CBEND

Bush to Electricity

A project implemented by the Desert Research Foundation of Namibia

Environmental Impact Assessment
CBEND Project

ASSESSMENT REPORT

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Namibia Agricultural Union

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1. Introduction

The Desert Research Foundation of Namibia (DRFN) is implementing a project entitled Combating Bush Encroachment for Namibia's Development (CBEND), which aims at converting invader bush, largely seen as an environmental problem especially in commercial farming areas, to electricity through bio-gasification. The project will thus establish a 250 kW electricity generation plant and feed electricity into the national grid. Fuel for the plant will be derived from harvested invader bush with the emphasis on bush thinning (at a rate of 20% to 50%) rather than bush clearing.

The project will contribute to addressing energy crises prevailing in Southern Africa by developing renewable and clean energies, whilst at the same time addressing the problem of land degradation. Further, through the specific design proposed by DRFN, rural revenue generation and employment potential are increased.

CBEND furthermore will initiate the establishment of an Independent Power Producer, who will enter into a Power Purchasing Agreement with a prospective client. This IPP will in all likelihood be the land owner, where the plant will be established and the owner of the bush resource earmarked for utilisation. The generation and sale of electricity requires an Electricity Generation License to be awarded by the Electricity Control Board. This license in turn requires that the project receives an environmental clearance from the Directorate for Environmental Affairs.

2. Background Information

2.1. Energy Supply in Namibia

Energy is a key strategic sector for Namibia's national development – in terms of its inputs to economic sectors and social services. Lack of access to energy services is documented to be a hindrance to sustainable development. Namibia's economy is described as energy intensive and this is attributed to the fact that the dominant economic sectors of mining and agriculture are highly dependent on energy resources. In 2007 alone, Namibia consumed approximately 15 TWh of energy. Almost 60% of this was attributed to liquid and gaseous fossil fuel use, 25% was in the form of electrical energy, while biomass accounted for almost 15% of the total energy used, and other renewable energy sources contributed to the reminder, i.e. less than 1%[1].

About 50% of Namibia's electricity is generated domestically, mainly from the 240 MW Ruacana hydropower plant. Thermal power generated at the Van Eck (120 MW) and Paratus (24 MW) power plants is relatively expensive since both oil and coal are imported fuels. Local electricity supply does not meet local electricity demand and Namibia therefore depends heavily on electricity imported from South Africa. Given the recent and projected increase in electricity demand in Southern Africa, South Africa in turn does not have sufficient surplus electricity to satisfy regional demand.

The Van Eck thermal power plant outside Windhoek, depends on imported coal and operates for several months per year, as electricity imports have reduced.

Picture: DRFN

The Namibian Government has put in place a policy framework that encourages the exploration and exploitation of the country's resources for the production of energy in a sustainable manner. In its long-term goal towards becoming an industrialized nation, Namibia needs to be at least partially independent of foreign energy[2]. To realize this goal, the Namibian Government has placed the sustainability of the energy sector as a priority in the implementation of Namibia's National Development Plan III (NDP3).

As a sub-sector in NDP3, the Namibia Government has set a goal of ensuring sufficient, adequate, secure, affordable, reliable supply of energy that is environmentally friendly and leads to a reduction in the country's reliance on energy imports. Namibia will achieve security

[1] [1] Desert Research Foundation of Namibia. 2008. Namibia National Issues Report on Key Sector of Energy with a Focus on Mitigation

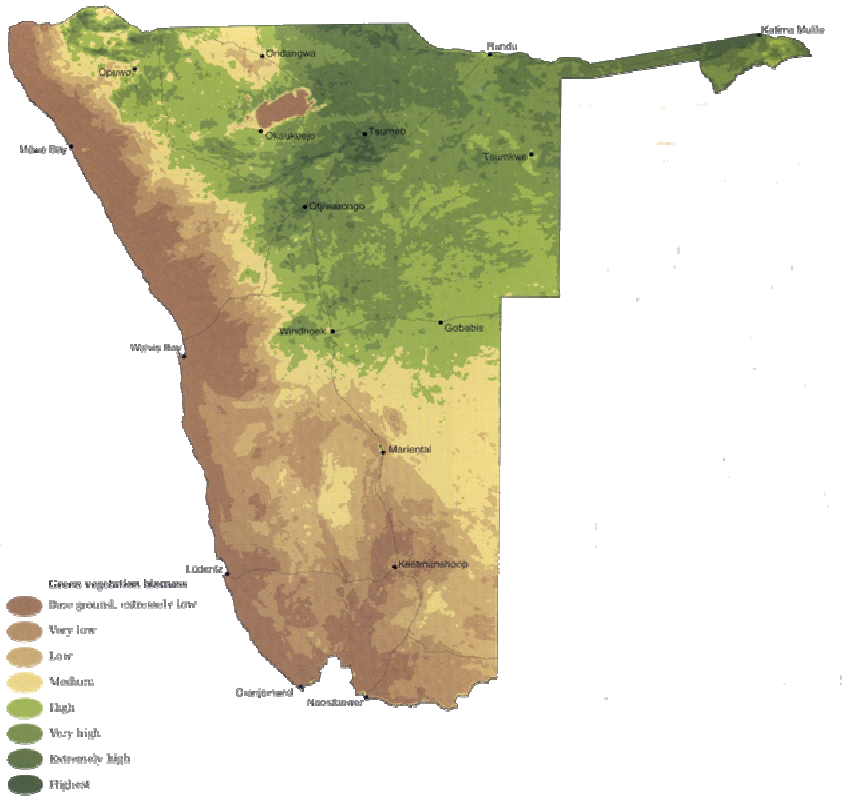
[2] National Planning Commission. 2004. Namibia Vision 2030

of energy supply through an appropriate diversity of economically competitive and reliable resources, with emphasis on the development of Namibian resources[3].

2.2. Bush Encroachment in Namibia

Trees and grasses have a strongly competitive interaction in dry land savannah ecosystems such as in Namibia. The competition is asymmetric though, since mature trees have a strong suppressive effect on grass production, while the direct effect of grass on mature trees is weak. However, where well established, dense grass cover prevails, it can inhibit the growth of small, establishing trees. The grass-on-tree effect mostly occurs indirectly through the effects of fire. While dry-season fires hardly damage the grasses, they can retard or kill the aboveground parts of the trees.

Figure 1: Biomass densities in Namibia[4]



Bush encroachment is the increase in the cover and biomass of woody plants over time, often relatively rapidly (over a few decades), and apparently irreversibly at a timescale of several decades. It has been observed all over southern Africa where non-migratory cattle ranching has been applied. Bush encroachment is thus most prevalent on commercial farms with fences that restrict or prevent movement.

Commercial cattle husbandry often leads to a reduction of grass fuel load through intensive grazing of cattle, and the natural effect of fire is reduced. In addition, numbers of most wildlife browsers, which also kept a check on tree growth, were dramatically reduced over the last century in order to lessen competition with domestic livestock. This resulted in a positive

[3] Ministry of Mines and Energy. 1998. The Namibian White Paper on Energy Policy.

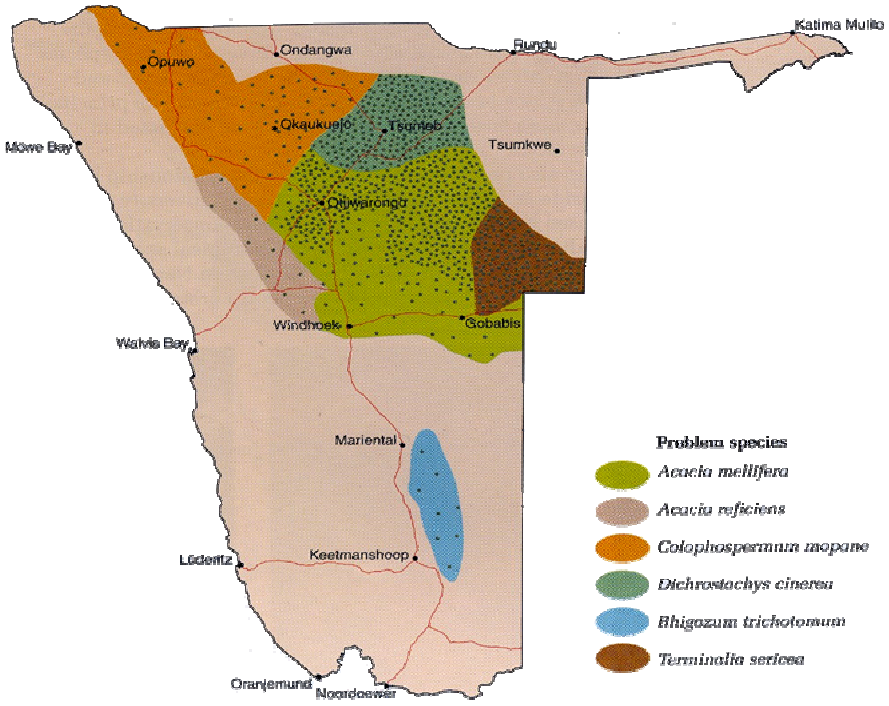
[4] Mendelson, J, 2002. Atlas of Namibia

feedback loop as tree cover increased, suppressing the growth of grasses, which in turn resulted in further enhanced tree growth.

Eventually the grass production has become too low, and the tree density too high, to practice economically-viable cattle production. This trend is difficult to reverse. Additionally, it has been suggested that the rising CO_2 content of the atmosphere further advantages woody plants with a C3 photosynthetic pathway over grasses that have a C4 pathway[5].

In bush encroached areas the grass production is low, often to the point where the ground is almost bare beneath the trees. Bush encroachment is more common on loamy and clayey soils than on sandy soils, since sandy soils often have a higher tree cover to start with. Bush encroachment is thus also regarded as part of the desertification process since the increase in the extent and density of woody vegetation occurs at the expense of other desirable grasses and forbs, resulting in an alarming reduction in agricultural productivity.

Figure 2: High density areas of bush encroachment in Namibia[6]



It is asserted that in the medium term (50 years) bush encroached land does not spontaneously revert to the former less bushy state, though it may do in longer time periods, and management interventions (e.g. mechanical or chemical tree clearing, introduction of a combination of browsers and fire) may be viable options for partly encroached land.

Bush encroachment is a serious environmental problem in Namibia and affects about 26 million ha of 82.4 million ha of Namibia's total land area. Approximately 65,000 households in communal areas and 6,283 commercial farmers with around 35,000 workers are dependent on livestock farming in the bush-affected areas. At present, the average number of dependants

[5] UNDP/DRFN, 2008. Climate Change: Vulnerability and Adaptation Assessment Namibia

[6] Mendelson, J, 2002. Atlas of Namibia

per household is 4.03[7]. This brings the total number of dependants on commercial farms to 140,000. Annual losses as a result of decline in the carrying capacity of Namibia's rangeland could be anything from 100% or more, with a concomitant loss in income (at present prices) of more than N$700 million per annum[8].

Bush encroachment has been documented to have a direct impact on the livelihoods of both commercial and communal farmers and their employees. It, along with other environmental factors, has led to a reduction of Namibia's commercial large livestock herd from 2.5 million in 1958 to 800,000 in 2001.

Despite the negative impacts in terms of agricultural productivity and livelihoods base, invader bush present positive opportunities of energy generation and the resultant impacts of improved ecosystem conservation, greater biodiversity, poverty alleviation, energy security and sustainable energy access for the underserved[9]. According to a study commissioned by the Renewable Energy and Energy Efficiency Institute (REEEI) at the Polytechnic of Namibia, there is an estimated total generation potential of about 60 MW[10] using small decentralized bush-to-electricity power plants. Considering that the individual size of these plants range between 200 to 500 kVA, this implies that a total number of 120 to 300 power plants could be established on communal land and commercial farm lands in Namibia.

There does not yet appear to be much data available on estimates of standing biomass of thickening bush species in Namibia. The DRFN (1997) uses the assumption that there is an average of 10 tonnes/ha of appropriate sized wood available over 10 million hectares, to come up with an estimate of 100 million tonnes of wood. The DRFN (1997) further assumes that 30% of this is harvestable on a sustainable basis over a 15 year cycle. There is increasing pressure of wood harvesting being put on Namibia's natural vegetation[11], so it becomes increasingly necessary to determine the availability of wood and to propose sustainable patterns of harvesting, both over space and time (Zimmermann, et al., 2002).

Bush clearing for crop production near Tsumweb, showing the density of bush on the left hand side.

Picture: DRFN

Studies have shown that about 10 tonnes per hectare of excess wood biomass is available for production. This represents over 100 million tonnes of raw materials available for different

[7] Agricultural Employers' Association of Namibia. 2002. *Wage survey*. Unpublished internal report, Windhoek

[8] de Klerk, J.N. 2004. *Bush encroachment in Namibia: report on phase 1 of the bush encroachment research, monitoring and management project*. Ministry of environment and tourism, Windhoek, Namibia

[9] VTT Technical Research Centre. 2007. *Bush Encroachment – The Challenging Resource for the Renewable Bioenergy in Na*mibia

[10] REEEI, 2008. *Electricity Supply and Demand Management Options for Namibia. A Technical and Economic Evaluation*

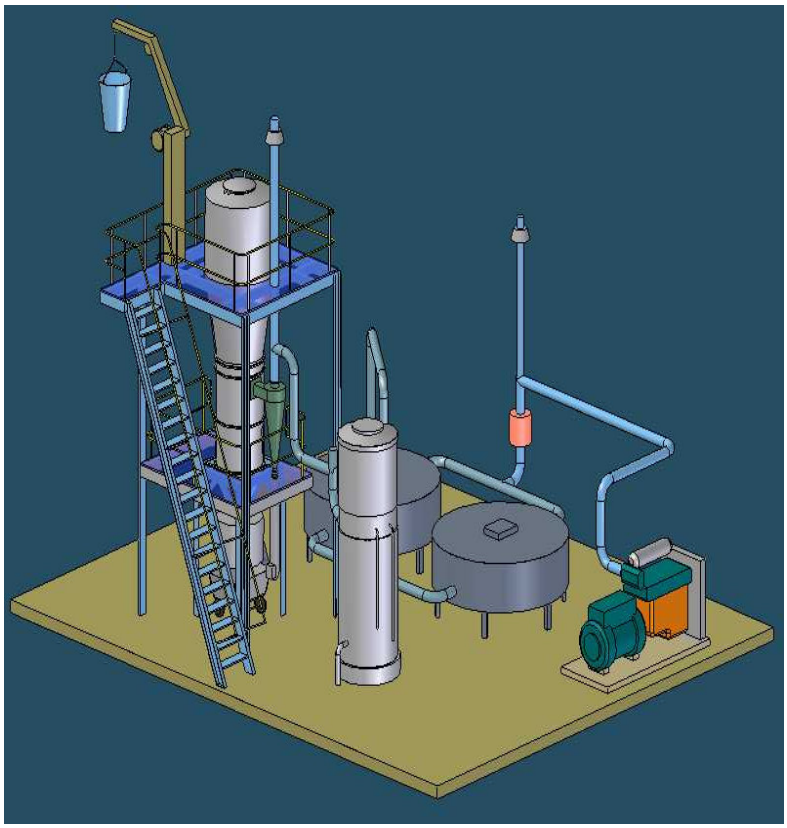
[11] About 1 million tonnes a year is used for firewood and about 0.3 million tonnes a year is used for charcoal production

kinds of uses. To solve the problem of bush encroachment in Namibia, it is needed to harvest about 1 million hectares per year assuming that the production cycle of the bushes is 10 years, provided that harvesting is selective and leaves sufficient bushes of different size classes for regeneration. However, it is likely that subsequent harvests would be lower and more difficult to obtain. Previously chopped bushes could then only be re-harvested on every third or fourth cycle, preferably after being pruned to maintain a more appropriate growth form, which is easier to harvest and more conducive to grass growth. If the harvested biomass amount per hectare is 10 tonnes (moisture content 20%), the total biomass potential to be harvested per year would be 10 million tonnes. This means about 40.8 TWh per year (Leinonen, et al., 2008). The total consumption of electricity in Namibia was 3.6 TWh in 2007[12]. Therefore, tapping into biomass for electricity production can contribute to Namibia's long-term goal of energy self-sufficiency.

2.3. Biomass gasification technology

Biomass Gasification is basically conversion of solid biomass, such as wood, wood waste or agricultural residues into a combustible gas mixture called "wood gas", "producer gas" or "synthesis gas". The process can theoretically be used for any biomass and it involves partial combustion of such biomass. This partial combustion process occurs when oxygen supply is less than adequate for combustion of biomass to be completed. Given that biomass contains carbon, hydrogen and oxygen molecules, complete combustion would produce carbon dioxide (CO_2) and water vapour (H_2O). Partial combustion produces carbon monoxide (CO) as well as hydrogen (H_2), which are both combustible gases.

Figure 3: Schematic of a small gasification plant[13]



[12] IPPR, 2008. *Planning Power: Review of Electricity Policy in Namibia*

[13] CarboConsult, 2007

In essence, a biomass gasification-to-electricity plant comprises a number of main components: a large gasification chamber is fed with biomass; pipes lead the gas produced in the process to a cooling tower, and on to gas cleaning chambers, and then to the gas-fired electricity generation plant. However, configurations and specifications for these components vary considerably, and the CBEND project will include an assessment of the most suitable technologies on the market, before the gasification plant is procured.

Solid biomass fuels are usually inconvenient, have low efficiency of utilization and can only be used for certain limited applications. Combustion is the normal conversion process and while direct thermal use in cooking, space heating, water heating or steam generation is possible (usually with low efficiencies), generation of electricity would require high/medium pressure steam boilers along with steam engines or turbines. This typically makes biomass energy-based steam power plants only cost-effective at capacities of several MW (megawatt). For small power needs (a few kilowatts to a few hundred kilowatts), this conversion technology is not only capital intensive and complex, it is also very inefficient.

Conversion of the same biomass to a combustible gas mixture like wood gas removes many of the problems associated with the use of solid biomass fuels. While conversion to gas results in loss of energy of 10 to 25%, use of gas can be highly efficient and hence overall efficiency would be much higher. Furthermore, the gas can be directly fed into internal combustion engines. It can also be employed at generation capacities of a few kilowatts to several megawatts. It is therefore well suited for decentralized and off-grid applications.

3. Relevant Legislation

3.1. National Development Plan (NDP3)

The National Development Plan (NDP3) recognizes energy as a pivotal sector in the country's economy and national development. NDP3 also recognizes the potential that renewable resources have in the sustainability of the energy sector in Namibia. Although there are considerable financial implications in the production of energy from renewable resources, their potential could outweigh these implications in the long-term. A long-term goal of "ensuring adequate, secure and efficient supply of energy that is environmentally friendly and leads to a reduction in the country's reliance on energy imports" is defined in NDP3. Among other strategies to achieve this goal, the Government of the Republic of Namibia has plans to increase local energy generation with conventional and renewable technologies.

3.2. The Namibian White Paper on Energy Policy 1998

The White Paper on Energy drafted during 1997/98 was promulgated by the Parliament in May 1998. The White Paper on Energy present six goals that serve as a framework for the energy sector in Namibia – effective governance, security and supply, social upliftment, investment and growth, economic competitiveness and efficiency and sustainability. The emphasis of the White Paper on Energy Policy is placed on developing measures that takes into account renewable energy options, as well as the regional and international energy sector constraints and opportunities. Here, the maximization of the renewable energy resources is important to ensure economic growth and national development.

3.3. Electricity Act 2007

The Electricity Act and regulations amended in 1998 was promulgated in 2007. The Electricity Act integrates the various energy sector requirements into a single overarching energy sector policy document. The act prohibits any person from generating electricity, trading of electricity, transmitting of electricity, supplying electricity, distributing electricity, importing electricity and exporting electricity without an Electricity Generation License. However, power plants of less than a 500 kVA capacity are exempted from obtaining such a license, where the electricity is not sold commercially.

The White Paper on Energy and the Electricity Act form the basis for the legal framework of the energy sector in Namibia.

3.4. Forestry Act and Forest Policy Statement

The Forestry Act 2001 (amended in 2005), is at present the only legislation that puts certain environmental considerations in place vis-à-vis the harvesting, transportation and marketing of Namibia's woody biomass resources. The act controls and regulates the harvesting and utilization of forest resources in Namibia. This also includes a range of invasive thorny shrub species that causes bush encroachment. The Forest Policy Statement promotes the sustainable and participatory management of forest resources and other woody vegetation, to enhance socio-economic development and environmental stability. The statement calls for forest management operations to realize maximum and efficient use of multiple products and services of the forests and in the process, maintain the ecological functions such as the conservation of biological diversity, soil and water resources, unique ecosystems and landscapes. The Forest Policy Statement promotes the harmonization of forest and other sectors, particularly

renewable energy. In commercial areas, the forest policy statement encourages the production and exportation of charcoal as a realistic land-use alternative in the process of mitigating the problem of bush encroachment. De-bushing for charcoal production enhances rangeland productivity and supplements income from livestock production. In line with this task, de-bushing is to be used for electricity generation which is envisaged to improve rural livelihoods through the creation of job opportunities.

3.5. Environmental Management Act 2007

The Environmental Management Act 2007 promotes the sustainable management of the environment and the use of natural resources in a sustainable manner. The act calls for assessment and control of activities which may have significant effects on the environment; and to provide for incidental matters. The act calls for the participation of all interested stakeholders and affected parties in decision making. Activities such as energy generation and distribution may not be undertaken without an Environmental Clearance Certificate.

3.6. Namibia's Environmental Assessment Policy 1995

According to Namibia's Environmental Assessment Policy, the environmental consequences of any development project are to be considered, understood and planned for throughout the entire lifespan of any project, that is, commencing with planning and ending with decommissioning.

3.7. Draft Bush Encroachment Policy Document

The initial draft of this policy document was completed in 2005 under the auspices of the Directorate of Forestry, but is as yet not endorsed by Cabinet. Based largely on the research results contained in the book *Encroacher Bush in Namibia (JN de Klerk, 2004)*, the document identifies the following bush species as contributing towards bush encroachment:

- Acacia erubescens (Blue thorn)
- Acacia fleckii (Plate thorn)
- Acacia reficiens (False umbrella thorn)
- Acacia meliffera (Black thorn)
- Colophospermum mopane (Mopane)
- Dichostrachys cinerea (Sickle bush)
- Terminalia prunioides (Purple-pod terminalia)
- Terminalia sericea (Silver terminalia)
- Catophractes alexandri (Trumpet thorn)
- Prosopis species (Prosopis)
- Rhigozum trichotomum (Three thorn)

3.8. National Agricultural Policy

Namibia's National Agricultural Policy (1995) aims to put strategies in place that would lead to improved agricultural productivity, real farm incomes and national and household food security. The policy views bush encroachment as a serious impediment to achieving these goals and advocates the eradication of invasive bush species as a strategy to improve productivity on both commercial and communal farming land. Specifically the policy advises that Government would "establish mechanisms to support farmers in combating bush encroachment effectively over both the short and long term". The policy identified charcoal, briquetting, chipboard manufacture and other bush utilisation industries as a means to achieving this strategy.

4. Description of Action

Woody biomass, comprising mostly of shrubs, is harvested on commercial farm land. The harvesting of bush will be conducted according to the Forest Stewardship Council (FSC) regulations and the Independent Power Producer will be FSC certified.

Harvesting will be done manually, by a team of about 15 persons using hand axes and pangas. The shrub species earmarked for harvesting are listed in the table below:

Table 1: Harvested bush species
Mopane (Colophospermum mopane)
Rooihak (Acacia reficiens)
Swarthak (Acacia mellifera)
Sekelbos (Dichrostachys cinerea)
Sandgeelhout (Terminalia sericea)
Driedoring (Rhigozum trichotomum)

Harvested shrubs will lie in the field for a period of about 30 days, in order for the wood to dry sufficiently to be chipped. A trailer-mounted chipper will be towed into the field regularly for the chipping of the wood, which is blown via a chute onto the loading bay of a 10-ton truck.

The truck transports the chipped wood to the power plant, which will likely be within a 5 km radius from the harvest site. Chipped wood is dumped and spread out on a large concrete slab for further drying. Then the chips are sieved in order to maintain a uniform size and stored in a large shed. This activity comprises some manual labour, but also a skid steer loader.

The biomass power plant to be used is a 200 m^2 downdraft gasification power plant, which comprises the gasification chamber, the gas cooling and filtering facility and the gas generator. Wood chips are continuously fed into the gasification chamber where, under intense heat, they release wood gas and finally disintegrates into ash and charcoal. The wood gas is extracted through pipes, cooled with water and cleaned via a series of saw dust filters. The cool clean gas acts as the fuel for an internal combustion engine that drives a generator, which produces electricity. This electricity is fed into a transformer connected to the distribution grid where it enters the national electricity supply system.

Water used during the gas cooling and cleaning process is continually recycled through an air cooled heat exchange system and a water treatment system. Engine cooling is also done with water, which is recycled through a cooling tower.

5. Environmental Baseline

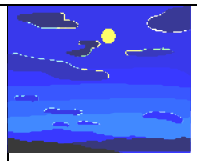
An initial environmental impact assessment[14] was conducted on the neighbouring farms, Reyneveld (# 367) and Pierre (#345), with absolute location of about S19°45' and about E16°35'. The farms are located in the Kunene Region's commercial farming area between Otavi and Outjo, about 30 km south of the Etosha National Park's southern border.

Like much of the area, both farms are characterised by bush encroachment at a density[15] of more than 8,000 bushes per hectare. The estimated bush coverage is between 75% and 100% of the farms and the predominant bush species are *Colophospermum mopane* and *Acacia mellifera*. Bush growth is mature, with 50% of the bush being higher than 2 meters, providing a yield of 15 to 20 tonnes (wet) per hectare.

The farm owner currently operates a charcoal production enterprise, employing more than 300 people, along with cattle production. Bush harvesting for charcoal production is an estimated 300 tonnes per month and the enterprise is certified through the Forest Stewardship Council.

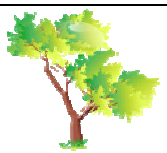
Further environmental baseline aspects are summarised in the table below. This information was gathered during a site evaluation in May 2009.

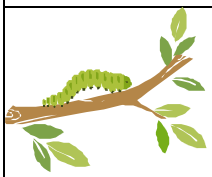
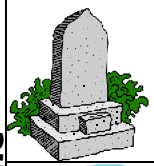
Table 2: Environmental baseline matrix

Environmental Components		Characteristics/ Species/ Biodiversity/ Parameters
Physical / Chemical	 **Air**	• No large-scale pollution is noticeable. • Small-scale air pollution is emitted from charcoal kilns, in the form of black carbon, and exposed earth and gravel roads, in the form of dust. • Kilns are scattered across a large area and no accumulation of pollution takes place. • Charcoal production is about 1,000 tonnes per week with resulting point source pollution across the area of about 4,000 tonnes per week. • Dust is mostly caused by traffic traveling on district road. • Some dust is also distributed through sandstorms that occur prior to the rainy season (August to November) • Dust emissions are predominantly in areas with low grass cover, such as heavily bush encroached areas.

[14] CBEND Site Evaluation Report, DRFN, March 2009

[15] CBEND Site Assessment Sheet, DRFN, November 2008

	 **Water**	• Area is arid, with mean annual rainfall of about 480mm • No perennial rivers dissect the area. • The area is characterized as Karstfeld with high permeability, which causes rain water to penetrate rapidly into the ground. • The Karstfeld has an extensive natural underground aquifer system and water quantity in the general area is substantial (boreholes with yields exceeding 5 m^3 per hour) • The water for use on the farm is obtained from earth dams, wells (captured run-off), boreholes and few natural fountains. • Water quality is suitable for human consumption, but with high lime content ("hard" water)
	 **Soils**	• Mixture of black clay soils, red clay soil (in the dolomite mountains) and in some areas red sand. • Aridisols, with low organic content are most common, with poorly developed inceptisols in some areas • Soil is generally not compacted and well aerated allowing easy root and water penetration. • The nutrient status has not yet been assessed.
	 **Geology**	• The Karstfeld area is characterized by extensive formations of limestones and dolomites at various depth beneath the topsoil • The area is generally level with scattered outcrops of dolomite hills which appear more like inselbergs rather than as an interconnected mountain range • The area was heavily weathered in past geologic history, which has resulted in extensive level surfaces, and minimal water erosion takes place today • Dolomite is brittle and not easily water soluble (unless powdered) which accounts for the high degree of water permeability of the area
Biological / Ecological	 **Natural Vegetation**	• The area is classified as mopane savanna, mountain savanna and Karstfeld • The frost-free climate encourages mixed vegetation of grasses, shrubs and trees (up to 15 m height) • Area is heavily bush encroached bush with a density of about 8,000 bushes per hectare covering more than 75% of the area • Dominant shrub and tree species are Mopane, Swarthak, Purple-pod Terminalia and Sekelbos
	 **Birdlife**	• Birdlife is abundant and diverse. • No bird poisoning (e.g as a measure to control pests and predators such as jackal) has occurred in the area for several decades. • No detailed birdlife count and diversity assessment was conducted.

	 **Reptiles**	• Reptile species are abundant and diverse. • No detailed reptile count and diversity assessment was conducted.
	 **Wildlife (mammals)**	• The area is located on Namibia's commercial farming land and extensive livestock production has taken place for several decades. • Large predatory animals such as lion and hyena are no longer found in the area, but leopard are still regularly observed. • Bush encroachment has reduced the open savannah habitat preferred by cheetah and they are thus scarce in the area. • Common herbivores in the area include Kudu, Oryx, Impala, Red Hartebeest, Blue Wildebeest, Burchell`s Zebra, Hartmann's Mountain Zebra, Duiker, Eland, Steenbuck and Damara Dikdik • Small predators include Antbear, Bat-Eared Fox, Jackal, Aardwolf and Yellow Mongoose, Duiker, Eland • Density of game is moderate and there is no large-scale hunting occurring in the area • Since there is no game-proof fencing, wildlife migrates freely. • No detailed wildlife count and diversity assessment was conducted.
	 **Aquatic life**	• Aquatic life is limited due to a lack of permanent surface water. • A man-made watering hole in a lime pit (artificially supplied during dry seasons from borehole water) supports small numbers of frog species and turtles. • Aquatic life in underground aquifers was not assessed. • No detailed aquatic life count and diversity assessment was conducted.
	 **Insects**	• Insect and arachnid species are abundant and diverse. • No large-scale and permanent crop production takes place in the area and except for routine dipping of livestock, no insecticides are used on a significant scale. • No detailed insect count and diversity assessment was conducted.
Sociological / Economic	 **Heritage sites**	• No ancestral burial grounds or areas of historical significance were identified. • No unique natural attractions with tourism potential were identified.
	 **Employment**	• The enterprise located in the area employs about 360 workers for the production of charcoal. • Charcoal production involves the manual cutting, trimming, burning, packaging and loading of charcoal derived from invader bush species. • The work force is highly migratory and originate mostly from the Kavango, Ohangwena, Oshana and Omusati Regions

		• Food supply is guaranteed through a weekly mobile store and regular trips to Otjiwarongo and Otavi. • Remuneration is on a production-basis and workers are allocated to different teams of about 30 persons each. • Each team comprises an elected supervisor/spokesperson and one or more nominated first aid providers. • Employer and employee relations are sound and no significant disputes have occurred since charcoal production commenced in the mid 1990s.
	 **Health**	• The area is generally free of malaria as there is no stagnant permanent water, but a diverse range of flies are plentiful in the area. • Snakes and scorpions occur in the area and do pose a health risk, but no major injuries or deaths have occurred. • HIV is not of great concern, since seasonal workers are reportedly chaste while away from home. • Prior to entering into a work contract, all workers undergo a medical examination for measles and tuberculosis. • Workers regularly participate in First Aid training. • Each harvesting team is provided with comprehensive First Aid kits, cellular telephone and emergency assistance is permanently on stand-by.
	 **Culture**	• The most prominent cultural aspects are church and soccer. • Long-term workers who have secured supervisory positions in the harvesting teams and are more permanently employed have been joined by their families. • Workers generally remain in their work area and seldom venture to neighbouring areas, due to discrimination from neighbours.
	 **Housing**	• A number of semi-permanent housing structures (mostly traditional housing from clay and thatch, but also corrugated iron shacks) are scattered in small clusters across the area. • These clusters are provided with piped borehole water and ablution facilities, in compliance with the stipulations of the Labour Act of 1992. • Where harvesting teams operate in a more remote part of the area, they opt to establish temporary shelters at the work site, instead of traveling each day. • At such temporary areas, water is provided by a water trailer.
	 **Management**	• The charcoal enterprise is certified through the Forest Stewardship Council (FSC), which sets international guidelines for sustainable wood resource utilization. • FSC accreditation allows the enterprise to market its product on the European markets.

		• The enterprise simultaneously operates 12 teams of 30 persons each and each team is coordinated by an elected supervisor/leader. • The team leader is in contact with management via cellular telephone. • A fulltime forester inspects each team on a weekly basis. • Remuneration of workers occurs every 6 weeks and is combined with a day-trip to Otjiwarongo for shopping and banking purposes.

6. Environmental Impact Results

The scoping activity for the environmental impact determined what possible environmental impact (both positive and negative) the harvesting of bush resources and the operation of the wood gasification technology used by the power plant are likely to have. The findings are presented in two different impact matrixes: for the harvesting chain and the power plant. The matrixes describe the type of impact, whether positive or negative and the significance of each.

6.1. Harvesting Chain Environmental Impact

The bush resources will be harvested at a rate of 2 tonnes per hectare (about 20% bush thinning) amounting to a total annual volume of 1,425 tonnes and an annually cleared area of 712 ha. Transportation of harvested bush will be by tractor with trailer or 10-ton truck and two trips every weekday. Harvesting will be manual using hand axes and pangas and the total number of harvesters, including driver and supervisor, will be about 15 persons. Only bush species classified as invasive will be harvested and harvesting will be conducted according to the guidelines prescribed by the Forest Stewardship Council (FSC). Furthermore, no harvesting activities without the valid permits issued by the Directorate of Forestry shall be conducted.

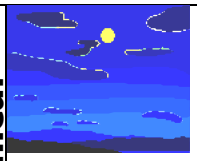
Bush harvesting activities as conducted by the Cheetah Conservation Fund, Otjiwarongo.

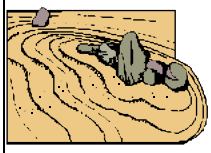
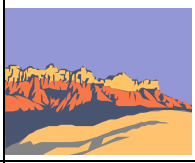
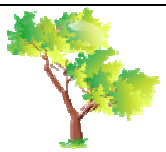
Picture: DRFN

The harvesting chain comprises: cutting, compiling, transport (logs), storage (logs), chipping, sieving, storage (chips), drying and handling.

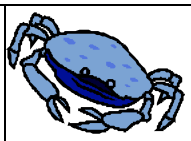
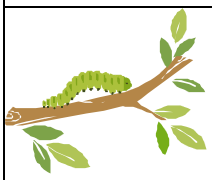
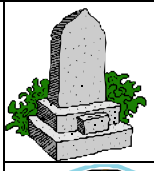
The table below summarises the anticipated environmental impacts that may result from the harvesting of bush resources.

Table 3: Environmental impact matrix – Harvesting Chain

Environmental Components			Possible environmental impacts	Significance
Physical / Chemical		**Air**	**Low negative** • Dust pollution due to transportation is confined to the public road only. • Dust pollution due to wood chipping will be limited through technical specifications. • Emissions from diesel-operated chipper and truck/tractor are likely to be minimal.	None

		• Noise pollution will be limited and not near human settlements. • Light pollution is unlikely.	
	 **Water**	**High positive** **Low negative** • Groundwater recharge due to removed bush will improve. • Oil and diesel spillages as a result of ill-maintained truck/tractor and/or chipping equipment may result, and maintenance of the equipment must be integrated into regular management activities. • No water pollution and/or excessive extraction of ground water are anticipated.	None
	 **Soils**	**Medium positive** **Low negative** • Topsoil loss due to wind and water erosion is unlikely to increase since grasses will take the place of removed bush. • Soil compaction is unlikely since no heavy machinery will be used. • Soil drainage is likely to improve and thus erosion may be reduced. • Loss of biomass and soil nutrients will be minimal, since leaves and twigs will remain in the field. • Nitrogen fixation and thus soil fertility will be largely unaffected due to the removal of less than 50% of existing bushes and no harvesting of protected species.	None
	 **Geology**	• No environmental impacts are anticipated.	None
Biological / Ecological	 **Natural Vegetation**	**High positive** **Low negative** • Natural vegetation shall be altered by about 20% through removing of invasive species. • Density and diversity of grass species is likely to improve. • Water competition between trees is likely to reduce, which may result in stronger growth of existing species. • Overall total diversity of natural vegetation is likely to increase. • Harvesting shall be controlled by a forester and be conducted according	None

		to FSC requirements. • Annual harvesting inspections by FSC accredited personnel will be conducted.	
	 **Birdlife**	**Low positive** • Reducing the bush thicket is likely to improve habitat diversity in the area. • Seed eating bird species are likely to increase. • Nesting sites and shelters for birds are unlikely to be affected due to only 20% reduction of bush density. • Increase in diversity and number of fauna species may increase opportunities for predators. • Overall total birdlife diversity is likely to increase. • Disturbance due to harvesting activities likely to be minimal and very localized.	None
	 **Reptiles**	**Low positive** • Reducing the bush thicket is likely to improve habitat diversity in the area. • Shelters for reptiles are unlikely to be affected due to only 20% reduction of bush density. • Increase in diversity and number of fauna species may increase opportunities for predators. • Overall total reptile diversity is likely to increase • Disturbance due to harvesting activities likely to be minimal and very localized.	None
	 **Wildlife (mammals)**	**High positive** • Reducing the bush thicket is likely to improve habitat diversity in the area. • Grazing herbivore species likely to increase. • Browsing herbivores unlikely to be affected due to only 20% reduction of bush density. • Increase in diversity and number of fauna species may increase opportunities for predators. • Overall total wildlife diversity is likely to increase. • Disturbance due to harvesting activities likely to be minimal and very localized.	None

	Aquatic life 	• No environmental impacts are anticipated.	None
	Insects 	**Low positive** • Reducing the bush thicket is likely to improve habitat diversity in the area. • Shelters for insects are unlikely to be affected due to only 20% reduction of bush density. • Overall total insect diversity is not likely to be affected.	None
Sociological / Economic	**Heritage sites** 	• No environmental impacts are anticipated.	None
	Employment 	**High positive** • Harvesting will require about 15 persons, which contributes towards rural employment opportunities. • Harvesting techniques are well established in the charcoal industry. • Harvesting teams will operate normal working hours, with weekends off. • It is likely that harvesters will undergo more specialized training and that these will be permanent positions.	None
	Health 	**Medium positive** **Low negative** • Frequent supervision and inspections, first aid training and emergency equipment will likely reduce instances of injury. • Inhalation of wood dust during chipping process is unlikely to pose respiratory risks (unless there are technical defects on the chipping equipment). • General hazards such as snake bites and scorpion stings will remain, but the risks are unlikely to increase. • Risk for injuries will remain, but are unlikely to increase. • Risk for infectious diseases will remain, but are unlikely to increase.	None
	Culture 	**Low positive** • Normal working hours imply that harvesters will spend time with family and friends more frequently and regularly.	None

	 **Housing**	**Low positive** • Permanent harvester positions and normal working hours imply that harvesters will reside in more permanent houses and can perform home improvements.	None
	 **Management**	**High positive** **Low negative** • Start-up phase will require greater managerial interventions until the harvesting process is routine. • It is unlikely that managerial activities will differ substantially from the current charcoal production. • Additional revenue may be generated from increased livestock production due to improved rangeland carrying capacity. • Additional revenue may be generated from increased wildlife diversity and density due to improved habitat diversity.	None

6.2. Power Plant Environmental Impact

The 250 kW power plant will require about 6 tonnes of chipped wood per day for a 16 hour operation. The plant will probably only operate on weekdays, from 06:00 to 22:00, and maintenance activities will be performed on Saturdays.

The plant requires cooling water for cooling and cleaning the wood gas and cooling the gas generator set. Total water consumption will be about 14 m^3 per day using an evaporative cooling process (however, forced air cooling is being considered, which will reduce this water consumption substantially). The gas cooling water will mix directly with hot gas and extract impurities such as tars from the gas. These impurities are extracted through a water purification system, collected, air dried and burnt in the gasifier.

Wood gas is further purified through a dual set of 800 kg saw dust filters. The saw dust is prepared on site, using a hammer mill, and is exchanged every 6 operating days. The soiled saw dust is burnt in the gasifier. The final wood gas contains less than 10 parts per million of tar and particulates and minimal greenhouse gases. Typical gas composition is summarised in the table below:

Table 4: Composition of wood gas	
CO	19 ± 3%
H_2	18 ± 2%
CO_2	10 ± 3%
N_2	50%
CH_4	Up to 3%

The gas generator will produce electricity, which is fed into the grid distribution network via a transformer. The transformer type will be as specified by the Electricity Control Board and will

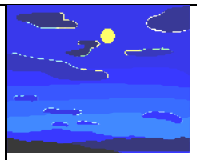
be free of PCBs (polychlorinated biphenyls). The generator is an internal combustion engine requiring oil lubrication and regular oil changes.

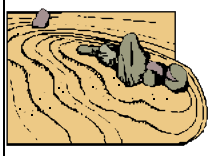
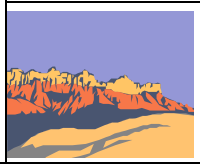
Spent wood fuel will turn into dry ash and bio char and the volume will be range between 0.3 to 0.6 tonnes per day depending on the bark content of the wood. This dry ash poses no health risk and can be used as a natural fertiliser, binder for brick production, sealing of earth dams and other applications.

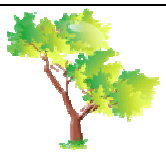
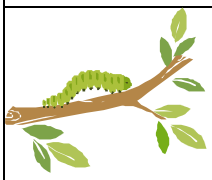
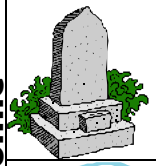
In overview, the power plant thus comprises: gasifier, gas cleaning, cooling ponds, generator, transformer, power line, ash discharge, water treatment and used oil.

The table below summarises the anticipated environmental impacts that may result from the operations and maintenance of the wood gasification power plant.

Table 5: Environmental impact matrix – Power Plant

Environmental Components		Possible environmental impacts	Significance
Physical / Chemical	 **Air**	**Low positive** **Medium negative** • Wood gas does not contain the pollutant gases SOx and NOx , which contribute towards global warming, acid rain, soil and water acidification, general corrosion, and photochemical smog. • The combustion of wood gas still releases CO2, but the process is considered carbon neutral since the CO2 amount released is equal to the CO2 absorbed by the woody biomass during its life cycle. • The CH4 content of wood gas is very low. • The overall release of greenhouse gases will be substantially less than burning wood through open combustion and/or burning diesel fuel in a diesel generator. • The evaporative cooling pond for gas releases polyaromatic hydrocarbon pollutants, but this amount is low (and will be avoided if forced air cooling is used) • Wet ash and charcoal residues would also release polyaromatic hydrocarbon pollutants, but a dry ash discharge system will be used, which will avoid these emissions. • Dust pollution due to transportation	None

		will be minimal and chips will be used as dust suppressant. • Dust pollution from the saw dust production can potentially cause respiratory ailments for workers, but can be prevented by using mouth guards. • Dust pollution from the dry ash discharge can potentially cause respiratory ailments for workers, but can be prevented by using mouth guards. • Spores of fungi (from organic decomposition through microorganisms) can be spread into the air if wood chips have been stored with too much humidity, but can be prevented by using mouth guards, improved ventilation of storage facilities and correct wood processing. • Noise pollution will be emitted from plant machinery and the generator. The latter will be installed in a separate room with sound-reduction.	
	 **Water**	**Medium negative** • Water consumption for both gas and generator cooling is less than 14m³ per day. • Water contamination from gas cleaning will contain tar residues and polyaromatic hydrocarbons and will be disposed of through drying and subsequent burning in the gasifier. • Contact between ground water and surface water with contaminated water shall be avoided. • A water treatment facility is integrated with the plants cooling pond.	None
	 **Soils**	**Low positive** • Dry ash residue is not considered toxic. • Dry ash may be used as a fertilizer. • The total footprint of the power plant is about 5,000 m² (0.5 ha).	None
	 **Geology**	• No environmental impacts are anticipated.	None

Biological / Ecological	 **Natural Vegetation**	• The total footprint of the power plant is small and very little vegetation clearing and earth works are required. • Dust pollution from the plant will be insignificant.	None
	 **Birdlife**	• The total footprint of the power plant is small and very little vegetation clearing and earth works are required. • Disturbance to birdlife will be insignificant. • The plant will be flood-lit during night time operations, which may attract insects and predating birds.	None
	 **Reptiles**	• The total footprint of the power plant is small and very little vegetation clearing and earth works are required. • Disturbance to reptiles will be insignificant.	None
	 **Wildlife (mammals)**	• The total footprint of the power plant is small and very little vegetation clearing and earth works are required. • Disturbance to reptiles will be insignificant. • The plant will be flood-lit during night time operations, which may attract insects and predating wildlife.	None
	 **Aquatic life**	• No discharge of contaminated water into groundwater and/or surface water will occur.	None
	 **Insects**	• The total footprint of the power plant is small and very little vegetation clearing and earth works are required. • Disturbance to insects will be insignificant. • The plant will be flood-lit during night time operations, which may attract insects.	None
Sociological / Economic	 **Heritage sites**	• No environmental impacts are anticipated.	None
	 **Employment**	**Medium positive** • The power plant's operation and maintenance will require about 7 persons, which contributes towards rural employment opportunities.	None

		• Plant construction will require about 20 persons for a period not exceeding 3 months. • Plant operators are likely to undergo specialized training and these are likely to be permanent positions. • Regular working conditions, permanent employment and a higher skills level will provide greater work place security.	
	 **Health**	**Medium negative** • Frequent supervision and inspections, first aid training and emergency equipment will likely reduce instances of injury. • Inhalation of wood dust during saw dust production process may pose respiratory risks, and mouth guards will be provided. • The power plant will be well ventilated in order ensure that any airborne emissions do not accumulate. • The power plant generates hot temperatures which may cause serious burns. Hazardous areas will be clearly demarcated. • Workers will be provided with safety gear, which will include safety boots, gloves, mouth guards, earmuffs and safety goggles. • Health and safety regulations for factories will be applied at the power plant.	None
	 **Culture**	**Low positive** • Regular working conditions, permanent employment and a higher skills level will provide greater work place security and ultimately lead to a higher standard of living and thus opportunities for education, cultural and religious activities.	None
	 **Housing**	**Low positive** • Permanent employment and normal working hours imply that plant operators will reside in more permanent houses and can perform home improvements more regularly.	None

	 **Management**	**Medium positive** **Medium negative** • Initial start-up phase will require greater managerial interventions until the power production process is routine. • At present no expertise in operating a power plant is in place and substantial capacity development activities will be conducted. • The recruitment of suitable staff and higher staff costs will put pressure on the economic performance of the plant.	None

7. Conclusion

The bush-to-electricity power plant that will be installed through the CBEND Project will be located on a commercial farm and be fueled with invader bush species. No full-scale environmental impact assessment was conducted, since the environmental scoping assessment did not identify any negative environmental impacts of any significance.

The power plant requires only about 6 tonnes of wood per day, which will be harvested from an area of about 3 ha per day, at a rate of 2 tonnes per ha. The bush density in the area is in excess of 10 tonnes per ha. Thus the rate of exploitation is very low.

The harvesting team will comprise about 15 persons and the area already hosts active charcoal production. Human impact as a result of harvesting is minimal in terms of disturbance of soil, vegetation, wildlife, birdlife and other. Pollution to soil and water resources due to human activities are unlikely.

Transportation of chipped materials from the filed to the power plant will be within a radius of about 10 km and will be along established farm roads and national district roads. The power plant will utilise a front loader skid steer, which will move chipped biomass within the confines of the power plant. No soil disturbances are anticipated.

Waste generation through the power plant's operations will be dry ash and biochar, CO_2 emissions from the generator and waste water containing tar residues and polyaromatic hydro carbons. The ash and biochar do not pose an environmental risk, unless ash is inhaled by workers over prolonged periods. The gaseous pollution is free of the most sever greenhouse gases and the CO_2 emissions are considered carbon neutral and thus do contribute towards increasing total CO_2 concentrations in the atmosphere. Waste water will undergo purification, which is an integral part of the power plant's processes and extracted waste substances are routinely burnt in the gasifier. Generated waste materials are also of very low quantities.

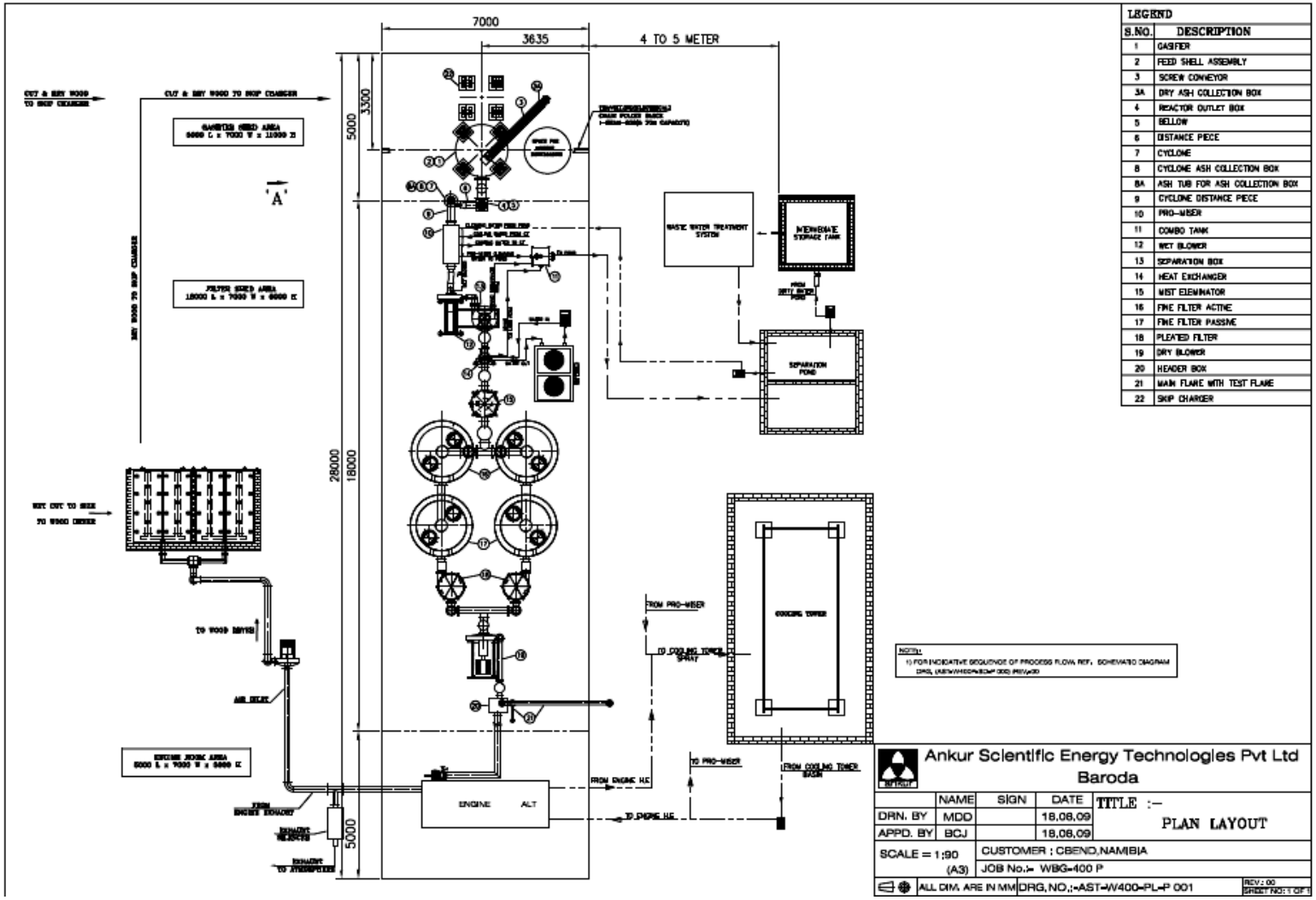
Water consumption, at 14 m^3 per day, is considered low and is mostly due to evaporation. This consumption will be further reduced due to the use of forced air cooling instead of evaporative cooling. Water will not be used as a dust suppressant or in any other large-scale applications.

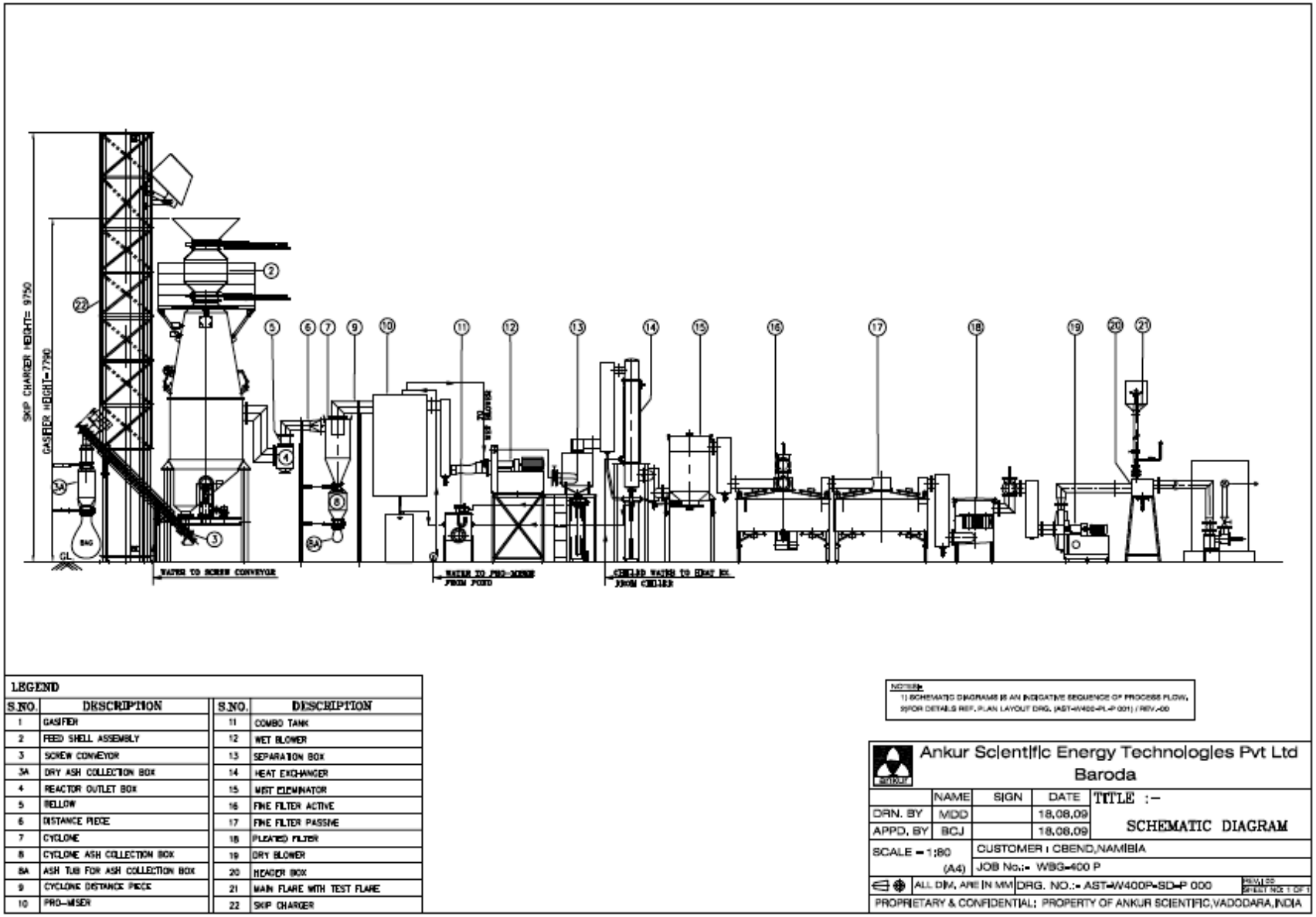
The CBEND Project is confident that no negative environmental consequences of any significance will result from the project.

8. Annex A: Site Map


Etosha Pan
ETOSHA NATIONAL PARK
Otjetjekua
Lindequist Gate
Namutoni
Mokuti Lodge
Halali
Okaukuejo
Anderson Gate
Gobaubvlakte
Otjovasondu
Galton Gate
TSUM
OTAVI
Kamanjab
Huab
Otjikondo
OUTJO
Fransfonteinberge
Fransfontein
KHORIXAS
(D2620)
Okongwe
Groot-
Paresis
Klein-
OTJIWARONGO
OKAKARARA
WATERBERG PLATEAU
C38
C40
C39
C35
C33
B1
C22
M63

9. Annex B: Technical Line Drawing of Gasification Plant





LEGEND

S.NO.	DESCRIPTION	S.NO.	DESCRIPTION
1	GASIFIER	11	COMBO TANK
2	FEED SHELL ASSEMBLY	12	WET BLOWER
3	SCREW CONVEYOR	13	SEPARATION BOX
3A	DRY ASH COLLECTION BOX	14	HEAT EXCHANGER
4	REACTOR OUTLET BOX	15	MIST ELIMINATOR
5	BELLOW	16	FINE FILTER ACTIVE
6	DISTANCE PIECE	17	FINE FILTER PASSIVE
7	CYCLONE	18	PLEATED FILTER
8	CYCLONE ASH COLLECTION BOX	19	DRY BLOWER
8A	ASH TUB FOR ASH COLLECTION BOX	20	HEADER BOX
9	CYCLONE DISTANCE PIECE	21	MAIN FLARE WITH TEST FLARE
10	PRO-MISER	22	SKIP CHARGER

NOTES:
1) SCHEMATIC DIAGRAMS IS AN INDICATIVE SEQUENCE OF PROCESS FLOW.
2)FOR DETAILS REF. PLAN LAYOUT DRG. (AST-W400-PLP 001) / REV.-00

Ankur Scientific Energy Technologies Pvt Ltd
Baroda

	NAME	SIGN	DATE	TITLE :-
DRN. BY	MDD		18.08.09	SCHEMATIC DIAGRAM
APPD. BY	BCJ		18.08.09	
SCALE = 1:80 (A4)	CUSTOMER : CBEND,NAMIBIA			
	JOB No.:- WBG-400 P			
ALL DIM. ARE IN MM	DRG. NO.:- AST-W400P-SD-P 000			REVISION SHEET NO: 1 OF 1

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10. Annex C: Site Layout of Power Plant with Ancillaries