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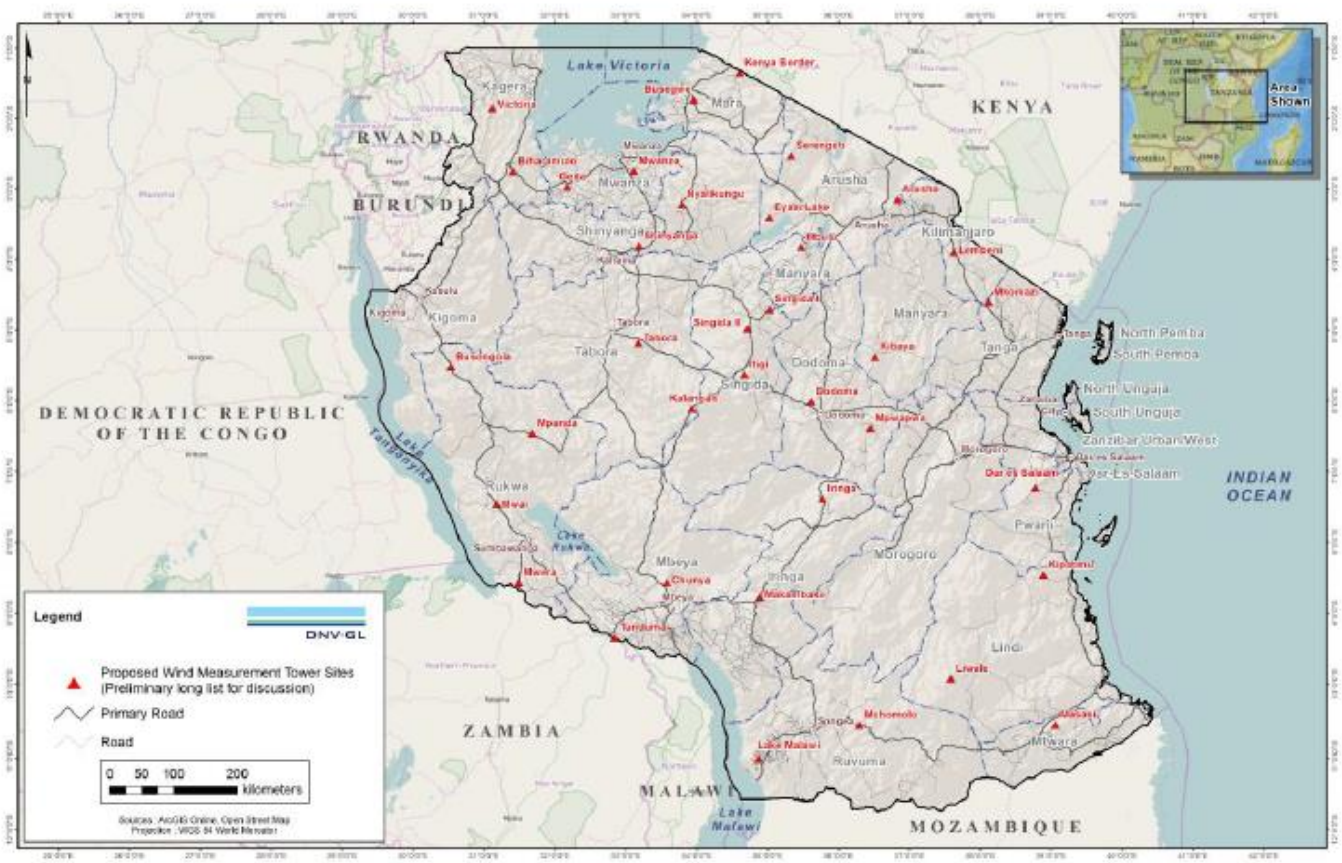
ESMAP
Energy Sector Management Assistance Program

Wind Resource Mapping in Tanzania

CLOSE OUT REPORT

DECEMBER 2016



This report was prepared by DNV GL, under contract to The World Bank.

This is a **close-out report** for the wind resource mapping component of the activity "Renewable Energy Resource Mapping and Geospatial Planning – Tanzania" [Project ID: P145287]. This activity is funded and supported by the Energy Sector Management Assistance Program (ESMAP), a multi-donor trust fund administered by The World Bank, under a global initiative on Renewable Energy Resource Mapping. Further details on the initiative can be obtained from the ESMAP website.

The above-mentioned project **has been concluded** due to funding limitations, and will not proceed to Phase 2 (collection of ground-based wind measurements) at this time. This document describes the activities that have been completed up to this point, and the planning that was done in preparation for Phase 2, which may be of interest and use to other stakeholders. Users are strongly advised to exercise caution when utilizing the information and the data contained. In the event of a reactivation of this project further information will be provided on the ESMAP website.

RENEWABLE ENERGY WIND MAPPING FOR TANZANIA

Close Out Report

The World Bank

Document No.: 702910-USSD-R-03
Issue: B**, Status:** Final
Date: 14 December 2016

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Task and objective:

Document activities which have been completed as part of Phase 1 and Phase 2 and describe next steps to move forward for re-initiation of project.

Prepared by:	Verified by:	Approved by:
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A	15 September 2016	DRAFT	L. Simmons	C. Gessert	M. Cookson
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1 INTRODUCTION

The World Bank ("Customer") retained Garrad Hassan America, Inc. ("DNV GL") to provide a validated mesoscale wind atlas for Tanzania, including associated deliverables and wind energy development training courses. Validation of the wind atlas was planned to be undertaken by installing several wind measurement meteorological towers throughout the country. Meteorological data collected at these sites over a two-year period were planned to provide the basis for validating the mesoscale modeling outputs.

On 25 May 2016, the World Bank informed DNV GL that the project was being concluded until further funding could be allocated. This report is being prepared as part of general close-out activities. This report describes the activities that have been completed to date and the next steps to move forward, if and when the project is re-activated.

2 PHASE 1 SUMMARY

2.1 Inception

A project inception meeting was held in Dar es Salaam in November 2014. The purpose of the meeting was to introduce the project to all stakeholders and allow for questions related to the scope of work. Further, DNV GL solicited input to guide development of the planned training courses.

2.2 Initial mesoscale modelling

In July 2015, DNV GL released the final Wind Modelling Report[1]. The report included a wind speed map, a wind speed uncertainty map, and an energy map of Tanzania. The data from the modelling activities was eventually made available on the IRENA online wind atlas[2][3][4].

An excerpt from the report:

"A new 2-km-resolution mesoscale wind atlas has been generated by DNV GL for the entire country of Tanzania, providing for the first time information on the potential resource. It is based on a complete 10-year simulation of the local and regional wind flows, and will serve as the foundation to a broader program of sustainable development of renewable energy in Tanzania, while dramatically increasing the awareness of the available resources within the country to both policy makers and potential investors.

A unique characteristic of this new 2 km resolution interim wind atlas is the availability of hourly output over the entire 10-year simulation period, which represents the full range of wind and thermal stratification conditions over Tanzania. It allows the monthly, seasonal, yearly, and inter-annual variation in the wind resource to be fully quantified. This unprecedented level of granularity will set the benchmark for a new era in the renewable energy mapping."

2.3 Site identification

In parallel with development of the mesoscale wind model, DNV GL identified a preliminary list of 36 sites to be considered for the wind measurement campaign (i.e., mast installation). A report was issued (702910-USSD-T-01-A) describing these locations and the met mast specifications. This report is included as part of the close out package. The sites were presented to the World Bank in the Candidate Site Identification Report[5] in July 2015. Each site was ranked according to a system developed by DNV GL which incorporated wind speed, wind speed uncertainty, potential for future commercial wind development, construction

[1] http://pubdocs.worldbank.org/en/353981471092387651/Tanzania-Wind-Mapping-Mesoscale-Modeling-Report-WB-ESMAP-May2015.pdf
[2] http://pubdocs.worldbank.org/pubdocs/publicdoc/2016/6/67511465222330367/GIS-Files-Tanzania-Wind-Mapping-Phase1-WBG-ESMAP-2015-07-10.zip
[3] http://213698bd603ab068ae30-38026bb8de994fbd5152239b0fb60388.r96.cf5.rackcdn.com/TZA/LIB_Files_Tanzania-Wind-Mapping_Phase1_WBG-ESMAP_2015-06-09.zip
[4] http://213698bd603ab068ae30-38026bb8de994fbd5152239b0fb60388.r96.cf5.rackcdn.com/TZA/GIS-Files_Tanzania-Wind-Mapping_12x24_Phase1_WBG-ESMAP_2015-06-09.zip
[5] http://pubdocs.worldbank.org/en/289831465287638659/Tanzania-Wind-Mapping-Site-Identification-Report-WB-ESMAP-July2015.pdf

complexity, ease of access, security and environmental and social sensitivity. In late July 2015, this list was later reduced to the 14 best sites, as proposed by DNV GL. Details of the selection are provided below.

The selection was as follows (in no specific ranking): Dar Es Salaam, Masasi, Mchomolo, Makambako, Iringa, Dodoma, Singinda II, Mbulu, Lembeni, Tabora, Geita, Busongola, Mwai, Busegwe.

This selection was based on the following:

1. **Diverse geographic coverage for all of Tanzania**

Note that Geita would cover the northwest region and possibly Rwanda and Burundi. Busongola and Mwai cover the western area, with no current grid. No masts have been suggested close to the Zambia border, since a site is planned in the Chanka area (south of the Tunduma proposed location) under the Zambian ESMAP initiative. Lembeni and Mbulu could provide valuable data for sites close to the Kenya border.

2. **Sites in areas where the interim wind atlas indicates excellent wind resource**

Generally, the sites ranged from 8.5 to 10 m/s in the Udzunga mountains, but also some sites with lower indicative wind resource in the range of 6 m/s (northwest or southeast, such as Mchomolo) were selected to adequately represent the spectrum of wind regimes.

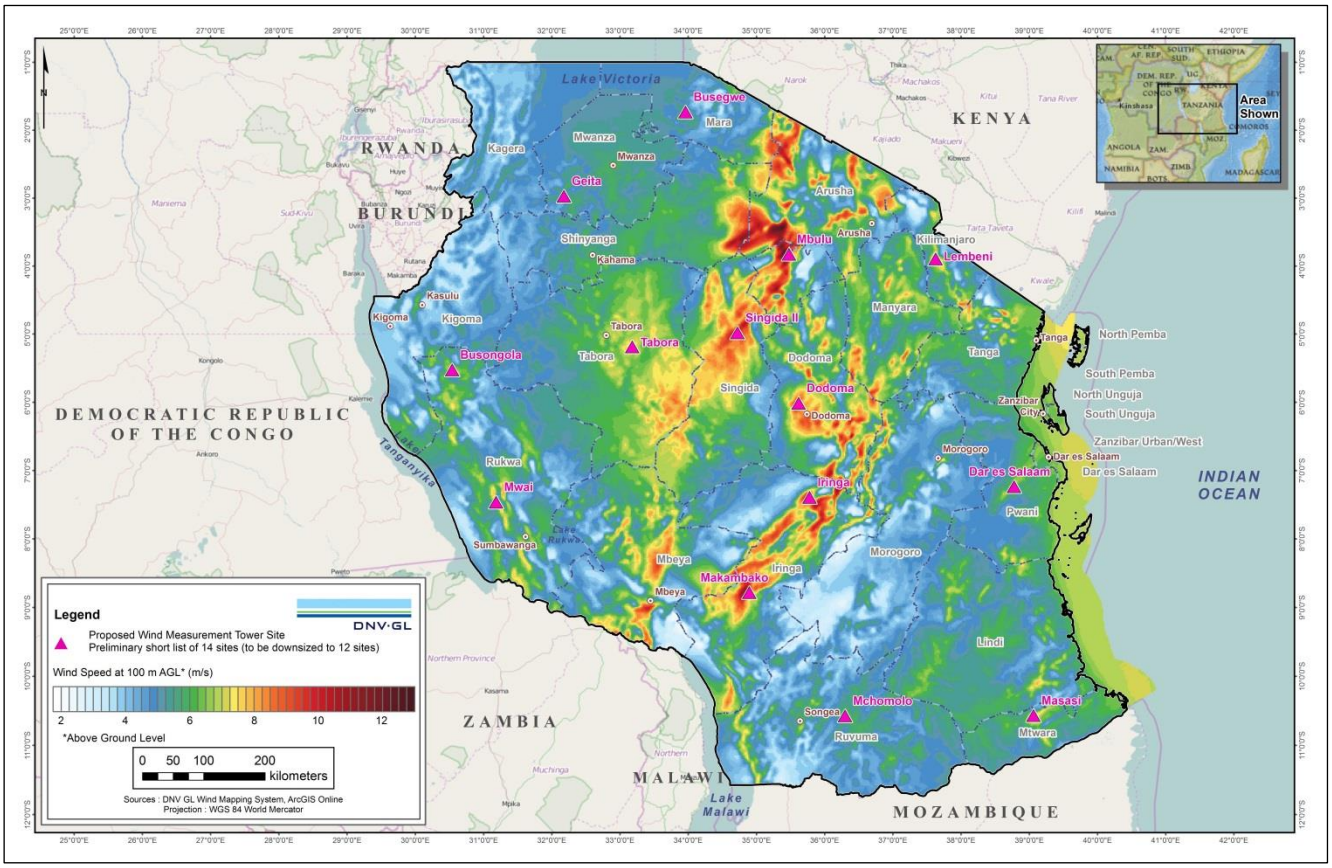

Figure 2-1 Top 14 candidate sites with average wind speed

3. Sites in areas where the interim wind atlas indicates high uncertainty

These include Iringa (highest at 1.6 m/s standard deviation), Dodoma, Mchomolo, Makambako, Masasi, Lembeni (and others). All sites have significant uncertainty with Dar Es Salaam having the lowest at 0.6 m/s (standard deviation).

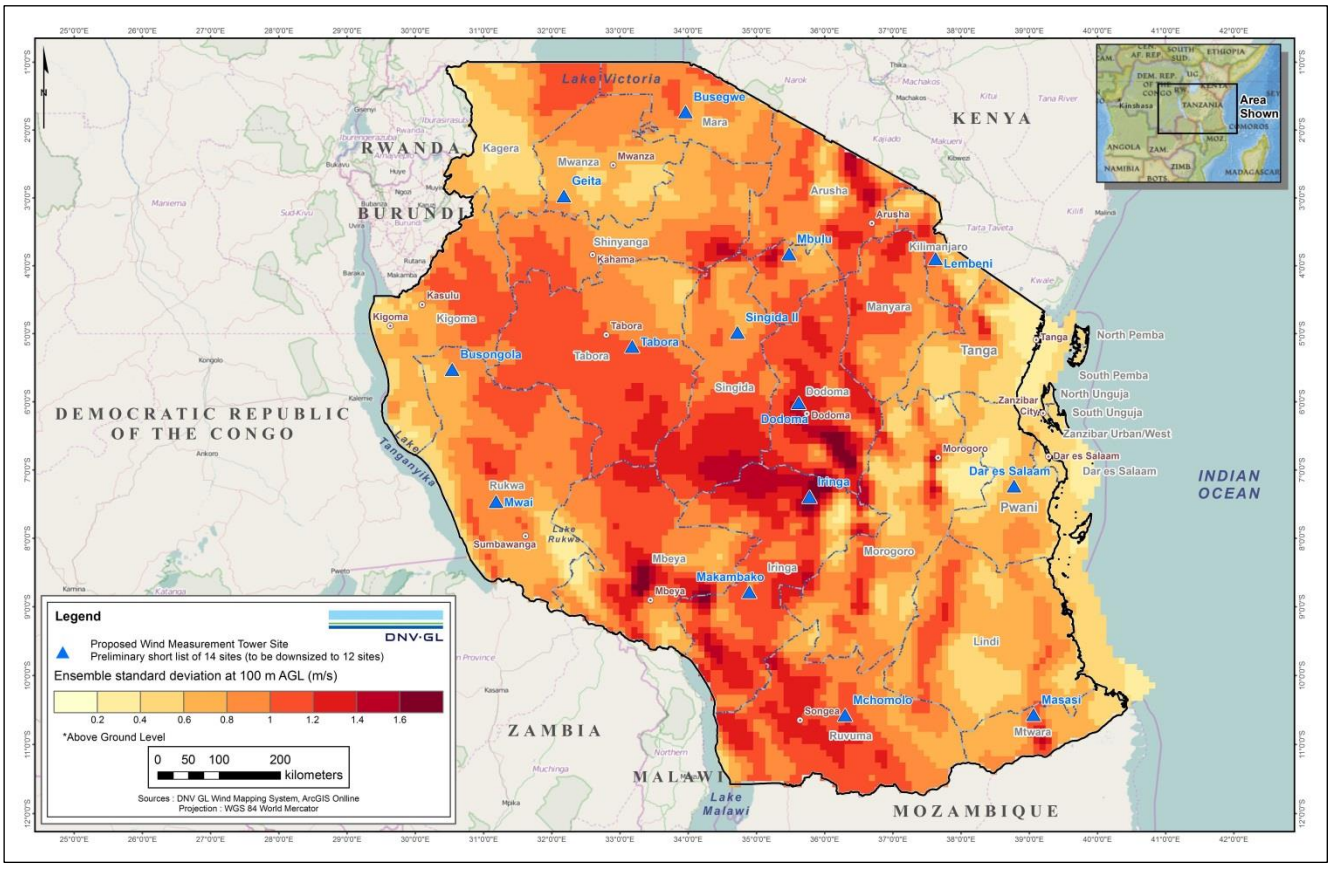

Figure 2-2 Top 14 candidate sites with wind speed uncertainty

4. Wide range of ground cover

Diversity in aerodynamic roughness length (RL), from 0.1 (various sites throughout) to 0.5 (Dar Es Salaam). Land cover such as bush, woodland, and cultivated land.

5. Spectrum of topographic complexity and terrain elevation

Ranging from flat sites (ex.: Masasi), to rolling hills, to medium-complex sites (ex.: Mbulu). From low lying Dar Es Salaam (400 m) to high sites such as Busongola and Mbulu (1500 m+). Note that sites at higher elevation present some technical challenges in terms of turbine technology and lower energy.

6. Proximity to infrastructure and load

Sites that are relatively close to major roads, towns, mining and planned/existing transmission (from the information we have). Sites that are close to the railway system, such as Dar Es Salaam, Makambako, Tabora, Singida II, and Lembeni.

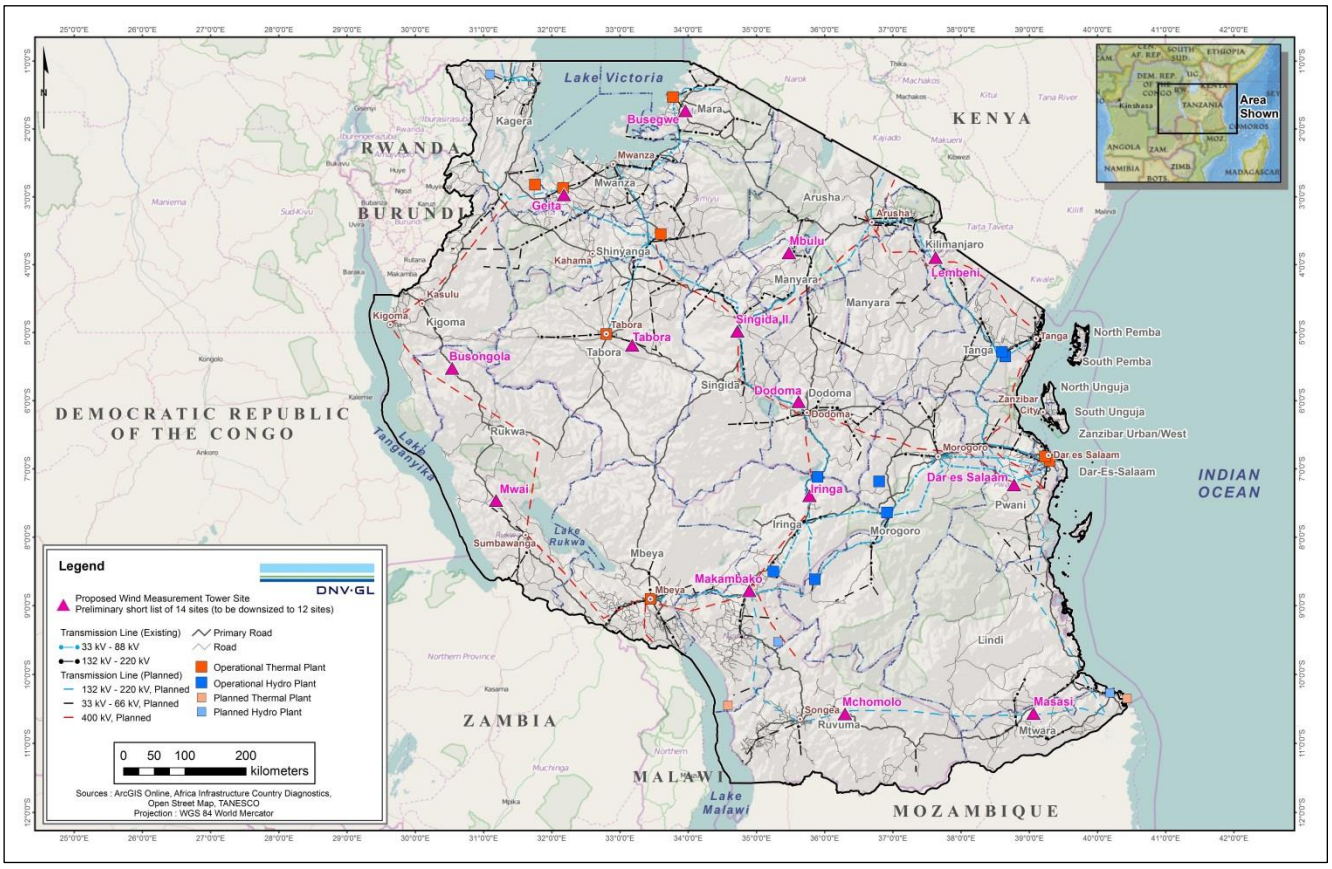

Figure 2-3 Top 14 candidate sites with proximity to infrastructure and load

7. Sites outside of environmentally sensitive areas, from the desktop information available

Note that this selection relied entirely on desktop work. It is also important to note that the process lacks good information on land control, and so this critical aspect has not yet been considered in the site selection.

After further discussions and attempts to engage the project stakeholders with the down selection process, DNV GL proposed the optimal 12 sites to be considered for the site visit and measurement campaign planning activities. These 12 sites are detailed in Table 2-1.

Table 2-1 Final 12 locations to be considered for site visits

Mast name	Region	Latitude	Longitude	Elevation [m]	Land cover
Iringa	Iringa	-7° 23' 29.13"	35° 46' 42.56"	1328	Cultivated Land
Makambako	Iringa	-8° 46' 55.99"	34° 53' 39.14"	1658	Bushland
Dodoma	Dodoma	-6° 0' 48.71"	35° 37' 8.12"	1186	Bushland surrounded by Cultivated Land
Singida II	Singida	-4° 58' 48.72"	34° 43' 20.57"	1622	Bushland
Masasi	Mtwara	-10° 34' 8.44"	39° 3' 42.26"	919	Cultivated Land and Bushland
Mbulu	Manyara	-3° 49' 33.34"	35° 28' 39.83"	1964	Cultivated Land
Tabora	Tabora	-5° 11' 10.05"	33° 10' 44.84"	1326	Cultivated Land
Lembeni	Kilimanjaro	-3° 53' 40.18"	37° 37' 39.37"	1016	Bushland
Busongola	Rukwa	-5° 31' 27.00"	30° 32' 17.95"	1716	Woodland
Dar es Salaam	Pwani	-7° 14' 8.59"	38° 46' 39.84"	386	Cultivated Land and Bushland
Mwai	Rukwa	-7° 27' 45.67"	31° 10' 54.62"	1681	Woodland
Geita	Mwanza	-2° 58′ 14.25″	32° 10′ 35.86″	1420	Cultivated Land and Bushland

2.4 Phase 1 workshop

A training workshop was conducted in Dar es Salaam 19 and 21 May 2015. Day 1 of the workshop included a presentation of the mesoscale mapping results and a review of the methodology for deriving the maps. Day 2 provided training on solar and wind power technology and development, including case study exercises using local renewable energy development scenarios. Feedback from the workshop was positive and relationships were further developed with and between the project stakeholders.

3 PHASE 2

Phase 2 of the project included the procurement, planning, installation, and operation of eight 80-m meteorological (met) masts for a two-year period. Planning and procurement activities were initiated and undertaken for a period of approximately nine months by DNV GL; however, no equipment procurement was ultimately completed upon request of the World Bank. The procurement activities included obtaining quotes for masts, civil works, shipping and customs, instrumentation and installation activities. Further, several civil design options were being considered.

3.1 Local partner selection

For the installation of the masts, DNV GL identified two local partners who were suitable candidates to perform this work. Pivotech is a Tanzanian company incorporated in 2007 that was identified during DNV GL's initial proposal development. While they remain one of the primary partner candidates, DNV GL also identified Ageco Energy & Construction Ltd as a potential partner. Ageco is one of the fastest growing electrical and solar energy contractors in Tanzania with experience in telecom and a focus on providing access to green energy. Ageco was prepared to conduct the site visits, plan for mast installation and complete the environmental project briefs, which were anticipated to be a requirement from the National Environmental Management Council (NEMC). Based on DNV GL's most recent interactions with Pivotech and Ageco, Ageco would be the preferred partner. However, further evaluation of Ageco's health and safety program would be required prior to final selection.

3.2 Environmental permitting

DNV GL prepared a letter to submit to NEMC to determine the environmental assessment requirements for each of the 12 sites. A draft of the letter can be found in Appendix A. There is uncertainty regarding whether the masts would be considered a permanent structure or a temporary structure by NEMC considering the planned 2-year campaign. In the case of a permanent structure, an Environmental Impact Assessment (EIA) certificate is expected to be required, but in the case of a temporary structure, the EIA certificate would not be needed.

Once the DNV GL letter was prepared, TANESCO was uncertain which project stakeholder should submit the letter to NEMC. DNV GL and the World Bank were in the process of getting clarity on this detail when the project was delayed. If the process is re-initiated, there should be a discussion with TANESCO to provide clear expectations about who is the project representative and interface with NEMC. Earlier discussions with the World Bank suggested that TANESCO should be taking this role in the future.

3.3 Site visit planning

Once the determination from NEMC is received, final planning for the site visits can be completed. It is expected that a representative from each of the following entities should attend the visits:

1. DNV GL
2. DNV GL's local partner for mast installation

3. Civil/geotechnical engineer for mast anchor and foundation installation review
4. Environmental consultant to prepare EIAs (if required by NEMC)
5. Ministry of Energy
6. Aviation authorities

The purpose and scope of the site visits is well defined in DNV GL's technical proposal.

3.4 Implementation plan

After completion of the site visits, the implementation plan should be drafted which will provide details of the following topics:

1. Summary of technical and environmental findings from the site visits
2. Recommendation for the final eight sites for mast installation
3. Project team organizational
4. Permitting and land control
5. Tower and instrumentation supply
6. Shipping and construction
7. Project schedule
8. Commissioning reports
9. Operations and maintenance
10. In-country capacity building
11. Photos and further details from the site visits

Once the implementation plan is drafted, or in parallel, procurement and permitting activities should be initiated.

4 PHASE 3 UPDATE

Phase 3 may include delivery of the updated mesoscale and initial microscale wind modelling reports. Provision of GIS outputs and calibration of the uncertainty map was also contemplated. Initially, a workshop was also planned to be conducted in Dar es Salaam. At the request of the World Bank, the workshop deliverable was revised to only include planning for a centralized workshop for all ESMAP Africa stakeholders, to be hosted elsewhere (e.g., Cape Town). World Bank has further indicated that Phase 3 activities may be pursued under a separate initiative. No Phase 3 activities were initiated by DNV GL during execution of the project.

APPENDIX A NEMC SITE LETTER

National Environment Management Council (NEMC)
Headquarters
PO Box 63154
Dar Es Salaam, Tanzania

DET NORSKE VERITAS (PTY) LTD
7 Walter Sisulu
Foreshore, Cape Town 8001
South Africa
Tel - +27 21 4181891
http://www.dnvgl.com/africa

Date:
November 25, 2015

Sub: environmental requirements for wind measurement meteorological masts

Dear NEMC representative,

The World Bank, working in partnership with TANESCO, has retained DNV GL to provide a validated mesoscale wind atlas for Tanzania. Validation of the wind atlas will be undertaken by installing **eight** temporary wind measurement meteorological masts throughout the country. Meteorological data collected at these sites over a **2-year period** will provide the basis for validating the mesoscale modelling outputs. The outputs and data provided under the Project are for Tanzania and will be owned by Tanzania, in order to provide a crucial tool for future wind energy development.

Various inputs were used to select twelve sites for potential development. The twelve sites are described in Attachment 1. For these twelve sites each will be evaluated for permitting (environmental, civil aviation, etc.), a site visit will be conducted and then based on input from all stakeholders, they will be further reduced to eight sites across Tanzania, with the emphasis of calibrating the national mesoscale wind map, but also with a secondary goal of siting masts in locations with a potential for future large scale wind farm development. Public data was used to identify and avoid environmental exclusion zones and high sensitivity areas such as national parks, forest reserves, game management areas, marsh areas, etc. Using available aerial imagery and other publically available information, settlements and known environmentally sensitive areas were also avoided.

Each wind measurement site will be comprised of a 80 meter (m) mast onto which instrumentation is installed, and fencing around the centre of the mast and around each anchor point (as needed). There is typically no need for an access road since the equipment is shipped on light trucks and can be handled without heavy machinery.

There will be **no permanent structure, no electrical service and no fuel-powered generator required for any site**. The equipment used on the tower requires a minimal amount of power and hence will be **self-powered with solar panels** installed directly on the tower. The site does not use oil or any other lubricant and therefore there is no risk of soil contamination.

A mast is typically secured to the ground with buried steel structure "anchors", which can be removed in the future. All excavations will be filled and compacted back into place. Any extra native material will be evenly spread across the site.

Further details of the planned structure and a typical site are available upon request.

2016 will see the installation of 8 state-of-the-art 80 m high meteorological wind measurements masts across Tanzania for the purpose of calibrating and improving the interim wind atlas generated during Phase 1 of the ESMAP work. The creation of this fully validated wind atlas will provide various departments of the Tanzanian Government and TANESCO with a valuable tool to assist with the planning of future wind energy development.

DNV GL requests guidance from NEMC regarding what is required in order to be in full environmental compliance during the evaluation and eventual construction of these temporary structures.

Sincerely,

Luke Simmons
Project Director – ESMAP Tanzania

Attachment 1. List of twelve sites

Mast Name	Region	Latitude	Longitude	Elevation [m]	Land Cover
Iringa	Iringa	-7° 23' 29.13"	35° 46' 42.56"	1328	Cultivated Land
Makambako	Iringa	-8° 46' 55.99"	34° 53' 39.14"	1658	Bushland
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