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PREFEASIBILITY STUDY FOR BIOMASS POWER PLANT, NAMIBIA

EXECUTIVE SUMMARY

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1 Introduction

WSP Environment & Energy was appointed by NamPower and KfW to undertake a pre-feasibility study in relation to the use of Namibian encroacher bush for commercial scale energy generation. The project team has comprised the following team members:

- WSP Environment & Energy (South Africa)
- WSP Environment & Energy (USA office)
- WSP Environment & Energy (UK office)
- IER, University of Stuttgart (Germany)
- Lithon Consultants (Namibia)

The Encroacher Bush to Power (EBtP) pre-feasibility study has been supplemented by additional and more detailed studies commissioned by the client subsequent to the original appointment (e.g. laboratory analysis, Thermoflex power plant modelling etc.). The findings of these additional studies have been incorporated into the pre-feasibility study findings where appropriate.

2 Executive Summary

Key findings of the NamPower encroacher bush to power pre-feasibility study are presented below for each of the main report sections. The technical assessment has confirmed that suitable biomass energy conversion plants can be constructed using modern American and European combustion equipment supplied to Namibia. An environmental screening assessment has confirmed the project will meet applicable standards and regulations related to plant emissions, water use and waste disposal. A review of the Namibian electricity transmission and distribution infrastructure has confirmed that interconnection and load matching can be accommodated at the three sites under consideration and that resistive losses are not expected to be a significant factor.

A detailed assessment of the supply chains required to harvest, process, and deliver biomass to the sites under consideration have revealed that break even fuel supply costs are very likely lower than current South Africa coal export prices. Investment models have been created which detail project cash flows, profit and loss statements, and investor returns for both the NamPower utility scenario as well as the private independent power producer (IPP) scenario. These models currently employ very conservative input assumptions related to capital investment requirements and financing terms; and therefore sensitivity analysis is used to provide visibility into how key financial metrics change when subjected to reasonable variations in assumptions. Financial modelling and policy assessment carried out for the study indicate that, although there currently exists a legal framework for private enterprises including IPPs and biomass suppliers to get involved, incentives are likely needed to overcome challenging project economics. NamPower will need to offer power purchase agreements (PPAs) at rates well above 80 N\$ cents per kWh to incentivize IPPs to enter the market or the Government of Namibia will need to establish incentives for land clearing, or some combination of both. Similarly, NamPower would also face a challenging economic environment should it choose to develop the project on behalf of its rate payers. Additional sensitivity analysis has been conducted to determine minimum electricity selling prices (MESP) needed to guarantee debt service coverage ratios greater than 1.2 and investor IRRs of at least 18%. For the NamPower scenarios, MESP in the range of 1.04 to 1.68 N\$/kWh are needed for the 20 MW scale plants, and in the IPP scenarios, MESP ranging from 1.2 to 1.98 N\$/kWh would be required to satisfy lenders and investors.

Careful consideration must be given in evaluating the cost of electricity supplied through imports and from competing new build options and these assessments should be made using commensurately conservative assumptions. Again, these conclusions have been reached using a modelling approach and set of conservative input parameters developed in consultation with key project stakeholders and realistic scenarios may exist which present a more optimistic view.

Carbon credit financing is likely to be available to the project developers, but probably only through the annual sale of offsets into the voluntary market as the long term viability of the CDM is uncertain. This additional

revenue stream is unlikely to change the fundamental economics of the project unless Gold Standard certification for the offsets could be achieved.

Moving forward, NamPower plans to conduct an Economic Rate of Return (ERR) assessment to quantify the economic benefit the project will yield on the larger Namibian economy. If positive, these results can be used to define the level of public funding which could be made available to support the development of the project. The Government of Namibia should then have basis to map out a set of targeted biomass supplier and electric grid feed-in incentives sufficient to attract private investment while still maintaining an acceptable EER on the whole.

Power Plant Technical Assessment

An assessment of several commercially available technologies has been performed to determine the most suitable scenario for generating electrical power from encroacher bush in Namibia. Broadly, a number of thermochemical technologies are available to NamPower including combustion, gasification and pyrolysis, but the commercial and technical maturity and the cost of producing electricity varies substantially.

Of these technologies combustion is by far the most commercialised to date and thus best suited to provide NamPower with low cost and reliable electricity, the key drivers of the technology assessment. It is also the lowest risk and hence most likely to attract financial support from risk-wary institutional investors. As discussed in the project inception report, WSP recommends the use of commercially proven combustion or staged gasification technologies for the conversion of biomass to heat energy for generating electricity. NamPower and its partners can expect that commercial combustion plants operating at this scale will have a net electrical efficiency of 20% at small (5 MWe) scales and upwards of 25% on larger (20 MWe) scales envisioned for the Ohorongo and Otjikoto sites. All of the furnace technologies (grate, circulating fluidised bed, and bubbling fluidised bed) perform similarly and will meet desired performance and emission rate criteria. Capital investment required to construct the plants ranges from 208 Milo. N\$ for the 5 MW scenario, 307 to 579 Milo N\$ for the 20 MW Ohorongo scenarios, and 351 to 629 Milo. N\$ for the 20 MW Otjikoto scenarios. The lowest specific investment cost (cost per MW of installed capacity) was found for the bubbling fluidized bed scenario located at Ohorongo cement, due in part to the low technology cost as well as infrastructure compatibilities found at the site.

There is also potential to use biomass as a replacement for coal at the existing Van Eck Power Station, particularly when biomass is pre-treated via a torrefaction process in order to transform it into a material with similar characteristics to coal. There may be good opportunities for using torrefied material at Van Eck but we do not consider an investment in a production system to be appropriate given the lack of commercial experience internationally. However, an arrangement to purchase torrefied material from a producer may offer potential.

Biomass Supply Chain

Two harvesting and transport process chains were analysed in the study. A third manual process chain was excluded due to farmer rejection. The financial assessment assumes that land owners will offer up the biomass material for free while accepting the free service of having their land cleared in the process. Additional sensitivity analysis is conducted to determine per ton delivered costs with a N\$ 200 per hectare cost associated with fuel procurement. Fuel production and delivery costs are assessed on an annualized basis where upfront capital investment is levelized using long term financing discounted by inflation. This approach allows the IPP or utility investor to estimate reasonable fuel delivery costs on a per tonne basis. The following outcomes can be summed:

1. Fully mechanized harvesting with cutter chipper exhibits the lowest biomass supply costs for the site at Otjikoto. At Ohorongo however the biomass supply costs are only slightly higher. All together the biomass supply costs are with about 275 N\$/t (16.7 N\$/GJ) at Otjikoto and 295 N\$/t (17.9 N\$/GJ) at Ohorongo Cement. These two scenarios will require capital investment totalling 123 and 118 Milo. N\$, respectively. To handle the fully mechanized harvesting, storage and transport a work force of about 70 - 72 people is needed, depending on the harvesting method.
2. Semi mechanised harvesting with skid steer and mobile chipper shows higher biomass generation costs due to a labour intensive harvesting and chipping. The required work force is 85 people i.e.

higher than the work force at Ohorongo and Otjikoto. However at Otjiwarongo the biomass supply is about one third lower than at Ohorongo or Otjikoto. Nevertheless the biomass supply costs are not much higher at 317 N\$/t (19.2 N\$/GJ) at the site in Otjiwarongo. This scenario will require a capital investment of 31 Milo. N\$ for purchase of harvesting and transport equipment.

Electricity Transmission & Distribution

Three sites with different scenarios were investigated when assessing the Namibian electricity network in terms of the integration of a biomass power plant, based on combustion technology into the network:

1. One, two, three or four 5 MW units at Otjiwarongo substation
2. One or two 10 MW units at Ohorongo Cement Plant
3. One or two 10 MW and 2 x 8 MW units at Otjikoto substation

All of the above sites and scenarios proved to be technically feasible. Otjiwarongo substation seems to provide the most benefits in terms of reduction in losses (although reduction of losses in all cases were not significant) and of matching the local load as well as in delaying transmission infrastructure. Some auxiliary services might also be provided by these plants. This should be studied in more detail as part of a full feasibility study.

The torrefaction of the intruder bush for use in Van Eck Coal-fired Power Plant was not considered in detail as Van Eck substation is already well integrated into the NamPower transmission network and no extra studies is consequently needed to verify whether the transmission infrastructure is appropriate for this option.

The information discussed is based on the author's personal knowledge of the Namibian electricity network as well as on discussions and studies in association with the NamPower Transmission Planning Department. Studies were done with the DigSilent PowerFactory simulation program on the NamPower database that has been developed on this simulation platform.

Power Plant Commercial Assessment

In the commercial assessment (Section 5), quotes for power plants with an electric generation capacity between 5 and 20 MW have been analysed with regard to the performance of the investment. The generation costs, IRR and return on assets have been identified, and a sensitivity analysis has been carried out to determine the impact of the total investment costs, the electricity price and the biomass supply costs on the commercial performance. The plant availability impacts slightly less on the commercial performance of the power plants than other key factors. Additionally, the labour has a minor impact on the return on assets.

It should be noted that many assumptions are quite conservative in this study especially for capital costs for biomass harvesting and supply machinery. In addition, the power project financial modelling has assumed a construction and commissioning period of 30 months before design performance and capacity factor are reached. The IPP scenarios assume debt borrowing rates at 11% and expected investor IRRs of 18%.

The outcomes of the financial analysis of the NamPower scenario can be summed as follows:

1. Otjiwarongo: The 5 MWe power plant with a grate boiler and the quote from Supplier A results in high generation costs of about 1.4 N\$/kWh. In comparison to a new coal power plant with generation costs of about 80 N\$/kWh, the power plant at Otjiwarongo will exhibit negative NPV as well as a negative EBIT. Also the return on assets is negative. Even a slightly positive Cash Flow the investment can be regarded unfavourable, also due to the DSCR of < 0.15.
2. Ohorongo Cement: Several 20 MWe power plants with fluidised bed or grate boiler were analysed. The generation costs of the analysed power plants are between 0.56 and 0.69 N\$/kWh and, therefore, clearly lower than the assumed generation costs of a new coal fired power plant in Namibia. The results show, that those options with low quote (from Supplier E) result in high IRR (IRR > 9%; WACC = 9 %) and, therefore, are favourable. Especially the quote from Supplier E results in high NPV and EBIT as well as a high return on assets (up to 6.1 % after tax), due to the

low investment cost. Therefore, a biomass power plant with an electricity generation of 20 MWe is a favourable investment at the Ohorongo cement facility.

3. Otjikoto Substation – At Otjikoto the same quotes as at Ohorongo were analysed for 20 MWe power plants. All together the results are positive but slightly lower (return on assets up to 4.3 %) than the same power plant at Ohorongo. This results mainly from the already existing cavils and buildings at Ohorongo Cement, which can be used. The overall investment, therefore, is higher at the site in Otjikoto than at Ohorongo Cement.
4. Minimum electricity selling prices far greater than current NamPower electricity selling prices are required to deliver DSCRs greater than 1.2 at current input assumptions. The most attractive scenario will require an electricity selling price of 104 N\$/kWh to deliver acceptable earnings from a lender perspective.

The outcomes of the financial analysis of the IPP scenario can be summed as follows:

5. Otjiwarongo: As in the NamPower Scenario, the 5 MWe power plant with a grate boiler and the quote from Supplier A results in high generation costs of about 1.6 N\$/kWh and negative net present value as well as a negative EBIT. Also the return on equity as well as the return on assets and DSCR is negative and, therefore, the investment can be regarded unfavourable. The results indicate that for this project to be financially attractive, a substantially higher purchase price tariff will need to be negotiated than the 80 N\$/kWh assumed in this study.
6. Ohorongo Cement: The results show that the quote from Supplier E shows the highest IRR (about 4.5%) and a DSCR of 0.8. The generation costs of the analysed power plants are slightly higher than those of the NamPower Scenario (between 0.72 and 0.90 N\$/kWh). The results suggest that a slightly higher tariff than the 80 N\$/kWh assumed in this study will be needed in order to ensure that the $IRR > WACC$ (although this condition was achieved for the cheapest quote).
7. Otjikoto Substation – At Otjikoto the same quotes as at Ohorongo were analysed for 20 MWe power plants. All together the results lower than the same power plant at Ohorongo.
8. Minimum electricity selling prices far greater than current NamPower electricity selling prices are required to deliver DSCRs greater than 1.2 and investor IRRs greater than 18% at current input assumptions. The most attractive scenario will require an electricity selling price of 120 N\$/kWh to deliver acceptable earnings for both private institutional investors.

Environmental Factors

The environmental screening process has identified that both the small (5 MWe) and larger (20 MWe) scale projects will trigger an Environmental Impact Assessment (EIA) under Namibian legislation, both for the power plant facilities as well as for the harvesting component. It is not entirely clear as to whether a commercial scale torrefaction facility will trigger any Namibian EIA clauses; however the harvesting component will nevertheless require an EIA to be undertaken.

No obvious “fatal” flaws have been identified in terms of successfully obtaining EIA approval under either Namibian or IFC standards.

A summary of the key environmental impacts identified follows:

1. All scenarios demonstrate relatively low demand for water (due to the selection of air cooled technology for the EBtP combustion plants) and Scenarios 1 and 2 (where the proposed locations are reasonably well known) are located in areas which should be able to meet the water demand through the use of treated groundwater or possibly even municipal supply. Scenarios 2a/2b would be expected to have the easiest route to water availability via the already installed groundwater boreholes at the cement plant (the water requirements would be expected to add around 10% onto the cement facility’s existing water demand).
2. Technical modelling indicates that air emissions are expected to meet World Health Organisation (WHO) guidelines for combustion plant air emissions.

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3. There is some debate regarding whether debushing can really be justified on the basis of improving the ecological value of the land and returning it to a more “natural” state. However, it does appear to be broadly accepted that the encroacher bush phenomenon is largely due to anthropogenic influence (over-grazing, reduced soil fertility, parcelling of Savannah land into discrete farms and limiting movement of game etc.) and that it would be preferable to debush much of the land to return it to a mixed woodland-Savannah landscape. The CCF, for example, promotes debushing as part of its activities to improve cheetah habitat. It is also noted that there is a precedent for approving an EIA for debushing, namely for the Energy For Future (EFF) harvesting operation associated with Ohorongo Cement. Hence, biodiversity issues are not considered to present a significant obstacle for environmental authorisation.
 4. All scenarios result in the production of relatively benign and small (by industrial standards) quantities of waste. A small amount of hazardous waste will be produced by the combustion plants; however the majority of waste will comprise post-combustion ash mixed with some lime and some other inputs. Waste management options include re-using the ash waste as a land amendment (i.e. fertilizer), re-using it as an input into building materials (ash bricks etc.), disposing of it to a nearby (non-hazardous) landfill, or building an on-site disposal facility to store the waste. For Scenario 2a/2b the ash could most probably be used as an input into the cement process (this was indicated as acceptable in principle by Ohorongo Cement) which would result in a zero waste outcome (in terms of ash).
 5. Various other aspects have also been evaluated (visual impacts, heritage, health & safety etc.) however none are considered to present serious difficulties.

Socio-economic Factors

The project falls in line with national and local development priorities in each of the site locations, serving to provide employment opportunities, skills development, local economic growth and importantly an improvement in the agricultural carrying capacity of the farmland where encroacher bush is harvested. The economic benefits of improved carrying capacity of land is likely to lead to both an improvement in local economic strength, as well as the increased capacity (resilience) of communities to cope with environmental stresses.

The study outlines the potential socio- economic impacts (both positive and negative) for further analysis during the scoping phase. Due to limitations in the understanding of final project scenario and harvesting area, a number of gaps in the knowledge still exist however which will require further assessment in a full feasibility study, which include:

1. Finalisation of combustion site location, and potentially impacted communities;
2. Finalisation of harvesting footprint location, and extent and vulnerability of potentially impacted communities;
3. Infield analysis of communities within development footprint including existing social, cultural uses of land, and analysis of the sensitivity of the local communities to labour influx and environmental disturbances;
4. Examination of existing skills base;
5. Establishment of options for employment sourcing and accommodation; and
6. In depth assessment of economic opportunities and knock on effect within the local economy and community resilience associated with the EBtP facility and bush clearing activities

Preliminary Carbon Assessment

The analysis performed demonstrates a relatively optimistic assessment of potential to generate carbon credits. Substantial uncertainties remain, particularly in terms of making an accurate determination of baseline

emissions. Additional work will need to be undertaken to establish the GHG emissions against which to measure the project (marginal or average grid emissions factor) in line with the proposed methodologies.

The option for CDM credits may be viable by the time the EBtP project commences, however at present there is no viable option for obtaining CDM credits (post 2012). Therefore, it is assumed that carbon credits produced would be sold into the voluntary carbon markets.

Market outlets may include registering the project with the Verified Carbon Standard (VCS) and additional certification with the Gold Standard may be possible to increase the project's credit market value. At current VCS market prices, conservative estimates put the annual revenue from the sale of offsets at 3 Milo. N\$ for the 5 MW scenario, and 13 Milo N\$ for the 20 MW scenarios. More optimistically, the project could generate revenues of 5 Milo. N\$ and 22 Milo. N\$ with Gold Standard certification, for the two scenarios respectively which could impact the project economics in a significant manner.

Energy Policy Framework

The Electricity Supply Industry (ESI) in Namibia is made-up of several players of which NamPower is most prominent due to its presence in Generation, Transmission, Distribution and Energy Trading. NamPower is currently the only Generator of electricity although several Independent Power Producers (IPPs) have been licensed, most notably in the Solar and Wind generation sector. In the Distribution sector there are three Regional Electricity Distributors (REDs) in which NamPower also has shareholding and several other players consisting of local authorities, regional councils and private companies.

An enabling legislative and regulatory environment exists for the introduction of IPPs into Namibia. Renewable or "green" energy is also being promoted in Namibia although there are no Renewable Feed-In Tariffs currently available. The licensing of an IPP that uses intruder bush to generate electricity will consequently depend on that IPP successfully negotiating a Power Purchase Agreement (PPA) with NamPower. Such a PPA should be acceptable from a customer and IPP standpoint by balancing the needs for affordable tariffs from a customer point of view and sufficient returns from the IPP investor point of view.

3 Reporting Format

This cover document briefly describes the final pre-feasibility reporting structure and the order in which the various reports should, ideally, be read.

The pre-feasibility study has been divided into **eight companion reports**. The reports are listed below **in the order in which it is recommended that they be read**:

1. Technical Report

The Technical Report should be read first. This report presents the technical (i.e. engineering) analysis of the EBtP alternatives in terms of power plant technologies, power plant sizes, as well as power plant locations. These aspects, when taken together, define the specific scenarios considered in the rest of the pre-feasibility study reports. The Technical Report characterizes the costs associated with the power plant component of the project (CAPEX and OPEX).

The Technical Report includes:

- Technical appendices (A – J) related to plant design, mass balances and the like (as a zip file). Much of this is a result of the Thermoflex modelling undertaken as a separate, but linked, deliverable.
- A companion "Additional Technical Data - NamPower Biomass Plant Design" pdf document that may be of use if the project proceeds to the next phase of development.
- An indicative plant layout (for Scenario 2b at Ohorongo Cement) as a separate pdf engineering drawing.

2. Biomass Supply Chain Report

This report characterizes the supply chain component of the study, for each of the scenarios defined in the Technical Report. It characterizes the biomass resource, and explains the model used to describe the

harvesting, handling, transport and storage of biomass from the field to the power plant. The Biomass Supply Chain Report characterizes the costs associated with the supply chain component of the project (CAPEX and OPEX). Also covered are aspects related to commercial farmer engagement.

In addition to the report, the following Excel files are also provided:

- “Biomass Spreadsheet 1 - IER_Calc-Tool_Biomass”. This tool can be used for further analysis of supply chain characteristics;
- “Biomass Spreadsheet 2 - National Encroacher Bush Estimates”; and
- “Biomass Spreadsheet 3 - Copy of Farmer Questionnaires – Data Evaluation”.

3. Transmission & Distribution

This report presents the findings of the Transmission & Distribution network and infrastructure study associated with each of the scenarios considered.

4. Commercial Assessment Report

The Commercial Assessment Report presents the overall financial feasibility analysis for the EBtP scenarios considered. Also discussed are various commercial aspects such as security of biomass feedstock supply and potential investment partners for the proposed projects.

In addition to the report, a 7z zip file is also provided (“Power-plant-tool – Nampower”). This file should be extracted using a program such as 7-Zip or similar. The Excel files contained in the zip file are linked and their structure should not be altered. A help file is included to assist. The financial tool can be used for further analysis of commercial feasibility.

Note: on the CD version, the files have already been extracted into their proper folders. Please refer to the “How to use.txt” file.

5. Environmental Screening Report

This report presents a preliminary environmental baseline for each of the scenarios considered and outlines the risk and opportunities presented by the project in terms of environmental outcomes. Environmental permitting conditions and other requirements are discussed in relation to Namibian legislation as well as IFC standards, and the implications of these requirements on critical project development timelines are assessed.

6. Socio-Economic Screening Report

This report presents a preliminary socio-economic baseline for each of the scenarios considered and outlines the risk and opportunities presented by the project in terms of socio-economic outcomes. Socio-economic assessment requirements are discussed in terms of applicable Namibian legislation as well as IFC guidelines.

7. Preliminary Carbon Assessment Report

This report presents a preliminary carbon balance as well as a preliminary feasibility assessment for securing potential carbon finance revenue streams.

8. Energy Policy Framework Report

This short report presents an overview to the existing energy policy framework in Namibia as well as existing energy supply conditions. It describes the outcomes of the project team’s meeting with the Electricity Control Board of Namibia (the national regulator) and their views on encouraging Independent Power Producers and renewable energy investment in Namibia. It outlines the licensing procedures required for securing regulatory approval from the regulator.

4 Additional Deliverables

As part of the deliverables handed over as part of the pre-feasibility study as well as additional works commissioned, WSP will include the library of photos and hand-cam videos taken during the Technical Team in-country site visit (June 11th – 15th 2012), to be provided electronically via flash drive.

Additionally, it is noted that previous reporting related to this study should also be referenced, as required. Previously submitted reports include:

- Inception Report (dated 09/03/2012);
- Briefing Note to NamPower And KfW Subsequent To The Post Inception Report Meeting (dated 16/03/2012);
- Technical Team Site Visit and Report Back (dated 02/07/2012);
- Photos/videos from both the Technical Team's country visit as well as photos from the environmental and social team country visit; and
- Laboratory Analysis Certificates.

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