis, are positive returns to the Project.

6.3 Future recommendations

It is stressed that this report is based on broad assumptions regarding the Project including the approach to the decommissioning task, the market conditions for contracting costs, and scrap value and resale options. DNV GL recommends that the net costs of decommissioning be reviewed closer to the end of the operating period (e.g., 2 to 4 years prior to the end of operations) when better visibility on these factors would be possible. Also at this time, the value of decommissioning could be reviewed against potential extended operational revenue. At the same time it would also be prudent to consider a “re-powering” scenario, in which case the existing turbines would be removed in the interest of constructing a more valuable project with larger, more efficient turbines. Any cost to remove the old turbines would be incurred as construction costs of the new wind power project.

7 REFERENCES

[1] Email from N. Pedder, Apex Clean Energy to K. Kallevig-Childers, DNV GL providing Project assumptions, 8 November 2017.

[2] Emails from N. Pedder, Apex Clean Energy to D. Pardo, DNV GL providing infrastructure assumptions, 21 and 22 November 2017.

[3] USGS web site: http://minerals.usgs.gov/minerals/pubs/commodity/

APPENDIX A – CUSTOMER PROVIDED INPUTS

1000	**Special requirements**	
1001	Decommissioning requirements applicable to the Project	n/a
1100	**Project Basics**	
1101	Wind Power Plant Name	Dakota Range
1102	Construction Status	County Permitting
1103	General Location	45.183878, -97.049304
1104	No. Wind Turbines in Grant County	72
1105	Make and Model of Wind Turbine	Vestas V136 4.2 MW
1106	Hub Height [m]	82
1107	Project Capacity [MW]	302.4 MW
1108	Project Design Life (civil, turbine, electrical and financial) [yr]	30
1109	Decommissioning to Occur After Which Project Year	2050
1110	No. of Substations to Remove	1
1111	No. of main project transformers	2
1112	No. of O&M buildings to Remove	0
1113	Length of Underground Collection System to Remove	280,184 lf
1114	Length of Overhead Collection System to Remove	0 lf
1115	Length of Transmission Line to Remove	1,320 lf
1116	Length of Project Access Roads to Reclaim [km]	101,050 lf
1117	No. of Meteorological Towers to Remove	3
1118	Average Height of Met Towers [m]	82
1119	Met tower type	Self-support
1200	**Additional Information**	
1201	COD date	2021
1202	Warranty term [yr]	Not provided
1203	Estimated Annual P50 Production Capacity Factor	Not provided
1204	Main step-up transformer voltage [kV/kV]	345/34.5
1205	Main step-up transformer rating [MVA]	167
1206	No. of Transmission Line Steel Poles	9
1207	No. of Transmission Line Wood Poles	0
1208	Project Layout file name	DKR_XCEL_LAY_20171108.KMZ
1209	Number of tower sections per Wind Turbine	3
1210	Site plan (incl. Electrical layout)	DKR_XCEL_LAY_20171108.KMZ
1211	Construction schedule	Not provided
1212	As built or issued for construction (IFC) drawings (civil & electrical)	Not provided
1213	Contracts in place or existing quotes/price	Not provided

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