Kipeto Wind Farm

ESIA Supplementary Report

September 2013

KIPETO ENERGY Limited

Kipeto Energy Ltd.

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1.0 Introduction

Kipeto Energy Ltd proposes to establish a commercial wind energy facility by constructing 63 wind turbine generators within an area of about 70km^2, with a maximum generating capacity of 100 MW.

This document is intended to supplement the original ESIA submitted to NEMA in March 2012 due to changes to the layout, further studies carried out and requirements of international standards such as IFC and OPIC due diligence requirements.

The proposed wind farm will be developed on land leased from local land owners; the wind turbines will be sited over a project area measuring approximately 70km^2. The original layout submitted to NEMA consisted of 67 no. turbines. The application was for 100MW Wind Farm. It is considered following extensive wind resource analysis that the GE 1.6-100 turbine is the most suitable turbine for this site. Following externsive site investigations, 63 no turbines were chosen on the basis of:

- Optimun yield
- Meeting environmental constraints such as
  - 500m from households
  - Noise impact less than 43dB(A) or in the case of landowners less than 45dB(A)
  - Outside a radius of 500m of any Osyris Lanceolata (East African Sandalwood) establishment
  - Away from the riverine areas that support sensitive habitats
  - Construction compound at least 100m away from water bodies
- Seperation distances of 7 * 3 rotor diameter spacing was employed in order to maximise the wind resource

The proposed development is for a wind farm consisting of 63 no. 1.6MW turbines and all associated development. The dimensions of the proposed turbines are:

- Hub height – 80m
- Blade Length – 50 m

- Rotor Diameter – 100m
- Overall height not exceeding - 130m

A receptor survey was conducted in order to quantify the number of properties within 1km (10 rotor diameters) of the proposed turbines. In total, 62 receptors were found. Noise and shadow flicker impact assessments were conducted on these receptors.

A 220 kV transmission line is required to connect the Kipeto wind energy facility to the national grid at the Isinya substation near the town of Kajiado. A separate ESIA has been completed in respect of this application and can be found in Volume V.

The documentation connected with this report is comprised as follows:

- Kipeto Wind Farm Supplementary Report
- Appendices
  - Noise Impact Assessment
  - Noise Impact Assessment IFC
  - Shadow Flicker
  - Layout Map

2.0 Environmental and Social Impact Assessment/ Wind Farm Site Original SEIA

The most significant environmental impacts associated with the proposed project include:

- Visual impacts on the natural scenic resources of the region;
- Local site-specific impacts as a result of the construction and operational phases of the project;
- Impacts on the social environment.

The findings of the specialist studies undertaken within the ESIA to assess both the benefits and potential negative impacts anticipated as a result of the proposed project concluded that:

- The landowners directly affected by the project are not opposed to it; through Free, Prior and Informed Consent (FPIC), affected land owners signed lease agreements with Kipeto Energy Limited. In order to enhance the local employment and business opportunities, the mitigation measures stated in the report should be implemented;
- The environmental impacts associated with the proposed wind energy facility will be minimized provided that the recommended mitigation, monitoring and management measures are implemented and given due consideration during the process of finalizing the wind energy facility layout;
- The proposed project represents an investment in clean, renewable energy which given the challenges created by climate change, represents a positive social benefit for society as a whole.

The significance of the majority of identified negative impacts can generally be reduced by implementing the recommended mitigation measures. Subsequently it is recommended that:

- All mitigation measures stated in this ESIA Study including those indicated in the specialist studies be implemented during the design and pre-construction phases respectively;
- The Environment Management Plan (EMP) should form part of the agreement with the contractors appointed to build and maintain the proposed wind energy facility, and will be used to ensure compliance with environmental specifications, IFC and/or OPIC requirements and management measures;
- The wind energy facility management will implement a monitoring program in order to understand the nature of impacts on avifauna due to the wind energy facility at the site;
- As far as practical, wind turbines and associated lay down areas and access roads which could potentially impact on sensitive receptors will be designed to avoid areas of high sensitivities. Where this is not possible, alternative mitigation measures detailed in this report are to be implemented;
- Disturbed areas will be rehabilitated as quickly as possible and an on-going monitoring program should be considered to detect and quantify any alien species;
- During the construction phase, unnecessary disturbance to habitats will be strictly controlled and the footprint of the impact should be kept to a minimum;

- A comprehensive storm water management plan will be compiled for the sub-station footprints prior to construction;
- Applications for all relevant and required permits required to be obtained by Kipeto Energy Limited must be submitted to the relevant lead agencies.

Post ESIA Additional Bird and Bat Studies

Additional bird and bats studies were carried out from May to December 2012 to enhance the ESIA studies and provide further baseline data to be used in determining the layout.

Birds

Additional bird surveys were carried out in 2012 following the acquisition of Kenyan environmental authorization for a proposed 100MW wind power generation project by Kipeto Energy Limited (KEL). This survey was carried out in the months of February to May and September to December respectively when most bird activities occur in the Kipeto area. The findings of all the 2012 bird studies are incorporated into a single report which can be found in **Kipeto Wind Farm SEIA and Appendices Post ESIA Studies**.

The objective of undertaking this avifauna survey was to delineate the avifauna behavior within the proposed wind farm area and refine any mitigation measures proposed in the Environment and Social Impact Assessment (ESIA) Study. The bird survey was carried out by Kurrent Technologies Ltd. working in association with ornithologists from the National Museums of Kenya (NMK).

The proposed project site lies within the Rift Valley in Kenya and is characterized by scattered Acacia woodland, scrub, small wetlands and streams. Rainfall in the Kipeto area generally occurs between the months of March to May (referred to as the long rains) and between October and December (referred to as the short rains).

The ornithological surveys carried out were used to identify birds that use the area for foraging, passage and breeding within the wind farm development footprint area and attempted to establish whether the wind farm would be within the flight-line of any species considered vulnerable to collision and subsequent mortality risks.

Flight line and transects surveys of birds was undertaken at the proposed Kipeto wind farm project site in order to assess potential collision risks on birds. Surveys were conducted from February to November 2012. All species observed were recorded together with other variables describing their use of habitat e.g. movements, numbers of individuals, flight behavior etc. Several species were recorded in varying numbers at the site during the surveys.

The results of the transect surveys for breeding birds indicates that only a few species were likely to breed within the project footprint area. These were all relatively small species and mostly passerines which are considered at low risk of collision with turbines.

Several species of raptors were recorded but in very low numbers. Raptor species were considered to be at potential collision risks with turbines. Among the raptors Augur Buzzards, Tawny eagles occurred throughout the field surveys, however their numbers were low.

The 2011/2012 avifaunal assessment in Kipeto provided information on the following:

- Bird species present in the general area of the proposed wind farm;
- The assessment so far includes a description of species in terms of their status such as migrants or resident and conservation status;
- The species have also been categorized under various groups and assessed according to their vulnerability to wind farm projects with raptors being most vulnerable and key targets for monitoring. Other medium size species have also been identified;
- Signs of breeding for few bird species such as Kori Bustard have also been observed;
- Seasonality, movement and habitat use of key raptors have been established.

The assessments so far indicate that wind farms impact on ornithological interests in a number of ways including loss of habitat due to the construction of turbine bases and tracks, displacement of birds as a result of disturbance, potential mortality through collision.

The 2011/2012 bird surveys provided important information to guide the implementation of the Kipeto wind energy project. Despite the high records of species recorded in Kipeto, there were no species of conservation concern listed under the various categories by the IUCN Red datalist of species observed during flight line and breeding surveys.

Mitigation measures for specific impacts have been identified, data that would provide data for assessing collision risk and mortality at the proposed sites for location of turbines.

Species considered potentially at risk from collisions recorded were relatively large species that included raptors such as Eagles, Vultures, Buzzards, goshawks in small numbers and Lesser Kestrels that were only observed in large numbers during the April 2011 but in 2012 they were recorded in low numbers.

Augur buzzard was the most abundant of the raptors and was observed regularly moving over all parts of the site. The raptors tended to be more abundant during the breeding season coinciding with the onset of rains with abundance of prey items. Several passerines were recorded with movements recorded rarely at potential collision height. The current survey has identified raptor species that are at potential collision risk although this must be considered low given their rarity at the site.

Observations of birds from vantage points detect only movements within daylight hours and when visibility is reasonable. It is possible that night movements of birds and some rarer breeding species were not detected in the surveys. Despite Kipeto being a point of migration within the greater Rift Valley, densities of migrating birds in the study area is low. Additionally, only a small fraction of the site is exposed to turbines. Birds may behave differently once turbines are erected; subsequently, post construction monitoring will need to be undertaken to provide additional information on avian behavior. New wind installations must be followed by detailed behavioral observation of soaring birds as well as further mapping of migration routes to establish any changes in bird behavior and movements during the post construction studies.

Bats

The 2012 bat baseline survey and an analysis of activities in the area where the proposed 100MW wind farm is to be developed by Kipeto Energy Limited (KEL) in Kajiado County, Rift Valley, Kenya was carried out with the objective of assess the diversity of bats, their use of the area and potential impact on those species from wind energy development in Kipeto using IFC Performance Standards1.

The assignment was undertaken by Kurrent Technologies Ltd. (KTL) on behalf of KEL which enjoined the expertise from bat specialist from National Museums of Kenya. The findings of all

the 2012 studies are incorporated into a single report which can be found in **Volume III Kipeto Wind Farm SEIA and Appendices Post ESIA Studies**.

The survey design, and methods of data collection and analysis employed, followed best practice in both scientific bat surveys and assessing impacts of wind energy developments on bats in countries such as UK, Canada and Australia. Importantly baseline survey and monthly activity monitoring took into consideration the IFC Performance Standard 6 titled **Biodiversity Conservation and Sustainable Management of Living Natural Resources**.

Methods adopted for the field surveys included bat captures and release, walking transects for recordings of bat ultrasound, static automated ultra sound recording and physical search of bat roosts over the proposed wind farm site in Kipeto. Further, standard equipment devices were employed to gather data during the surveys. In particular, mist-nets were used to capture bats while Anabat SD2 ultra sound and Bat box bat detectors were used in the automated static recording and walking transects respectively.

Taxonomic identification was informed by the acoustic reference library on Kenyan bats, scientific reference bat collections at National Museums of Kenya (NMK), recent publications such as Monadjen et al (2010), Thorn and Kerbis (2009) and Pertterson and Webala 2012. Taxonomic names adopted for the recorded species followed standard binomial nomenclature and Wilson and Reeder (2005), which is a world authority in mammal taxonomic and geographic reference.

Fifteen species of bats from 8 families were recorded in the general area between March and December 2012. The records include one family of Fruit bat, *Epomorphorus wahlbergi*, and seven other families represented by several insect eating bats.

Higher densities of bat species and activities were recorded near wooded areas and valleys (e.g. around T26, T42, T62-64), than in open grass fields (e.g. around T1-T20). In open areas, bats were recorded near man-made water pans while in wooded areas, enhanced bat activity was recorded between trees, bushes, over streams, along dry valleys and over vegetation.

Bats were observed to be more active early in the night between 1900Hrs and 2100Hrs, than later at night and dawn in all the studied turbine locations in Kipeto.

Seven caves and two tree bat roosts were identified of which one cave situated 500m NE of turbine location T26 had at least six pregnant Hildebrandt's Horseshoe bats, *Rhinolophus hildebrandtii*. The rest of the caves appeared to used by bats only occasionally or at night.

The one cave containing pregnant Hildebrandt's horseshoe bat is considered as CRITICAL HBITAT in accordance with IFC Performance Standards 6 line 16 (IFC Performance standard 2012).

In view of the fact that all the 15 bat species recorded in Kipeto are not listed as of conservation concern in the IUCN Red list, potential risk to the species are considered low. This is because the 15 species are commoner species found elsewhere in Kenya and is observed to be on low activity in the Kipeto wind power project footprint area. The development of the proposed wind power project should however take mitigation measures especially avoiding wooded and bush hedgerows by at least 50 meters.

3.0: Supplement to Kipeto Wind Farm ESIA

Once the layout of the wind farm was determined and due to the necessity to construct a transmission line for the purposes of connecting the wind farm to the Kenya Power System further studies were required to supplement the original ESIA namely

- Ecology
- Avifauna
- Bats
- Visuals.

The scope of the Transmission Line ESIA was expanded to include the permitted Wind Farm and also to address cumulative impacts. Also the findings of the Kipeto Wind Farm ESIA served as a baseline information for the Transmission Line ESIA studies.

It was also necessary to continue with the Stakeholder Engagement Process. Please refer to the Transmission Line ESIA

- Appendix D SIA

- Appendix E SEP
- Appendix G IPP.

The entire approach to the Stakeholder Engagement process and the protection of the Indigenous People as defined by the IFC is dealt with in **Volume 5 Kipeto Wind Farm and Transmission Line SEP.** This volume also includes minutes of meetings held.

An updated shadow flicker and noise impact analysis was carried out and is appended to this report.

Ecology

Please refer also to the **Transmission Line ESIA Appendix C** for the Ecology Impact Assessment which included the area of the Kipeto Wind Farm as part of it scope. The Kipeto-Isinya landscape is diverse and characterized by different habitats complementing support for the wild herbivores and local communities. The diversity of plant species is high in the south eastern area of the proposed transmission line. Generally, there are mixed habitats and species; the upper areas have more grassland, which are easily affected by harsh climatic conditions such as drought.

The main impacts that were identified and resolved for purpose of assessment were the potential alteration of terrestrial plant through the destruction of plants and the introduction of alien invasive plant species; temporary obstruction of movement of wild-herbivores; potential poaching for bush meat; potential exposure to wild herbivores and; potential alteration of aquatic habitats. A risk assessment matrix developed by Kurrent Technologies Ltd. was used to determine potential ecological risks that the Kipeto wind energy project would pose to the environment. The risk matrix has a score of up to 100. According to the risk assessment matrix, when an impact score is more than 30 (-ve) then recommendation is made. After the assessment was undertaken, impacts that were given special attention due to exceeding the threshold were alteration of terrestrial plants (-36), introduction of alien invasive plant species (-48), alteration of aquatic habitat (-32), temporary obstruction of wild herbivores (-32).

The impacts recommended for mitigation include the avoidance of the destruction of habitats and a change in the behavior of personnel. A detailed environmental management plan is proposed at

the end to guide on issues to be addressed and assignment of responsibility on monitoring development. A review of the ecological impact assessment, of the proposed Electric Power Transmission Line project activities was carried out in accordance with the IFC EHS guideline for Electric and Power Transmission and Distribution. A field study was conducted to determine areas that would be affected adversely by the project activities. The potential impacts on ecological system in the Kipeto-Isinya area were reviewed in accordance with IFC Performance Standard and EHS guidelines, while, the Kurrent Technologies Ltd EIA study risk matrix was used to analyze impacts. Cumulative impacts from reasonably foreseeable similar projects and other activities were assessed on both habitats and movements of animals.

Following on from the original Ecological Impact Assessment some specific findings require further investigation in particular references to Acalypha and Cyperus species. A review of the ecology impact assessment as part of the due diligence process questioned whether Acalypha species is present in Africa. Some Acalypha species are also found in Kenya as indigenous species as well besides other parts of Africa. The species in this genus are however more common in the South America than Africa. The species that are in the IUCN red list of threatened species are mainly ornamental and are endemic mostly in the South America and one in Democratic Republic of Congo (Africa). There are some ornamental species in Kenya but these are exotic and only found in homes. The species encountered is indigenous and widely distributed in the country. A full species identification would require complete phenological observation based on all season observation, that is, to see its flowers and seeds other than just leaves. Absence of these can make identification reach at genus level difficult.

Similarly the cyperus species is distributed throughout all continents in both tropical and temperate regions and is often found in East Africa.

Also as the Grey-Crown Crane bird was observed on one of the water resource pan off the ROW (60 m wide) during the ecology survey but was not observed during any of the ornithology surveys the ornithologist from the Museum of Kenya who carried out the bird studies was requested to comment. The response received is as follows

The presence of a globally endangered species does not necessarily trigger a designation of Critical Habitat. Despite the fact that this species were observed the numbers were very low in fact the species were only observed once during the 2 year survey period. The Grey-crowned

crane doesn't seem to be a resident in the area and it is considered that the ecologist sighting is an opportunistic observation. The Rupells Vulture was only observed at the beginning of the survey in May 2011; the only listed species that occurred often was the African White-Backed Vulture in passage and it was only observed actively using the site when there was a dead zebra. Raptors are known to range widely as they have extensive home ranges. Following on from this and the low numbers noted, the impacts on the species shouldn't raise a red flag. None of the raptor species is resident apart from the Augur Buzzard which is listed as Least Concern. The post construction monitoring plan will consider these species as targets for monitoring.

Access Roads

The designed Kipeto Wind Farm turbine access roads are networked on the turbine areas (T1 to T63. These roads will facilitate movement of equipments during construction and monitoring phase of the project. The total distance of the access road is estimated at 29.8 km. Almost two thirds of the roads are distributed in the southern area of Kipeto while the rest are in the northern extent. A total area of 24 ha will be cleared off by construction of roads.

Potential adverse impacts of the road are envisaged during the construction phase and minimal impacts during operation due to the clearing of vegetation. The distribution of vegetation observed along the transmission line route indicates that there is a larger covering the bottom half of the southern side of the project area. It contains the bulk of species and the woody biomass in the area existing as bushes and woodland. The northern side consists only of grasslands and population of *Acacia drepanolobium*.

During wet seasons, animals especially the herbivores are distributed in the southern areas where bushes and woodland occur. This also include baboons that are conspicuous on the southern riverines and can be heard calling from far.

Construction activities are envisaged to impact varyingly on different aspects of biodiversity; these include impacts on terrestrial plants, sensitive habitats (riverines and woodlands), mammals, and herpetofauna.

Construction activities will generally be restricted to day light hours. This provides time for foraging for nocturnal animals; this group is normally sensitive to presence of human activities and flood lights at night.

During dry season the upland is dry of grasses but the lowland still has grass, herbs and shrub reserves. Most of the herbivores migrate to this area thus construction activities during the dry season can affect utilization of this area. If possible and practical, construction should be scheduled after the onset of rainfall. Generally, vegetation in the area responds quickly to rainfall hence herbivores will disperse to avoid any adverse impacts.

In order to avoid aquatic habitat alteration, the contractors will be required to work under a strict duty of care to avoid any contamination of surface waters.

Bridge

As part of the project design it is planned to construct a small bridge to facilitate access between T55 and T57. The design of the bridge will be decided at EPC stage but is likely to be a plinth measuring approximately 5m long and 5m wide. The bridge will be treated as part of the access network in terms of impact assessment.

The area where the bridge is located consists of woody biomass in the area existing as bushes and woodland. Standard construction procedures and mitigation measures as described in the ecology impact assessment will be implemented to protect the habitat and water resources impacted.

Bat Studies

Bats have been assessed in conjunction with the Transmission Line ESIA for cumulative impact. Please refer to **the Transmission Line ESIA Appendix B** for the full report.

The assessments found Impact of habitat loss, alteration and disturbance could be ameliorated by maximizing use of existing roads and trucks for vehicles. A waste management plan is also recommended to proactively guide on-site and off-site waste disposal.

The bats documented are not of critical conservation concern, nationally or regionally. None of the recorded species are either IUCN listed as threatened or known to be endemic, hence the overall remark that Kipeto-Isinya area is moderate bat conservation area.

Due to paucity in the knowledge of NMK bat specialists on how local bat species including suspected migratory ones could be affected by wind turbines and power lines, a monitoring plan is recommended during operations. The monitoring plan should be integrated within the construction and operational plans.

Birds

The ornithological impact assessment was further enhanced by additional studies as part of the scope of the proposed 220kV transmission line project. Please refer to **Appendix A of the Transmission Line ESIA.** The study aims to define the baseline environment and potential ornithological impacts associated with the project in order to develop mitigation measures that aim to minimize the negative impacts of the project while optimizing the positive impacts. Cumulative effects on the wind farm, transmission line and associated infrastructure are also assessed both at a local and national scale.

This study has been conducted to satisfy the Kenyan Environmental Management and Co-ordination Act 1999, which is the legislation that governs EIA studies in Kenya. The study further aims to satisfy the requirements of applicable avifauna related treaties and conventions and the procedures of the World Bank Group.

The ornithological impact assessment of the transmission line comprised discussions and consultations with the proponent and stakeholders; initial site reconnaissance; desk study and literature review; preparation of data collection instruments; field visits for consultations and observations; data analysis and report writing.

Bird surveys were carried out along the proposed 17km transmission line. Additional studies were also conducted on the wind farm site to relate how the different actions will impact on bird species cumulatively. No fatal flaws were identified which could prevent the project from proceeding.

There has been a substantial increased interest in wind farm developments globally. Most of the areas proposed for wind energy are also important areas for birds especially raptors and water birds. Whilst renewable energy development is crucial to the region's growth and to combating climate change, the impacts for soaring birds—including collision and electrocution with power lines and wind turbines—is considerable. The scale of energy development is huge, with over five million kilometers of transmission lines planned globally between 2010 and 2015. The Rift Valley/Red Sea region provides some of the best wind resources in the world. It is important to follow precautionary approaches that ensure potential cumulative impacts are considered and avoided where possible in accordance with existing environmental protection in EMCA and the 2012 International Finance Corporation's Performance Standards on Environmental and Social Sustainability. It should however be noted that not all the proposed wind farms presently under consideration are operational. However this assessment will consider that all potential wind farms will become operational in a reasonably foreseeable time frame.

The cumulative impact assessment in this report focused on known proposed wind farms in Kenya. The proposed projects would have the potential to impact on avifauna in a cumulative manner. Each project is expected to have additional potential impacts depending on the size, location and the interactions with different bird species.

The cumulative impacts assessment also focused on key vulnerable bird groups that include migrating raptors and breeding birds. The key cumulative effects identified were direct mortality through collision from wind turbines, transmission lines and barrier effect resulting from wind farms. Results from cumulative effects assessment indicate minimal residual impacts on birds with effective implementation of mitigation measures. A comprehensive post monitoring plan will reduce any anticipated impacts.

Hydrology

The volumes of water needed to be used have been calculated as:

- Concrete: 5000 m^3

- Roads and hardstandings: 21.300 m^3

- Maintenance roads and hardstandings: 60 m^3 per day in the working area

Several options for procuring water exist. The procurement of water including any permits required will be managed by the EPC contractor.

- Construct a borehole on site and abstract water. A permit from the Water Resource Management Authority (WRMA) is required for this. It is unlikely that enough water will be abstracted using this method alone but it could be used in combination with other supply means. It is considered likely that at least one borehole will be sunk on site to meet the water needs of the project. Care will need to be taken to not impact on other boreholes in the area. The borehole will be turned over to the community once construction is completed
- Purchase water and transport to site from within Kenya. This is standard procedure for major construction projects in Kenya.
- Potable water for catering and welfare facilities will also be supplied by the EPC contractor from an accredited source.

Visuals

The power line will connect a wind energy facility with the Kenya national grid at the Isinya Substation. As such the cumulative visual impact of the wind energy facility and the power line should be considered. In the regional context the visual impact of the wind turbines is likely to overshadow that of other structures associated with the facility. They will be visible over much greater distances than power lines and pylons.

Other existing structures such as the highly visible communication towers visible on the hills on the edge of the Rift Valley have already introduced structures visually similar to power line pylons into the viewshed and the existing landscape is not that of a pristine wilderness area with a sense of remoteness.

The cumulative visual impact of a power line in this region is therefore expected to be **low**.

Appendices

Shadow Flicker

Noise

Noise (IFC Guidance)

Layout

Project:
Kipeto Wind Farm

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Galetech Energy Development Limited
Cootehill Enterprise Park, Cootehill
IE-CO. Cavan
+353 86 8222803

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

Assumptions for shadow calculations

Maximum distance for influence
Calculate only when more than 20 % of sun is covered by the blade
Please look in WTG table

Minimum sun height over horizon for influence	3	°
Day step for calculation	1	days
Time step for calculation	1	minutes

Sunshine probability S (Average daily sunshine hours) [NAIROBI / DAGOR ETTI]

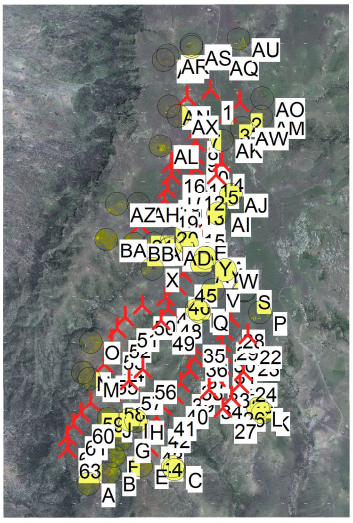
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9.22	9.20	8.45	7.04	6.12	5.08	4.28	4.16	6.18	7.43	6.87	8.47

Operational time

N	NNE	ENE	E	ESE	SSE	S	SSW	WSW	W	WNW	NNW	Sum
9	166	2,234	3,960	1,628	516	158	44	26	9	9	0	8,759

Idle start wind speed: Cut in wind speed from power curve

A ZVI (Zones of Visual Influence) calculation is performed before flicker calculation so non visible WTG do not contribute to calculated flicker values. A WTG will be visible if it is visible from any part of the receiver window. The ZVI calculation is based on the following assumptions:
Height contours used: Height Contours: 30m DEM.wpo (3)
Obstacles used in calculation
Eye height: 1.5 m
Grid resolution: 10.0 m



Scale 1:200,000
New WTG Shadow receptor

WTGs

	UTM (south)-WGS84 Zone: 37				WTG type						Shadow data	
	East	North	Z [m]	Row data/Description	Valid	Manufact.	Type-generator	Power, rated [kW]	Rotor diameter [m]	Hub height [m]	Calculation distance [m]	RPM [RPM]
1	241,518	9,814,533	2,001.7	T1	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
2	242,287	9,814,211	2,016.3	T2	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
3	241,983	9,813,919	2,016.5	T3	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
4	241,811	9,812,609	2,009.3	T4	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
5	241,666	9,812,289	2,010.0	T5	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
6	240,896	9,814,346	1,990.2	T6	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
7	241,197	9,813,779	1,995.6	T7	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
8	241,132	9,813,467	1,992.9	T8	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
9	241,121	9,813,152	1,990.4	T9	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
10	241,110	9,812,795	1,983.2	T10	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
11	241,139	9,812,463	1,993.1	T11	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
12	241,009	9,812,116	1,994.6	T12	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
13	240,997	9,811,749	1,989.7	T13	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
14	240,849	9,811,434	1,980.0	T14	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
15	241,016	9,811,132	1,989.9	T15	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
16	240,484	9,812,584	1,965.6	T16	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
17	240,481	9,812,278	1,974.1	T17	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
18	240,372	9,811,908	1,971.1	T18	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
19	240,304	9,811,604	1,968.8	T19	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
20	240,309	9,811,184	1,976.9	T20	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
21	239,650	9,810,976	1,966.0	T21	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
22	242,508	9,808,042	1,989.4	T22	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
23	242,456	9,807,732	1,971.4	T23	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
24	242,386	9,807,063	1,972.6	T24	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
25	242,296	9,806,744	1,980.5	T25	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
26	242,075	9,806,392	1,965.8	T26	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
27	241,849	9,806,088	1,952.9	T27	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
28	242,053	9,808,480	1,992.8	T28	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
29	241,894	9,808,151	1,994.4	T29	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
30	241,823	9,807,832	1,987.8	T30	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
31	241,849	9,807,527	1,979.3	T31	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
32	241,801	9,807,219	1,966.0	T32	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

	UTM (south)-WGS84 Zone: 37				WTG type						Shadow data	
	East	North	Z	Row data/Description	Valid	Manufact.	Type-generator	Power, rated	Rotor diameter	Hub height	Calculation distance	RPM
			[m]					[kW]	[m]	[m]	[m]	[RPM]
33	241,680	9,806,908	1,970.8	T33	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
34	241,480	9,806,600	1,948.3	T34	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
35	241,019	9,808,087	1,980.9	T35	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
36	241,086	9,807,712	1,989.8	T36	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
37	241,104	9,807,410	1,987.9	T37	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
38	240,967	9,807,102	1,973.4	T38	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
39	240,727	9,806,771	1,966.0	T39	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
40	240,567	9,806,459	1,965.6	T40	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
41	240,247	9,806,158	1,932.4	T41	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
42	240,093	9,805,851	1,911.9	T42	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
43	239,918	9,805,406	1,897.4	T43	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
44	239,894	9,805,086	1,884.7	T44	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
45	240,799	9,809,679	1,962.3	T45	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
46	240,632	9,809,356	1,981.3	T46	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
47	240,334	9,809,033	1,965.5	T47	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
48	240,394	9,808,731	1,954.6	T48	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
49	240,214	9,808,419	1,933.0	T49	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
50	239,713	9,808,827	1,928.3	T50	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
51	239,266	9,808,515	1,906.6	T51	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
52	239,050	9,808,209	1,903.6	T52	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
53	238,901	9,807,900	1,888.0	T53	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
54	238,894	9,807,590	1,863.9	T54	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
55	238,712	9,807,260	1,832.7	T55	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
56	239,730	9,807,130	1,895.5	T56	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
57	239,362	9,806,829	1,847.7	T57	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
58	238,908	9,806,542	1,814.4	T58	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
59	238,346	9,806,262	1,794.4	T59	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
60	238,088	9,805,967	1,785.8	T60	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
61	237,902	9,805,663	1,784.8	T61	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
62	237,727	9,805,357	1,783.8	T62	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0
63	237,737	9,805,049	1,773.8	T63	Yes	GE WIND ENERGY	GE 1.6-1,600	1,600	100.0	80.0	2,000	0.0

Shadow receptor-Input

		UTM (south)-WGS84 Zone: 37								
No.	Name	East	North	Z	Width	Height	Height a.g.l.	Degrees from south cw	Slope of window	Direction mode
				[m]	[m]	[m]	[m]	[°]	[°]	
A	H1	238,289	9,804,115	1,776.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
B	H2	238,843	9,804,402	1,783.7	1.0	1.0	1.0	0.0	90.0	"Green house mode"
C	H3 - Landowner	240,567	9,804,494	1,824.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
D	H4 - Landowner	240,527	9,804,574	1,830.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
E	H5	239,692	9,804,593	1,851.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
F	H6	238,962	9,804,841	1,794.7	1.0	1.0	1.0	0.0	90.0	"Green house mode"
G	H7 - Landowner	239,158	9,805,289	1,807.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
H	H8 - Landowner	239,552	9,805,763	1,818.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
I	H9 - Landowner	239,370	9,805,797	1,814.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
J	H10 - Landowner	238,818	9,805,823	1,808.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
K	H11 - Landowner	242,903	9,805,979	1,896.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
L	H12 - Landowner	242,773	9,806,097	1,907.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
M	H13	238,311	9,806,877	1,798.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
N	H14 - Landowner	238,146	9,807,035	1,811.9	1.0	1.0	1.0	0.0	90.0	"Green house mode"
O	H15 - Landowner	238,354	9,807,857	1,854.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
P	H17 - Landowner	242,829	9,808,634	2,002.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Q	H20 - Landowner	241,230	9,808,650	1,982.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
R	H21 - Landowner	241,154	9,808,714	1,976.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
S	H22	242,411	9,809,196	1,989.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
T	H23	242,409	9,809,203	1,989.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
U	H24	242,397	9,809,234	1,989.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

...continued from previous page

No.	Name	UTM (south)-WGS84 Zone: 37 East	North	Z [m]	Width [m]	Height [m]	Height a.g.l. [m]	Degrees from south cw [°]	Slope of window [°]	Direction mode
V	H25 - Landowner	241,585	9,809,237	1,969.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
W	H26	241,904	9,809,758	1,968.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
X	H27 - Landowner	239,984	9,809,790	1,949.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Y	H28	241,380	9,810,075	1,959.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
Z	H29	241,380	9,810,075	1,959.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AA	H30	241,380	9,810,075	1,959.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AB	H31	241,380	9,810,075	1,959.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AC	H32	240,420	9,810,327	1,970.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AD	H33	240,451	9,810,359	1,973.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AE	H34 - Landowner	240,895	9,810,492	1,981.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AF	H35	240,026	9,810,477	1,960.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AG	H36 - Landowner	240,511	9,810,602	1,984.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AH	H37 - Landowner	239,608	9,811,508	1,985.9	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AI	H38	241,721	9,811,251	1,989.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AJ	H40 - Landowner	242,056	9,811,765	2,002.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AK	H41	241,830	9,813,200	2,009.3	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AL	H42 - Landowner	240,194	9,813,053	1,966.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AM	H44 - Landowner	242,863	9,813,827	2,028.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AN	H45	240,424	9,814,088	1,986.7	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AO	H46	242,890	9,814,302	2,022.1	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AP	H47	240,277	9,815,331	2,000.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AQ	H48 - Landowner	241,665	9,815,401	1,963.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AR	H49	240,390	9,815,444	2,009.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AS	H50	241,013	9,815,670	1,970.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AT	H51	241,013	9,815,728	1,969.8	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AU	H52	242,260	9,815,884	1,944.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AV	H53	242,260	9,815,884	1,944.4	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AW	H54 - Landowner	242,342	9,813,531	2,023.5	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AX	H55 - Landowner	240,670	9,813,845	1,979.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AY	H56	241,294	9,809,897	1,954.0	1.0	1.0	1.0	0.0	90.0	"Green house mode"
AZ	H57	239,044	9,811,509	2,018.9	1.0	1.0	1.0	0.0	90.0	"Green house mode"
BA	H58	238,761	9,810,570	2,006.2	1.0	1.0	1.0	0.0	90.0	"Green house mode"
BB	H59	239,503	9,810,467	1,943.6	1.0	1.0	1.0	0.0	90.0	"Green house mode"

Calculation Results

Shadow receptor

No.	Name	Shadow, worst case: Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values: Shadow hours per year [h/year]
A	H1	0:00	0	0:00	0:00
B	H2	0:00	0	0:00	0:00
C	H3 - Landowner	0:00	0	0:00	0:00
D	H4 - Landowner	0:00	0	0:00	0:00
E	H5	0:00	0	0:00	0:00
F	H6	21:41	120	0:25	7:46
G	H7 - Landowner	39:06	153	0:30	18:41
H	H8 - Landowner	34:26	117	0:40	14:25
I	H9 - Landowner	52:20	147	0:32	20:59
J	H10 - Landowner	56:01	204	0:36	26:52
K	H11 - Landowner	24:46	76	0:31	8:21
L	H12 - Landowner	59:18	110	0:47	19:39
M	H13	12:45	50	0:22	6:13
N	H14 - Landowner	64:43	140	0:39	25:33
O	H15 - Landowner	62:10	154	0:40	29:11
P	H17 - Landowner	13:14	49	0:22	7:55
Q	H20 - Landowner	37:46	139	0:31	16:05
R	H21 - Landowner	51:05	180	0:30	21:14

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

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No.	Name	Shadow, worst case: Shadow hours per year [h/year]	Shadow days per year [days/year]	Max shadow hours per day [h/day]	Shadow, expected values: Shadow hours per year [h/year]
S	H22	1:02	28	0:03	0:25
T	H23	1:00	27	0:03	0:23
U	H24	1:00	26	0:04	0:25
V	H25 - Landowner	19:11	109	0:21	9:59
W	H26	10:46	72	0:13	6:08
X	H27 - Landowner	13:48	38	0:28	7:33
Y	H28	0:00	0	0:00	0:00
Z	H29	0:00	0	0:00	0:00
AA	H30	0:00	0	0:00	0:00
AB	H31	0:00	0	0:00	0:00
AC	H32	0:00	0	0:00	0:00
AD	H33	0:00	0	0:00	0:00
AE	H34 - Landowner	5:19	58	0:08	1:36
AF	H35	0:00	0	0:00	0:00
AG	H36 - Landowner	14:26	61	0:16	4:10
AH	H37 - Landowner	46:04	191	0:24	21:39
AI	H38	29:35	109	0:29	15:00
AJ	H40 - Landowner	15:50	111	0:14	6:41
AK	H41	44:15	131	0:24	16:26
AL	H42 - Landowner	44:30	130	0:25	19:26
AM	H44 - Landowner	8:49	40	0:18	4:02
AN	H45	63:46	179	0:39	28:33
AO	H46	41:22	138	0:33	24:23
AP	H47	0:00	0	0:00	0:00
AQ	H48 - Landowner	0:00	0	0:00	0:00
AR	H49	0:00	0	0:00	0:00
AS	H50	0:00	0	0:00	0:00
AT	H51	0:00	0	0:00	0:00
AU	H52	0:00	0	0:00	0:00
AV	H53	0:00	0	0:00	0:00
AW	H54 - Landowner	5:55	76	0:07	2:48
AX	H55 - Landowner	40:32	100	0:43	21:34
AY	H56	48:12	74	0:45	29:06
AZ	H57	1:48	48	0:03	0:51
BA	H58	6:20	60	0:09	2:15
BB	H59	9:03	45	0:13	3:12

Total amount of flickering on the shadow receptors caused by each WTG

No.	Name	Worst case [h/year]	Expected [h/year]
1	T1	19:16	6:59
2	T2	28:48	16:14
3	T3	32:42	17:55
4	T4	3:44	1:53
5	T5	0:00	0:00
6	T6	10:26	3:44
7	T7	65:39	33:51
8	T8	53:18	17:42
9	T9	25:33	13:24
10	T10	13:13	6:41
11	T11	0:00	0:00
12	T12	15:05	5:04
13	T13	7:49	3:45
14	T14	16:02	7:01
15	T15	29:55	15:20
16	T16	0:00	0:00
17	T17	0:20	0:06
18	T18	0:16	0:06
19	T19	16:46	7:29

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SHADOW - Main Result

Calculation: Shadow Flicker Predictions

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No.	Name	Worst case [h/year]	Expected [h/year]
20	T20	20:14	9:55
21	T21	21:19	6:35
22	T22	0:00	0:00
23	T23	0:00	0:00
24	T24	0:00	0:00
25	T25	0:00	0:00
26	T26	37:08	10:57
27	T27	18:26	9:06
28	T28	33:49	18:55
29	T29	0:00	0:00
30	T30	0:00	0:00
31	T31	0:00	0:00
32	T32	0:00	0:00
33	T33	0:00	0:00
34	T34	18:10	5:19
35	T35	0:08	0:04
36	T36	0:00	0:00
37	T37	0:00	0:00
38	T38	0:00	0:00
39	T39	0:00	0:00
40	T40	4:51	1:50
41	T41	32:54	11:46
42	T42	45:50	21:34
43	T43	30:54	14:53
44	T44	31:31	14:41
45	T45	67:13	39:27
46	T46	15:32	7:36
47	T47	27:16	9:16
48	T48	21:33	11:20
49	T49	8:56	4:19
50	T50	0:00	0:00
51	T51	0:00	0:00
52	T52	10:18	3:39
53	T53	28:53	14:23
54	T54	19:33	9:22
55	T55	54:37	20:01
56	T56	8:26	3:52
57	T57	14:25	7:45
58	T58	0:00	0:00
59	T59	7:37	2:24
60	T60	13:24	5:13
61	T61	9:18	4:52
62	T62	14:36	6:12
63	T63	2:58	1:16

Project:
Kipeto Wind Farm

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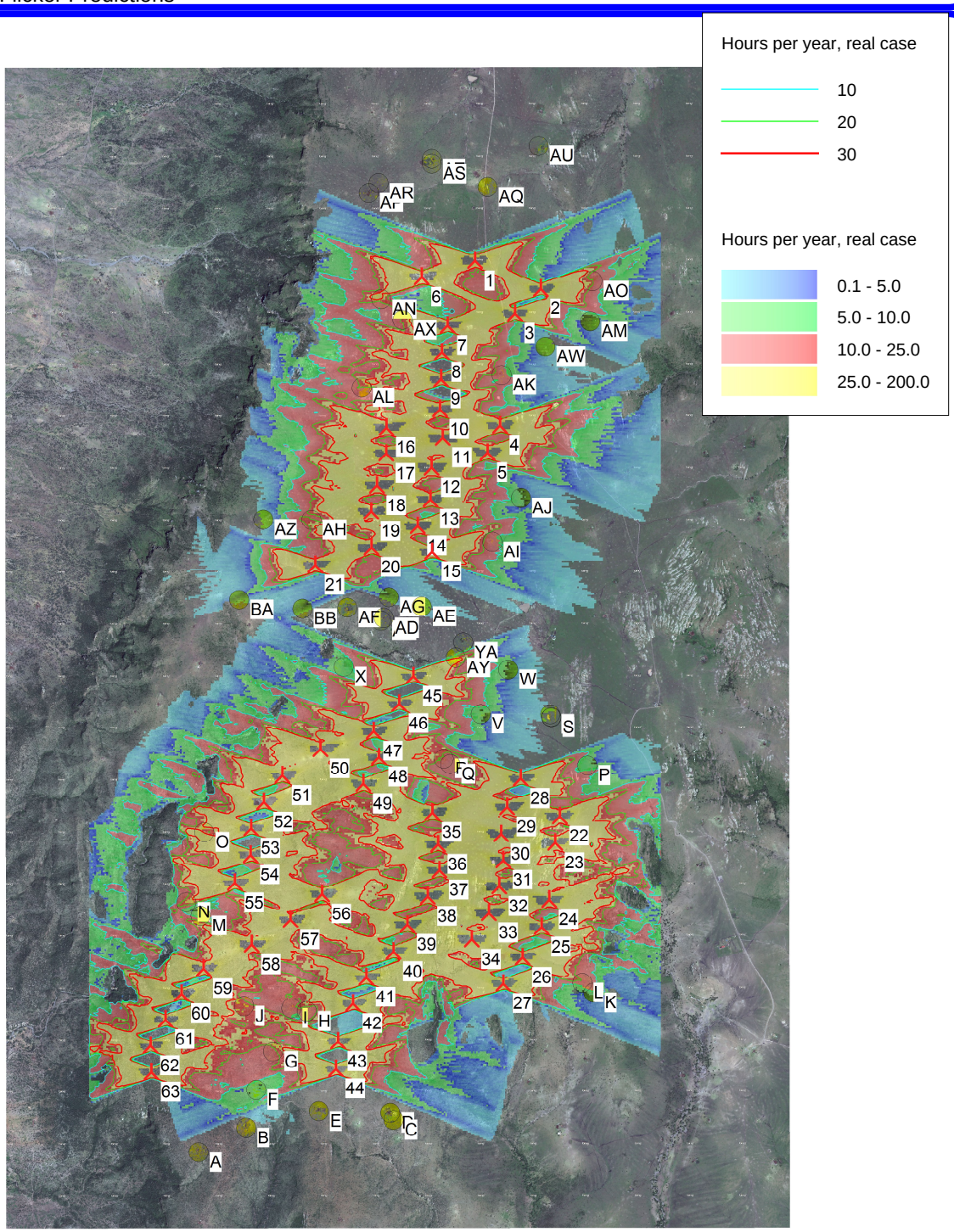
IE-CO. Cavan
+353 86 8222803

Calculated:
02/09/2013 18:16/2.8.579

SHADOW - Map

Calculation: Shadow Flicker Predictions



0 1 2 3 4 km

Map: Bitmap map: Kipeto Bing Aerail.jpg , Print scale 1:75,000, Map center UTM (south)-WGS84 Zone: 37 East: 240,340 North: 9,810,100

New WTG Shadow receptor

Flicker map level: Height Contours: 30m DEM.wpo (3)

Chapter 12

Noise Impact Assessment

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12.2 Proposed Development 3
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12.1 Introduction

This Chapter of the EIS assesses the potential noise impacts generated by the proposed wind farm development on the noise-sensitive locations in the vicinity of the site. GED Ltd. in association with Mr. Mike Simms, Acoustic Consultant conducted an assessment into the likely noise impact associated with this proposed wind farm during both the construction and operational phases. The noise predictions were calculated for the proposed Kipeto Wind Farm of 63 no. turbines and 62 households.

During the operation of the wind farm, the principal source of noise will be generated by the wind turbines themselves, by the blades rotating in the air (aerodynamic noise) and by internal machinery, and to a lesser extent, the generator (mechanical noise). Calculations in this assessment are based on a 63 turbine layout with each turbine modelled on an 80m hub height and a 100m rotor blade diameter to represent Kipeto. All receptors within 1km (10 rotor diameters) of a proposed turbine are assessed for noise impact. As the prevailing wind direction in this part of Kenya is easterly, it is considered the potential for greatest noise impact is at receptors to the west of the wind farm.

In assessing the noise impact of a wind development on the existing environment, information from the turbine manufacturer on operating noise sound levels is required. In addition, the existing noise levels in the environs of the subject lands must be established. In undertaking a baseline noise survey acoustic data must be correlated with wind speed in order to provide a comprehensive assessment.

12.1.1 Purpose of the Noise Impact Assessment

The purpose of the noise impact assessment is to quantify the generated noise levels at nearby noise-sensitive locations resulting from the construction and operational phases of the wind farm to ensure compliance with the recommended guidance of Republic of Kenya The Environmental Management and Coordination (Noise And Excessive Vibration Pollution Control) Regulation, 2008 Arrangements of Regulation as listed on the National Environment Management Authority Kenya (NEMA)[1].

Predictions of worst-case noise levels will be carried out based on the proposed site layout and the manufacturer's guaranteed noise levels for turbines for the site. "Worst-case" noise

levels in this instance means that receptors are considered to be downwind of all wind turbines, which clearly cannot happen in practice at all houses simultaneously.

Background monitoring to establish baseline noise levels will be carried out in January 2012 once micro-siting of turbines has been finalised.

12.2 Proposed Development

The proposed development is for a wind farm consisting of 63 no. 1.6MW turbines and all associated development. The dimensions of the proposed turbines are:

- Hub height – 80m
- Blade Length – 50 m
- Rotor Diameter – 100m
- Overall height not exceeding - 130m

A site layout map can be found in Appendix 12.1. This map identifies all receptors assessed and their identification number.

12.3 Receiving Environment

Kipeto Energy Limited proposes to develop a 100MW capacity wind farm approximately 18km north-west of Kajiado town in the Rift Valley Province. The proposed project will be undertaken in the Esilanke area, Oloyangani (Kipeto) sub-location, south Keekonyokei location in Kiserian, Kajiado division. The proposed wind farm will be developed on land leased from local land owners; the wind turbines will be sited over a project area measuring approximately 70km^2. A full site description is given in Chapter 2.

12.4 Receptor Survey

A receptor survey was conducted in order to quantify the number of properties within 1km (10 rotor diameters) of the proposed turbines. In total, 53 receptors were found.

12.5 Noise Prediction Model

There are 62 households located within 1km of a proposed turbine (10 rotor diameters). To predict the noise generated at these properties, noise modelling was conducted using WindPRO software, version 2.8.579. Please refer to Appendix 12.1 for detailed results of the prediction model.

The noise prediction model was run using a wind speed of 12 m/s at 10 m height. All criteria are based on L_{A90} levels rather than L_{Aeq}: L_{A90} is the 90th percentile noise level which is exceeded for 90% of the time. As wind turbines will be operating continuously throughout its particular operating range the L_{A90} level is much more useful in identifying noise which may be attributed directly to the wind farm rather than L_{Aeq} which will be affected by short term influences such as a passing car or plane or short-term noise from external influences including wildlife or man-made sources.

The "A" suffix denotes the fact that the sound levels have been "A-weighted" in order to account for the frequency characteristics of human hearing. All sound pressure levels are expressed in terms of decibels (dB) relative to $2x10^{-5}$ Pa.

The Noise prediction model implements the International Standard ISO 9613-2, Acoustics – Attenuation of Sound during Propagation Outdoors[2]. The propagation model described in Part 2 of this standard provides for the prediction of sound pressure levels based on conditions favourable to noise propagation.

The ISO propagation model calculates the predicted sound pressure level by taking the source sound power level for each turbine in separate octave bands and subtracting a number of attenuation factors according to the following:

Predicted Octave Band Noise Level =

$$L_w + D - A_{geo} - A_{atm} - A_{gr} - A_{bar} - A_{misc}$$

These factors are discussed in detail below. The predicted octave band levels from each of the turbines are summed together to give the overall 'A' weighted predicted sound level from all the turbines acting together.

12.5.1 L_W - Source Sound Power Level

The proposed development consists of 63 no. GE 1.6MW turbines. The parameters of this turbine type are as follows:

Turbine Elements	*GE 1.6 100*
Rotor diameter	100m
Hub height	80m
Cut-in wind speed	3m/s
Cut-out wind speed	25m/s

Table 12.5.1.1: Wind Turbine Parameters of the GE 1.6MW Turbine Model

The sound power level of a noise source is normally expressed in dB re:1pW. Noise predictions for this site have been based on sound power levels of the GE 1.6MW turbine. This assessment is based on warranted sound power levels for this turbine, as indicated in Table 12.6.1.2 below.

Wind Speed at 10m Height (m/s)	*Sound Power Level , dB(A) re 10^{-12}W* *GE 1.6MW*
4	95.0
5	99.5
6	104.2
7	106.8
8 and upwards	107.0

Table 12.5.1.2: – Wind Turbine Sound Power Levels

In accordance with the manufacturer's recommendations, these values include safety factor of 2dB for the purposes of calculating predicted noise levels.

12.5.2 – Directivity Factor

The directivity factor allows for an adjustment to be made where the level of sound radiates from the source in a non-uniform manner. In this case the sound power level is measured in a down wind direction, corresponding to the worst case propagation conditions considered here and needs no further adjustment.

12.5.3 A_{geo} – Geometrical Divergence

The geometrical divergence accounts for spherical spreading in the free-field from a point sound source resulting in attenuation depending on distance according to:

$$A_{geo} = 20 \times \log (d) + 11$$

where d = distance from the turbine

Each of the wind turbines may be considered as a point source beyond distances corresponding to one rotor diameter.

12.5.4 A_{atm} – Atmospheric Absorption

Sound propagation through the atmosphere is attenuated by the conversion of the sound energy into heat. This attenuation is dependent on the temperature and relative humidity of the air through which the sound is travelling and is frequency dependent with increasing attenuation towards higher frequencies. The attenuation depends on distance according to:

$$A_{atm} = d \times \alpha$$

where d = distance from the turbine and
α = atmospheric absorption coefficient in dB/m

Values of 'α' from ISO 9613 Part 1, corresponding to a temperature of 15ºC and a relative humidity of 70% have been used for these predictions, which give relatively low levels of atmospheric attenuation and correspondingly worst case noise predictions, as given below.

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
Atmospheric Absorption Coefficient (dB/m)	0.0001	0.0004	0.0011	0.0023	0.0041	0.0087	0.0264	0.0937

Table 12.6.4.1: Assumed Octave Band Atmospheric Attenuation Coefficients

12.5.5 A_{gr} – Ground Effect

Ground effect is the interference of sound reflected by the ground interfering with the sound propagating directly from source to receiver. The prediction of ground effects is inherently complex and depends on the source height, receiver height, propagation height between the source and receiver and the ground conditions. The ground conditions are described according to a variable G, which varies between 0 for 'hard' ground (includes paving, water,

ice, concrete & any sites with low porosity) and 1 for 'soft' ground (includes ground covered by grass, trees or other vegetation). The predictions have been carried out using a source height corresponding to the proposed height of the turbine nacelle, a receiver height of 4 m and an assumed ground factor G = 0.5.

12.5.6 A_{bar} – Barrier Attenuation

The effect of any barrier between the noise source and the receiver position is that noise will be reduced according to the relative heights of the source, receiver and barrier and the frequency spectrum of the noise. The barrier attenuations predicted by the ISO 9613 model have, however, been shown to be significantly greater than that measured in practice under down wind conditions. The results of a study of propagation of noise from wind farm sites carried out for ETSU-R-97[3] concludes that an attenuation of just 2 dB (A) should be allowed where the direct line of sight between the source and receiver is just interrupted and that 10 dB (A) should be allowed where a barrier lies within 5m of a receiver and provides a significant interruption to the line of sight. It should be noted that no barrier attenuation has been used in any of the noise predictions for this site.

12.5.7 A_{misc} – Miscellaneous Other Effects

ISO 9613 includes effects of propagation through foliage, industrial plant and housing as additional attenuation effects. These have not been included here and any such effects are unlikely to significantly reduce noise levels below those predicted.

12.6 Noise Criteria

12.6.1 Noise in the Environment

Wind farms are generally situated in rural environments where there are few sources of noise. When wind speeds are high, noise tends not to be a problem since any noise generated is masked by wind induced noise effects, particularly that of the trees and vegetation being blown. However, at lower wind speeds or in particular sheltered locations, the wind induced background noise may not be sufficient to mask any noise generated by wind turbines. At these low speeds, the generated noise levels may be so low as to generate very little impact.

Noise levels are normally expressed in decibels. Noise in the environment is measured using the dB(A) scale which includes a correction for the response of the human ear to noises with different frequency content. As a general rule, for noises of the same nature, a change of

3dB(A) is the minimum perceptible under normal conditions, and a change of 10dB(A) corresponds roughly to halving or doubling the loudness level of a sound[1].

All measurements are based on L_{A90} levels rather than L_{Aeq}. L_{A90} is the 90th percentile noise level which is exceeded for 90% of the time. As wind turbines will be operating continuously throughout its particular range the L_{A90} level is more useful in identifying noise which may be attributed directly to the wind farm rather than L_{Aeq} which will be affected by short term influences such as a passing car or localised agricultural activities.

12.6.2 Construction Phase

The major activities which result in construction noise are the construction of roads, construction of foundations and wind turbine erection. Typical sound levels 10m from construction equipment are found in BS5228:2009 *Code of practice for noise and vibration control on construction and open sites*[4], presented in Table 12.7.2.2 below.

Noise Source	*BS5228 Ref.*	*dB(A) $L_{Aeq,10m}$*
Excavator (22t)	C2.3	78
Dozer	C2.12	81
Dump Truck (tipping fill)	C2.30	79
Roller (rolling fill)	C2.37	79
Concrete Mixer Truck	C4.20	80
Mobile Telescopic Crane	C4.39	77
Mini Tracked Excavator (5t)	C4.68	74

Source: BS5228:2009 *Code of practice for noise and vibration control on construction and open sites*

Table 12.6.2.2 Typical Sound Levels from Construction Equipment

As can be seen, the expected noise levels are below the criteria in Table 12.7.2.1 for weekdays and Saturdays. It should also be noted that most houses are considerably further away from any part of the proposed works and as such the scenario described above is very much a worst case. Additionally, the construction works will progress around the site, thus any construction noise impact on any particular house will be transitory.

12.6.3 Operational Phase

Noise is generated by wind turbines as they rotate to generate power. This only occurs above the 'cut-in' wind speed and below the 'cut-out' wind speed. Below the cut-in wind speed

there is insufficient strength in the wind to generate efficiently and above the cut-out wind speed the turbine is automatically shut down to prevent any malfunctions from occurring. The cut-in speed at turbine hub height is normally 3m/sec and the cut out wind speed is normally around 25 m/sec at hub height (80m) on the GE 1.6 turbine model.

The principal sources of noise resulting from wind turbines are:

1. Aerodynamic noise
2. Mechanical noise

12.6.3.1 Aerodynamic Noise

Aerodynamic noise is caused by blades passing through the air and it is generally broadband in nature which can have a swishing character. This noise is a function of many factors including blade design, rotational speed, and wind speed and inflow turbulence. Aerodynamic noise has been substantially reduced over time due to improvements in turbine design.

As a result, aerodynamic noise is wind speed dependant, and the sound power output from a turbine must be measured and quoted relative to wind speed. The reference sound power output from a turbine is typically provided by the manufacturer over a range of wind speeds.

Careful design of the rotor blades ensures that aerodynamic noise is minimised. Special consideration is given to the blade tips which, due to their relatively high velocities, generate the most noise. Nevertheless, it should be noted that aerodynamic noise is an unavoidable by-product of wind generated electricity. The use of sufficient separation distances is therefore the fundamental design option available to wind farm developers for the control of noise at residential properties.

12.6.3.2 Mechanical Noise

Mechanical noise is generated by components inside the turbine nacelle (usually the gearbox and generator) and can be radiated by the shell of the nacelle, blades and the tower structure.

Unlike aerodynamic noise, mechanical noise has the potential to be tonal in nature, i.e. it is concentrated at a few discrete frequencies. Mechanical noise can be successfully controlled at the design stage of the turbine, using advanced gearbox design and anti-vibration techniques. As mentioned above technological developments in engineering practices have in general

limited mechanical noise output. The tonal audibility for the GE 1.6 is such that no correction is required to be applied to predicted noise levels at noise-sensitive locations.

12.7 Legislation and Guidance

Kenya

LEGAL NOTICE NO. 61

THE ENVIRONMENTAL MANAGEMENT AND COORDINATION (NOISE AND EXCESSIVE VIBRATION POLLUTION) (CONTROL) REGULATIONS, 2009

FIRST SCHEDULE

(reg. 5, 6(1), 11(1))

MAXIMUM PERMISSIBLE NOISE LEVELS

Zone		*Sound Level Limits dB(A) (Leq,14 h)*		*Noise Rating Level (NR) (Leq,14 h)*	
		Day	Night	Day	Night
A.	Silent Zone	40	35	30	25
B	Places of worship	40	35	30	25
C.	Residential : Indoor Outdoor	45 50	35 35	35 40	25 25
D.	Mixed residential (with some commercial and places of entertainment)	55	35	50	25
E.	Commercial	60	35	55	25

Time Frame

Day: 6.01 a.m. – 8.00 p.m. (Leq, 14 h)
Night: 8.01 p.m. – 6.00 a.m. (Leq, 10h)

The proposed development at Kipeto is on Masai owned land where there are 62 households. These households correspond with the prescribed levels for zone C above which

SECOND SCHEDULE

(r. 13(1), 14 (1)(b))

MAXIMUM PERMISSIBLE NOISE LEVELS FOR CONSTRUCTIONS SITES
(Measurement taken within the facility)

Facility		*Maximum Noise Level Permitted (Leq) in dB(A)*	
		Day	Night
(i)	Health facilities, educational institutions, homes for disabled etc.	60	35
(ii)	Residential	60	35
(iii)	Areas other than those prescribed in (i) and (ii)	75	65

Time Frame:

Day: 6.01 a.m. – 6.00 p.m. (Leq, 14 h)
Night: 6.01 p.m. – 6.00 a.m. (Leq, 14 h)

demonstrates sound level limits of 40dB(A)$_{Leq,14\ hr}$ during the day and 35dB(A)$_{Leq14hr}$ at night.

The Second Schedule of the regulations deal with the maximum permissible noise levels for construction sites with (II) pertaining to this assessment. The maximum allowable noise level is 60 Leq dB(A) during the day and 35Leq dB(A) at night.

UK Guidance

"*The Assessment and Rating of Noise from Wind Farms*" – ETSU-R-97 September 1996, published by the UK Department of Trade and Industry[3]

The ETSU-R-97 report was produced by a UK working group on Wind Turbine Noise. The aim of the working group was to provide information and advice to developers and planners on the environmental assessment of noise from wind turbines. The document describes a framework for the measurement of wind farm noise and gives indicative noise levels thought

to offer a reasonable degree of protection to wind farm neighbours, without placing unreasonable restrictions on wind farm development or adding unduly to the costs and administrative burdens on wind farm developers or local authorities. The suggested noise limits and their reasonableness have been evaluated with regard to regulating the development of wind energy in the public interest. They have been presented in a manner that makes them a suitable basis for noise-related planning conditions or covenants within an agreement between a developer of a wind farm and the local authority.

The Noise Working group recommends that the fixed limit for night time is 43dB(A). This limit is derived from the 35dB(A) sleep disturbance criteria referred to in planning policy Guidance note (24 PG24). An allowance of 10dB(A) has been made for attenuation through an open window and 2dB subtracted to account for the use of $L_{A90,10min}$ rather than $L_{Aeq,10min}$ ETSU-R-97 document, which also comments, in respect of houses where the occupant has an interest in the development:

> *… that both day- and night-time lower fixed limits can be increased to 45dB(A) and that consideration should be given to increasing the permissible margin above background where the occupier of the property has some financial involvement in the wind farm.*

The suggested noise limits take into account the fact that all wind turbines exhibit the character of noise described as blade swish to a certain extent. ETSU-R-97 recommends that a penalty should be added, however, to the predicted noise levels, where any tonal component is present. The level of this penalty is related to the level by which any tonal components exceed audibility.

This guidance has been adopted in many countries including Ireland.

Wind Farm Planning Guidelines 2006 (Ireland)[5]

In general, a lower fixed limit of 45 dB(A) or a maximum increase of 5dB(A) above background noise at nearby noise sensitive locations is considered appropriate to provide protection to wind energy development neighbours. However, in very quiet areas, the use of a margin of 5dB(A) above background noise at nearby noise sensitive properties is not necessary to offer a reasonable degree of protection and may unduly restrict wind energy developments which should be recognised as having wider national and global benefits. Instead, in low noise environments where background noise is less than 30 dB(A), it is recommended that the daytime level of the $L_{A90,\,10min}$ *of the wind energy development noise be limited to an absolute level within the range of 35-40 dB(A)."*

The Guidelines recommend that
Separate noise limits should apply for day-time and for night-time. During the night the protection of external amenity becomes less important and the emphasis should be on preventing sleep disturbance. A fixed limit of 43dB(A) will protect sleep inside properties during the night."

The Guidelines consider that *noise is considered unlikely to be a significant problem where the distance from the nearest turbine to any noise sensitive property is more than 500 metres. Planning authorities may seek evidence that the type(s) of turbines proposed will use best current engineering practice in terms of noise creation and suppression"*

12.8 Prediction of Likely Noise Impacts

When considering a development of this nature, the potential noise impact on the surroundings must be considered for each of two distinct stages: the short term impact of the construction phase and the longer term impact of the operational phase. Given the nature of this development, it is unlikely that there will be any significant overlap of these phases.

12.7.1 Construction Phase

A variety of items of plant will be in use, such as excavators, lifting equipment, dumper trucks, compressors, and generators. There will be vehicular movements to and from the site that will make use of existing roads.

Due to the nature of the activities undertaken on a large construction site, there is potential for generation of significant levels of noise. The flow of vehicular traffic to and from a construction site is also a potential source of noise levels. The potential for vibration at neighbouring sensitive locations during construction is typically limited to excavation works and lorry movements on uneven road surfaces. Due to the proximity of sensitive locations to the site access point, the more significant of these is likely to be uneven road surfaces.

Due to the fact that the construction program has been established in outline form only, set out in Chapter 3 of the EIS, it is difficult to calculate the actual magnitude of noise emissions to the local environment. However, Table 12.7.2.2 indicates typical noise levels that would be expected from the proposed construction site during the various phases of the construction project.

For the purposes of the assessment, it is assumed that equipment will be operating at distances in excess of 350m during soil excavation / access track construction and 500m during the foundation/turbine erection/general construction phases from non-involved properties in the vicinity of the proposed development.

12.8.2 Predicted Noise Levels during Operational Phase

Noise levels for 62 households in the vicinity of the site were predicted for this wind speed. The results are re-produced in Appendix 12.1 below. It should be noted that these predictions represent downwind propagation in all directions, which clearly cannot happen at all locations simultaneously.

The lower fixed noise level limit is 43dB L_{A90} for non-involved houses and the lower fixed noise level limit for involved houses is 45dB L_{A90}.

The predicted noise levels lie within the adopted criteria in all cases. The noise impact of the wind farm is considered acceptable.

Conclusions

The environmental noise impact of the proposed wind farm at Kipeto has been analysed and shown to be generally within the criteria in the *ETSU-R-97* at the noise survey locations.

12.9 Proposed Mitigation Measures for Noise Impacts

12.9.1 Mitigation measures – Construction Phase

Construction activities will give rise to noise on site from the increased traffic as well as the construction activity. The second schedule of the 2009 regulations deal with the maximum permissible levels of noise allowed due to construction activities.

To ensure that construction noise remains below "nuisance" levels, reference is made to BS 5228: Part 1: 1997 (Noise Control on Construction and Open Sites – Part 1. Codes of Practice for Basic Information and Procedures for Noise Control) which offers detailed guidance on the control of noise from demolition and construction activities.

Accordingly all construction traffic to be used on site should

- Have effective well-maintained silencers.
- Operators of all mobile equipment will be instructed to avoid unnecessary revving of machinery.
- Where possible the contractor will be instructed to use the least noisy equipment.
- With efficient use of well-maintained mobile equipment considerably lower noise levels than those predicted can be attained.
- The Project Engineer will closely supervise all construction activity.
- Construction activity due to its nature is a temporary activity and thus any impacts will be short term typically 6-12 months.

The following mitigation measures for control of construction noise will be implemented, as recommended in BS 5228: Part 1:1997

- The hours of construction activity will be limited to between 08.00 hours and 20.00 hours Monday to Friday and 08.00 hours and 18.00 hours on Saturdays. It should be noted that it may be necessary to commence turbine base concrete pours from 06.00 due to time constraints incurred by the concrete curing process. Additional emergency works may also be required outside of normal working hours as quoted above.
- Communication links will be established and maintained between the developer, contractor, Local Authority and local residents.
- Equipment and technology with generation of low noise levels will be selected where possible.
- Noise generating equipment will be located as far as possible away from local noise sensitive areas identified.
- In the unlikely event that irregularities or complaints arise, the source of the problem will be sought and dealt with.
- Temporary barriers or screens can be erected if necessary around noisy equipment such as generators and compressors.

12.8.2 Mitigation Measures – Operational Phase

Mitigation against noise from the proposed development consists of the following measures:

- Site layout design to ensure minimal disruption to sensitive receptors
- It is recommended that, additional post development noise monitoring in accordance with international noise standards in particular ISO 1996: "Description and measurement of environmental noise" be carried out to monitor accurately the acoustic impact of development according to site atmospheric conditions and corrected for background speeds at any potentially sensitive locations.

Mitigation measures have already been put in place by siting the wind turbines in an appropriate position to cause the minimum impact at the nearest noise sensitive location and also by choosing a turbine size that is appropriate to the demands of power generation and noise impact.

A warranty agreement will be drawn up with the manufacturer of the turbines for this site to ensure that the noise output will not contain any significant audible tones.

References

1. The Environmental Management and Coordination (Noise and Excessive Vibration Pollution) (Control) Regulations, 2009 www.nema.go.ke

2. International Organization for Standardization, 1996. ISO 9613-2, *Acoustics – Description, Measurement and Assessment of Environmental Noise:* Parts 1 and 2.

3. ETSU-R-97: UK Department of Trade and Ind*ustry, 1996. The Assessment and Rating of Noise from Wind Farms.*

4. *British St*andards Institution, 1997. BS 4142:1997 *Method for rating industrial noise affecting mixed residential and industrial areas.* London: BSI

5. DoEHLG's (2006) *Wind Energy Development Guidelines for Planning Authorities.*

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NOISE ASSESSMENT FOR IFC GENERAL EHS GUIDELINES

FOR A WIND FARM DEVELOPMENT AT KIPETO, KAJIADO PROVINCE, KENYA

Purpose of Issue	Date of Issue	Author	Checked	Approved
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Galetech Energy Developments
Unit 1
Cootehill Enterprise Centre,
Cootehill,
Co. Cavan
Tel: + 353 (0) 49 5555050

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1. INTRODUCTION

Galetech Energy Developments Limited (GED) understands Kipeto Energy Ltd (KEL) are developing a wind farm project at Kipeto in the Kajiado Province of Kenya. The project consists of 63 no. GE 1.6-100 wind turbines located approx 45km south of Nairobi and approx 16km north west of Kajiado.

The nature of the land is mountain pasture with residents living in 'homesteads' – small groups of one-storey houses. The locations of these houses were obtained from field survey using a GPS device with sub-meter accuracy. 76 dwellings were identified within 1km of a proposed turbine. 13 landowners have agreed to move their dwellings to a different location on their plot to allow for turbines on their land. Taking these changes into account, there remain 62 noise-sensitive locations within the study area. These locations have been assessed in this report.

This document presents the results of the noise assessment based on the criteria set out in the International Finance Corporation document *General EHS Guideline.*

2. ASSESSMENT CRITERIA

This assessment is based on the International Finance Corporation document *General EHS Guidelines.* These are general guidelines and do not contain any wind farm specific information. In this instance reference is made to Table 1.7.1 in these guidelines, in which maximum noise level of 55 dB $L_{Aeq,1hr}$ for daytime and 45 dB $L_{Aeq,1hr}$ for night-time are given. As the wind farm would operate at any time of day or night, the daytime limit is not relevant and the night-time limit is considered to apply throughout daytime and night-time periods.

3. WIND TURBINE SOUND POWER LEVELS

The table below shows the wind turbine sound power levels used in this assessment. This levels are taken directly from the manufacturer's documentation (dated 2013) which can be found in Appendix 1 of this report. Uncertainty allowances have not been taken into account.

Wind speed at 10m above ground	Sound Power Level, dB(A) re 10^{-12}W at Octave-Band Centre Frequency (All values A-weighted)								
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**Overall**
4	71.9	79.2	85.5	87.6	87.3	85.5	77.2	56.6	93.0
5	75.9	83.8	90.4	92.4	91.2	89.9	82.9	62.5	97.5
6	80.1	88.1	95.1	97.7	95.5	93.9	87.8	68.8	102.2
7	83.6	91.0	95.6	99.1	100.6	97.1	88.3	68.6	104.8
8	83.8	91.3	95.5	98.8	101.0	97.3	87.8	68.9	105.0
9	83.8	91.3	95.6	98.9	101.1	97.1	87.2	67.7	105.0
10 to cutout	83.6	91.1	95.6	99.0	101.2	96.7	86.5	67.3	105.0

Table 1 Wind turbine sound power levels of the GE 1.6-100 (80m hub height) at various wind speeds

4. PREDICTED NOISE LEVELS

The noise levels were predicted using the WindPRO software package version 2.8.579. This package predicts noise levels based at noise-sensitive locations using the method described in ISO 9613: *Acoustics – Attenuation of sound during propagation outdoors*. The model also contained terrain data to reflect correctly the differences in land height of each turbine and noise-sensitive location. The parameters used in the WindPRO noise model are outlined in table 2 below.

Noise calculation model: ISO 9613-2 General
Wind speed: 12m/s (worst case)
Turbine LwaRef: 105dB(A)
Ground attenuation: General, Ground factor: 0.5
Meteorological coefficient, C0: 0.0 dB
Noise values in calculation: All noise values are mean values (LWA)
Pure tones: Pure and Impulse tone penalty are added to WTG source noise
Height above ground level (Imission height): 4.0 m

Table 2 WindPRO model parameters

The predicted noise levels are the total noise level at each noise-sensitive location due to the wind farm. Wind farm noise is generally assessed in terms of $L_{A90,10\ min}$, where given the nature of the noise, is generally accepted that the L_{A90} of measured wind farm noise is 2dB lower than the L_{Aeq} value. However the WindPRO software was configured in this instance to predict the noise levels at each dwelling in terms of L_{Aeq}. The predicted noise levels at each dwelling are shown in Table 2 below:

Dwelling	Easting	Northing	Z	Imission height	Predicted Noise Level dB, L_{Aeq}
H01	238,289	9,804,115	1,776.60	4	36.7
H02	238,843	9,804,402	1,783.80	4	37.7
H03	240,567	9,804,494	1,824.60	4	38.5
H04	240,527	9,804,574	1,831.00	4	39.2
H05	239,692	9,804,593	1,851.90	4	41.6
H06	238,962	9,804,841	1,794.50	4	39.8
H07	239,158	9,805,290	1,807.10	4	42.0
H08	239,552	9,805,763	1,818.20	4	44.9
H09	239,370	9,805,797	1,815.00	4	43.7
H10	238,818	9,805,821	1,808.10	4	43.8
H11	242,903	9,805,979	1,897.20	4	40.2
H12	242,773	9,806,097	1,907.20	4	41.7
H13	238,311	9,806,877	1,797.60	4	44.5
H14	238,146	9,807,035	1,812.10	4	43.1
H15	238,354	9,807,857	1,854.20	4	44.3
H17	242,829	9,808,634	2,002.10	4	42.1
H20	241,230	9,808,650	1,982.30	4	45.0
H21	241,154	9,808,714	1,976.40	4	44.9
H22	242,411	9,809,196	1,989.10	4	40.6
H23	242,409	9,809,203	1,989.10	4	40.5
H24	242,397	9,809,234	1,989.00	4	40.4
H25	241,618	9,809,160	1,971.50	4	42.4
H26	241,904	9,809,758	1,968.50	4	39.7
H27	239,984	9,809,790	1,949.10	4	42.7
H28	241,380	9,810,075	1,959.30	4	41.5
H29	241,380	9,810,075	1,959.30	4	41.5
H30	241,380	9,810,075	1,959.30	4	41.5
H31	241,380	9,810,075	1,959.30	4	41.5
H32	240,420	9,810,327	1,970.40	4	42.8
H33	240,451	9,810,359	1,973.70	4	42.8
H34	240,895	9,810,492	1,981.20	4	43.1
H35	240,016	9,810,502	1,961.80	4	43.0

H36	240,511	9,810,602	1,984.70	4	43.8
H37	239,608	9,811,508	1,986.00	4	43.9
H38	241,721	9,811,251	1,989.60	4	42.6
H40	242,056	9,811,765	2,002.10	4	42.4
H41	241,830	9,813,200	2,009.20	4	45.0
H42	240,194	9,813,053	1,966.50	4	43.8
H44	242,863	9,813,827	2,028.50	4	40.1
H45	240,424	9,814,088	1,986.70	4	42.6
H46	242,890	9,814,302	2,022.30	4	40.1
H47	240,277	9,815,331	2,000.40	4	35.5
H48	241,665	9,815,401	1,963.50	4	37.7
H49	240,390	9,815,444	2,009.70	4	35.3
H50	241,013	9,815,670	1,970.80	4	35.4
H51	241,013	9,815,728	1,970.20	4	35.0
H52	242,260	9,815,884	1,944.80	4	33.4
H53	242,260	9,815,884	1,944.80	4	33.4
H54	242,344	9,813,532	2,023.60	4	43.2
H55	241,930	9,813,379	2,013.30	4	44.5
H56	241,294	9,809,897	1,953.90	4	42.7
H57	239,044	9,811,509	2,018.60	4	39.6
H58	238,761	9,810,570	2,006.40	4	37.9
H59	239,503	9,810,467	1,944.10	4	42.1
H60	239,433	9,804,877	1,828.80	4	42.5
H61	239,155	9,804,860	1,807.70	4	40.5
H62	239,339	9,806,212	1,842.70	4	44.9
H63	242,349	9,812,478	2,003.00	4	42.8
H64	239,841	9,809,478	1,944.40	4	43.8
H65	243,068	9,808,217	1,997.10	4	42.5
H67	243,453	9,808,084	1,955.00	4	39.3
H68	241,101	9,815,055	1,988.30	4	40.8

Table 1 Predicted noise levels at each dwelling in L_{Aeq}

5. CONCLUSIONS

Noise levels due to the proposed wind farm have been predicted and shown to be within the adopted criteria.

APPENDIX 1: NOISE PROFILE OF THE GE1.6 100

GE Power & Water

– Original Instructions –

Technical Documentation
Wind Turbine Generator Systems
1.6-100 - 50 Hz and 60 Hz

Product Acoustic Specifications

Normal Operation according to IEC
Incl. Octave Band Spectra
Incl. 1/3rd Octave Band Spectra

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1 Introduction

This document summarizes the acoustic emission characteristics of 1.6-100 wind turbine for normal operation, including calculated apparent sound power levels $L_{WA,k}$, as well as uncertainty levels associated with the apparent sound power levels, tonal audibility, and calculated third octave band apparent sound power level.

All provided sound power levels are A-weighted.

GE continuously verifies specifications with measurements, including those performed by independent institutes. If a wind turbine noise performance test is carried out, it needs to be done in accordance with the regulations of the international standard IEC 61400-11, ed. 2.1: 2006 and Machine Noise Performance Test document.

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2 Normal Operation Calculated Apparent Sound Power Level

The apparent sound power levels $L_{WA,k}$ are initially calculated as a function of the hub height wind speed v_{HH}. The corresponding wind speeds v_{10m} at 10 m height above ground level have been evaluated assuming a logarithmic wind profile. In this case a surface roughness of z_{0ref} = 0.05 m has been used, which is representative of average terrain conditions.

$$v_{10m} = v_{HH} \frac{\ln\left(10m / z_{0ref}\right)}{\ln\left(hub\ height / z_{0ref}\right)} \quad *$$

The calculated apparent sound power levels $L_{WA,k}$ and the associated octave-band spectra are given in Table 1 and Table 2 for two different hub heights. The values are provided as mean levels as a function of v_{10m} for Normal Operation (NO) over cut-in to cut-out wind speed range. The uncertainties for octave sound power levels are generally higher than for total sound power levels. Guidance is given in IEC 61400-11, Annex D.

1.6-100 – Normal Operation Octave Spectra									
Standard wind speed at 10 m [m/s]		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10-Cutout**
Hub height wind speed at 80 m [m/s]		**4.2**	**5.6**	**7.0**	**8.4**	**9.7**	**11.1**	**12.5**	**14-Cutout**
Frequency (Hz)	**31.5**	62.5	62.2	66.1	70.0	73.3	73.6	73.5	73.3
	63	72.1	71.9	75.9	80.1	83.6	83.8	83.8	83.6
	125	79.0	79.2	83.8	88.1	91.0	91.3	91.3	91.1
	250	85.0	85.5	90.4	95.1	95.6	95.5	95.6	95.6
	500	88.2	87.6	92.4	97.7	99.1	98.8	98.9	99.0
	1000	87.7	87.3	91.2	95.5	100.6	101.0	101.1	101.2
	2000	84.0	85.5	89.9	93.9	97.1	97.3	97.1	96.7
	4000	74.4	77.2	82.9	87.8	88.3	87.8	87.2	86.5
	8000	54.5	56.6	62.5	68.8	68.6	68.9	67.7	67.3
	16000	6.9	12.2	17.9	23.2	25.4	24.9	25.8	27.2
Total apparent sound power level $L_{WA,k}$ [dB]		**92.9**	**93.0**	**97.5**	**102.2**	**104.8**	**105.0**	**105.0**	**105.0**

Table 1: Normal Operation Calculated Apparent Sound Power Level, 1.6-100 with 80 m hub height as a function of 10 m wind speed (z_{0ref} = 0.05 m), the octave band spectra are for information only

* Simplified from IEC 61400-11, ed. 2.1: 2006 equation 7

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1.6-100 – Normal Operation Octave Spectra									
Standard wind speed at 10 m [m/s]		**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10-Cutout**
Hub height wind speed at 96 m [m/s]		**4.3**	**5.7**	**7.1**	**8.6**	**10.0**	**11.4**	**12.8**	**14-Cutout**
Frequency (Hz)	**31.5**	62.4	62.4	66.6	70.6	73.6	73.6	73.5	73.3
	63	72.1	72.0	76.5	80.6	83.8	83.8	83.7	83.6
	125	79.0	79.5	84.4	88.6	91.2	91.3	91.3	91.1
	250	85.0	85.8	91.0	95.5	95.6	95.6	95.6	95.6
	500	88.2	87.7	93.0	98.2	99.0	98.8	98.8	99.0
	1000	87.6	87.4	91.7	96.2	100.9	101.1	101.1	101.2
	2000	84.1	85.8	90.5	94.4	97.4	97.3	97.0	96.7
	4000	74.5	77.6	83.6	88.2	88.5	87.6	87.0	86.5
	8000	54.7	56.9	63.4	69.2	69.5	68.2	67.5	67.3
	16000	7.4	12.6	18.5	23.7	25.7	24.8	26.0	27.2
Total apparent sound power level $L_{WA,k}$ [dB]		**92.9**	**93.1**	**98.1**	**102.7**	**105.0**	**105.0**	**105.0**	**105.0**

Table 2: Normal Operation Calculated Apparent Sound Power Level, 1.6-100 with 96 m hub height as a function of 10 m wind speed (z_{0ref} = 0.05 m), the octave band spectra are for information only

At 10 m wind speeds lower than 5 m/s the sound power levels decreases, and may get so low that the wind turbine noise becomes indistinguishable from the background noise. For a conservative calculation the data at 5 m/s may be used.

For 10 m wind speeds above 10 m/s, the wind turbine has reached rated power and the blade pitch regulation acts in a way that tends to decrease the noise levels. For a conservative calculation the data at 10 m/s may be used.

The highest normal operation calculated apparent sound power level for the 1.6-100 is $L_{WA,k}$ = 105.0 dB.

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3 Uncertainty Levels

The apparent sound power levels given above are calculated mean levels. If a wind turbine noise performance test is carried out, it needs to be done in accordance with the regulations of the international standard IEC 61400-11, ed. 2.1: 2006. Uncertainty levels associated with measurements are described in IEC/TS 61400-14.

Per IEC/TS 61400-14, L_{WAd} is the maximum apparent sound power level for 95 % confidence level resulting from n measurements performed according to IEC 61400-11 standard: $L_{Wad} = L_{WA} + K$, where L_{WA} is the mean apparent sound power level from IEC 61400-11 testing reports and $K = 1.645\ \sigma_T$.

The testing standard deviation values σ_T, σ_R and σ_P for measured apparent sound power level are described by IEC/TS 61400-14, where σ_T is the total standard deviation, σ_P is the standard deviation for product variation and σ_R is the standard deviation for test reproducibility.

Assuming $\sigma_R < 0.8$ dB and $\sigma_P < 0.8$ dB as typical values leads to a calculated K < 2 dB for 95 % confidence level.

4 Tonal Audibility

The tonal audibility ($\Delta L_{a,k}$), when measured in accordance with the IEC 61400-11 standard, for the GE's 1.6-100 is less than or equal to 2 dB.

5 IEC 61400-11 and IEC/TS 61400-14 Terminology

- $L_{WA,K}$ is wind turbine apparent sound power level (referenced to 10^{-12}W) measured with A-weighting as function of reference wind speed v_{10m}. Derived from multiple measurement reports per IEC 61400-11, it is considered as a mean value
- σ_P is the product variation i.e. the 1.6-100 unit-to-unit product variation; typically < 0.8 dB
- σ_R is the overall measurement testing reproducibility as defined per IEC 61400-11; typically < 0.8 dB with adequate measurement conditions and sufficient amount of data samples
- σ_T is the total standard deviation combining both σ_P and σ_R
- **$K = 1.645\ \sigma_T$** is defined per IEC/TS 61400-14 for 95 % confidence level
- R_0 is the ground measuring distance from the wind turbine tower axis per IEC 61400-11, which shall equal the hub height plus half the rotor diameter
- $\Delta L_{a,k}$ is the tonal audibility according to IEC 61400-11, described as potentially audible narrow band sound

6 1/3rd Octave Band Spectra

The tables in Annex I are showing the 1/3rd octave band values for different hub heights in different wind speeds.

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Reference:

- IEC 61400-1. Wind turbines – part 1: Design requirements. ed. 2. 1999
- IEC 61400-11, wind turbine generator systems part 11: Acoustic noise measurement techniques, ed. 2.1, 2006-11
- IEC/TS 61400-14, Wind turbines – part 14: Declaration of apparent sound power level and tonality values, ed. 1, 2005-03
- MNPT – Machine Noise Performance Test, Technical documentation, GE 2011

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Appendix I - Calculated 1/3rd Octave Band Apparent Sound Power Level $L_{WA,k}$

1.6-100 - Normal Operation 1/3rd Octave Band Spectra									
Standard wind speed at 10 m [m/s]		3	4	5	6	7	8	9	10-Cutout
Hub height wind speed at 80 m [m/s]		4.2	5.6	7.0	8.4	9.7	11.1	12.5	14-Cutout
Frequency (Hz)	25	52.2	52.1	55.8	59.7	63.0	63.2	63.1	62.9
	32	56.6	56.4	60.2	64.1	67.4	67.7	67.6	67.4
	40	60.6	60.3	64.2	68.2	71.5	71.7	71.7	71.5
	50	63.7	63.5	67.4	71.4	74.7	75.0	75.0	74.8
	63	66.5	66.2	70.3	74.4	77.8	78.1	78.0	77.8
	80	69.7	69.5	73.6	77.8	81.4	81.6	81.6	81.4
	100	72.3	72.2	76.5	80.7	84.3	84.5	84.5	84.3
	125	74.1	74.2	78.7	82.9	86.1	86.4	86.4	86.2
	160	75.6	76.1	80.8	85.2	87.6	88.0	88.0	87.9
	200	77.8	78.4	83.3	87.8	89.3	89.5	89.6	89.6
	250	80.2	80.9	85.7	90.4	90.9	91.0	91.1	91.1
	315	81.8	82.1	87.0	92.0	91.8	91.5	91.6	91.6
	400	82.8	82.7	87.5	92.7	92.7	92.3	92.4	92.5
	500	83.7	83.1	87.8	93.2	94.3	93.9	93.9	94.1
	630	83.8	82.8	87.4	92.8	95.5	95.3	95.4	95.6
	800	83.1	82.2	86.5	91.5	96.0	96.0	96.2	96.3
	1000	82.8	82.3	86.1	90.4	95.9	96.4	96.5	96.6
	1250	82.7	82.9	86.6	90.3	95.6	96.3	96.4	96.4
	1600	81.1	82.0	86.0	89.7	93.9	94.5	94.5	94.1
	2000	79.0	80.8	85.3	89.3	92.2	92.2	91.9	91.4
	2500	76.3	79.0	83.9	88.2	90.1	89.5	88.9	88.4
	3150	72.8	75.7	81.4	86.0	86.9	86.1	85.6	84.9
	4000	68.1	70.7	76.7	82.0	81.8	81.8	80.8	80.4
	5000	62.7	64.4	71.0	76.5	76.2	76.5	75.0	74.9
	6300	54.3	56.3	62.3	68.5	68.3	68.5	67.4	66.9
	8000	41.6	44.5	50.0	55.9	56.8	57.1	56.2	55.6
	10000	26.1	30.3	35.5	41.0	42.8	42.7	42.7	42.6
	12500	6.9	12.2	17.9	23.1	25.4	24.9	25.7	27.2
	16000	-20.0	-14.2	-7.1	-1.8	0.1	0.1	2.3	4.5
	20000	-48.8	-43.5	-35.1	-28.4	-27.7	-26.3	-23.5	-20.9
Total apparent sound power level $L_{WA,k}$ [dB]		92.9	93.0	97.5	102.2	104.8	105.0	105.0	105.0

Table 3: Calculated Apparent 1/3rd Octave Band Sound Power Level (A-weighted) 1.6-100 with 80 m hub height as Function of Wind Speed v_{10m}

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1.6-100 - Normal Operation 1/3rd Octave Band Spectra									
Standard wind speed at 10 m [m/s]		3	4	5	6	7	8	9	10-Cutout
Hub height wind speed at 96 m [m/s]		4.3	5.7	7.1	8.6	10.0	11.4	12.8	14-Cutout
Frequency (Hz)	25	52.1	52.2	56.4	60.2	63.2	63.2	63.1	62.9
	32	56.6	56.5	60.7	64.7	67.7	67.7	67.6	67.4
	40	60.6	60.5	64.7	68.7	71.7	71.7	71.6	71.5
	50	63.7	63.6	67.9	72.0	75.0	75.0	74.9	74.8
	63	66.5	66.4	70.8	74.9	78.0	78.1	78.0	77.8
	80	69.7	69.7	74.2	78.4	81.6	81.6	81.5	81.4
	100	72.3	72.4	77.0	81.2	84.5	84.6	84.4	84.3
	125	74.0	74.5	79.3	83.5	86.3	86.4	86.3	86.2
	160	75.6	76.4	81.4	85.7	87.9	88.0	88.0	87.9
	200	77.8	78.8	83.9	88.2	89.5	89.6	89.6	89.6
	250	80.3	81.2	86.4	90.8	91.0	91.1	91.0	91.1
	315	81.8	82.4	87.7	92.3	91.7	91.6	91.5	91.6
	400	82.8	82.8	88.2	93.1	92.6	92.4	92.4	92.5
	500	83.6	83.2	88.5	93.7	94.2	93.9	93.9	94.1
	630	83.7	82.9	88.1	93.4	95.5	95.4	95.4	95.6
	800	83.1	82.3	87.1	92.2	96.1	96.1	96.2	96.3
	1000	82.7	82.5	86.6	91.1	96.3	96.5	96.5	96.6
	1250	82.7	83.1	87.1	90.9	96.0	96.4	96.4	96.4
	1600	81.1	82.2	86.5	90.3	94.2	94.6	94.4	94.1
	2000	79.1	81.1	85.8	89.7	92.5	92.2	91.8	91.4
	2500	76.5	79.3	84.5	88.6	90.2	89.5	88.8	88.4
	3150	73.0	76.2	82.0	86.4	87.0	86.0	85.5	84.9
	4000	68.2	71.2	77.4	82.3	82.1	81.6	80.7	80.4
	5000	62.8	64.9	71.8	76.8	76.8	75.9	75.0	74.9
	6300	54.4	56.6	63.1	68.9	69.2	67.8	67.2	66.9
	8000	41.9	44.8	50.8	56.4	57.5	56.8	55.9	55.6
	10000	26.5	30.6	36.2	41.5	43.3	42.5	42.6	42.6
	12500	7.4	12.6	18.5	23.7	25.7	24.8	26.0	27.2
	16000	-19.5	-13.7	-6.4	-1.3	0.2	0.4	2.8	4.5
	20000	-48.5	-42.9	-34.2	-27.8	-27.6	-25.7	-22.9	-20.9
Total apparent sound power level $L_{WA,k}$ [dB]		92.9	93.1	98.1	102.7	105.0	105.0	105.0	105.0

Table 4: Calculated Apparent 1/3rd Octave Band Sound Power Level (A-weighted), 1.6-100 with 96 m hub height as Function of Wind Speed v_{10m}

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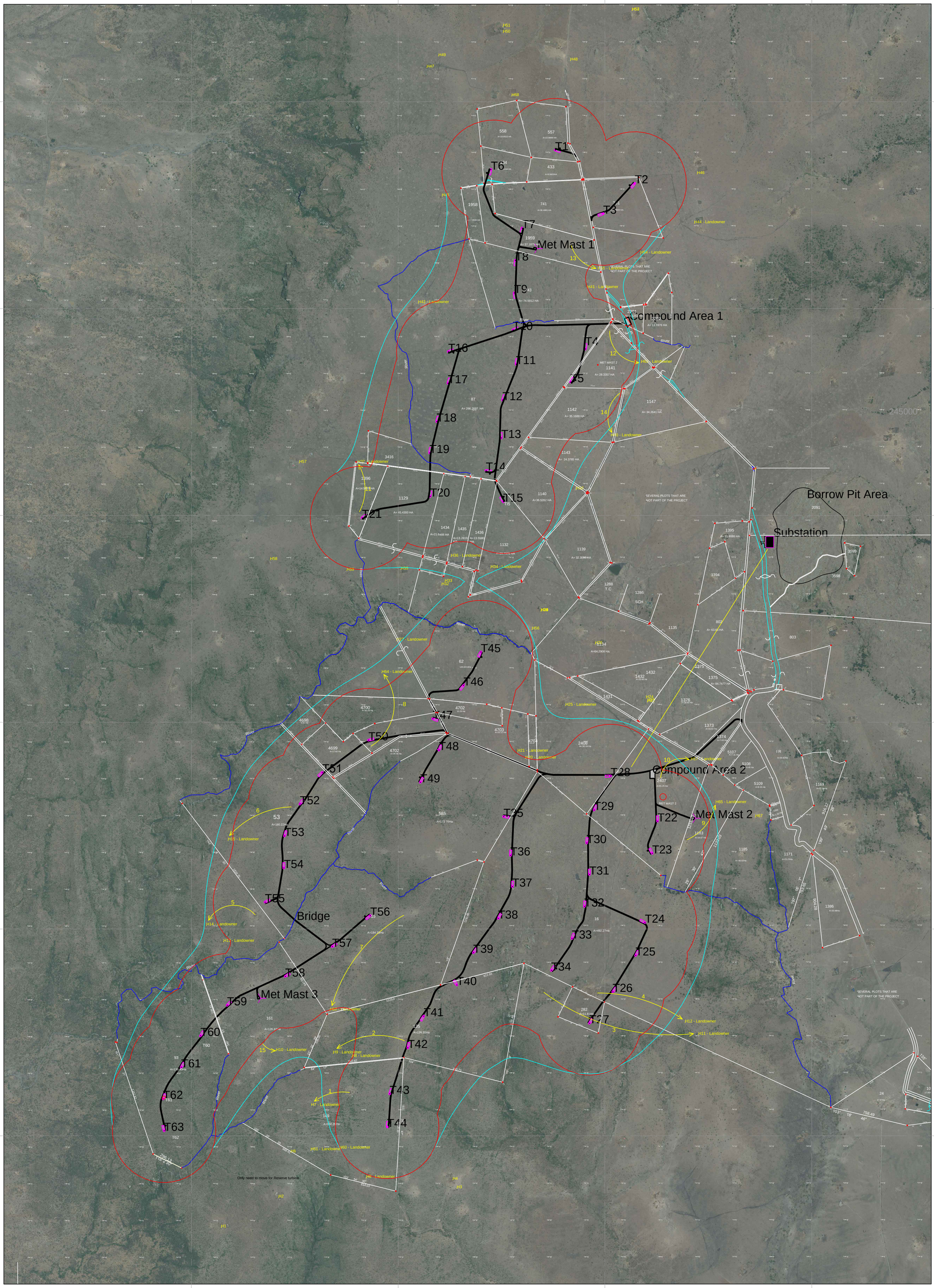

Legend:

Tx	Turbine Location
	Turbine & Crane Hardstanding
	Proposed Road Infrastructure
	Public road

No Dwellings should be located inside the RED Line (45dB or 500m)

No Non-Landowner Dwellings should be located inside the CYAN Line(43dB)

Notes:

-Layout based on GE1.6MW (100m rotor) turbine
-All Coordinates in UTM Zone 37S & WGS84 Datum

Date:	Rev:	Description:	Drawn By:

Drawing No.: 130728/CMP/GD/002	Revision No.: 0
Scale: 1:20,000	Date: 30/08/2013
Drawn By: C.M.P	Checked By: H.B / Confirmed By: D.S.

Galetech Energy Developments,
Cootehill Enterprise Centre,
Cootehill, Co Cavan
Ireland

Client: Kipeto Wind Farm

Job Title: Kipeto Wind Farm

Drawing Title: Revised Layout - August 2013