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NAIROBI

OL-NDANYAT POWER COMPANY LIMITED

FEASIBILITY STUDY REPORT

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5/14/17

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CONTENTS

EXECUTIVE SUMMARY

GENERATION TYPE

Wind power generation plants are proving to be a great contribution to a more sustainable, ecologically and sound power generation landscape. The Ol Ndanyat Project will generate zero emission wind power and supply it to the National Grid. Phase I of the proposed project will generate 10 MW from 5 Wind Turbine Generator (WTG), Phase 2 scale-up to 20 MW and Phase 3 scale-up to 30 MW. The grid is 2.5 km away from interconnection point.

OWNERSHIP OF THE PROJECT

The project is being promoted by Ol Ndanyat Power Limited, a locally registered limited liability company under the Companies Act (Cap 486) of the Laws of Kenya.

As a private limited liability company, the principal laws affecting its operations are:

1) Energy Act, 2006.
2) The Environmental Management and Coordination Act (EMCA, 1999).
3) The OSHA, 2007.
4) The Water Act, 2002.
5) Public Health Act, 1986 (revision).
6) The Companies Act, 1951.
7) Wildlife (Conservation and Management) Act, 1985 (revision).
8) Forest Act, 2005.
9) Building Code, 1997.
10) Local Government Act, 1998 (revision).
11) Trade Licensing Act, 1994 (revised).
12) Physical Planning Act, 1996.
13) Radiation Protection Act, 1985.
14) Workmen's Compensation Act, 1988 (revision).

The company is fully compliant with all the statutory legal and tax requirements. Attached are copies of the following documents:-

- Certificate of registration/incorporation,
- PIN certificate,
- VAT certificate,
- Tax compliance certificate
- To be obtained – Electricity Generation license.

The company registered in 2011 has nominal shareholding of 100,000 divided among the following shareholders and directors:-

Shareholder	Shareholding	% Shareholding
Simon Igecha	10	0.1%
Frankie Beauttah	10	0.1%
Joseph Mbugua	10	0.1%

Their brief profiles are as follows:-

- Simon Igecha: Forty years of experience in the construction industry.

- He has been Involved In construction of WTG foundations, control room and acquiring the statutory approvals.
- Frankie Beauttah: B.Sc. (Math), B. Tech (Mech. Eng.), thirty years of experience in installation, design, fabrication and ex-ray inspection of welded joints of pen stock for hydro power turbine generators, steam pipes and lattice wind towers of 50 to 120 meters. Expert in installation of wind data measurement instruments, data collection and analysis.
- Joseph Mbugua: Mr. Mbugua is a holder of Higher National Diploma in Telecommunications and a similar one in Business Administration. He has held senior management positions and sits on several boards of private company in the country. He is 49 years old.

WIND RESOURCE ASSESSMENT

KenGen conducted wind measurements in the Ngong hills area between August 2006 and August 2009. A study was conducted in 2007 which confirmed availability of an excellent wind resource for wind energy development as well commercial and technical viability for wind energy generation from the Ngong Hills. Based on the results of the study, KenGen embarked on the development of the 5.1MW wind farm on the northern part of the hills which was commissioned in August 2009.

Subsequent preliminary studies and assessment conducted by KenGen estimate that the Ngong Hills forest area alone is capable of supplying approximately 100MW of wind energy to the grid. About 35MW of this capacity can be developed within the northern part of the forest while the remaining 65MW lies within the Corner Baridi side, which is the area where the Ol Ndanyat project is sited.

The preliminary results have revealed that the area is recording an annual average wind speed of approximately 8 m/s which is capable of recording an annual wind farm load factor of approximately 35%.

Ol Ndanyat commenced collection of its wind data in March 2012 and available data available up to September 2012 are attached as Annex I

PROPOSED INVESTMENT /FINANCING

The investment structure of the project is as follows;

OL-NDANYAT

Sources & Applications of Funds

Investments ('000'000)			
	Owners		
	Common Shares Sold		
	Par Value (USD)	$4,000,000.00	
	Sub-Total Shareholder Investment ('000'000)	**$4.00**	
	External Investors - Private Placement		
	Land (Acres)	55.00	
	Value/Acre (USD)	$265,000.00	
	Sub-Total Investor Funds ('000'000)	**$14.58**	
	Total Investments ('000'000)	**$18.58**	13.75%
Borrowing/Debt ('000'000)			
	Commercial Loan (10 Years @ 8.5%) - TAGA FZ	$68.08	
	Short-term Debt	$-	

	Total Borrowed Funds ('000'000)	**$68.08**	50.41%
Other Sources			
	Local Facility - Credit Line	$11.90	
	Income from Debt Service - Long	$33.33	
	Income from Debt Service - Short	$3.16	
	Total Other Sources ('000'000)	**$48.39**	35.83%
Total Investments and Loans		**$86.66**	64.17%
Total Project Cost		**$135.05**	100.00%

CONCLUSION

The proposed project reduces greenhouse gas emissions by supplying

Zero-emission wind power to the National Power Grid, which replaces the same amount of electricity generated by fossil fuel fired power plants connected to National Power Grid, and therefore avoids the CO_2 emissions in the generating the same amount of electricity provided by the fossil fuel fired power plants.

Being an environmentally sound energy supply technology, the wind power is one of the priority development projects in Kenya. The contributions of the proposed project to sustainable development goals are summarized as follows:

- Being located in a power grid dominated by thermal power plants, development of the proposed project will not only reduce GHG emissions but also mitigate local environmental pollution caused by air emissions from the thermal power plants. The wind farm is 2 km away from the grid.
- The proposed project will be helpful to diversify power mix of National Power grid.
- The proposed project will be helpful in meeting local electricity demand and reducing the dependence on exhaustible and expensive fossil fuel for power generation.

INTRODUCTION TO THE PROJECT

LOCATION

The proposed project is located in Kajiado County, Ngong Hills Area in Kenya, 45km from Nairobi City Centre, and 3km off Nairobi – Magadi Road from Corner Baridi. The size of the land is 55 acres.

The geographical co-ordinates are:-

- South 01^{o} 29' 15.4"
- East 036^{o} 38' 29.8"
- Height Above Sea level – 1920m
- See figure 1, 2 and 3 below for the site plan

Figure 1

Figure 2

Site house and wind mast

Land Topography

Figure 3

WTG POSITIONS

POSITIONS FOR 12 WIND TURBINES IN THE PROPOSED PROJECT

WTG No.	NORTHING	EASTING	ALTITUDE
1	237801.5	9838063	1998
2	238004.8	9837679	1981
3	237384.4	9836821	1917
4	237884.9	9836774	1914
5	237429.9	9836394	1943
6	237921.3	9836308	1918
7	237494.3	9835865	1905
8	237929.7	9835698	1898
9	237575.8	9835403	1919
10	237682.4	9835086	1909
11	237779.9	9834740	1913
12	237728.5	9834381	1916

PROJECT VIABILITY, DESIGN, DEVE LOPMENT AND OPERATION OF THE PROPOSED WIND FARM

INTRODUCTION

Ol Ndanyat Power Ltd. Intends to employ international standards during design, construction and operation of its electricity generating project. These standards will be employed during the design, construction and operation of the proposed wind farm.

PROJECT VIABILITY

1 Objective

This document is an analysis of the wind resource to conduct wind turbine technology selection at OL Ndanyat wind power farm in Kenya. The objective of this report is to summarize the wind conditions and other information relevant to the suitability analysis of appropriate turbines for the specific project site.

2 Site Descriptions

The proposed project is located in southern Kenya. Local terrain is a small mountain; The site is characterized by a smooth ridge system around 1800m to 2000m. While the general land use in the region is mainly open grass land, just have several small house observed from Google Earth. Road C58 passes by wind farm field. Figure below shows the location of project.

Figure 2.1 Project location

3. WTG Selection

3.1. WTG Layout and Wind Parameters

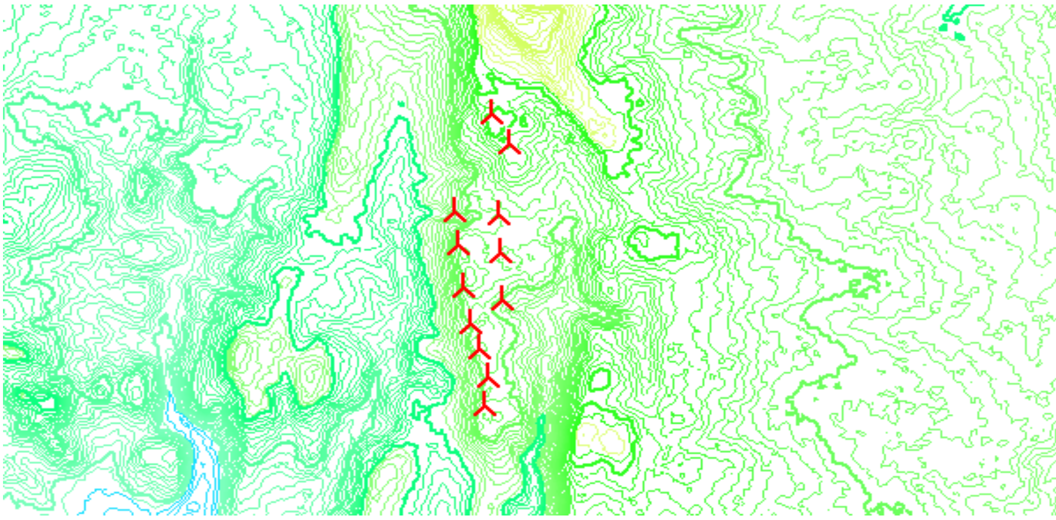

Figure4.1 Layout for 12 units of 2.5MW turbine

(red signals show OL Ndanyat turbines)

According to preliminary results, GOLDWIND GW109/2500 (90mHH, IEC IIIA) is selected for OL Ndanyat wind farm. Goldwind use WT, WindPRO 3.0 to calculate electrical energy combined with designated power curves. Besides, wind regime parameters @90m are also summarized in Table 4.1.

Table 4.1 Summary of wind parameters of the project

Parameters	Value	Comments
Altitude[m]	1852 -1998	
Terrain	Smooth ridge	
Air density [kg/m^3]	0.96	
Annual wind speed of Mast [m/s]	9.22	42m(extend to 1 year with Mast 's data)
Weibull fitted condition	normal	
Annual wind speed (WTGs) [m/s]	9.21(8.09~9.9)	90m
Maximum wind speed in 50a [m/s]	23.8(20.9~25.6)	90m
Gust factor	1.19	
Extreme wind speed in 50a [m/s]	28.4(24.9-30.5)	90m
Turbulence intensity	0.097 (0.08~0.11)	I 15@90m
Inflow angle [degree]	4.88(0.6~9.4)	90m
Wind shear exponent	0.07(0.03~0.15)	
Air temperature (Co)	19.6	Measured on Mast

3.2. WTG Selection

The Maximum wind speed in 50a -10mins is less than 37.5m/s. air density is lower than standard situation, although, the wind speed is over 9.9m/s, we have finished the load calculation, GW109/2500 (90m HH, IEC IIIA) is suitable for OL Ndanyat wind farm.

4. Loss Analysis

The loss factors are shown in table 4.1. Annual outputs are showed in table 4.2.

Table 4.1 Loss Factors

Lost factor	value	Note
Air density loss	1	included in WindPRO
Wake effect	1	included in WindPRO
Topographic effect	1	included in WindPRO
Blade degradation(not due to icing)	0.98	
Turbine availability	0.97	
Turbine power curve guarantee	1	
High and low temperature loss and hysteresis	1	
High wind hysteresis	0.997	
Marginal loss factor	1	
Site net loss factor	1	
Other equipment availability	0.995	
BOP(Substation)	0.995	
Electrical loss	0.97	
Facility consumption	0.995	
Wind sector management	1	
Environment assessment	1	
E-grid limitation	1	
total loss factor	0.9056	

Conclusions

According to the wind analysis, the annual mean wind speed of WTG site is from 8.09 to 9.9m/s with main wind direction is ENE and E. Long term effect is not considered at this moment. Based on above parameters, **GW109/2500 (90mHH, IEC IIIA) is** suitable for OL Ndanyat wind farm.

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ol ndanyat

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Calculated:
2016-6-28 9:47/3.0.619

PARK - Main Result

Calculation: GW109

Wake Model N.O. Jensen (RIS?/EMD)

Calculation Settings

Air density calculation mode	Individual per WTG
Result for WTG at hub altitude	0.954 kg/m3 to 0.968 kg/m3
Air density relative to standard	77.9 % to 79.0 %
Hub altitude above sea level (asl)	1,942.8 m to 2,090.0 m
Annual mean temperature at hub alt.	17.9 ¡ãC to 18.9 ¡ãC
Pressure at WTGs	797.2 hPa to 811.1 hPa

Wake Model Parameters

From angle [¡ã]	To angle [¡ã]	Terrain type	Wake decay constant
180.0	180.0		0.040

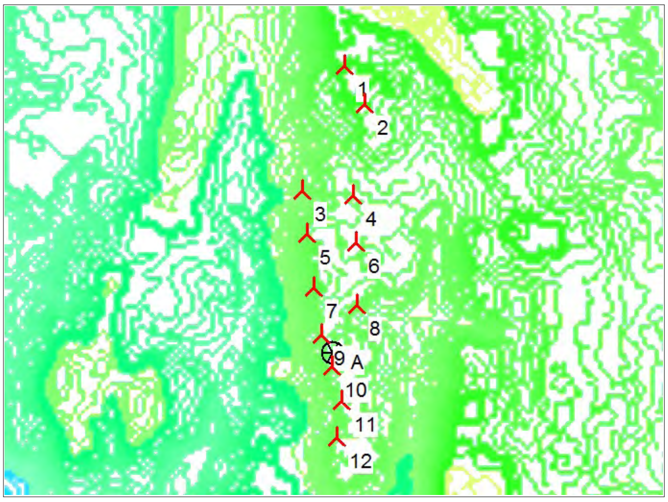
Displacement heights from objects

Wake calculation settings

Angle [¡ã] start	end	step	Wind speed [m/s] start	end	step
0.5	360.0	1.0	0.5	30.5	1.0

Wind statistics KE mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m.wws

WAsP version WAsP 10 RVEA0151.dll 1, 5, 5, 0



Scale 1:75,000
New WTG Site Data

Key results for height 50.0 m above ground level

Terrain UTM (south)-WGS84 Zone: 37

	Easting	Southing	Name of wind distribution	Type	Wind energy [kWh/m2]	Mean wind speed [m/s]	Equivalent roughness
A	237,692	9,835,217	90m for wasp	WAsP (WAsP 10 RVEA0151.dll 1, 5, 5, 0)	4,299	8.4	1.5

Calculated Annual Energy for Wind Farm

WTG combination	Result PARK [MWh/y]	Result-13.4% [MWh]	GROSS (no loss) Free WTGs [MWh/y]	Park efficiency [%]	Specific results¡è) Capacity factor [%]	Mean WTG result [MWh/y]	Full load hours [Hours/year]	Mean wind speed @hub height [m/s]
Wind farm	141,006.0	122,111.2	144,258.2	97.7	46.4	10,175.9	4,070	9.5

¡è) Based on Result-13.4%

Calculated Annual Energy for each of 12 new WTGs with total 30.0 MW rated power

Links	WTG type Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Displacement height [m]	Power curve Creator	Name	Annual Energy Result [MWh]	Result-13.4% [MWh]	Park Efficiency [%]	Mean wind speed [m/s]
1 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,546.1	9,999	99.85	9.23
2 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,925.4	10,327	99.83	9.46
3 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,367.1	9,844	94.70	9.44
4 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	12,025.1	10,414	99.75	9.50
5 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	10,982.9	9,511	91.16	9.49
6 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	12,060.0	10,444	99.73	9.52
7 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,594.8	10,041	95.76	9.54
8 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	12,065.9	10,449	99.71	9.52
9 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,327.6	9,810	93.62	9.52
10 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	11,998.0	10,390	99.35	9.51
11 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	12,061.1	10,445	99.83	9.51
12 A	No	Goldwind	109-2500-2,500	2,500	109.0	90.0	0.0	USER	GW109-10%-measurement2016	12,052.0	10,437	99.75	9.51

WTG siting

UTM (south)-WGS84 Zone: 37

	Easting	Southing	Z [m]	Row data/Description
1 New	237,802	9,838,063	2,000.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (1)
2 New	238,005	9,837,679	1,990.1	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (2)
3 New	237,384	9,836,821	1,852.8	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (3)
4 New	237,885	9,836,774	1,910.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (4)

To be continued on next page...

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Calculated:
2016-6-28 9:47/3.0.619

PARK - Main Result

Calculation: GW109

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	UTM (south)-WGS84 Zone: 37			
	Easting	Southing	Z [m]	Row data/Description
5 New	237,430	9,836,394	1,922.7	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (5)
6 New	237,921	9,836,308	1,920.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (6)
7 New	237,494	9,835,865	1,924.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (7)
8 New	237,930	9,835,698	1,897.6	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (8)
9 New	237,576	9,835,403	1,901.5	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (9)
10 New	237,682	9,835,086	1,920.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (10)
11 New	237,780	9,834,740	1,910.0	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (11)
12 New	237,729	9,834,381	1,911.2	Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (12)

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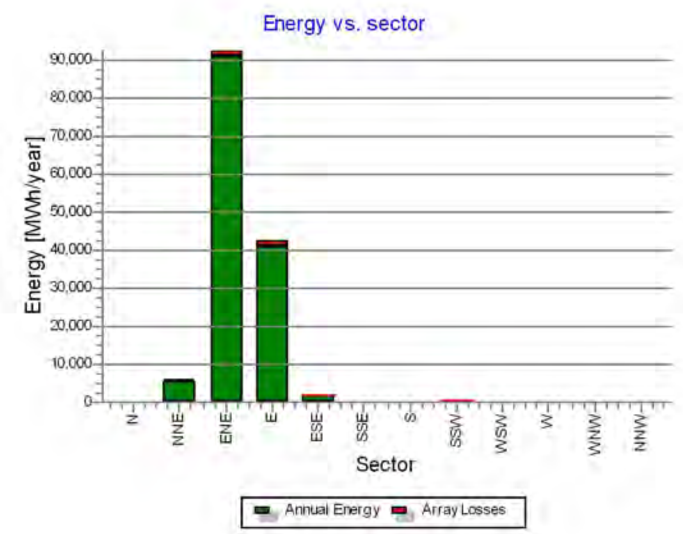
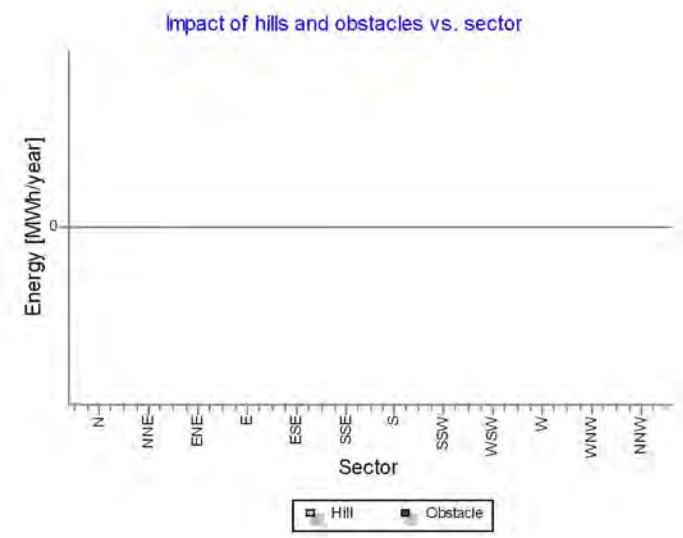
PARK - Production Analysis

Calculation: GW109WTG: All new WTGs, Air density varies with WTG position 0.986 kg/m3 - 1.001 kg/m3

Directional Analysis

Sector		0 N	1 NNE	2 ENE	3 E	4 ESE	5 SSE	6 S	7 SSW	8 WSW	9 W	10 WNW	11 NNW	Total
Roughness based energy	[MWh]	60.7	5,947.8	92,729.4	42,412.4	1,830.7	179.2	205.5	373.0	216.1	63.7	141.7	98.2	144,258.3
-Decrease due to array losses	[MWh]	26.1	327.0	1,507.1	1,104.7	75.1	31.0	84.2	54.4	15.1	4.4	7.5	15.5	3,252.3
Resulting energy	[MWh]	34.6	5,620.8	91,222.2	41,307.7	1,755.6	148.2	121.3	318.5	200.9	59.3	134.2	82.6	141,006.0
Specific energy	[kWh/m2]													1,259
Specific energy	[kWh/kW]													4,700
Decrease due to array losses	[%]	43.1	5.5	1.6	2.6	4.1	17.3	41.0	14.6	7.0	6.9	5.3	15.8	2.25
Utilization	[%]	19.2	25.0	20.6	23.8	33.5	28.1	19.7	28.1	30.4	30.5	32.3	28.6	21.8
Operational	[Hours/year]	38	413	4,236	2,738	335	103	135	262	161	53	78	55	8,608
Full Load Equivalent	[Hours/year]	1	187	3,041	1,377	59	5	4	11	7	2	4	3	4,700





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Calculated:

2016-6-28 9:47/3.0.619

PARK - Power Curve Analysis

Calculation: GW109WTG: 1 - Goldwind 109-2500 2500 109.0 !-! GW109-10%-measurement2016, Hub height: 90.0 m

Name: GW109-10%-measurement2016
Source: tianhailiang

Source/Date	Created by	Created	Edited	Stop wind speed [m/s]	Power control	CT curve type	Generator type	Specific power kW/m2
2016-4-26	USER	2016-4-26	2016-4-28	25.0	Pitch	User defined	One generator	0.27

HP curve comparison - Note: For standard air density and weibull k parameter = 2

Vmean	[m/s]	5	6	7	8	9	10
HP value Pitch, single generator (2009)	[MWh]	4,200	6,452	8,728	10,829	12,515	14,045
Goldwind 109-2500 2500 109.0 !-! GW109-10%-measurement2016	[MWh]	4,072	6,225	8,330	10,216	11,806	13,071
Check value	[%]	3	4	5	6	6	7

The table shows comparison between annual energy production calculated on basis of simplified "HP-curves" which assume that all WTGs performs quite similar - only specific power loading (kW/m^2) and single/dual speed or stall/pitch decides the calculated values. Productions are without wake losses.
For further details, ask at the Danish Energy Agency for project report J.nr. 51171/00-0016 or see windPRO manual chapter 3.5.2.
The method is refined in EMD report "20 Detailed Case Studies comparing Project Design Calculations and actual Energy Productions for Wind Energy Projects worldwide", jan 2003.
Use the table to evaluate if the given power curve is reasonable - if the check value are lower than -5%, the power curve probably is too optimistic due to uncertainty in power curve measurement.

Power curve

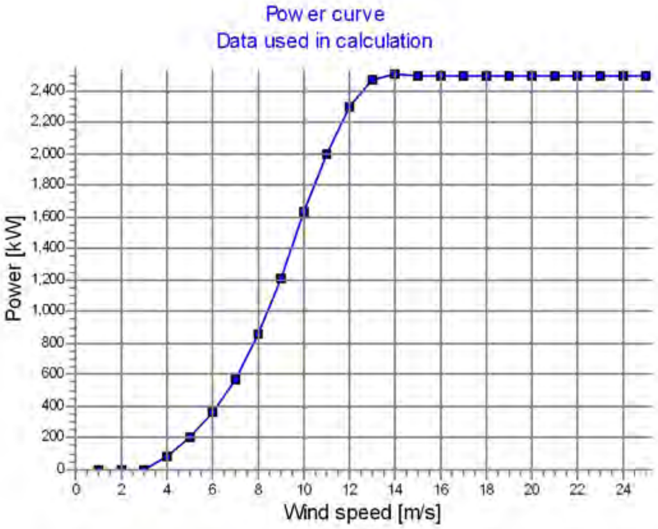
Original data from Windcat, Air density: 1.225 kg/m3

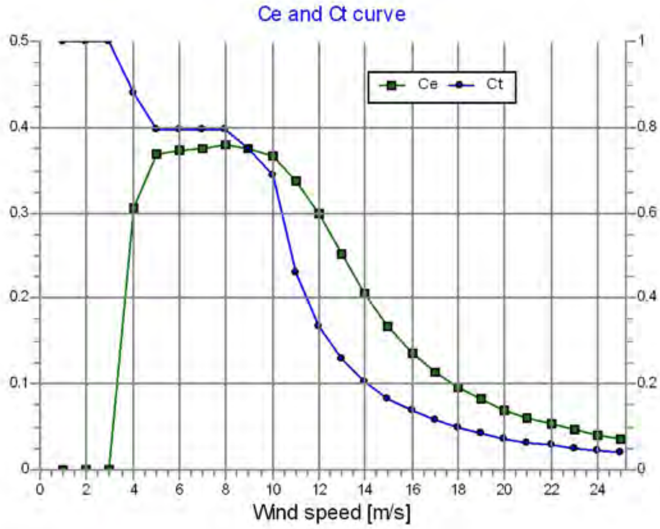
Wind speed [m/s]	Power [kW]	Ce	Wind speed [m/s]	Ct curve
3.0	23.0	0.15	3.0	1.00
3.5	74.5	0.30	3.5	0.96
4.0	112.4	0.31	4.0	0.88
4.5	190.1	0.36	4.5	0.81
5.0	274.1	0.38	5.0	0.79
5.5	358.3	0.38	5.5	0.79
6.0	467.0	0.38	6.0	0.79
6.5	591.1	0.38	6.5	0.79
7.0	741.6	0.38	7.0	0.79
7.5	920.5	0.38	7.5	0.79
8.0	1,109.4	0.38	8.0	0.79
8.5	1,338.3	0.38	8.5	0.78
9.0	1,598.7	0.38	9.0	0.75
9.5	1,814.2	0.37	9.5	0.72
10.0	2,063.2	0.36	10.0	0.69
10.5	2,274.6	0.34	10.5	0.56
11.0	2,440.1	0.32	11.0	0.46
11.5	2,491.6	0.29	11.5	0.39
12.0	2,509.2	0.25	12.0	0.34
12.5	2,500.0	0.22	12.5	0.29
13.0	2,500.0	0.20	13.0	0.26
13.5	2,500.0	0.18	13.5	0.23
14.0	2,500.0	0.16	14.0	0.20
14.5	2,500.0	0.14	14.5	0.18
15.0	2,500.0	0.13	15.0	0.17
15.5	2,500.0	0.12	15.5	0.15
16.0	2,500.0	0.11	16.0	0.14
16.5	2,500.0	0.10	16.5	0.13
17.0	2,500.0	0.09	17.0	0.11
17.5	2,500.0	0.08	17.5	0.11
18.0	2,500.0	0.08	18.0	0.10
18.5	2,500.0	0.07	18.5	0.09
19.0	2,500.0	0.06	19.0	0.08
19.5	2,500.0	0.06	19.5	0.08
20.0	2,500.0	0.05	20.0	0.07
20.5	2,500.0	0.05	20.5	0.07
21.0	2,500.0	0.05	21.0	0.06
21.5	2,500.0	0.04	21.5	0.06
22.0	2,500.0	0.04	22.0	0.06
22.5	2,500.0	0.04	22.5	0.05
23.0	2,500.0	0.04	23.0	0.05
23.5	2,500.0	0.03	23.5	0.05
24.0	2,500.0	0.03	24.0	0.04
24.5	2,500.0	0.03	24.5	0.04
25.0	2,500.0	0.03	25.0	0.04

Power, Efficiency and energy vs. wind speed

Data used in calculation, Air density: 0.954 kg/m3 New windPRO method (adjusted IEC method, improved to match turbine control) <RECOMMENDED>

Wind speed [m/s]	Power [kW]	Ce	Interval [m/s]	Energy [MWh]	Acc.Energy [MWh]	Relative [%]
1.0	0.0	0.00	0.50- 1.50	0.0	0.0	0.0
2.0	0.0	0.00	1.50- 2.50	0.0	0.0	0.0
3.0	0.0	0.00	2.50- 3.50	10.1	10.1	0.1
4.0	87.4	0.31	3.50- 4.50	44.9	55.0	0.5
5.0	204.7	0.37	4.50- 5.50	115.8	170.8	1.5
6.0	359.2	0.37	5.50- 6.50	225.1	395.9	3.4
7.0	571.8	0.37	6.50- 7.50	386.3	782.2	6.8
8.0	863.0	0.38	7.50- 8.50	622.8	1,404.9	12.2
9.0	1,218.0	0.38	8.50- 9.50	926.6	2,331.5	20.2
10.0	1,634.4	0.37	9.50-10.50	1,232.9	3,564.4	30.9
11.0	1,996.7	0.34	10.50-11.50	1,461.4	5,025.8	43.5
12.0	2,306.6	0.30	11.50-12.50	1,545.9	6,571.7	56.9
13.0	2,470.5	0.25	12.50-13.50	1,434.7	8,006.4	69.3
14.0	2,509.0	0.21	13.50-14.50	1,180.5	9,186.9	79.6
15.0	2,500.0	0.17	14.50-15.50	889.6	10,076.5	87.3
16.0	2,500.0	0.14	15.50-16.50	619.3	10,695.8	92.6
17.0	2,500.0	0.11	16.50-17.50	396.4	11,092.2	96.1
18.0	2,500.0	0.10	17.50-18.50	231.7	11,323.9	98.1
19.0	2,500.0	0.08	18.50-19.50	123.0	11,446.9	99.1
20.0	2,500.0	0.07	19.50-20.50	59.0	11,505.9	99.7
21.0	2,500.0	0.06	20.50-21.50	25.5	11,531.4	99.9
22.0	2,500.0	0.05	21.50-22.50	9.9	11,541.3	100.0
23.0	2,500.0	0.05	22.50-23.50	3.5	11,544.7	100.0
24.0	2,500.0	0.04	23.50-24.50	1.1	11,545.9	100.0
25.0	2,500.0	0.04	24.50-25.50	0.3	11,546.1	100.0





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PARK - Terrain

Calculation: GW109Site Data: A - 90m for wasp

Obstacles:
0 Obstacles used

Roughness:
Calculation uses following MAP files:
F:\project\kenya\Ol Ndanyat Project\1.Wind Data\Model\WT\rough ol.map
Min X: 235,380, Max X: 240,620, Min Y: 9,830,751, Max Y: 9,849,805, Width: 5,240 m, Height: 19,054 m

Orography:

PARK - Wind Data Analysis

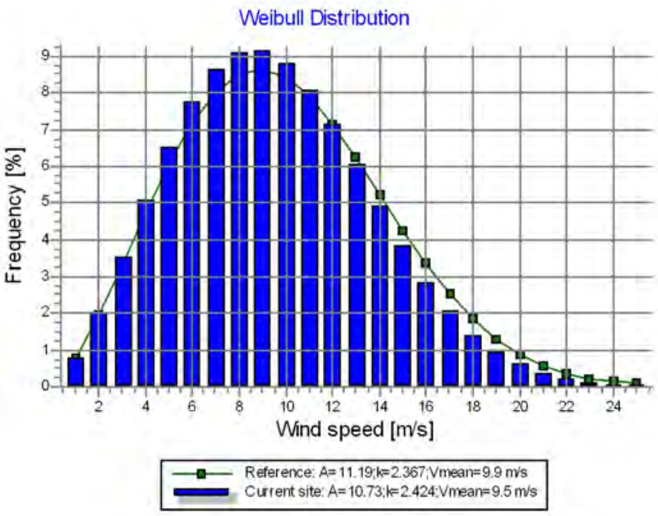
Calculation: GW109Wind data: A - 90m for wasp; Hub height: 90.0

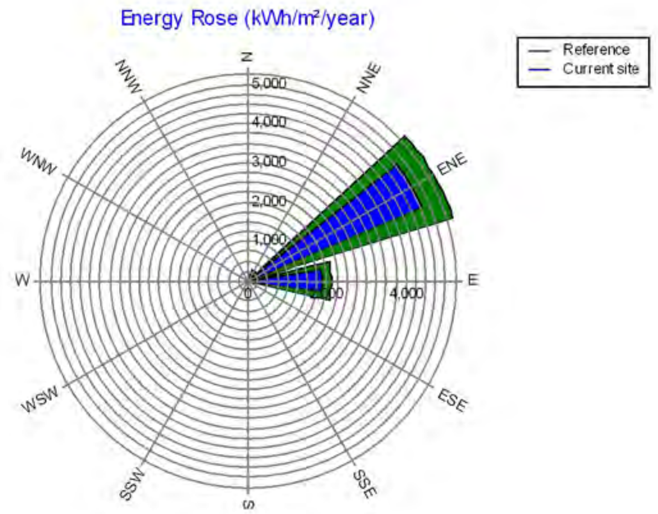
Site coordinates
UTM (south)-WGS84 Zone: 37
East: 237,692 North: 9,835,217

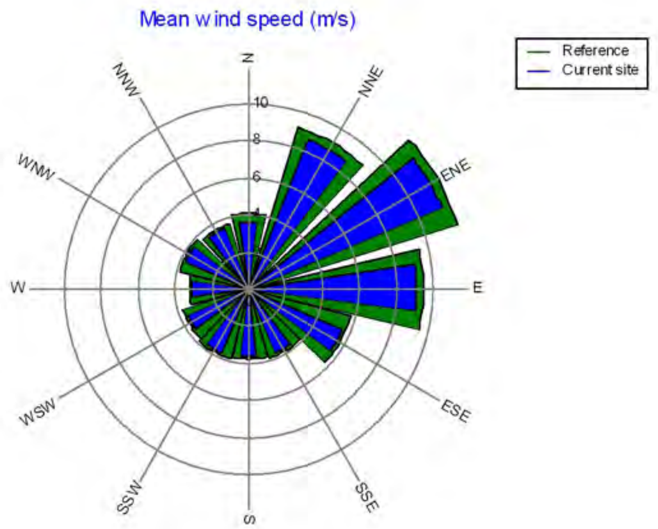
Wind statistics
KE mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m.wws

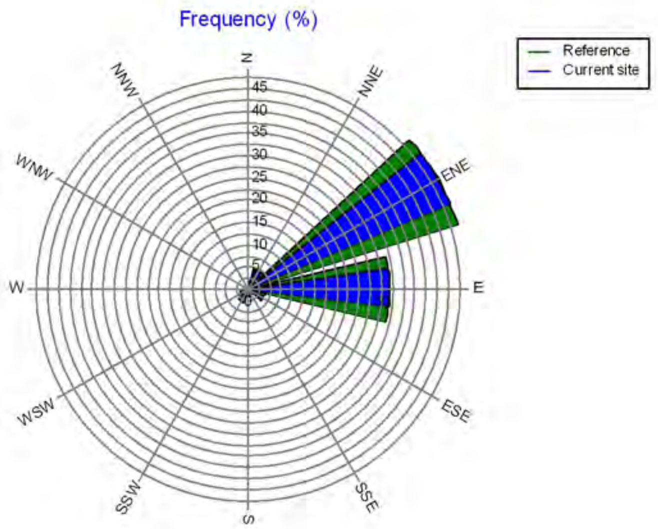
Weibull Data

	Current site				Reference: Roughness class 1		
Sector	A-parameter [m/s]	Wind speed [m/s]	k-parameter	Frequency [%]	A-parameter [m/s]	k-parameter	Frequency [%]
0 N	4.13	3.66	2.053	0.4	4.60	1.715	0.5
1 NNE	9.80	8.71	2.607	4.8	10.28	2.603	4.9
2 ENE	12.67	11.40	3.486	49.2	13.20	3.475	49.3
3 E	10.25	9.11	2.568	31.8	10.68	2.563	31.7
4 ESE	6.24	5.52	2.287	3.9	6.44	2.359	3.8
5 SSE	4.20	3.72	2.119	1.2	4.36	2.100	1.2
6 S	4.09	3.62	2.193	1.6	4.26	2.169	1.6
7 SSW	4.21	3.74	2.623	3.0	4.35	2.576	3.0
8 WSW	4.06	3.60	2.432	1.9	4.21	2.397	1.9
9 W	3.50	3.11	1.740	0.6	3.65	1.753	0.6
10 WNW	4.23	3.75	2.076	0.9	4.38	2.052	0.9
11 NNW	3.97	3.54	1.756	0.6	4.13	1.743	0.6
All	10.73	9.51	2.424	100.0	11.19	2.367	100.0









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Calculated:
2016-6-28 9:47/3.0.619

PARK - Wind Data Analysis

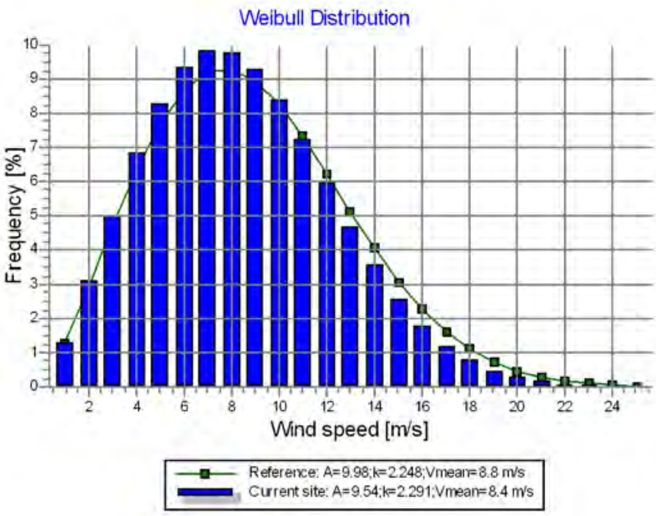
Calculation: GW109Wind data: A - 90m for wasp; Hub height: 50.0

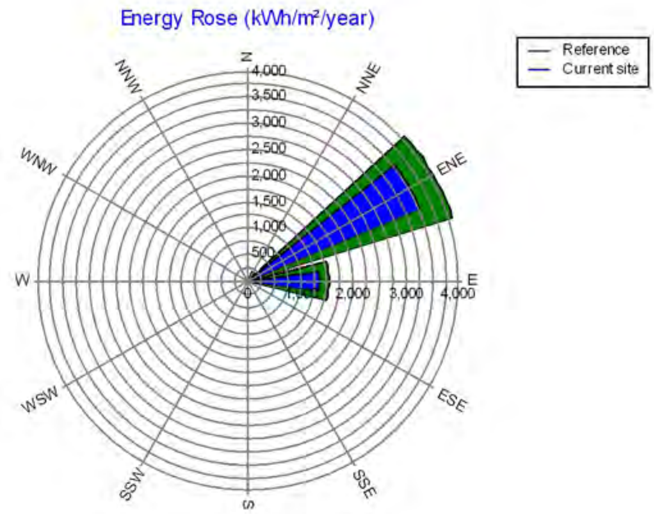
Site coordinates
UTM (south)-WGS84 Zone: 37
East: 237,692 North: 9,835,217

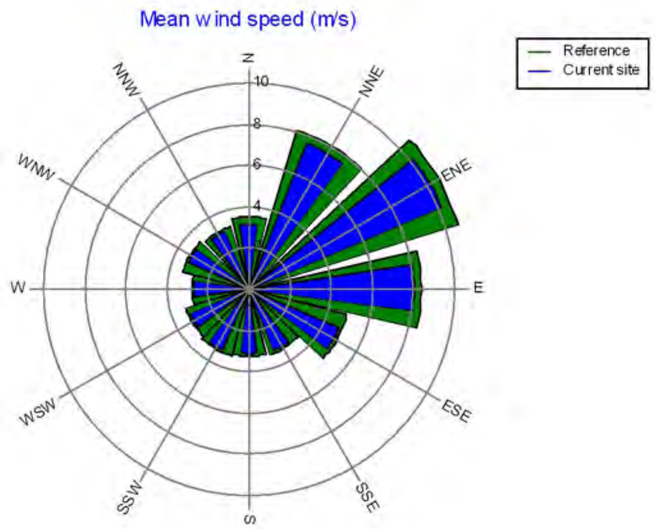
Wind statistics
KE mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m.wws

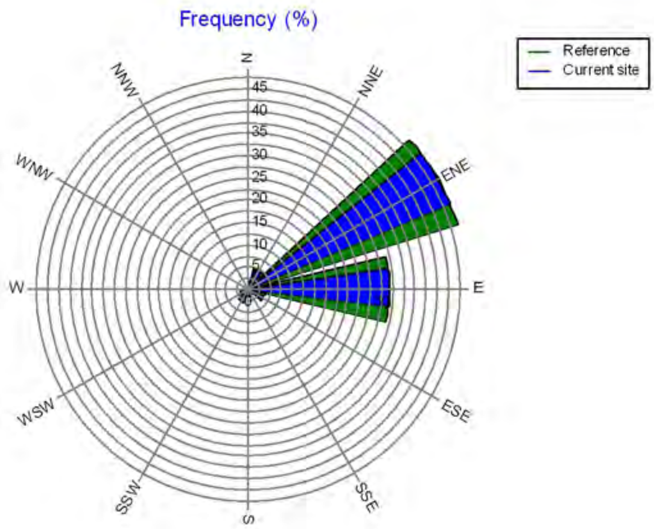
Weibull Data

Sector	Current site A-parameter [m/s]	Current site Wind speed [m/s]	Current site k-parameter	Current site Frequency [%]	Reference: Roughness class 1 A-parameter [m/s]	Reference: Roughness class 1 k-parameter	Reference: Roughness class 1 Frequency [%]
0 N	3.59	3.18	1.908	0.4	3.95	1.630	0.5
1 NNE	8.59	7.62	2.436	4.8	9.06	2.450	4.9
2 ENE	11.38	10.20	3.268	49.2	11.90	3.280	49.3
3 E	9.07	8.04	2.393	31.8	9.48	2.410	31.7
4 ESE	5.37	4.75	2.143	3.9	5.56	2.240	3.8
5 SSE	3.61	3.20	1.979	1.2	3.76	1.990	1.2
6 S	3.52	3.12	2.045	1.6	3.67	2.050	1.6
7 SSW	3.63	3.22	2.459	3.0	3.76	2.440	3.0
8 WSW	3.50	3.10	2.271	1.9	3.63	2.270	1.9
9 W	3.00	2.68	1.631	0.6	3.14	1.660	0.6
10 WNW	3.64	3.22	1.947	0.9	3.77	1.950	0.9
11 NNW	3.40	3.04	1.643	0.6	3.54	1.650	0.6
All	9.54	8.45	2.291	100.0	9.98	2.248	100.0









Project:
ol ndanyat

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Calculated:
2016-6-28 9:47/3.0.619

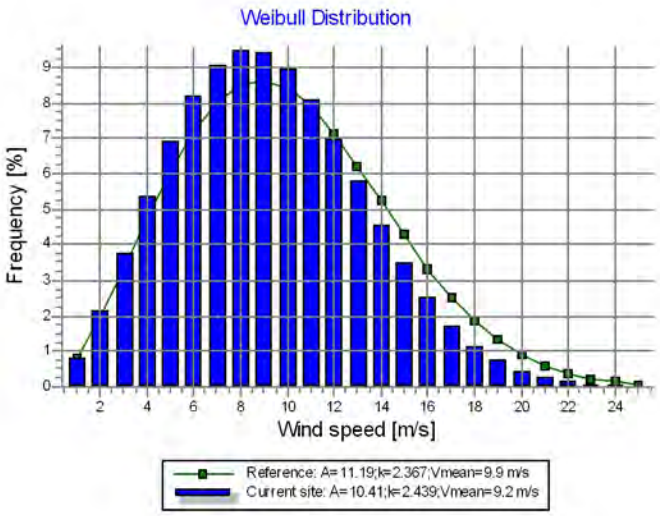
PARK - Wind Data Analysis

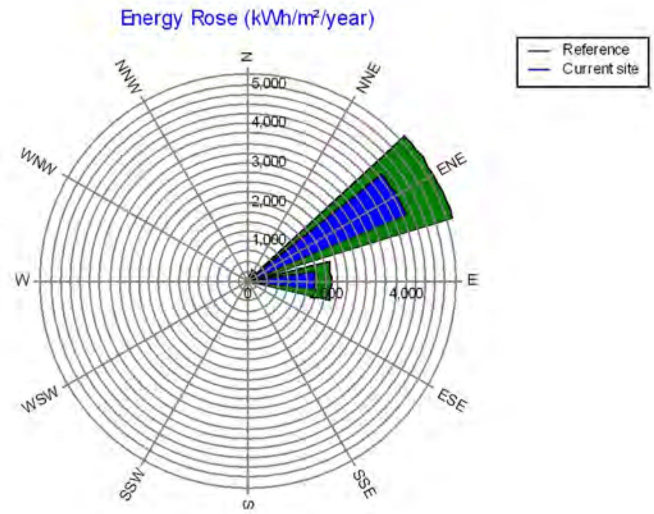
Calculation: GW109Wind data: A - 90m for wasp; Hub height: 90.0

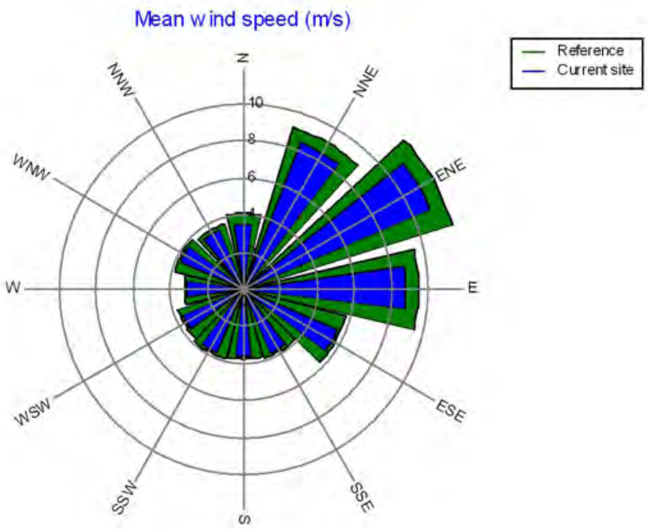
Site coordinates
UTM (south)-WGS84 Zone: 37
East: 237,802 North: 9,838,063
Goldwind 109-2500 2500 109.0 !-! hub: 90.0 m (TOT: 144.5 m) (1)
Wind statistics
KE mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m.wws

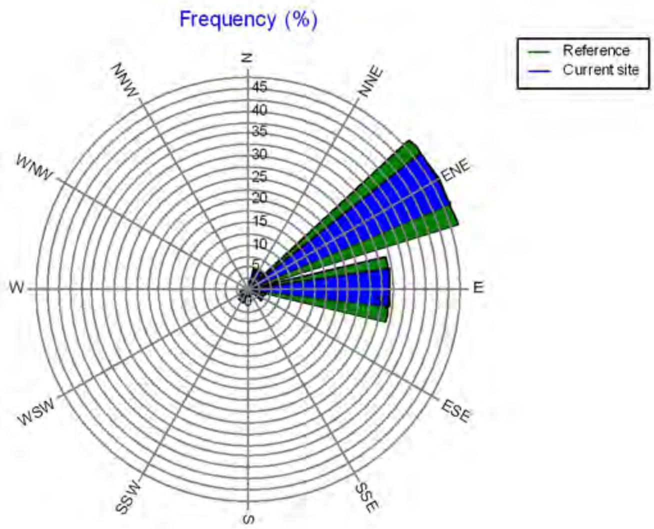
Weibull Data

	Current site				Reference: Roughness class 1		
Sector	A-parameter [m/s]	Wind speed [m/s]	k-parameter	Frequency [%]	A-parameter [m/s]	k-parameter	Frequency [%]
0 N	3.95	3.49	2.162	0.4	4.60	1.715	0.5
1 NNE	9.56	8.49	2.611	4.8	10.28	2.603	4.9
2 ENE	12.27	11.04	3.494	49.2	13.20	3.475	49.3
3 E	9.92	8.81	2.572	31.9	10.68	2.563	31.7
4 ESE	6.26	5.54	2.295	3.9	6.44	2.359	3.8
5 SSE	4.21	3.73	2.119	1.2	4.36	2.100	1.2
6 S	4.09	3.62	2.193	1.6	4.26	2.169	1.6
7 SSW	4.19	3.72	2.631	3.0	4.35	2.576	3.0
8 WSW	4.05	3.59	2.432	1.9	4.21	2.397	1.9
9 W	3.50	3.11	1.740	0.6	3.65	1.753	0.6
10 WNW	4.23	3.75	2.076	0.9	4.38	2.052	0.9
11 NNW	3.87	3.45	1.760	0.6	4.13	1.743	0.6
All	10.41	9.23	2.439	100.0	11.19	2.367	100.0









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Calculated:
2016-6-28 9:47/3.0.619

PARK - Park power curve

Calculation: GW109

Wind speed [m/s]	Power Free WTGs [kW]	Park WTGs [kW]	N [kW]	NNE [kW]	ENE [kW]	E [kW]	ESE [kW]	SSE [kW]	S [kW]	SSW [kW]	WSW [kW]	W [kW]	WNW [kW]	NNW [kW]
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3.5	547	466	178	380	483	479	491	375	202	380	483	479	491	379
4.5	1,608	1,459	840	1,372	1,485	1,480	1,507	1,290	843	1,375	1,484	1,480	1,508	1,303
5.5	3,408	3,138	1,985	2,956	3,187	3,179	3,227	2,820	2,035	2,956	3,187	3,179	3,227	2,841
6.5	5,548	5,154	3,491	4,904	5,224	5,211	5,284	4,686	3,540	4,906	5,223	5,212	5,284	4,719
7.5	8,532	7,938	5,470	7,535	8,045	8,025	8,133	7,243	5,560	7,538	8,045	8,026	8,133	7,275
8.5	12,467	11,607	8,062	11,026	11,761	11,732	11,889	10,612	8,178	11,029	11,760	11,733	11,889	10,658
9.5	17,241	16,174	11,469	15,492	16,369	16,334	16,529	14,898	11,653	15,500	16,368	16,336	16,529	14,947
10.5	21,826	20,922	15,811	20,473	21,100	21,077	21,246	19,670	16,066	20,481	21,100	21,078	21,246	19,696
11.5	26,107	25,495	21,017	25,233	25,637	25,623	25,732	24,474	21,255	25,234	25,637	25,623	25,732	24,516
12.5	29,208	28,859	26,048	28,729	28,942	28,937	28,998	28,254	26,225	28,730	28,942	28,934	28,997	28,253
13.5	29,980	29,912	29,062	29,907	29,934	29,934	29,945	29,751	29,113	29,904	29,935	29,934	29,945	29,724
14.5	30,008	30,016	29,950	30,028	30,016	30,017	30,015	30,011	29,950	30,028	30,016	30,016	30,015	29,999
15.5	30,000	30,000	30,008	30,000	30,000	30,000	30,000	30,002	30,005	30,000	30,000	30,000	30,000	30,001
16.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
17.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
18.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
19.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
20.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
21.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
22.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
23.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
24.5	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Description:
The park power curve is similar to a WTG power curve, meaning that when a given wind speed appears in front of the park with same speed in the entire wind farm area (before influence from the park), the output from the park can be found in the park power curve. Another way to say this: The park power curve includes array losses, but do NOT include terrain given variations in the wind speed over the park area.
Measuring a park power curve is not as simple as measuring a WTG power curve due to the fact that the park power curve depends on the wind direction and that the same wind speed normally will not appear for the entire park area at the same time (only in very flat non-complex terrain). The idea with this version of the park power curve is not to use it for validation based on measurements. This would require at least 2 measurement masts at two sides of the park, unless only a few direction sectors should be tested, AND non complex terrain (normally only useable off shore). Another park power curve version for complex terrain is available in windPRO.

The park power curve can be used for:

1. Forecast systems, based on more rough (approximated) wind data, the park power curve would be an efficient way to make the connection from wind speed (and direction) to power.
2. Construction of duration curves, telling how often a given power output will appear, the park power curve can be used together with the average wind distribution for the Wind farm area in hub height. The average wind distribution can eventually be obtained based on the Weibull parameters for each WTG position. These are found at print menu: >Result to file< in the >Park result< which can be saved to file or copied to clipboard and pasted in Excel.
3. Calculation of wind energy index based on the PARK production (see below).
4. Estimation of the expected PARK production for an existing wind farm based on wind measurements at minimum 2 measurement masts at two sides of wind farm. The masts must be used for obtaining the free wind speed. The free wind speed is used in the simulation of expected energy production with the PARK power curve. This procedure will only work suitable in non complex terrains. For complex terrain another park power curve calculation is available in windPRO (PPV-model).

Note:
From the >Result to file< the >Wind Speeds Inside Wind farm< is also available. These can (e.g. via Excel) be used for extracting the wake induced reductions in measured wind speed.

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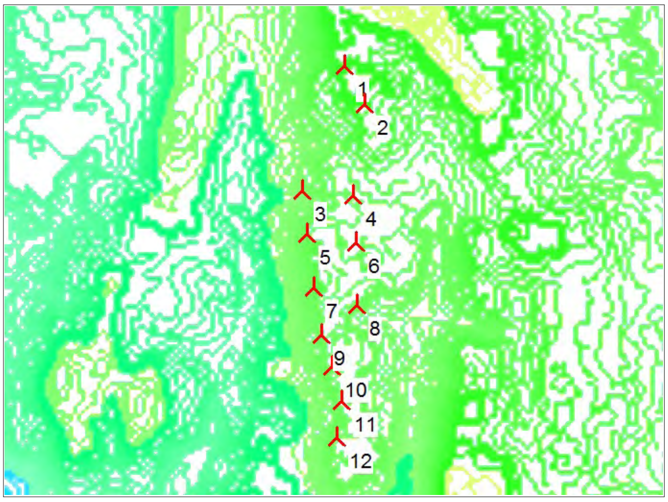
Calculated:
2016-6-28 9:47/3.0.619

PARK - WTG distances

Calculation: GW109

WTG distances

	Z [m]	Nearest WTG	Z [m]	Horizontal distance [m]	Distance in rotor diameters
1	2,000.0	2	1,990.1	434	4.0
2	1,990.1	1	2,000.0	434	4.0
3	1,852.8	5	1,922.7	429	3.9
4	1,910.0	6	1,920.0	467	4.3
5	1,922.7	3	1,852.8	429	3.9
6	1,920.0	4	1,910.0	467	4.3
7	1,924.0	8	1,897.6	466	4.3
8	1,897.6	9	1,901.5	461	4.2
9	1,901.5	10	1,920.0	334	3.1
10	1,920.0	9	1,901.5	334	3.1
11	1,910.0	10	1,920.0	359	3.3
12	1,911.2	11	1,910.0	363	3.3
Min	1,852.8		1,852.8	334	3.1
Max	2,000.0		2,000.0	467	4.3



Scale 1:75,000

New WTG

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Calculated:
2016-6-28 9:47/3.0.619

PARK - Wind statistics info

Calculation: GW109

Main data for wind statistic

File	F:\project\kenya\Ol Ndanyat Project\1.Wind Data\Model\WINDPRO\KE mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m.wws
Name	mast on site(2015.1.1-2015.12.31) - C Synth 90.00 m
Country	Kenya
Source	USER
Mast coordinates	UTM (south)-WGS84 Zone: 37 East: 237,692 North: 9,835,217
Created	2016-6-28
Edited	2016-6-28
Sectors	12
WAsP version	WAsP 10 RVEA0151.dll 1, 5, 5, 0

Additional info for wind statistic

Source data	mast on site(2015.1.1-2015.12.31)
Data from	2015-1-1
Data to	2015-12-31
Measurement length	12.0 Months
Recovery rate	81.0 %
Effective measurement length	9.7 Months

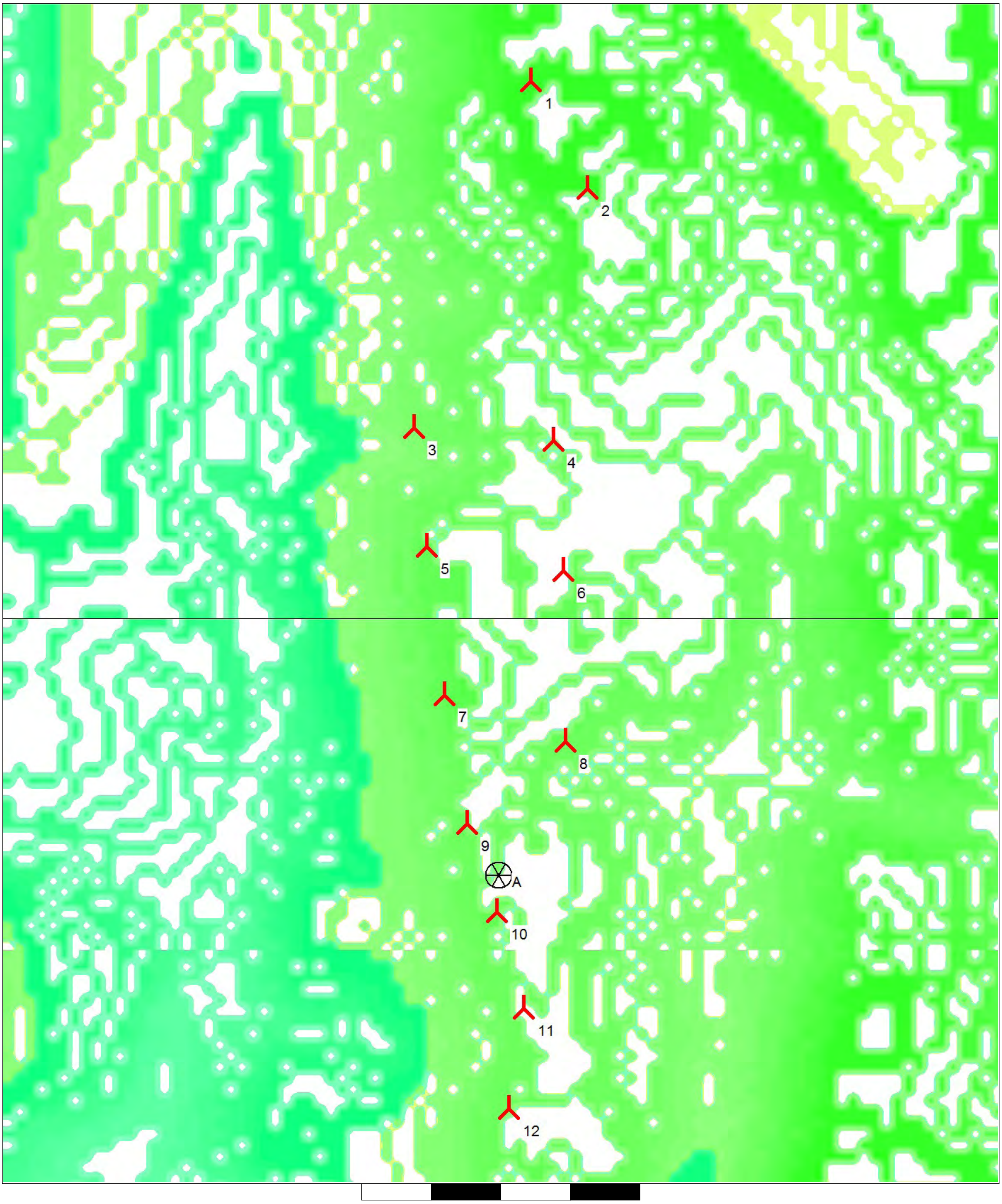
Note

To get the most correct calculation results, wind statistics shall be calculated with the SAME model and model parameters, as currently chosen in calculation. For WAsP versions before 10.0, the model is unchanged, but thereafter more model changes affecting the wind statistic is seen. Likewise WAsP CFD should always use WAsP CFD calculated wind statistics.

Licensed user:
Goldwind International Holdings (HK) Limited
Floor 20, Tower A, Gemdale Plaze 91, Jianguo Road, Chaoyang District
CN-BEIJING 100022
+86 1057672853
tianhailiang / tianhailiang@goldwind.com.cn
Calculated:
2016-6-28 9:47/3.0.619

PARK - Map

Calculation: GW109



Map: Blank map_ScreendumpCopy001 , Print scale 1:20,000, Map center UTM (south)-WGS84 Zone: 37 East: 237,695 North: 9,836,222

New WTG Site Data

DESIGN AND OPERATION

DESIGN CONCEPT

The purpose of this section is to provide the design concept of our proposed plan to establish a wind farm on the proposed site.

GENERAL CONSIDERATIONS

The design concept is based on the following general considerations:

a) The project site is located at an elevation of 1920 meters above sea level.
b) The site is predominantly clear grassland with a few isolated scrub areas, windbreaks and clusters withtrees.
c) The site is placed in the highlands, in Earthquake Zone 2 based on Munich Re Groups Classification, which have a temperate climate with a double rainy season. The temperature varies during the year from 8ºC to 26ºC.
d) The site falls within the flight path for aircrafts landing at the Jomo Kenyatta International Airport and Wilson Airport and therefore careful considerations have to be made to avoid communication interference. In addition, approval by the Kenya Civil Aviation Authority (KCAA) has been obtained before commencement of any development. The approval allows erection of masts up to 100 meters high
e) There is a clear transportation route from the port of Mombasa to site to enable transportation of heavy equipment to site for installation.
f) Wind Turbines need to comply with a “minimum rose distances”, i.e. minimum spacing for turbines within the same row and minimum spacing between turbines with parallel rows perpendicular to the dominant wind direction.
g) The site has an excellent wind energy resource as determined through ongoing measurements which commenced in March 2012 and are ongoing at present. The suitability of the site is also confirmed through studies conducted by Solar and Wind Energy Resource Assessment (SWERA) in the year 2008. Available wind data results between March 2012 and September 2012 are attached in Annex 1
h) The locations selected for the turbines have to take into consideration proximity to properties within the neighborhood.
i) The bulk power supply point closest to the project site is the 66kV Overhead line to Magadi from Nairobi West 220/66 kV Substation. This line is rated at approximately 45MVA. The next closest supply point is the 132kV Kipevu - Juja Road line whose nearest connection point is approximately 30km at Athi River.

WIND RESOURCE ASSESSMENT

KenGen conducted wind measurements in the Ngong hills area between August 2006 and August 2009. A study was conducted in 2007 which confirmed availability of an excellent wind resource for wind energy development as well commercial and technical viability for wind energy generation from the Ngong Hills. Based on the results of t

KenGen embarked on the development of the 5.1MW wind farm on the northern part of the hills which was commissioned in August 2009.

Subsequent preliminary studies and assessment conducted by KenGen estimate that the Ngong Hills forest area alone is capable of supplying approximately 100MW of wind energy to the grid. About 35MW of this capacity can be developed within the northern part of the forest while the remaining 65MW lies within the Corner Baridi side, which is the area where the Ol Ndanyat project is sited.

The preliminary results have revealed that the area is recording an annual average wind speed of approximately 8 m/s which is capable of recording an annual wind farm load factor of approximately 35%.

Ol Ndanyat commenced collection of its wind data in March 2012 and available data available up to September 2012 are attached as Annex 4

DETERMINATION OF WIND FARM CAPACITY

Preliminary results show that a wind farm of about 40 MW can be established within the area of the project site.

In carrying out these estimations, wind turbines have been spaced at regular intervals to allow for a balanced layout that maximizes energy generation by minimizing wake effects and interference between wind turbines. A minimum turbine spacing of 5 rotor diameters in the prevailing wind direction and 3 rotor diameters in the perpendicular direction has been considered.

Wind turbines have also been located in low turbulence areas. Areas with trees have been found to have a potential for generating a considerable amount of turbulence that would significantly undermine the wind turbine power production.

The locations selected for the wind turbines take into consideration proximity to properties, keeping a safe distance of at least 300m from the existing residences.

Due to the fact that the project site is along the flight path, approvals have been sought from KCAA for erection of masts at the site. KCAA has approved erection masts of up to 100 meters which is more than adequate for our purpose.

The wind farm shall consist of medium sized commercially tested and proven wind turbines with a lifetime of about 20 years. The specific model of the wind turbine to be installed shall be determined through a competitive bidding process.

Medium Voltage Collector Network

Power generated from each wind turbine shall be stepped up to 33kV. The step up transformers for each wind turbine shall preferably be dry type installed within the wind turbine or shall be of oil type but installed within burglar proof containers outside of the wind turbines at the foot of the tower of each wind turbine on top of a concrete foundation.

The 33kV output from several wind turbines shall then be collected together to form a single circuit using 33kV Ring Main Units. The number of turbines per circuit shall be determined during the detailed design stage but shall be in accordance with the relevant International Electro-technical Commission (IEC) standard or equivalent.

A 33kV switching substation is to be established for each block to enable connection and disconnection of various circuits as well as connection of the entire block to the grid.

All the cable connections between wind turbines and between wind turbines and switching substations shall be underground, laid at a depth of not less than 1.2metres from the ground level and shall be installed in compliance with all relevant safety regulations in consideration of pastoral requirements of the neighboring communities. The cables shall be laid in manner that will minimize any possible the impact to the environment.

In addition to 33kV power cables to be installed, there shall also be installed control and data cables between turbines and between turbines and the 33kV wind farm switching substations. These cables shall also be laid underground.

Electrical Interconnection

Distance from existing grid – 2.5 km

The bulk power supply point for the region in the existing 66kv over headline which is linked to the wider 66 KV sub-transmission network with Nairobi. The 10MW output of the new wind farm shall be transported through the same line

Each WTG will have a unit generator transformer which shall transform the output of the WTG from the generation voltage to 11KV. The 11KV side of each unit generator transformer shall be connected to the Wind Farm switching substation through a Ring Main Unit (RMU) consisting of a Circuit Breaker and one or two isolators (s). The power generated from the WTGs will be collected to Wind Farm Substation.

All the 11KV cabling will be through appropriately sized underground copper cables. Sizing of the cable shall be realized in accordance to relevant IEC Standards.

The proposed project will supply and install a suitably sized cable, test and commission an 11KV indoor switching substation as shown on drawing No. OLPL/ND/001 and OLPL/ND/002 attached under Annex I/to this document. 11kv copper underground cable will be supplied and installed from 11KV bus-bar of the new Wind Farm substation to the outdoor 11KV Air Break Switch (ABS) of the 11/66KV step-up substation as shown in drawing No. OLPL/ND/001.

The Grid parameters to be applied shall be as per the Kenya Electricity Grid Code which may be freely accessed from http: //www.erc.go.ke/grid.htm. The WTGs and all other farm systems will be designed to withstand electrical faults and any other abnormal operating conditions that may occur in the grid.

Apart from the traditional anti-islanding protection systems such as over-frequency and over-voltage, the WTG shall be equipped with rate of change of frequency and voltage vector shift to ensure reliable islanding detection. This shall be necessary for those WTG capable of limited islanding running due to presence of capacitors and power converters.

All necessary measures shall be taken to ensure for a trouble free operation of the WTGs under the prevailing grid conditions. The power quality of the WTGs shall be such as to ensure their introduction does not compromise grid stability.

Sub-Station Design

See Drawing No. OLPL/ND/002

Interconnecting Equipment

All the power generated from the WTGs to the Wind Farm Substation will be collected through network shown on drawing No. OLPL/ND/001. There will not be more than three (3) WTG interconnected in one circuit.

General Protection

(Over Voltage, under voltage, Over Frequency, Under Frequency, loss of mains)

The generator and the associated low-voltage winding of the step transformer shall be treated as an isolated system to guard against the generator feeding into system earth faults. More detail description of the proposed protection will be submitted.

Generator-transformers protection

The transformer HV side shall be connected to the 11KV Wind Farm Substation through an in-tower 11KV Circuit

Breaker. This breaker will be an integral part of a Ring Main Unit comprising a breaker and one/two isolators. The breaker will be provided with integral over-current, earth fault protection systems to obviate the need for installation of 11KV current transformers.

The transformer will be equipped with oil temperature protection (alarm 1st stage, trip 2nd stage) system. Equally the transformer will be provided with pressure relief device. The oil temperature and pressure relief devices will be provided with auxiliary contacts for alarm and trip purpose.

Generator and Turbine Earthing

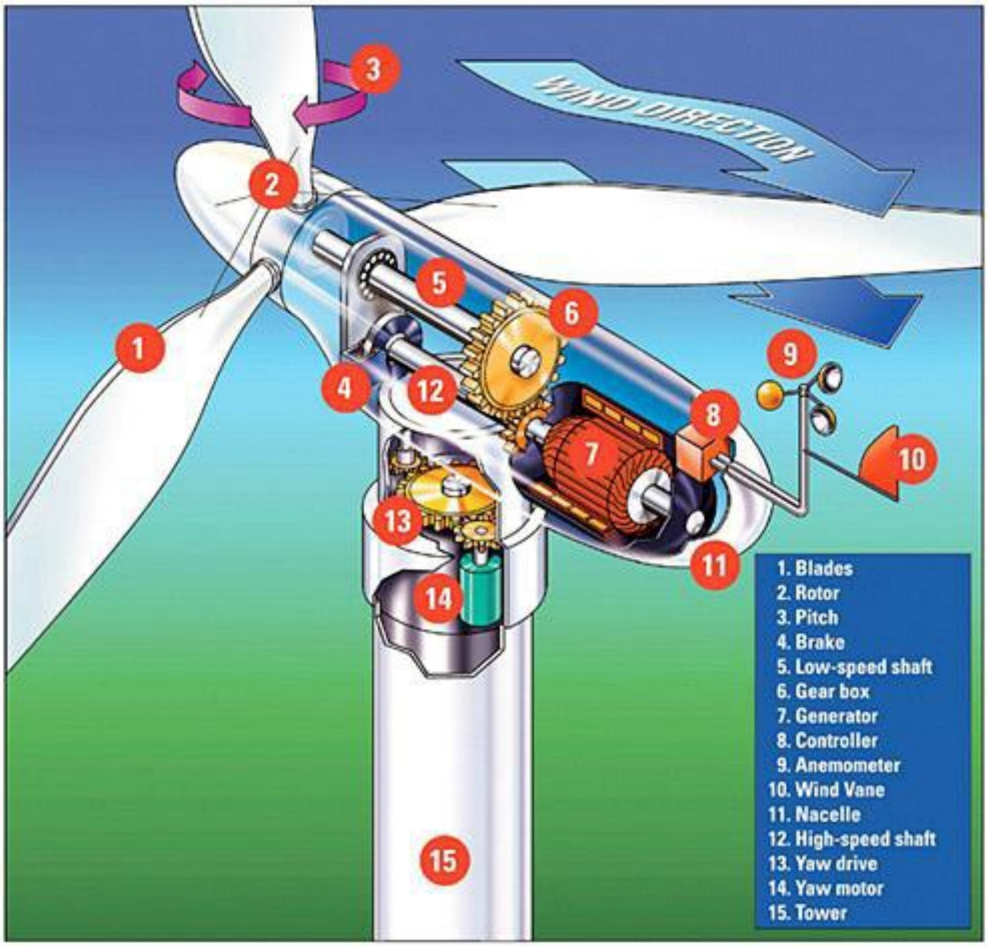
An effective earthing system shall be provided. It shall be so design that in case of any fault, whether inside or out the substation, the voltage to earth of any part that is supposed to earthed shall be within the limits stated by IEC regulations. The measured earth resistance shall not exceed 0.5 Ohm.

The proposed project will prepare design for the earthing system including drawings together with calculations steps, touch potentials within acceptable limits, thereby ensuring safety to the personnel. The design shall be based on the soil specific resistivity at the project site.

DESCRIPTION OF WIND TURBINE GENERATORS

A Wind Turbine Generator (WTG) is a machine that is powered by the energy of wind. It is designed to convert wind energy into more useful forms using rotating of blades. The rotor extracts energy from the wind and converts it into useful electrical energy power.

A wind turbine is made up of two or three rotor attached to the top of a tower. As wind blows it spins the rotor. As the rotor spins the energy of the movement of the propellers gives power to a generator. Because winds are strong up off the ground, wind turbine towers are about 30m tall to allow the rotor to catch more wind energy. The turbines are built with a device that turns the rotor so that it always faces the wind. They move at high speed and energy produced from them has to be stored due to wind inconsistencies. A typical turbine has the following components:-



Ol Ndanyat would prefer to go with a hub height of 100 meters which has already been approved by the KCAA. Other features for the wind turbine to be installed shall be as follows:

Rotor

The turbines have three-bladed rotors with pitch regulation for power output optimization and control. The rotors speed are variable in order to maximize the aero-dynamic efficiency, and speed compliance during power regulation minimizes the dynamic loads on the transmission system.

Blades

The blades are made of fiberglass-reinforced epoxy. The blades are cast in one piece, leaving no weak points at the glue joints and providing optimum quality. The aerodynamic and structural designs have special safety factors.

Rotor Hub

The rotor hub is cast in nodular iron and fitted to the main shaft with a flange connection. The hub is large enough to provide a comfortable working environment inside the structure for two service technicians during maintenance of bolt connections and pitch bearing.

Blade Pitch System

The blade pitch arrangement is used to optimize and regulate power output through the operating range. The blades are feathered to minimize wind loads during standstill under extreme wind conditions.

Main Shaft & Bearing

The main shaft is forged in alloy steel and is hollow for the transfer of power and signals to the blade pitching system. The main shaft is supported by a self-aligning double spherical roller bearing, grease lubricated from an automatic lubrication system. The bearing seals are maintenance-free labyrinth seals.

Gearbox

The gearbox is a three-stage planetary-helical design. The planetary-helical, high-torque stage provides a compact high-performance construction. The intermediary and high-speed stages are normal helical stages arranged with an offset of the high-speed shaft and thus allowing passage of power and control signals to the pitch systems. The gearbox is equipped with large-capacity cooling and filtering systems that ensure optimum operating conditions.

Generator

The generator is a fully enclosed asynchronous machine with squirrel-cage rotor, which does not require slip rings. The generator rotor construction and stator windings are specially designed for high efficiency at partial loads. The generator is internally ventilated and cooled with an air-to-air heat exchanger.

Mechanical Brake

The mechanical brake represents the secondary safety system of the turbine. It is fitted to the gearbox high-speed shaft and has two hydraulic calipers.

Yaw System

The yaw bearing is an externally geared ring with a friction bearing. Eight electric planetary gear motors drive the yawing. The yaw gear motors are fitted with brakes, assisting the passive friction of the bearing for stable maintenance of the yaw position.

Controller

A standard industrial computer is the basis of the turbine controller. The controller is self-diagnosing and includes a keyboard and display for easy status readout and adjustment of settings.

Power Conversion

The power conversion system allows generator operation at variable speed, frequency and voltage while supplying power at constant frequency and voltage to the MV transformer. The power conversion system is a modular arrangement for easy maintenance.

Tower

The turbine is mounted on a tapered steel tower expected to be about 100 m high.

Operation

The wind turbine operates automatically, self-starting when the speed reaches an average speed of 3-5 m/s. During operation below rated power, the pitch angle and rotor speed are continuously adjusted to maximize the aerodynamic efficiency. Rated power is attained at wind speeds of about 13 – 14 m/s, and at high wind speeds the output is regulated at rated power. Speed compliance during power regulation minimizes the dynamic loads on the transmission system. If the maximum wins speed exceeds operational limit of 25 m/s the turbine is shut down for feathering of the blades. When the wind drops below the restart speed, the safety system resets automatically.

Remote Control

The turbine must be equipped with a Supervisory Control and Data Acquisition (SCADA) system. The system offers remote control and a variety of status views and useful reports from a standard internet web browser. The status views present electrical and mechanical data, operation and fault status, meteorological data and grid station data.

Turbine Condition Monitoring

In addition to the SCADA, the turbine should be equipped with a web-based Turbine Condition Monitoring (TCM) system. The TCM carries out precise condition diagnostics the main turbine components continuously and in real time. It gives early warning on possible component failures by continuous comparison of current vibration spectra. The TCM has various alarm levels, from information through alerting level to turbine shutdown.

WIND FARM INFRASTRUCTURE AND ANCILLIARY EQUIPMENT

WIND FARM INSTALLATION EQUIPMENT

Wind Farm installation equipment shall include the following:

a) Lorries weighing approximately 5 tons for delivery of construction sand and cement at site.
b) Grader
c) Water browsers
d) Tippers
e) Self-propelled rollers (10-15tonnes)
f) Low Loaders delivering wind turbine generator components (tower sections, nacelle, blades, hub and electrical switchgear and equipment).
g) Crawler Cranes with lifting capacities of approximately 100 tons for unloading of wind turbine components and cranes with lifting capacities of approximately 350 tons for wind turbine erection works.
h) Cars of approximately 2000 cc-4000 cc used by construction personnel at site.
i) Excavators for all excavations required for access roads, wind turbine foundations, cable trenches and crane hard standings (platforms).
j) Measurement tools including tape measures, Theodolites, GPS maps.
k) Temporary offices and shelter for the Contractor, Consultant and Client during the construction period.

CONSTRUCTION MATERIALS

Local construction materials shall include the following:

- Sand or quarry dust
- Soft soil for backfilling of cable trenches
- Cement
- Roofing materials (stone coated metallic sheets, ceramic tiles)
- Local Quarry stones
- Cables
- Water
- Gravel
- Ceiling Boards
- Wood for internal building fittings

- Steel reinforcement bars and aluminum materials for building fittings

ASSOCIATED FACILITIES & DEVELOPMENT

Apart from the wind farm turbines and power evacuation facilities, the following developments shall also be undertaken by the company:

a) Construction of office facilities to be used for Operations and Maintenance of the wind farm once commissioned. The facilities shall be used for management of the Corner Baridi wind farm. It is estimated that a total of ten (10) technical staff consisting of both Engineers and technicians shall be required for the purpose of operations and maintenance of the wind farm.
b) Ol Ndanyat shall productively engage with the community through Corporate Social Responsibility (CSR) activities specifically those targeting conservation of the forest.

REQUIREMENTS FOR ACCESS ROADS

Route for transportation of wind turbines from the port of Mombasa to site has been investigated by Ol Ndanyat and found to be satisfactory. However, access road from the main road at Corner Baridi to site needs to be improved. Ol Ndanyat's wind farm development plan will include construction of permanent access road. Construction of asphalt road is not foreseen but may be done if found necessary.

The specifications of the access road shall be as follows:

ROUTE SECTION

Half width shall be 6 meters since use of crawler cranes with is foreseen

Leveling must be improved with a compaction quality of more than 97% of the Optimum Proctor. The heaviest weight transported at any one moment shall not be more than 30 tons.

The types of road surface for designing the sub-base shall have to be chosen according to the materials defined by geotechnical investigations. The thickness of the road surface must be at least 35 cm depending on geotechnical data (25 cm for the sub-base and 10 cm for the base).
The recommended slopes are max. 60^0 (1 for 2) for leveled ground and max. 35^0 (3 for 2) for embankments and road surface slopes.

ROAD GEOMETRY-TOP VIEW

Length of straight stretches shall be at least 40 metres. Curvature radii shall be more than 35 metres (except for very special cases to be discussed with turbine manufacturer).

Regarding over-widths applied to curves (the widths are measured from the road axis –half widths) where radii are less than 60 metres (curve joining input tangent IT and output tangent OT). The transition length from the straight stretch to the start of the over-width (Straight-IT) and vice versa (OT-Straight) must be at least 45 metres. Transition curves (clothoids) shall not be used. The transverse banking to be applied to a road type section must not exceed 3% according to the following table.

Radii	Banking
From 30 to 80m	3%
From 80 to 179m	2.5%
From 170 to 400m	2%
From 400 to 1500m	1.5%

ROAD GEOMETRY-LONGITUDINAL

The recommended length between consecutive agreement vertices shall be from 110 to 125metres.

The recommended length of the tangents (input and output) shall be at least from 40 to 50 metres. The recommended value for the complete tangent (from IT to OT) must be at least 80 to 90 metres.

The average regular slopes shall not exceed 8%. In some exceptional cases, they may reach 12% in short sections (less than or equal to 300 metres) or even more if they have an appropriate road surface.

PROJECT IMPLEMENTATION SCHEDULE

Milestones:

- Acquired 55 acres – Wind Farm
- Ministry of Energy Clearance – 30MW
- Topographical Survey Completed
- KCAA Clearance
- Wind Data Logger – Installed
- Tender Document – Complete

Table below shows the proposed implementation plan for the three proposed project component involving Wind Turbine Generation systems for the National Grid

Description	2Q2013	3Q2013	4Q2013	1Q2018	3Q2018	4Q2018	2Q2025	3Q2025	4Q2025
10MWh Phase I									
Tendering (Turnkey)									
Construction									
Commissioning									
20MWh Phase II									
Tendering (Turnkey)									
Construction									
Commissioning									
30MWh Phase III									
Tendering (Turnkey)									
Construction									
Commission									

Gap Analysis & Operating Timelines:

- Feasibility Studies – September 2012
- Environmental Impact Assessment – September 2012
- Technical Report – April 2013
- Project Implementation Report – June 2012
- Power Purchase Agreement – October 2012
- Transfer of Land/Lease – Dec. 2011
- Valuation of Land – Dec. 2012
- Site Office – Feb. 2012
- Borehole – January 2012
- Access Road - January 2013
- Electricity Supply - Nov. 2012

- Geotechnical Survey – Nov. 2012
- Perimeter Wall – Nov. 2012
- Ministry of Energy License of Power Generation – Nov. 2012
- Ministry of Land Physical Planning Act – Nov2012
- County Licenses – Nov. 2012

INDUSTRY ANALYSIS OVERVIEW

Kenya's Vision 2030 is the country's development blueprint covering the period 2005 to 2030. It aims at making Kenya a newly industrialized, middle income country providing high quality of life for all its citizens by the year 2030. It aims to achieve this through an economic development programme aimed at achieving an average Gross Domestic Product (GDP) of 10% per annum over the next 25 years.

All the key growth sectors in Vision 2030 require substantial amounts of energy creating more demand and making the already poor supply situation worse. There is therefore a high and sustainable demand for electricity.

The electricity generation from Renewable Energy will reduce over-reliance on hydropower, which presently contributes 54 per cent. By 2018 hydro-power is expected to contribute 28% in the power mix, while thermal will provide 18%. The effective hydro-power capacity is 728MW of the total 1,342 MW, which players in the sector say does not augur well for supply security due to increased frequency of droughts.

During dry period, hydropower is cut by half to 300MW which has always forced the government to resort to expensive thermal production and imports. The investment in renewable energy sources for electricity is very expensive but the long term benefits are cheaper power rates. The peak demand for the country is 1,200MW against an effective generation capacity of 1,342 MW there is a challenge to meet the peak demand which is already far below the industry standard reserve margin of 15%-20%.

Kenya's electricity mix is dominated by hydro generation (over 50%) and thus highly vulnerable to weather conditions and climate change. The climatic conditions of 1998 - 2000 and 2008 – 2009 curtailed hydropower generation and led to severe energy shortages which culminated into power rationing. This fluctuation in hydropower generation made the country appreciate the linkages between energy, environment and the country's socio-economic development.

The Government has prepared a Medium-Term Plan and the overall program Gives a special emphasis to expanding the access of the rural and urban poor to basic services such as electricity, water and sanitation.

High capital cost and lack of sufficient wind regime data are some of the barriers affecting the exploitation of wind energy resource. Moreover, potential areas for wind energy generation are far away from the grid and load centres requiring high capital investment for the transmission lines.

GOVERNMENT FEED-IN-TARIFF POLICY

In 2008, the Government of Kenya started the implementation of the feed-in-tariff (FIT) scheme in order to accelerate the expansion of the renewable energy power generation within the country. The types of energy sources covered by the scheme included hydro, wind and biomass. Power purchase agreements were set up with pre-determined prices for each of the energy sources for a specified installed capacity and over a time span of 15 years.

Two years later, in January 2012, the FIT scheme was revised to include more energy sources. The terms of the power purchase agreements were modified, with the timespan of the contracts lengthened to 20 years and the prices offered were increased as shown in the table below.

	Wind	Hydro	Biomass	Solar	Geothermal
2008 Feed-in tariff	Maximum of USD 0.09 per kWh up to 50 MW capacity	Maximum of USD 0.06 to 0.12 per kWh for 0.05 MW to 10 MW capacity	Maximum of USD 0.045 to 0.07 up to 40 MW capacity	-	-
2010 Feed-in tariff	Maximum of USD 0.12 per kWh for 0.5 to 100 MW capacity	Maximum of USD 0.06 to 0.12 per kWh for 0.5 MW to 10 MW capacity	Maximum of USD 0.06 to 0.08 per kWh for 0.5 to 100 MW capacity	Maximum of USD 0.20 per kWh for 0.5 to 10 MW capacity	Maximum of USD 0.085 per kWh up to 70 MW capacity

The feed-in-tariff is expected to bring additional benefits to Kenya, including energy poverty reduction and job creation. The FIT will encourage an estimated additional energy generation capacity of 1,300 MW. This represents a significant increase in Kenya's energy generation capabilities, more than doubling the present capacity of around 1,100 MW. Increased investment in renewable energy will also mean an increase in jobs as the local population will be given employment opportunities at all stages of electricity generation, from the power plant construction and grid connection to operations and maintenance.

ELECTRICITY DEMAND DRIVERS:

Electricity is required in the following sector:- manufacturing, key agro-processing, to develop special economic clusters and Small and Medium Enterprise (SME) Industrial parks for operating equipment and machinery, lighting, cooking, refrigeration, transportation, water pumping for irrigation etc.

Vision 2030 also envisages increased access to social services. This quest for social transformation is targeted at eight key sectors, namely:- Education and Training, Health, Water and Sanitation, Environment, Housing and Urbanization, Gender, Youth and Vulnerable Groups, Equity and Poverty Elimination, and Science, Technology and Innovation. Provision of good education requires provision of adequate and appropriate energy for lighting and cooking in all educational institutions such as schools and colleges around the country.

All key growth sectors in Vision 2030 require substantial amounts of energy creating more demand and making the already poor supply situation worse. There is therefore a high and sustainable demand growth for electricity.

ELECTRICITY DEMAND

There is a strong electricity demand growth in Kenya that is being driven by a combination of normal economic growth, increased connection rate by KPLC and enhanced rural electrification programme in an effort by the Government to achieve its electricity access target of 40% by year 2020.

Based on Vision 2030 development plans and econometric modelling applied in the LCPDP demand forecast for a 20 year period, in line with Vision 2030, is shown below:

Fiscal Year ending 30th June	Net Power Demand Peak (MW)	Net Energy Demand (GWh)
2008/09	1,188	7,032
2009/10	1,334	7,889
2010/11	1,481	8,748
2011/12	1,672	9,867
2012/13	1,838	10,844
2013/14	2,029	11,963
2014/15	2,242	13,210
2015/16	2,487	14,648
2016/17	2,767	16,284
2017/18	3,066	18,033
2018/19	3,401	19,996
2019/20	3,774	22,178
2020/21	4,188	24,601
2021/22	4,647	27,289
2022/23	5,151	30,233
2023/24	5,706	33,479
2024/25	6,318	37,062
2025/26	6,995	41,017
2026/27	7,742	45,385
2027/28	8,568	50.211
2028/29	9,480	55,544
2029/30	10,489	61,440

Adapted from Ministry of Energy

SWOT ANALYSIS

Strengths

- Wind Energy
- Clean Renewable
- No GHG
- No fossil fuel
- Eco – Culture farming - grazing can be carried on the wind farm Project.
- Training and add value to the economy
- Very high demand
- Government Policy Encouragements as in Feed-in-Tariff
- The Wind Farm is located only 4km from the grid transmission point.

Weaknesses

- Investment costs for the plant
- The Operation and maintenance (O&M) cost
- Financial costs and return on the invested capital
- Estimated lifetime of the power plant
- Amount of electricity to be generated
- High cost and lack of sufficient wind regime data
- Interest on the capital
- Quota for Wind Energy Feed-in-Tariff being exhausted
- Investors and Management team have no previous experience in power generation and contractual agreement

Opportunities

- Technical Training
- Job creation in operational and maintenance
- Saving on cost of importing fossil fuel
- Low cost of electricity
- Economic benefit
- Clear energy for women and children who use firewood, charcoal and kerosene which leads to disproportionate vulnerability to associated indoor pollution.

Threats – are the following but the Kenya Government Policy has allocated Feed-in-Tariff quota for each section.

- Biogas
- Geothermal
- Hydropower
- Solar Energy
- Bio fuel
- Biomass

MONITORING, CONTROL AND EVALUATION

The proposed project shall supply a Remote Control and Monitoring System (RCMS) for the centralized supervision of the operation and acquisition of operation data from the individual WTGS and the meteorological monitoring mast. The system shall be installed in the control room at the wind farm substation and control building and shall consist of:-

- Computer terminals
- Remote control and monitoring software
- All necessary cabling
- Transmission equipment (modem, transmitter/receiver system etc.)
- Hardware & software to interconnect with remote dispatch centre
- Hardware & software to allow access to the system
- Printer

The RCMS (including cables) shall be protected against over voltage, lighting and static discharges. Preference shall be given to the use of fibre optic cables. Underground cables shall be used and the cables and their connecting items shall be protected against water and harsh weather conditions.

The control cable will – where possible – be laid in parallel to the 11kv cables, but shall be well protected against the bad influence of these cables. A back-up system

(U.P.S. uninterrupted power supply) shall be supplied and installed to ensure normal operation of the system for a period of at least 30 minutes to avoid the loss of data.

In case the RCMS fails, the operation of the individual turbines will not be disturbed. The system shall be able to distinguish between communication error and turbine error. The remote control function shall be protected against unauthorized access.

The following functions will be enabled by the remote control system:-

a. Start and stop of individual WTG and complete wind farm (normal and emergency).
b. Yawing individual (both clockwise and counter clockwise)
c. Pitching individual WTG
d. Reset of individual WTG and complete wind farm
e. Change of the parameters (to be enabled after end of warranty period). The final control parameters shall be supplied after the final taking over.

SUPERVISORY CONTROL & DATA ACQUISITION (SCADA)

The new wind farm will be equipped with a SCADA system to enable Remote Monitoring and Control of the wind farm from the local control room as well as from a remote location.

OPERATIONAL PLAN

The Proposed Project is an E.P.C. and O&M which will be in five year periods i.e. 2013 to June 2018.

The overall scope of works under the project includes the following:-

- Design, supply, installation, testing and commissioning of a grid connected wind farm with capacity of approximately 10MW consisting of:
- WTG with total installed capacity of 10MW – The first 2 years.
- Electrical collector network with an 11 KV wind farm switching substation.
- The connection to the National Grid point - 2km from the Wind Farm
- Monitoring Control and Evaluation
- Improvement of the existing main road and construction of new access roads to the turbines and tothe substations. This will ensure smooth access during construction through to the maintenance phase.
- The Tender Documents have a clause where manufacturer's warranty, guaranty and performance guarantee are addressed in details.
- Training of OL-Ndanyat's maintenance personnel to equip them with adequate knowledge and skills for trouble free maintenance of the turbines beyond warranty period. The personnel shall be instructed in all aspects of plant design, manufacture and operation and maintenance of the works as detailed.

ENVIRONMENTAL IMPACT ASSESSMENT

The company has already undertaken a comprehensive Environmental Impact Assessment leading to being granted a license to undertake the project by National Environmental Management Authority. The salient aspects to be looked into during implementation and later during the operational life of the project are summarized below, while the NEMA certificate is attached in the Annexes.

Environmental/Social Aspect	Parameter	Mitigation/Management Measures	Monitoring Method	Monitoring Frequency	Responsibility
CONSTRUCTION PHASE					
Legal Compliance	Applicable legislation and standards	Review of all applicable legislation as presented in this document and ensure compliance	No. of valid licenses. No. of non-compliances records	As necessary	OL-Ndanyat/ Contractor
Air Emission	Dust Vehicular Movement. Use of generators (if applicable)	Wetting of the road. Reduced traffic movement. Installation of speed limit. Emission of toxic gases	Visual inspection. No. of road wetting time. No. of complaints. Traffic Volume and survey. Air borne particles . Air dispersion and pollution monitoring from generators	Entire project implementa-tion period	Contractor
Noise and Vibration	Occupational and ambient noise	Reduce night time noise level. Reduce vehicular movement. Reduce occupational exposure by providing earmuffs.	Measurement in dB in specific impact areas for occupational and ambient levels (nearest receptor)	Daily	Contractor
Solid waste Management	Site office waste. Construction debris	Develop a solid waste management plan. Contract a licensed solid waste transporter. Recycle, reuse or sale.	Type and volume of wastes. Storage and disposal methods. Assessment of compliance with local council by-laws	Daily	Contractor
Environmental/Social aspects	**parameter**	**Mitigation/management measures**	**Monitoring method**	**Monitoring Frequency**	**Responsibility**
	Oil and grease hardness	Reduce the amount of wastewater through water conservation and recycling.	Effluent monitoring and analysis. Rate of water consumption.	Daily	Contractor/OL-Ndanyat

Water Management/ Quality	Water quantity Sewage disposal.	Appropriate disposal of waste water after treatment. Construction of septic tanks/soak pits to contain sewage waste. No impact is expected on surface water resources.			
Energy Consumption	Units/day (from grid) or fuel consumption from generators.	Use energy efficient equipments. Reduce fuel consumption by doing group of activities together.	Units consumed or specific fuel consumption/day.	Daily	Contractor
Soil pollution and erosion	Develop from vehicles, gensets.	Oil spills prevention Interventions to prevent soil contamination	Measure soil element component visual inspection.	Daily	Contractors
	Erosion	Develop a soil erosion control plan. Re-grass and restore site to original condition.	Visual inspection site recovery soil erosion prevention initiatives.	As necessary	Contractor

Environmental/Social aspect	Parameter	Mitigation/management measures	Monitoring method	Monitoring frequency	Responsibility
Occupational health & safety	Number of accidents/incidents during construction. Public safety and complaints. Livestock safety. Road safety. Fire preparedness.	Establish a site clinic and provide a first aid kit. Establish a fire response plans in liaison with KFS. Safety awareness to all workers. Install safety signs for workers and public in English and Kiswahili especially along the access roads in and out of the forest reserve. Constitute a safety committee to do safety inspections and audit.	No. of incidences/accidents Number of safety inspections Number of incidences, Number safety complaints.	Daily	Contractor/OL-Ndanyat

		Develop emergency response plans. Enforce use of PPE.			
Security	Vandalism Theft	Procure security services. Fence off storage and work areas. Establish contacts with local administration and KFS.	Number of incidences. Safety measures installed.	Regularly	Contractor
Grazing Management	Access to grazing areas	Ensure KFS establishes and communicates grazing plans to contractor. Safety sign and fencing off work areas.	Number complaints livestock accessing site in as per the management plan.	regularly	KFS/Contractor
Environmental/Social aspect	**Parameter**	**Mitigation/management measures**	**Monitoring method**	**Monitoring frequency**	**Responsibility**
Tourist/Visitors	Access to hill top	Provide safe pathways to the hilltop. Prevent vehicular access for safety.	Number of complaints. Number of persons accessing site/day	Daily	Contractor/ KFS/KWS
Archeological historical artifacts found during excavation	Relics/historic al artifacts found during excavation.	Place and date of findings. Storage and information the National Museums of Kenya.	Number of historical artifacts found.	When necessary	Contractor/ OL-Ndanyat/ National Museums of Kenya.
Conflicts	Access to project land with squatters	Report to KFS and local administration for resolution.	Type and number of conflicts.	Where applicable.	Contractor/ OL- Ndanyat/ Museum.
Flora & Fauna	Disturbance of wildlife and vegetation outside the project site.	Inform KWS or KFS of any wildlife loss or incidences related to the project. Restrain form getting fuel wood and timber from the vegetated part of the forest.	Wildlife incidences associated with the project.	As necessary	Contractor/ KWS
Chemical Management	Amount/ volume Handling and storage waste disposal	Develop proper chemical and oil storage facilities.	No. of spill/incidences visual inspection.	Monthly	Contractor

		Develop spill and waste disposal response plan.			
OPERATION PHASE					
Civil aviation and aircraft navigation safety	Aviation warning lights Markings.	Maintain aviation warning life and report failure to KCAA and OL-Ndanyat immediately. Ensure recommended aviation warning colors do not fade.	Multi-gas detectors	24 hours/ continuous.	OL-Ndanyat/ KCAA.
Environmental/Social Aspect	**Parameter**	**Mitigation/Manage-ment Measures**	**Monitoring Method**	**Monitoring Frequency**	**Responsibility**
Avian Population (birds)	Species and types e.g. preying, small birds, migratory. Death	Install bird scare on the tower to scare off the birds from perching.	Monitor bird mortality associated with turbines.	Daily	OL-Ndanyat /Kenya National Museums
Noise	Turbine noise	Installation of low noise turbines. Installation of turbines away from residential units.	Periodic measurement of noise at various receptors	Monthly	OL-Ndanyat
Waste oil Management	Handling & spillage during Maintenance	Removal and disposal of waste oil from site after maintenance. In-site treatment of contaminated soil. No storage of oil on site. Develop management procedure under EMS ISO 14001.	Volume of waste oil generated per month. Visual inspection of soil contamination	After every maintenance and auditing	OL-Ndanyat/ NEMA
Solid waste Management	Maintenance waste Domestic waste from site attendant	Storage of maintenance wastes together with other OL-Ndanyat scrap metals awaiting disposal. Re-use	Monitor volume of and handling procedures. Recycling of spare parts.	Regularly	OL-Ndanyat

		where necessary. Storage of domestic garbage in bins and disposal in designated offsite landfills. Develop management procedure under EMS ISO 14001.	Conservation of resources Dumpsite inspection.		
Environmental/Social Aspect	**Parameter**	**Mitigation/Management Measures**	**Monitoring Method**	**Monitoring Frequency**	**Responsibility**
Natural habitat	Flora Fauna	Rehabilitation and maintain open sites. Restrains of employees from destruction of vegetation and attacking wild animals.	Site housekeeping status. Complaints from KWS and KFS	As necessary	OL-Ndanyat/ KWS/KFS
Health and Safety	Safety manuals Accident and incident monitoring. EHS audits Servicing of fire appliances	Proper equipment maintenance to guard against blade throw, turbines fires etc. Provide hand held fire extinguisher on site. Provide safety clothing to all workers. Keep accident records. Staff training on safety issues , conduct EHS audits on quarterly basis, Establish a safety committee	No of incidences and fire equipment service. No. of fire drills . No. of incidences/accidents Records of training. No. of non-conformances	Regularly as necessary	OL-Ndanyat /ERC/NEMA
Security	Vandalism Theft	Employ day and night guards. Fence off individual turbines	Number of incidences	As necessary	OL-Ndanyat/KFS
Tourists/ Visitors	Access to hilltop for recreation and sporting	Ensure ease of access and safety of visitors/tourists to site. Promote learning about wind turbines	Number of visitors/tourists accessing site.	Daily	KWS
Grazing	Access to grazing site	Fencing of the turbine area only and not the entire project site to allow access to livestock	Ease of access to site through regular observation	Yearly	OL-Ndanyat/KFS

Environmental/Social Aspect	Parameter	Mitigation/Management Measures	Monitoring Method	Monitoring Frequency	Responsibility
Other Social Concerns	Complaints interaction with stakeholders. Corporate social responsibilities	Keep records of community complaints. Identify corporate social responsibility	No. of complaints in a month. No. of corporate social responsibility	As necessary	OL-Ndanyat
DECOMMISSIONING PHASE					
Safety	Vehicular movement and public safety. Workers safety. Visitors and tourist safety.	Provide adequate warning signs during decommissioning. Provide PPE to workers. Re-route visitors track if necessary	Number of incidences	Daily	OL- Ndanyat/ Contractor
Solid Wastes	Wind turbines and other wastes	Develop transport Storage and disposal plans of all the parts. Sale as scrap.	Type and disposal method	As necessary	OL-Ndanyat/ Contractor
Noise	Vehicular movement. Dismantling of equipment	Reduce decommissioning time. Decommission at daytime. Provide workers with earmuffs,	Duration and noise levels. Prevention initiatives	Daily	Contractor
Dust	Vehicular movement and removal of equipments	Wet as necessary. Reduce speed	Number of road wettings. Visual inspection	Daily	Contractor
Soil Erosion, Site Rehabilitation and closure	Site vulnerability status. Soil erosion type. Rehabilitation and stabilization.	Develop and implement soil erosion control plan. Rehabilitate and re-vegetate as recommended by KFS. Monitor site stabilization and housekeeping.	Soil loss control Site restoration	After all equipments and fences have been removed from site	OL-Ndanyat/ Contractor/KFS

CAPITAL COST ESTIMATE

Estimated total capital costs of the project are US$130.89, as is summarized in the table below;

SOURCES AND USES OF FUNDS

OL-NDANYAT
Sources & Applications of Funds

Investments ('000'000)			
	Owners		
	Common Shares Sold		
	Par Value (USD)	$4,000,000.00	
	Sub-Total Shareholder Investment ('000'000)	**$4.00**	
	External Investors - Private Placement		
	Land (Acres)	55.00	
	Value/Acre (USD)	$265,000.00	
	Sub-Total Investor Funds ('000'000)	**$14.58**	
	Total Investments ('000'000)	**$18.58**	13.75%
Borrowing/Debt ('000'000)			
	Commercial Loan (10 Years @ 8.5%) - TAGA FZ	$68.08	
	Short-term Debt	$-	
	Total Borrowed Funds ('000'000)	**$68.08**	50.41%
Other Sources			
	Local Facility - Credit Line	$11.90	
	Income from Debt Service - Long	$33.33	
	Income from Debt Service - Short	$3.16	
	Total Other Sources ('000'000)	**$48.39**	35.83%
Total Investments and Loans		**$86.66**	64.17%
Total Project Cost		**$135.05**	100.00%

OL-NDANYAT
Sources & Applications of Funds

Uses of Funds
Assets

Development Costs ('000'000)				
	Start-Up Expenses	$4.00		
	Project Land/Site	$14.58		
	Total Development Costs ('000'000)	**$18.58**	13.75 %	
Construction (EPC) Costs ('000'000)				
	TURBINES (WTG)			
	12 x Goldwind GW109-2500 WTG (2,500kW), including freight and transport (China to Kenya)	$33.63		
	Sub-Total WTG Cost	**$33.63**		
	Total WTG Cost	**$33.63**	24.90 %	
	ELECTRICAL WORKS			
	66kV Transmission Line	$0.96		
	WF Sub-station	$-		
	66kV Equipment	$2.30		
	Protection, Control and Telemetry	$1.42		
	Collector switchgear	$0.53		
	Reactive compensation	$2.11		
	Colletor network cable trenching	$0.95		
	Cable collector network and WTG transformers	$2.69		
	Sub-Total Electrical Works ('000'000)	**$10.96**		
	Add: 5% Contingency on Electrical Works	**$0.55**		
	Total Electrical Works ('000'000)	**$11.50**	8.52 %	
	CIVIL & OTHER WORKS			
	Preliminary & General	$2.00		
	Civil Engineering and design	$0.32		
	Shared Contractor facilities	$0.92		
	Occupational Health and Safety	$0.28		
	Environmental Management	$0.36		
	Detailed Ground (Geotechnical) Investigation	$0.28		
	Total Land Mass Concrete Foundations	$5.01		
	New On-Site Roads	$2.87		
	Existing Road Upgrades	$1.97		
	Hard Standings	$0.36		
	Provision for Construction Water	$0.07		

	Reconstruction and Maintenance	$0.24	
	Meteorological Mast	$0.20	
	Sub-station Civils and Facility Buildings	$3.04	
	Sub-Total Civil & Other Expenses ('000'000)	**$17.92**	
	Add: 5% Contingency on Civil Works	**$0.90**	
	Total Civil & Other Expenses ('000'000)	**$18.81**	13.93 %
	Management Cost		
	Add: Management Cost	$1.83	
	Sub-Total Management Costs	**$1.83**	
	Total Civil + Management Costs	**$20.64**	15.29 %
	Total Construction/EPC Costs	**$65.78**	48.71 %
	Total Development & Construction Costs	**$84.35**	62.46 %
Finance Costs ('000'000)			
	Withholding Taxes (2 years @ 15%)	$-	
	Cost of Finance (8.5% on Long-term debt)	$33.33	
	Cost of Finance (16% on Short-Term debt)	$3.16	
	Legal & Other Fees @ 1% of Investment + VAT	$0.66	
	Finance Procurement fees @ 2.5% of Investment + VAT	$1.64	
	Sub-Total Finance Procurement Expenses ('000'000)	**$38.79**	
	Total Finance Procurement Expenses ('000'000)	**$38.79**	28.73 %
Working Capital - ('000'000)			
	Administrative Costs (2 Years inc. Insurance)	$5.00	
	Accumulated VAT on WTG Equipment	$-	
	Accumulated VAT on Electrical Works	$1.84	
	Accumulated VAT on Civil Works	$3.30	
	Other Taxes (import Duty, Customs Duty, IDF, RL)	$0.76	
	Other Costs (2 Years)	$1.00	
	Total Working Capital Reserves	**$11.90**	8.81 %
TOTAL APPLICATIONS OF FUNDS ('000'000)		**$135.05**	100.00%

EPC COSTS

Total indicative EPC costs are as follows;

Construction (EPC) Costs ('000'000)			
	TURBINES (WTG)		
	12 x Goldwind GW109-2500 WTG (2,500kW), including freight and transport (China to Kenya)	$33.63	
	Sub-Total WTG Cost	**$33.63**	
	Total WTG Cost	**$33.63**	51.13%
	ELECTRICAL WORKS		
	66kV Transmission Line	$0.96	
	WF Sub-station	$-	
	66kV Equipment	$2.30	
	Protection, Control and Telemetry	$1.42	
	Collector switchgear	$0.53	
	Reactive compensation	$2.11	
	Colletor network cable trenching	$0.95	
	Cable collector network and WTG transformers	$2.69	
	Sub-Total Electrical Works ('000'000)	**$10.96**	
	Add: 5% Contingency on Electrical Works	**$0.55**	
	Total Electrical Works ('000'000)	**$11.50**	17.49%
	CIVIL & OTHER WORKS		
	Preliminary & General	$2.00	
	Civil Engineering and design	$0.32	
	Shared Contractor facilities	$0.92	
	Occupational Health and Safety	$0.28	
	Environmental Management	$0.36	
	Detailed Ground (Geotechnical) Investigation	$0.28	
	Total Land Mass Concrete Foundations	$5.01	
	New On-Site Roads	$2.87	
	Existing Road Upgrades	$1.97	
	Hard Standings	$0.36	
	Provision for Construction Water	$0.07	
	Reconstruction and Maintenance	$0.24	
	Meteorological Mast	$0.20	
	Sub-station Civils and Facility Buildings	$3.04	
	Sub-Total Civil & Other Expenses ('000'000)	**$17.92**	
	Add: 5% Contingency on Civil Works	**$0.90**	
	Total Civil & Other Expenses ('000'000)	**$18.81**	28.60%

Management Cost		
Add: Management Cost	$1.83	
Sub-Total Management Costs	**$1.83**	
Total Civil + Management Costs	**$20.64**	31.38%
Total Construction/EPC Costs	**$65.78**	100.00 %

OTHER COSTS

Finance costs are as follows;

Finance Costs ('000'000)		
	Withholding Taxes (2 years @ 15%)	$-
	Cost of Finance (8.5% on Long-term debt)	$33.33
	Cost of Finance (16% on Short-Term debt)	$3.16
	Legal & Other Fees @ 1% of Investment + VAT	$0.66
	Finance Procurement fees @ 2.5% of Investment + VAT	$1.64
	Sub-Total Finance Procurement Expenses ('000'000)	**$38.79**
	Total Finance Procurement Expenses ('000'000)	**$38.79**

Working capital will be required to cover key business expenses during the construction period as follows;

Working Capital - ('000'000)		
	Administrative Costs (2 Years inc. Insurance)	$5.00
	Accumulated VAT on WTG Equipment	$-
	Accumulated VAT on Electrical Works	$1.84
	Accumulated VAT on Civil Works	$3.30
	Other Taxes (import Duty, Customs Duty, IDF, RL)	$0.76
	Other Costs (2 Years)	$1.00
	Total Working Capital Reserves	**$11.90**

OWNER COSTS

The owners have facilitated the development costs of the project as follows;

Development Costs ('000'000)		
	Start-Up Expenses	$4.00
	Project Land/Site	$14.58
	Total Development Costs ('000'000)	**$18.58**

OPERATING COSTS

INITIAL OPERATING COST ESTIMATES

The project will attract business operational expenses throughout its operations cycle, this includes during the construction, testing and sales periods.

Operating costs during construction are as follows;

Working Capital - ('000'000)		
	Administrative Costs (2 Years inc. Insurance)	$5.00
	Accumulated VAT on WTG Equipment	$-
	Accumulated VAT on Electrical Works	$1.84
	Accumulated VAT on Civil Works	$3.30
	Other Taxes (import Duty, Customs Duty, IDF, RL)	$0.76
	Other Costs (2 Years)	$1.00
	Total Working Capital Reserves	**$11.90**

OPERATION & MAINTENANCE COSTS

The management will engage the services of a professional project management company to maintain and operate its power production facilities at an estimated cost of 2% of the EPC cost or US$ 1.32 Million (estimate). Total O&M costs for the first 10 years are estimated at US$ 13.2.

GENERAL AND ADMINISTRATION COSTS

The average GA costs during the 20 Year operations tenure of the project is US$7.79 p.a. inclusive of O&M, depreciation, insurance and relevant operational taxes. This represents an average GA margin of 51.93% over sales.

FINANCIAL EVALUATION

BASE CASE MODEL

The financial model is based upon the following information;

- The project is currently in talks with prospective financiers and thus indicative financial costs have been communicated to the project
- EPC based technical input and output data
- EPC based Bill of Quantities (indicative)
- Project advised information including studies, proposals and other technical information provided by the owners
- Wind Power industry capital and operating costs

In this model, certain factors privy to this type of project have been accounted for including a 10 year income tax holiday, as well as other charges including impact of taxation to various aspects of the model. Power sales are regulated by the PPA and the price of energy sold is fixed to the issued fit tariffs.

The Base Case Net Present Value (NPV) is sensitive to wind power output, operating costs and capital costs.

Base Case Scenario

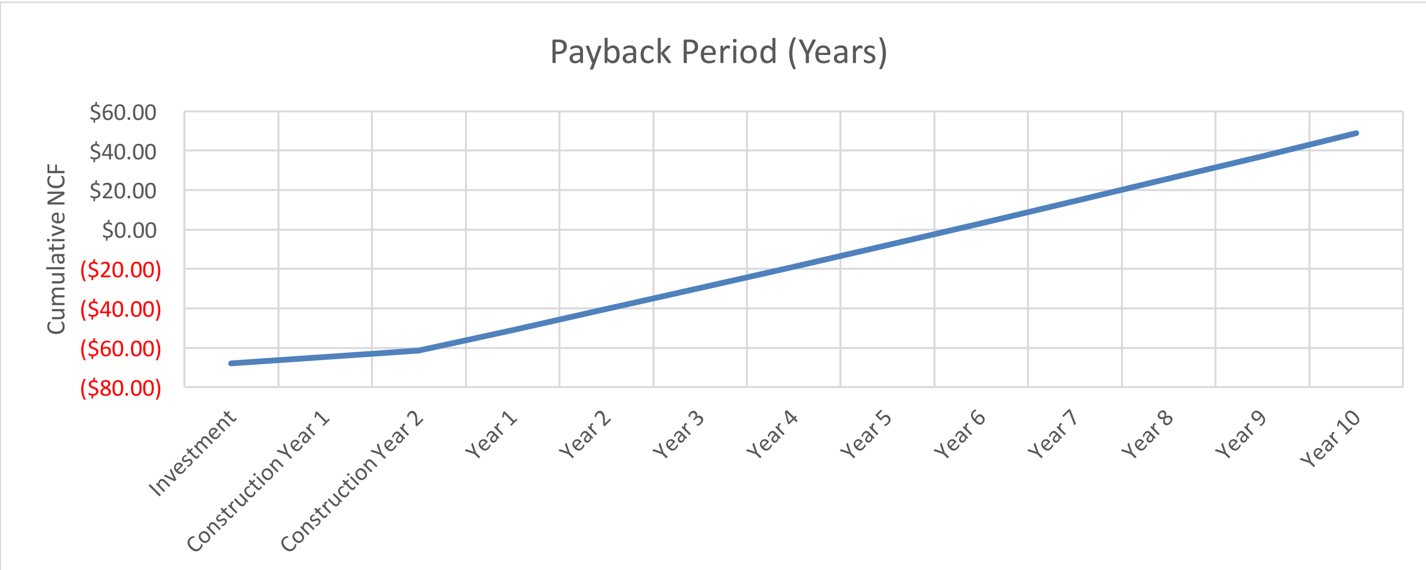
Result	Unit	Value
Project NPV	USD Million	$37
Project IRR	%	16.05%
Break Even Period	Months	24
Payback Period	Months	84
Operating Surplus	USD Million	$146.27
Total Capital Cost	USD Million	$135.05

INVESTMENT ANALYSIS

Investment Analysis

		GRACE PERIOD											
	Investment	Construction Year 1	Construction Year 2	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Investment	$68	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Income from Debt		$6	$6	$6	$5	$5	$4	$4	$3	$3	$2	$1	$0
Principal Repayment		$0	$0	$5	$5	$5	$6	$6	$7	$8	$8	$9	$10
Income from Shared Profits		($2)	($2)	$0	$0	$1	$1	$1	$1	$1	$1	$1	$1
Combined Income Stream	**($68)**	**$3**	**$3**	**$10**	**$11**	**$11**	**$11**	**$11**	**$11**	**$11**	**$11**	**$11**	**$12**
Cumulative Net Cashflow	**($68)**	**($65)**	**($61)**	**($51)**	**($40)**	**($30)**	**($19)**	**($8)**	**$3**	**$14**	**$26**	**$37**	**$49**
ROI	-100%	-95%	-90%	-75%	-59%	-44%	-28%	-11%	5%	21%	38%	55%	72%
Payback Period (Years)	7(5 Operational)												
Investment IRR (10 Years)	8.20%												
Investment IRR (20+2 Years)	8.82%												
ROI at Debt Repayment	72%												

Payback Table



CONCLUSION

The proposed project reduces greenhouse gas emissions by supplying Zero-emission wind power to the National Power Grid, which replaces the same amount of electricity generated by fossil fuel fired power plants connected to National Power Grid, and therefore avoids the CO_2 emissions in the generating the same amount of electricity provided by the fossil fuel fired power plants.

Being an environmentally sound energy supply technology, the wind power is one of the priority development projects in Kenya. The contributions of the proposed project to sustainable development goals are summarized as follows:

- Being located in a power grid dominated by thermal power plants, development of the proposed project will not only reduce GHG emissions but also mitigate local environmental pollution caused by air emissions from the thermal power plants. The wind farm is 2km away from the grid.
- The proposed project will be helpful to diversify power mix of National Power grid.
- The proposed project will be helpful in meeting local electricity demand and reducing the dependence on exhaustible and expensive fossil fuel for power generation.

The lack of access to affordable and clean energy has a number of implications for poor households, and for women in particular including:-

a. Women and children disproportionately suffer from health problems related to gathering and using traditional fuel and cooking in poorly ventilated indoor conditions. These include respiratory infections, cancer, and eye diseases.
b. High opportunity costs related to time spent gathering fuel and water which limits their ability to engage in education and income-generating activities resulting in dramatically different literacy rates and school enrolment levels between men women.
c. Lack of electricity in the rural areas is an added hindrance to women's access to useful media information such as market for their produce, health information and civic education.

The base load generation is currently from hydro and geothermal resources. However, the hydro component has become unreliable due to the frequent droughts being experienced across the country as a result of climate change. This has led to deployment of fossil fuel-fired plants for base load generation and load-shedding. Continuous running of fossil-fuel fired plants increased tariffs as well as GHG emissions. To mitigate this trend, the Government is promoting the use of renewable energies that are clean, environmentally friendly and less susceptible to climate changedisruptions.

The debt and equity funding will be utilized to support this renewable wind energy project in order to achieve accelerated development of the resources and increase the contribution to the generation capacity energy mix.

GRID CONNECTION STUDY

1.0 Background

Ol Danyat Ltd. proposes to expand capacity of its proposed wind farm at Ol Danyat in Kona Baridi area from 10MW to 30 MW. The power collection point and step up substation will be located approximately 3 km from the existing Embakasi – Matasia – Magadi 66 kV line and about 13 km from Matasia 66/11kV substation. These are the nearest existing alternative points of connection to the grid. A third potential point of connection would be Ngong (Kimuka) 220/66 kV substation currently under construction about 31 km from the proposed wind farm. A previous study established that the 10 MW wind farm could be connected via a loop in - loop out connection to Matasia – Magadi 66 kV line.

This study is a review of the previous analysis to assess the feasibility of connecting the 30 MW wind farm to Matasia – Magadi 66 KV line and to assess other available connection options to determine the most optimal scheme for connecting the wind farm to the grid. The study will also evaluate system short circuit fault levels to assess power system strength with respect to the proposed intermittent power generation and adequacy of the existing network switchgear.

2.0 Existing network conditions

2.1 Matasia substation

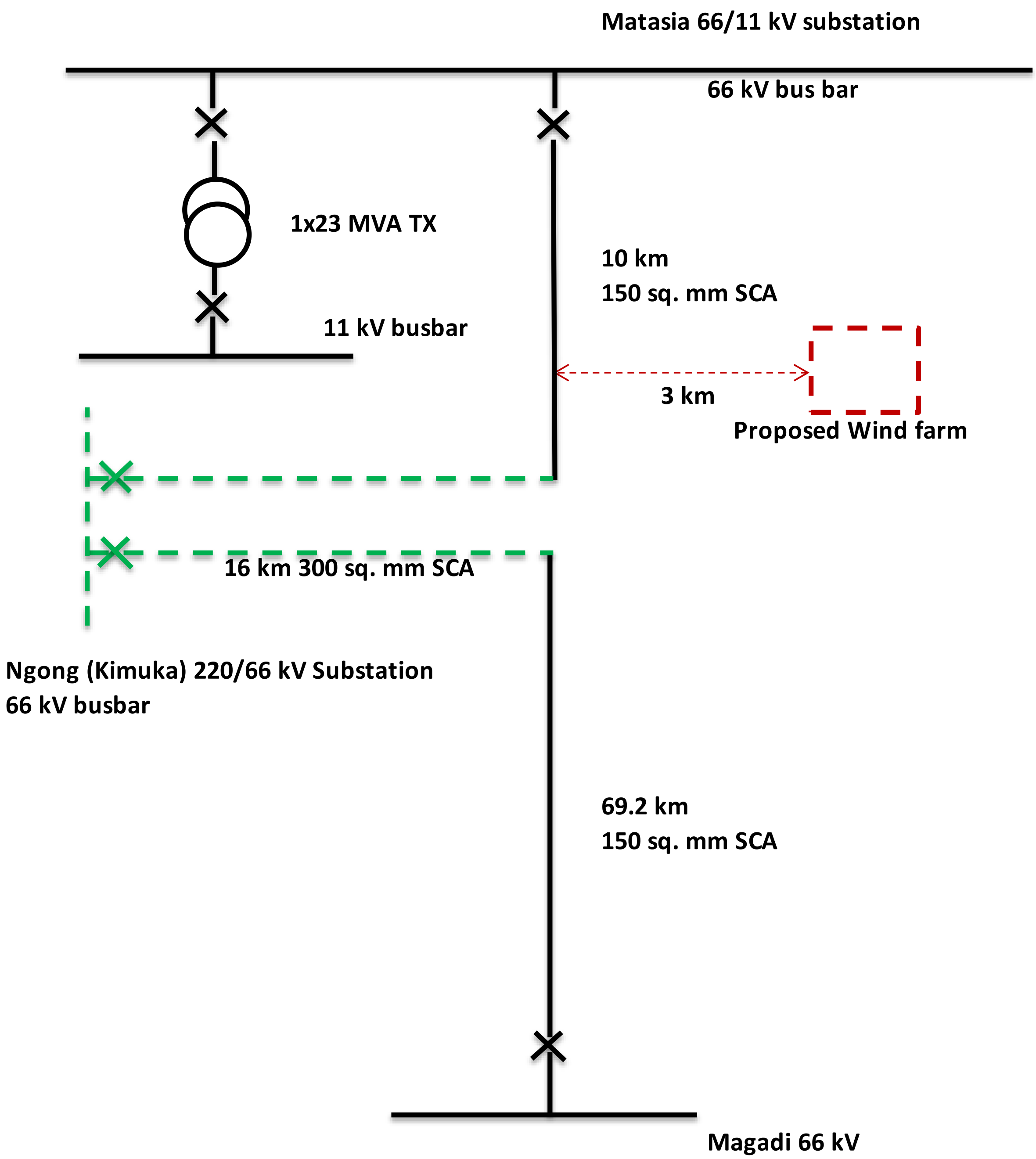
Matasia is a 1x23 MVA 66/11 kV substation with current peak load estimated at 16 MW. It is located 13 km from the proposed Ol Ndanyat wind farm site and is supplied off Magadi ex Embakasi 66kV feeder. The substation has neither a spare bay, nor adequate space for expansion and connection of an additional 66 kV feeder will require investment in additional land and substation extension.

2.2 New Ngong (Kimuka) 220/66 kV substation

The proposed new substation which is currently under construction is a 2x200 MVA transformers 220/66 kV substation with six 66 kV feeders, located about 31 km from the proposed Ol Ndanyat wind farm. The substation is scheduled for completion by 2017.

Fig. 1 below is a single line diagram illustrating the existing network in the project area.

Fig. 1: Existing project area network schematic diagram



2.4 Existing network flows and short circuit fault analysis

Based on analysis of the existing network it is envisaged that the wind farm may be connected to the grid at 66 kV voltage level. Three potential points of connection are identified as follows:-

(i) Looping in and out the existing Magadi 66 kV line near Ol Ndanyat windfarm
(ii) Matasia 66/11 kV substation
(iii) New Ngong (Kimuka) 220/66 kV substation

Load flow analysis on the expected network by 2017 without the wind farm indicates good voltage profiles and no network overloads. Table 1 below is a summary of existing system load flow analysis results. For further details see load flow diagram annex 1, section 5.1

Table 1: Existing system load flow analysis results

Line	Loading (%)	
	System peak	System off-peak
Ngong (Kimuka) – Ol Ndanyat T off	26.3	11.5
Ol Ndanyat T off - Matasia	41.3	14.1
Ngong (Kimuka) - Magadi	18.7	18.5

Maximum and minimum system short circuit fault levels are as summarized in table 2 below. Table 2:

Proposed connection points short circuit fault levels

BUS	3 phase Short circuit fault levels							
	Maximum				Minimum			
	S(MVA)	I(AMPS)	X/R	*SCR	S(MVA)	I(AMPS)	X/R	SCR
Matasia	308	2696	2.52	10.3	305	2665	2.85	10.2
Ol Danyat T off	516	4518	3.91	17.2	505	4417	4.47	16.8
Ngong (Kimuka)	1450	12682	6.57	48.3	1355	11850	7.98	45.2

*SCR (short circuit ratio) = S_{SC} (MVA)/S_W (MW) -------- (1)

Where S_{SC} is the short circuit power at the PCC and S_W is the power produced by the wind farm

Short circuit ratio is a measure of network bus strength with respect to connection of intermittent power. A strong bus with respect to connection of the wind farm indicates insignificant impact on power quality (Voltage fluctuations and flicker) while a weak bus points to poor power quality.

A system bus is considered weak with respect to connection of a certain rating of intermittent generation if SCR is less than 10 and strong if SCR is greater than 20.

Based on short circuit fault analysis results it therefore follows that new Ngong 220/66 kV substation is considered strong with respect to connection of the 30 MW wind farm. Kona Baridi is considered strong enough and Matasia substation marginal with respect to connection of the wind farm.

2.2.1Voltage variation

Voltage variation is a function of both SCR and X/R ratio and is estimated from the following expression:
Voltage variation, $dU = S_W/S_{sc} (\cos(\beta-\alpha))$ -- ---(2)

$$dU = 1/SCR (\cos(\beta-\alpha))$$

Where S_W and S_{sc} are as defined above, β is the angle of network short circuit impedance and α is the phase angle of wind farm output current

2.2.2 Flicker severity

Flicker severity is dependent on the source of power, generator characteristics and voltage variation. Short term flicker can be estimated from the expression:

$P_{st} = 0.365*R*F*(r)^{0.31}*(dUmax/U)\%$ (*Andreas Spring et. al., Effects of Flicker in a Distribution Grid)*

Where R is the frequency factor, F is the form factor; r is the repetition rate per minute and (dUmax/U)%, the maximum voltage variation in percentage. Typical valuses for R and F are 0.2 and 1.4.

Short term flicker planning limits are; Pst < 0.9 for medium voltage systems and Pst < 0.8 for high voltage systems.

3.0 WIND FARM CONNECTION STUDIES

Methodology

The study considered three grid connection options for the proposed wind farm as outlined here below. For each of the alternative options, load flow and short circuit fault level studies were carried out to assess adequacy of the network and strength of the point of connection with respect to the proposed wind power generation. Short circuit fault levels were evaluated at both system peak and off peak to determine the least expected values that are to be used in establishing the maximum wind farm capacity that may be connected at either of the considered points of connection without compromising power quality.

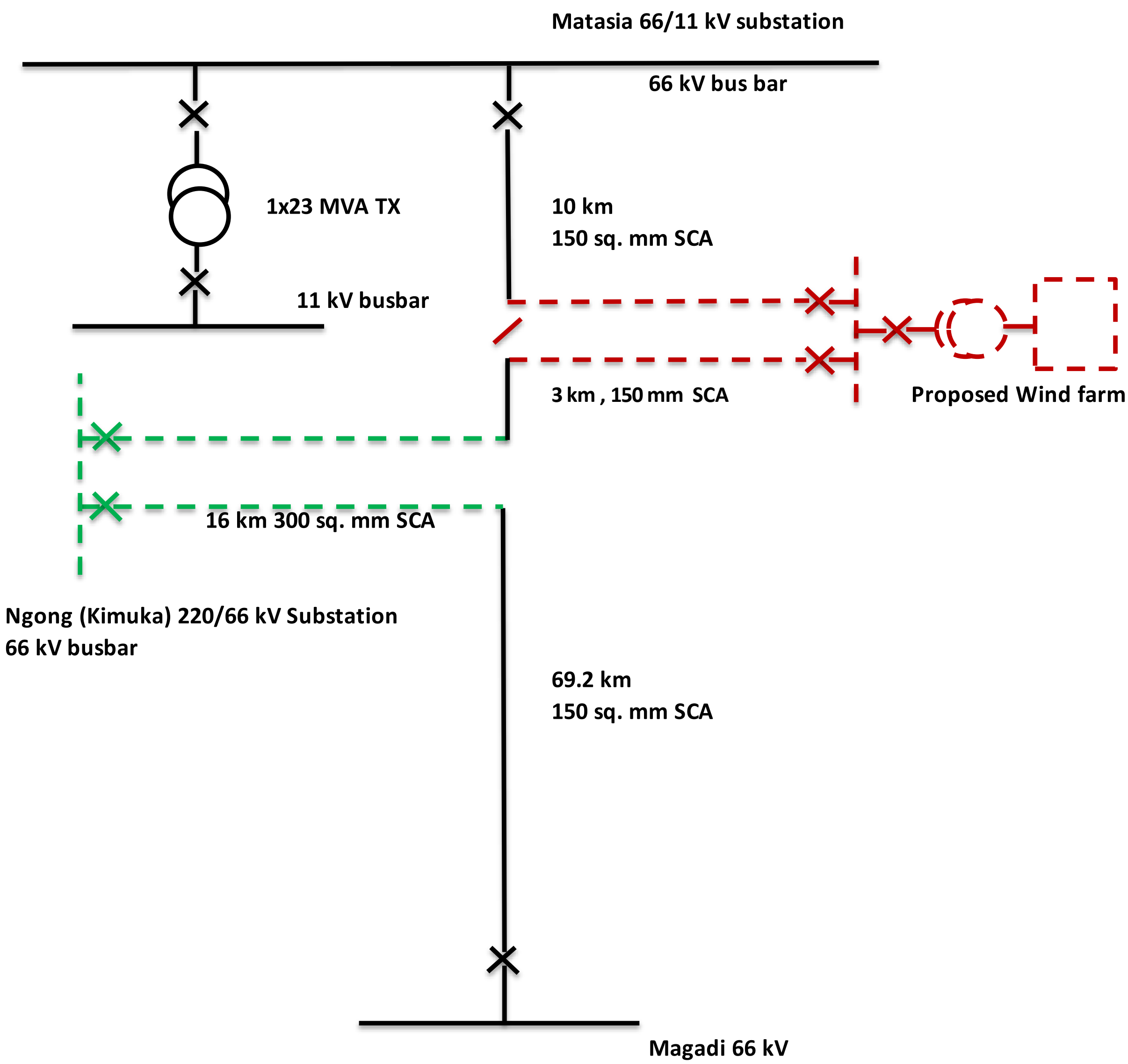
1. Option 1: Looping in and out new Matasia- Ngong (Kimuka) 66 kV line
2. Option II: Connection at Matasia 66/11 kV substation
3. Option III: Connection at New Ngong (Kimuka) 220/66 kV substation

3.1 Option 1: Looping in and out Matasia – Ngong (Kimuka) 66 kV line at Kona Baridi.

This connection option entails construction of an estimated 3 km 66 kV double circuit line in 150 mm^2 SCA conductor from the proposed wind farm 66 kV switch yard to the proposed Ngong (Kimuka) – Matasia 66 kV line. The double circuit line will facilitate creation of two 66 kV feeders at the wind farm switchyard; Ol Ndanyat – Ngong and Ol Ndanyat – Matasia feeders.

The proposed connection is illustrated in the single line schematic diagram Fig. 2 below.

Fig 2. Proposed connection option I schematic diagram



3.1.1 Load flow analysis

Load flow analysis results indicate that no system overload is expected at both system peak and off peak with full wind farm output. Table 3 below is a summary of option 1 load flow analysis results.

Table 3: Option I: Expected key lines loading

Line	Loading (%)	
	System peak	System off-peak
Ol Ndanyat - Matasia	41.0	14.2
Ol Ndanyat - Ngong substation	25.2	47.6
Ngong – Magadi	18.7	18.6

For further details see load flow analysis results diagram annex 2, section 5.2

3.1.2 Short circuit fault analysis

Table 4 below is a summary of expected system short circuit fault levels and short circuit ratios at the proposed point of connection and other system buses in the project area.

Table 4: Expected Short circuit fault levels at proposed POC and other system buses

BUS	Short circuit fault levels							
	Maximum				Minimum			
	S(MVA)	I(AMPS)	X/R	*SCR	S(MVA)	I(AMPS)	X/R	SCR
Matasia S/S	296	2587	2.45	9.9	290	2537	2.77	9.7
Ngong S/S	1478	12925	6.75	49.3	1381	12084	8.35	46.0
Ol Ndanyat Tee	549	4798	4.16	18.3	533	4659	4.77	17.8
Ol Ndanyat	**481**	**4205**	**3.58**	**16.0**	**468**	**4092**	**4.07**	15.6

A comparison of table 4 and table 2 indicates that installation of the wind farm will elevate system fault levels slightly but insignificantly compared to 66 kV switchgear rating of 31.5 kA at various substations.

Short circuit ratio calculation results indicate that Ol Ndanyat is marginal with respect to connection of the 30 MW wind farm.

3.1.3 Voltage variation

The maximum voltage variation is expected at minimum system short circuit fault level. Assuming 0.95 power factor output current, expected Voltage variation on interconnection at Ol Ndanyat 66 kV bus bar is determined as

$dU = S_w / S_{sc} (\cos(\beta - \alpha))$

$= 1/SCR (\cos(\beta - \alpha))$

$= 1/15.6 * \cos(76.2-18.2)$

$= 3.4\%$

This is within the required voltage deviation limit of +/- 5% at 66 kV voltage level.

3.1.3 Flicker emission

Assuming repetition rate of 10 per minute and the determined voltage variation at Kona Baridi 66 kV bus, applying the expression in 2.2 above gives short term flicker,

$P_{st} = (0.365)*(0.2)*(1.4)*(10)^{0.31}*(3.4)$

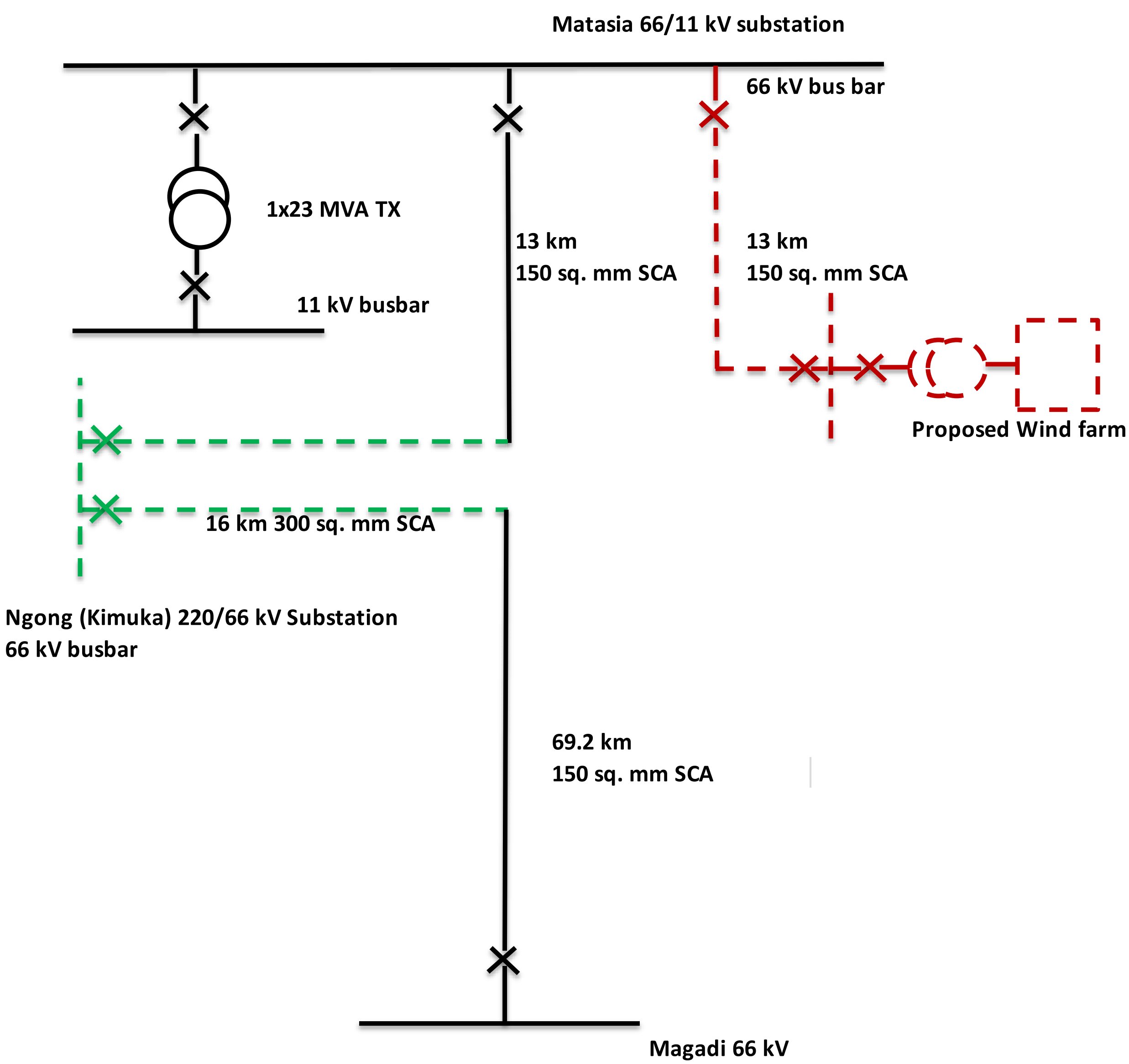
$= 0.71$

This is below the flicker limit level of 0.9 for medium voltage system.

3.2 Option 2: Connection at Matasia 66/11 kV Substation

This connection option entails construction of 13 km of 66 kV line in 150 mm^2 SCA conductor from the proposed wind farm 66 kV switch yard to Matasia substation 66 kV switch yard. The proposed connection is illustrated in the single line schematic diagram Fig. 3 below.

Fig3. Proposed connection option 2 schematic diagram



3.2.1 Load flow analysis

Load flow analysis results indicate that no system overload is expected with the 30 MW wind farm production. Table 5 below is a summary of expected key lines loading with full wind farm generation. For further details see load flow diagram annex 3, section 5.3

Table 5: Summary of expected key lines loading

Line	Loading (%)	
	System peak	System off-peak
Ol Ndanyat – Matasia	60.8	62.3
Matasia – Ngong(Kimuka)	27.6	48.1
Ngong -- Magadi	18.7	18.6

3.2.2 Short circuit fault analysis

Table 6 below is a summary of expected system short circuit fault levels and short circuit ratios at Matasia substation (the proposed point of connection option II) and other buses in the project area.

Table 6: Expected short circuit fault levels and SCR at the POC

BUS	Short circuit fault levels							
	Maximum				Minimum			
	S(MVA)	I(AMPS)	X/R	*SCR	S(MVA)	I(AMPS)	X/R	SCR
Matasia S/S	**339**	**2970**	**2.77**	**11.3**	**331**	**2898**	**3.13**	**11.0**
Ngong S/S	1473	12885	6.74	49.1	1377	12045	8.3	45.9
Ol Ndanyat Tee	543	4754	4.14	18.1	528	4618	4.73	17.6

The expected lowest short circuit ratio with respect to connection of 30 MW wind farm at Matasia substation is estimated at 11.0 and therefore Matasia substation is considered marginal for connection of the proposed wind farm.

3.2.3 Voltage variation

The maximum voltage variation is expected at minimum system short circuit fault level. Assuming 0.95 power factor output current, expected Voltage variation on interconnection at Ngong substation 66 kV bus bar is determined as

$dU = S_w / S_{sc} (\cos(\beta-\alpha))$

$= 1/SCR (\cos(\beta-\alpha))$

$= 1/11 * \cos(72.3-18.2)$

$= 5.3\%$

This is above the required voltage deviation limit of +/- 5% at 66 kV voltage level.

3.2.3 Flicker emission

Assuming repetition rate of 10 per minute and the determined voltage variation at Ngong (Kimuka) 66 kV bus, applying the expression in 2.2 above gives short term flicker,

Pst = (0.365)*(0.2)*(1.4)*(10) ^0.31*(5.3)

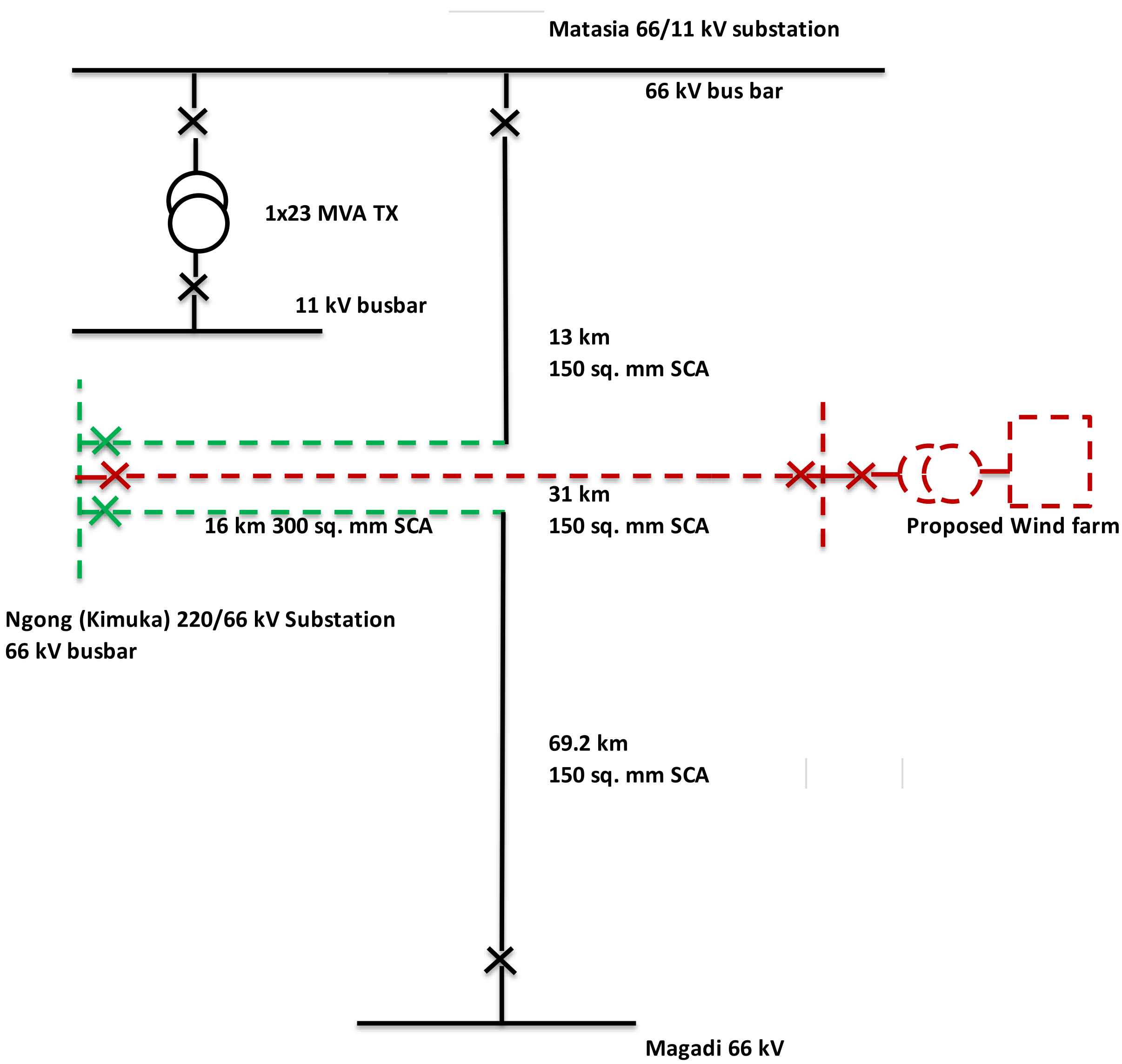
= 1.1

This is above the flicker limit level of 0.9 for medium voltage system.

Option 3: Connection at new Ngong (Kimuka) 220/66 kV Substation

This connection option entails construction of 31 km of 66 kV line in 150 mm^2 SCA conductor from the proposed wind farm 66 kV switch yard to Ngong (Kimuka) substation 66 kV switch yard. The proposed connection is illustrated in the single line schematic diagram Fig. 4 below.

Fig4. Proposed connection option 3 schematic diagram



3.3.1 Load flow analysis

Load flow analysis results indicate that no system overload is expected with the 30 MW wind farm production. Table 7 below is a summary of expected key lines loading with full generation at the wind farm. For further details see load flow diagram annex 4, section 5.4

Table 7: Summary of expected key lines loading

Line	Loading (%)	
	System peak	System off-peak
Ol Ndanyat – Ngong	62.1	62.7
Ngong - Matasia	41.6	14.2
Ngong - Magadi	18.8	18.7

3.3.2 Short circuit fault analysis

Table 8 below is a summary of expected system short circuit fault levels and short circuit ratios at Ngong substation (the proposed point of connection option III) and other buses in the project area.

Table 8: Expected short circuit fault levels and SCR at the POC

BUS	Short circuit fault levels							
	Maximum				Minimum			
	S(MVA)	I(AMPS)	X/R	*SCR	S(MVA)	I(AMPS)	X/R	SCR
Ngong S/S	**1470**	**12856**	**6.64**	**49.0**	**1377**	**12040**	**8.26**	**45.9**
Matasia S/S	308	2692	2.51	10.3	304	2660	2.85	10.1
Ol Ndanyat Tee	517	4523	3.91	17.2	506	4424	4.49	16.9

Expected lowest short circuit ratio with respect to connection of the 30 MW wind farm at Ngong substation is estimated at 45.9 and therefore Ngong substation is considered strong for connection of the proposed wind farm.

3.3.3 Voltage variation

The maximum voltage variation is expected at minimum system short circuit fault level. Assuming 0.95 power factor output current, expected Voltage variation on interconnection at Ngong substation 66 kV bus bar is determined as

$dU = S_w / S_{sc} (\cos(\beta-\alpha))$

$= 1/SCR (\cos(\beta-\alpha))$

$= 1/45.9 * \cos(83.1-18.2)$

$= 0.9\%$

This is within the required voltage deviation limit of +/- 5% at 66 kV voltage level.

3.3.4 Flicker emission

Assuming repetition rate of 10 per minute and the determined voltage variation at Ngong (Kimuka) 66 kV bus, applying the expression in 2.2 above gives short term flicker,

Pst = (0.365)*(0.2)*(1.4)*(10) ^0.31*(0.9)
= 0.19
This is below the flicker limit level of 0.9 for medium voltage system.

4.0 Results analysis and recommendations

4.1 Load flow studies

Load flow studies results for the proposed 30MW Ol Ndanyat wind farm indicate the three proposed connection alternatives considered may adequately evacuate the power generation at the wind farm without overloading any section of the network.

4.2 Short circuit fault levels analysis

Due to the intermittent nature of wind generation, its connection to the power system can compromise the supply quality, particularly causing large voltage fluctuations beyond the acceptable +/- 5% at the point of connection. The amount of wind power that can be connected at a particular point in the system is therefore limited, depending on the network relative strength (system impedance) at the point of connection. High system impedance results to large voltage fluctuations with changes in wind power output while low system impedance results to lower voltage fluctuations and therefore higher capacity to absorb wind power.

The three considered connection schemes will result to power quality indicator levels at the POC as follows:

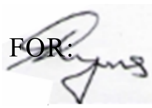
Table 9: System study analysis results summary

Indicator	Option 1	Option 2	Option 3
Short circuit ratio (SCR)	15.6	11	45.9
Voltage variation (%)	3.4	5.3	0.9
Flicker severity	0.71	1.1	0.19

Based on this analysis both option 1 and option 3 will have insignificant impact on power quality at the POC and are therefore technically feasible. Options II is accordingly not technically feasible. Short circuit fault analysis results indicate that network short circuit fault levels will be slightly elevated on commissioning of the wind farm. The values will however not exceed or approach the ratings of currently installed equipment at the considered 66 kV points of connection, which is 31.5 kA.

4.3 Recommendation

Based on this study option II, connection via loop in – Loop out at proposed Ngong – Matasia 66 kV line is recommended as the least expensive technically viable grid connection option. However if the said 66 kV line is not implemented as proposed, connection at the new Ngong 220/66 kV substation which currently under implementation is recommended as the most technically feasible grid connection option.

Report by: Cyrus Njungu FOR: 

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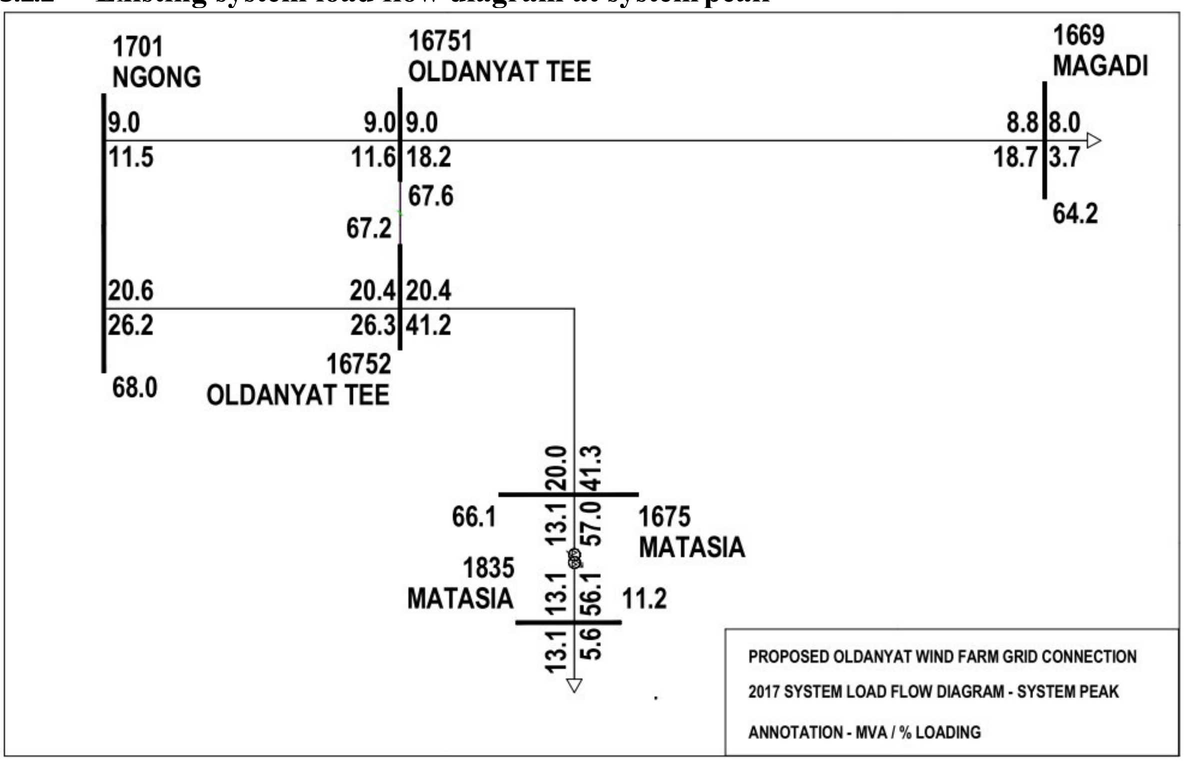
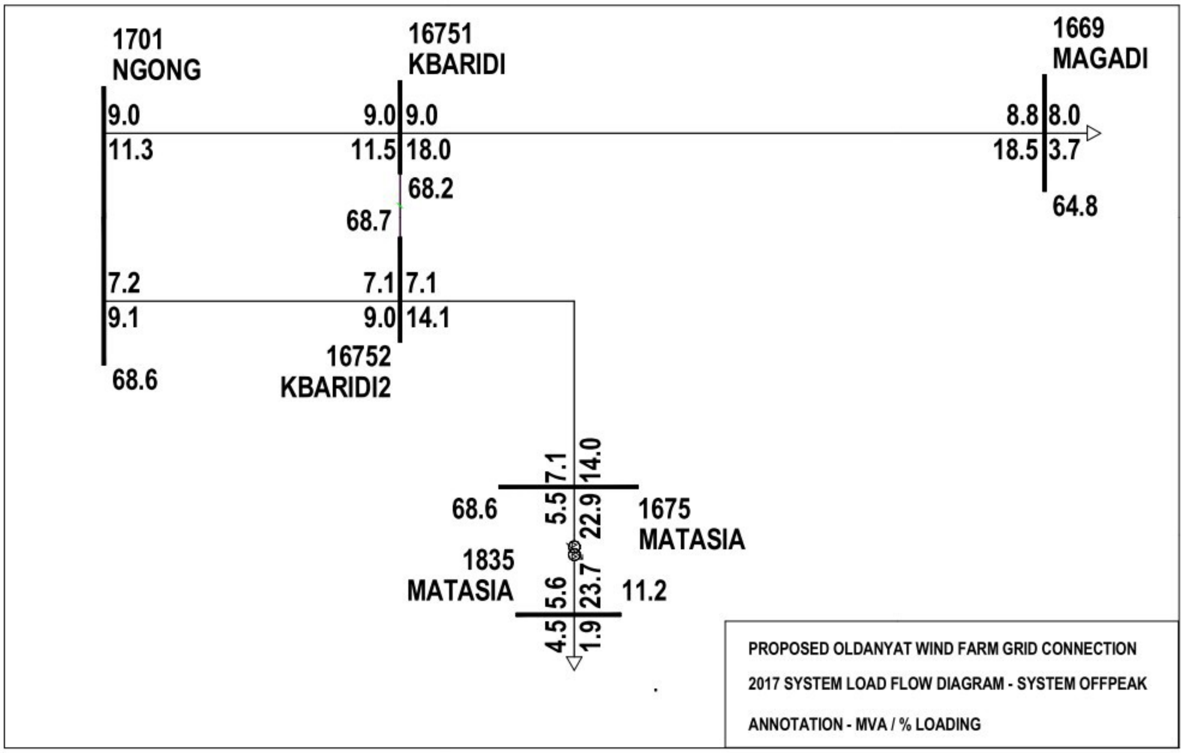
5.0 Annexes

5.1 Annex 1: Existing network load flow diagrams

5.1.1 Existing system load flow diagram at system peak

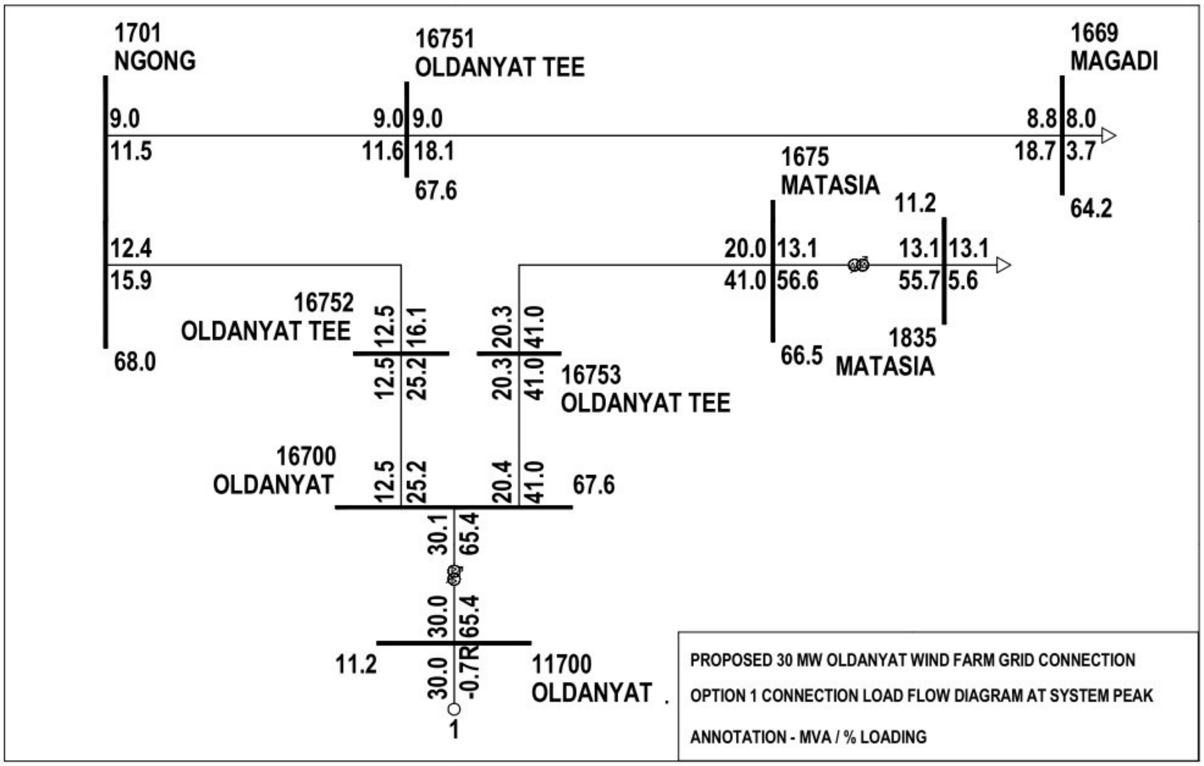


5.1.2 Existing system flow diagram at system off-peak

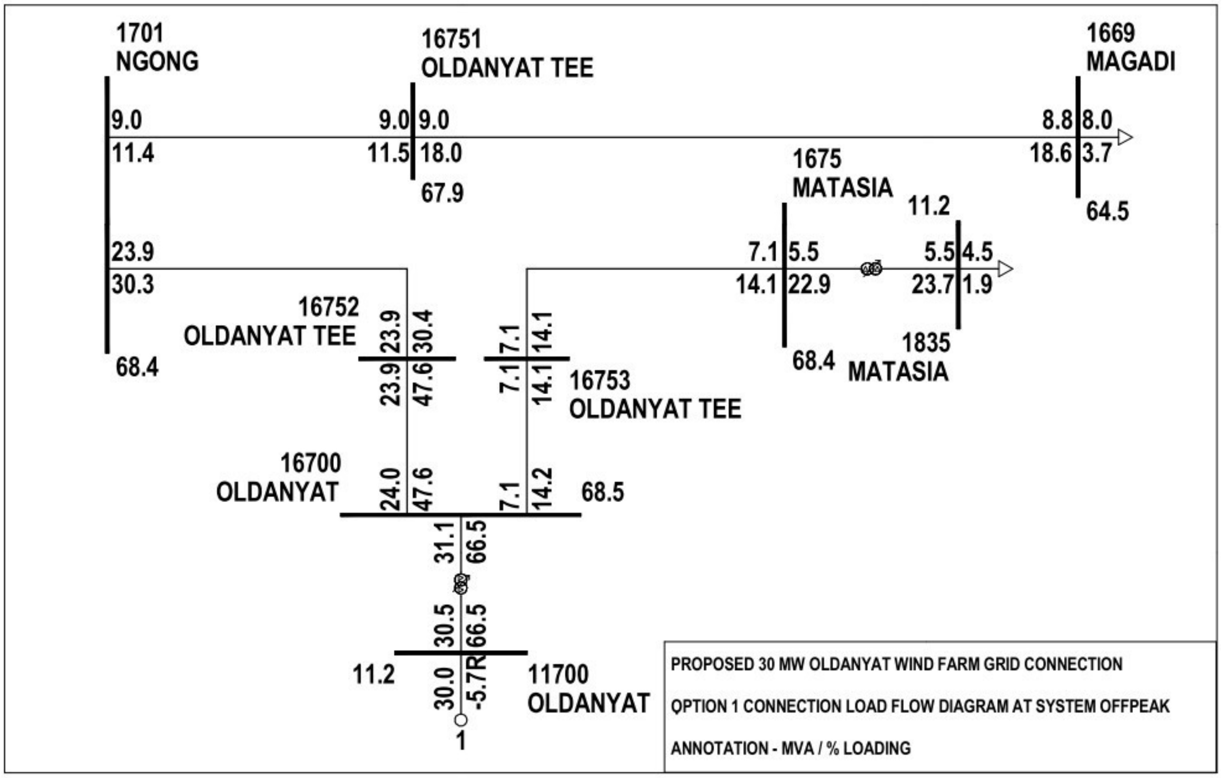


5.2 Annex 2: Option 1 connection load flow diagrams

5.2.1 Option I load flow diagram at system peak

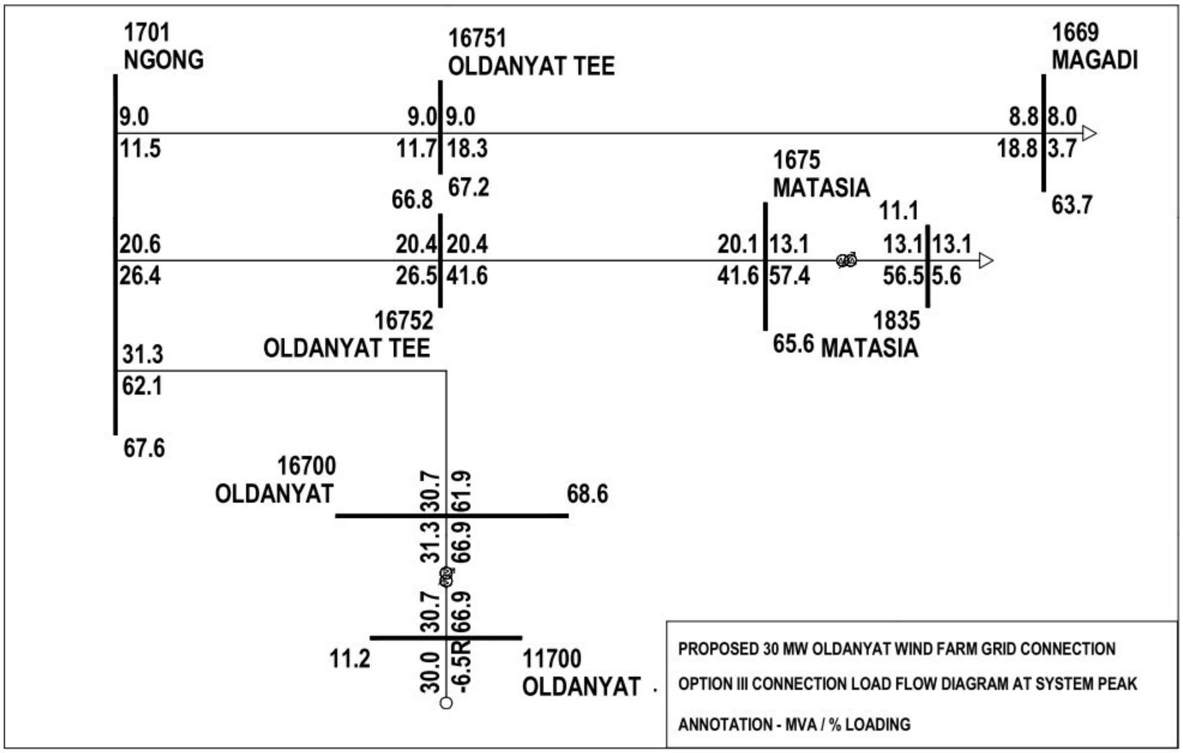


5.2.2 Option I load flow diagram at system off peak

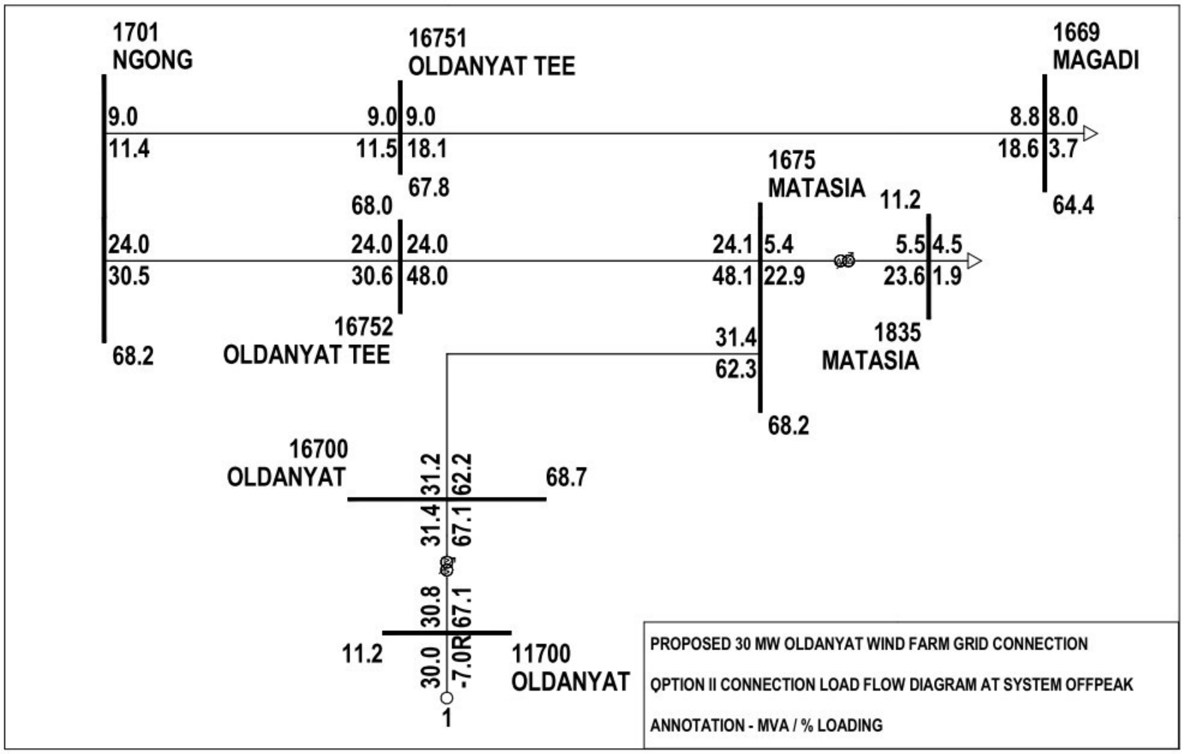


5.3 Annex 3: Option II connection load flow diagrams

5.3.1 Option II load flow diagram at system peak

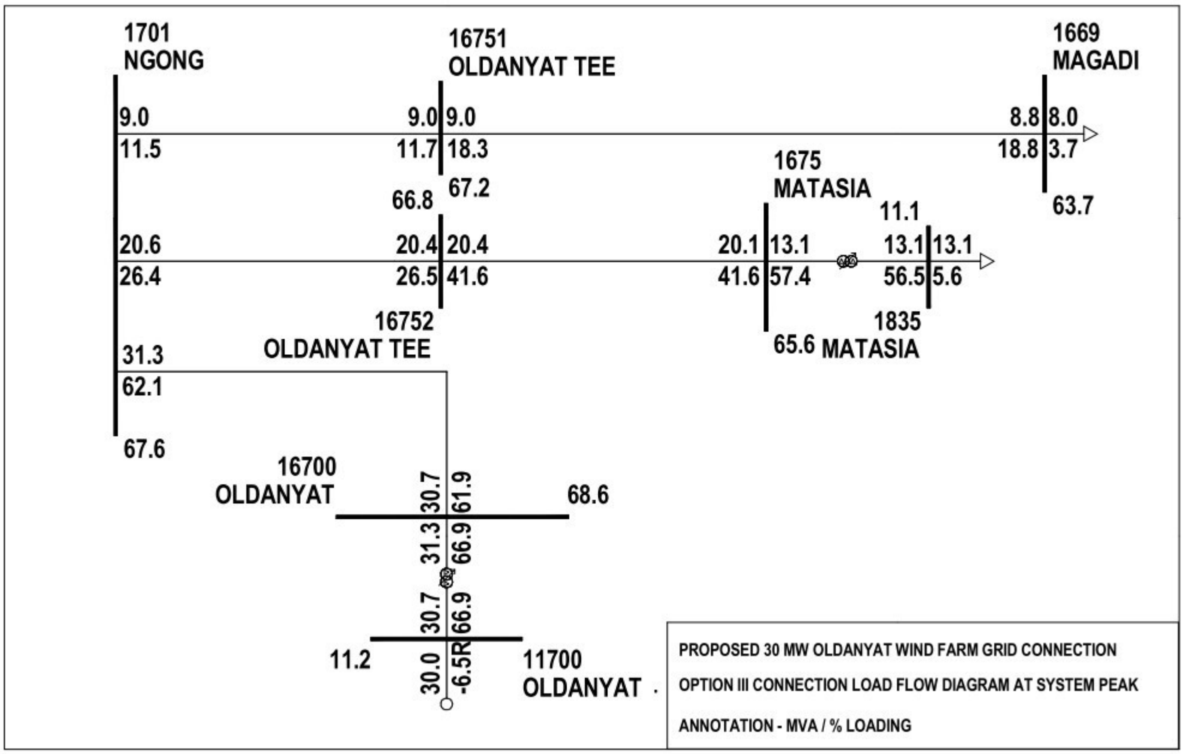


5.3.2 Option II load flow diagram at system off-peak

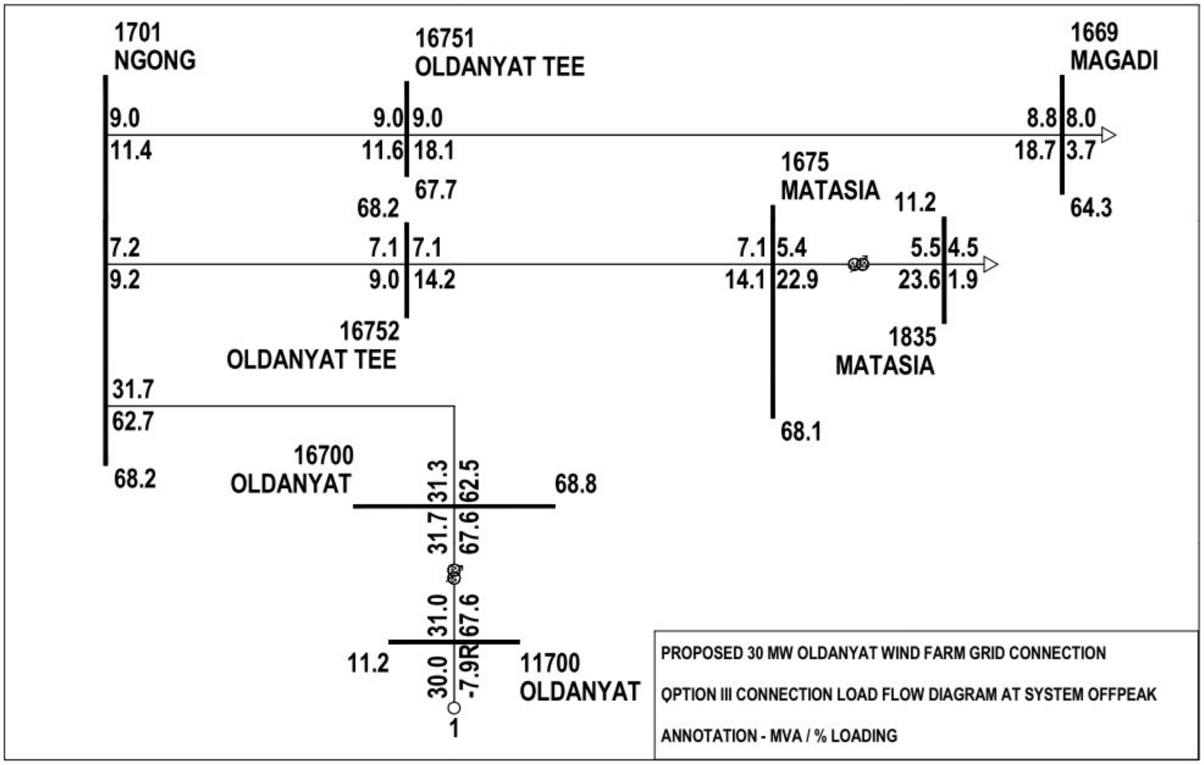


5.4 Annex 4: Option III connection load flow diagrams

5.4.1 Option III load flow diagram at system peak



5.4.2 Option III load flow diagram at system off-peak



1) FINANCIAL PROJECTIONS

- Source and application of funds
- Cash flow
- Cost and income statement
- Carbon points calculations

2) SENSITIVITY ANALYSIS

- Effect of annual electricity supplied decline by 10%
- Effect of annual electricity supplied decline by 20%

3) OL NDANYAT CERTIFIC ATES AND STATUTORY DOCUMENTS

- Certificate of Incorporation
- Taxpayer Registration Certificate

- National Environmental Management Authority License
- Kenya Forest Service Clearance
- Kenya Wildlife Service Clearance
- Title Deed of Project Site

4) OL NDANYAT SITE WIND DATA

See attached Wind Suitability Analysis Report

5) PROPOSED WIND PROJECTS IN KENYA

a) Lake Turkana Wind Project (Turkana) – 300MW proposed output from 383 wind turbines generating 850KW each. Still in the startup phase. (http://laketurkanawindpower.com/)

b) Aeolus Wind Project (Kinangop and Ngong) - 160MW. Still in the startup phase. (http://www.bloomberg.com/news/2011-11-15/aeolus-starts-on-kenyan-wind-power-project-business-daily-says.html)

c) Kipeto Energy) - 100MW (Ngong). Yet to begin. (http://www.evwind.es/noticias.php?id_not=16316)

d) NB

e) All the 3 projects mentioned above are foreign owned. Ol Ndanyat Power is the only indigenous and locally owned wind energy project in Kenya.