



# Road Map to a Biomass Industrial Park

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## Biomass Partnership with Namibia

Version 11 March 2021

## Imprint

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| Synopsis:        | <p>The present Road Map (RM) is a guideline that provides recommendation for action, with regard to the development of a Biomass Industrial Park (BIP) in Namibia based on the insights gained during the last 18 month of project work. The RM outlines and describes the activities and necessary steps conducted in order to create a decisive business environment that potentially triggers the implementation of a BIP in Namibia. Based on a specific case study, the RM provides information on which realms are relevant and which process steps are necessary to successfully implement a BIP in Namibia. The RM is based on the fulfillment of performance phases 1 (basic assessment) and phase 2 (preliminary planning) defined according to German HOAI.</p> |
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## List of acronyms and abbreviations

|                        |  |
|------------------------|--|
| <b>a</b>               | Annum/year   |
| <b>A</b>               | Total solar panel Area                                       |
| <b>AC</b>              | Alternative Current  |
| <b>AMS</b>             | Approved Methodologies Small Scale                           |
| <b>ARA</b>             | Amsterdam-Rotterdam-Antwerp region                           |
| <b>ASTM</b>            | American Society for Testing and Materials                   |
| <b>ATO</b>             | African Timber Organization                                  |
| <b>BAT</b>             | Best available technologies                                  |
| <b>BaU</b>             | Business as Usual  |
| <b>BIP</b>             | Biomass Industrial Park                                      |
| <b>BuToVal</b>         | Bush to Value  |
| <b>CAPEX</b>           | Capital Expenditure  |
| <b>CDM</b>             | Clean Development Mechanism                                  |
| <b>CE</b>              | Circular Economy   |
| <b>CEN</b>             | European Committee for Standardization                       |
| <b>CER</b>             | Certified Emission Reduction                                 |
| <b>CH<sub>4</sub></b>  | Methane  |
| <b>CHED</b>            | Common Health Entry Document                                 |
| <b>CHP</b>             | Combined Heat and Power                                      |
| <b>CITES</b>           | Convention on International Trade in Endangered Species      |
| <b>CO<sub>2</sub></b>  | Carbon Dioxide   |
| <b>CO<sub>2e</sub></b> | Carbon Dioxide Equivalent                                    |
| <b>COC</b>             | Certificate of Conformity                                    |
| <b>d</b>               | Day  |
| <b>DAS</b>             | De-bushing Advisory Service                                  |
| <b>DC</b>              | Direct Current   |
| <b>DIN</b>             | Deutsches Institut für Normung                               |
| <b>DM</b>              | Dry matter content   |
| <b>DTS</b>             | Data transfer system   |
| <b>DWT</b>             | Metric tons of deadweight                                    |
| <b>E</b>               | Energy generated form panels                                 |
| <b>EAT</b>             | Earnings after Tax   |
| <b>EBIT</b>            | Earnings before Interest, Tax                                |
| <b>EBITDA</b>          | Earnings before Interest, Tax, Depreciation and Amortization |
| <b>EBT</b>             | Earnings before Tax  |

|                        |  |
|------------------------|--|
| <b>EF</b>              | Emission factor  |
| <b>EnMS</b>            | Energy Management System   |
| <b>EUR</b>             | Euro   |
| <b>EUTR</b>            | European Union Timber Regulation                                   |
| <b>EZT</b>             | Electronic Customs Tariff  |
| <b>FM</b>              | Fresh raw material   |
| <b>FOB</b>             | Freight on Board   |
| <b>FSC</b>             | Forest Stewardship Council   |
| <b>FTA</b>             | Free Trade Agreement   |
| <b>g</b>               | Gram   |
| <b>GGED</b>            | Gemeinsames-Gesundheitseingangsdokument                            |
| <b>GHG</b>             | Green House Gas  |
| <b>GIZ</b>             | German Development Assistance                                      |
| <b>GMT</b>             | Green metric tons  |
| <b>GPC</b>             | Global Protocol for Community                                      |
| <b>GWP</b>             | Global Warming Potential   |
| <b>h</b>               | Hour   |
| <b>HCVF</b>            | High conservation value forests                                    |
| <b>HGB</b>             | German Commercial Code   |
| <b>hrs.</b>            | Hours  |
| <b>h<sub>w</sub></b>   | Latent heat of water vapor   |
| <b>Hz</b>              | Hertz  |
| <b>ICLEI</b>           | International Council for Local Environmental Initiatives          |
| <b>IEC</b>             | International Electrotechnical Commission                          |
| <b>IfaS</b>            | Institute for Applied Material Flow Management                     |
| <b>IFRS</b>            | International Financial Reporting Standards                        |
| <b>ILO</b>             | International Labour Organization                                  |
| <b>IPCC</b>            | Intergovernmental Panel on Climate Change                          |
| <b>IPM</b>             | Integrated pest management   |
| <b>IRR</b>             | Internal Rate of Return  |
| <b>ISEAL</b>           | International Social and Environmental Accreditation and Labelling |
| <b>ISO</b>             | International Organization for Standardization                     |
| <b>ITTO</b>            | International Tropical Timber Organization                         |
| <b>kg</b>              | Kilo gram  |
| <b>km</b>              | Kilometres   |
| <b>KPI</b>             | Key Performance Indicator  |
| <b>kVa</b>             | Kilo volt ampere   |
| <b>kW</b>              | Kilo watt  |
| <b>kW<sub>el</sub></b> | Kilo watt electrical   |
| <b>kWh</b>             | Kilo watt hour   |

|                        |   |
|------------------------|---|
| <b>kW<sub>p</sub></b>  | Kilo watt peak  |
| <b>kW<sub>th</sub></b> | Kilo watt thermal   |
| <b>l</b>               | Litre   |
| <b>LCIA</b>            | London Court of International Arbitration                     |
| <b>LCoE</b>            | Levelized cost of energy                                      |
| <b>LED</b>             | Light Emitting Diode  |
| <b>LKR</b>             | Lanka Rupee   |
| <b>LPG</b>             | Liquid Petroleum Gas  |
| <b>m</b>               | Mass/month  |
| <b>m<sup>2</sup></b>   | Square meter  |
| <b>m<sup>3</sup></b>   | Cubic meter   |
| <b>MACS</b>            | Maritime Carrier Shipping GmbH & Co                           |
| <b>MAWF</b>            | Ministry of Agriculture, Water and Forestry                   |
| <b>MCPFE</b>           | Ministerial Conference on the Protection of Forests in Europe |
| <b>MFA</b>             | Material Flow Analysis  |
| <b>MFM</b>             | Material Flow Management                                      |
| <b>min</b>             | Minute  |
| <b>MITSMED</b>         | Ministry of Industrialization, Trade and SME Development      |
| <b>MJ</b>              | Mega joule  |
| <b>mm</b>              | Millimetre  |
| <b>MoU</b>             | Memorandum of Understanding                                   |
| <b>MSDS</b>            | Material safety data sheet                                    |
| <b>MW</b>              | Mega watt   |
| <b>MW<sub>el</sub></b> | Megawatt electrical   |
| <b>MWh</b>             | Megawatt hour   |
| <b>N<sub>2</sub>O</b>  | Nitrous oxide   |
| <b>NAD /N\$</b>        | Namibian Dollar   |
| <b>NaOH</b>            | Sodium hydroxide  |
| <b>N-BIG</b>           | Namibia-Biomass Industry Group                                |
| <b>NCA</b>             | Namibia Charcoal Association                                  |
| <b>NCPA</b>            | Namibia Charcoal Producers Association                        |
| <b>NDP</b>             | National Development Plan                                     |
| <b>NO<sub>x</sub></b>  | Oxides of Nitrogen  |
| <b>NPC</b>             | National Planning Commission                                  |
| <b>NPV</b>             | Net present value   |
| <b>NUST</b>            | National University of Science and Technology                 |
| <b>NVC</b>             | Net calorific value   |
| <b>°C</b>              | Celsius   |
| <b>OF</b>              | Oxidation fraction  |
| <b>OPEX</b>            | Operating Expenditure   |

|                  |   |
|------------------|---|
| <b>P&amp;L</b>   | Profit and Loss account                               |
| <b>PBP</b>       | Payback period  |
| <b>PDCA</b>      | Plan Do Check Action                                  |
| <b>PEFC</b>      | Program for the Endorsement of Forest Certification   |
| <b>PPP</b>       | Public-Private Partnership                            |
| <b>PR</b>        | Performance ratio, coefficient for losses             |
| <b>PTO</b>       | Power take-off  |
| <b>PV</b>        | Photovoltaic  |
| <b>Pvt. Ltd.</b> | Private Limited                                       |
| <b>r</b>         | Solar panel yield                                     |
| <b>RE</b>        | Renewable Energy                                      |
| <b>REC</b>       | Resources and Energy Efficiency Check                 |
| <b>RED</b>       | Renewable Energy Directive                            |
| <b>ROI</b>       | Return on investment                                  |
| <b>RUBIC</b>     | Rural Bioeconomy Centre                               |
| <b>SADC</b>      | South African Development Community                   |
| <b>SBP</b>       | Sustainable Biomass Program                           |
| <b>SME</b>       | Small and Medium Enterprises                          |
| <b>SOC</b>       | Substance of concern                                  |
| <b>ST</b>        | Solar thermal   |
| <b>SURE</b>      | Sustainable Resource Verification Scheme              |
| <b>t</b>         | ton/tonne   |
| <b>TRACES</b>    | Trade Control and Expert System                       |
| <b>UNECE</b>     | United Nations Economic Commission for Europe         |
| <b>UNFCCC</b>    | United Nations Framework Convention on Climate Change |
| <b>UNIDO</b>     | United Nations Industrial Development Organization    |
| <b>USD</b>       | United States Dollar                                  |
| <b>V</b>         | Volt  |
| <b>VAT</b>       | Value added tax                                       |
| <b>VSD</b>       | Variable speed drive                                  |
| <b>w/w</b>       | Weight for weight                                     |
| <b>WACC</b>      | Weighted Average of Cost of Capital                   |
| <b>WBCG</b>      | Walvis Bay Corridor Group                             |
| <b>WC</b>        | Working Capital                                       |
| <b>Wm</b>        | Mass of Water   |
| <b>WWF</b>       | World Wide Fund for Nature                            |
| <b>X</b>         | Moisture  |
| <b>η</b>         | Efficiency  |

# 1 Executive Summary

Biomass industrial parks (BIP), the proposition herein, is a practical solution addressing Namibia's longstanding *bush encroachment* issue which is identified as an ecological and socio-economic catastrophe. A direct consequence of unsustainable land management and animal husbandry, bush encroachment currently affects over 30% of Namibian land area and, inter alia, had reduced the country's rangeland production capacity by about two-thirds, severely impacted the traditional grazing-based cattle industry, negatively and severely impacted the biodiversity, depleted the groundwater sources and its recharge capacity, etc. However, on the flip side, there are over 450 million tonnes of an untapped renewable resource, *id est* biomass, thriving on 45 million hectares.

The principal input being biomass, BIPs essentially provide a practical solution to the underlying issue, where, by utilizing the bothersome biomass at an industrial scale not only control the bush encroachment but also create a multitude of economic, social and environmental benefits/value. To that end, this project aims to create a sustainable biomass industry in Namibia that converts a *burden-to-bounty* which, in the process exploit sectoral synergies—including public and private sectors—in order to create a spectrum sustainable products and services of high value that caters to local, regional and international markets. Some of the notable features of the project include the creation of regional added value (RAV), climate protection, biodiversity conservation, innovative and sustainable business models, etc.

This project exclusively employs a set of leading-edge sustainability tools and models, *videlicet* Material Flow Management (MFM), bio-economy (BE), and Circular Economy (CE), pioneered and perfected over two decades by the Institute for Applied Material Flow Management (IfaS) of the Trier University of Applied Sciences to achieve the

project's triple-bottom-line (TBL) targets. Unique and pioneering in many ways, this project will establish a practical example of how a man-made environmental issue could be resolved sustainably employing current technologies and resources. Through its sustainable industrial metabolic processes optimized socially, economically and ecologically to suit the local conditions, BIPs will directly retard, stop, and reverse the ongoing bush encroachment of savanna lands of Namibia.

Among others, the project measures include practical models for the utilisation of bush biomass for which new and innovative technical, logistical, and economic value-added chains will be implemented with a focus on maximising the regional value-added. Specifically, the efficient and sustainable biomass harvesting strategies, business upscaling strategies/plans, partnerships for effective logistics including intercontinental export of products, the dissemination of know-how on establishing BIPs, bio-economy and the like, and socio-economic capacity building, etc. are also targeted and will be achieved in the project, simultaneously.

This document, *the road map*, is a concise guide clarifying the key domains of BIP implementation that includes the aspects of site selection, logistics, technologies, products and services certification procedures, social services for the residents, assessment and verification of GHG balance, etc. Furthermore, this road map presents a detailed account of the key aspects of the implementation of the first BIP; designed for a 30-hectare bush-encroached land—with the potential to acquire another 70 hectares for future expansions—in the Otjiwarongo Municipality that has excellent infrastructure including utilities, logistics and associated infrastructure, services, etc. which are vital to the success of the intended business processes of the BIP.

Referred to herein as the BIP model, the detailed technicalities of the BIP framework of operations are presented covering five domains that include a.) harvesting, b.) post-harvest activity, c.) biomass processing, d.) residential planning and additional

services, and e.) logistics. On the five domains, the road map elaborates the key actions, specific outcomes, key issues and limitations, etc. based on a comprehensive assessment. The aim here is to improve the clarity and understanding of the association between the status quo situation of Namibian bush encroachment issue and how the BIP aim to and can address the key issues sustainably.

The BIP modelled herein plans to operate on a constant supply of 250,000 t/a of bush biomass which is considered a steady-state capacity according to the current site/location characteristics—which is quite pivotal to the sustainable operations—and its infrastructure capacities. Logistics, which is also a critical and limiting element to the functionality of a BIP seems ideal in this project considering the selected site in Otjiwarongo Municipality, which has access to both rail and road transportation and also its access to a commercial seaport—Walvis Bay—for the intended international business operations.

A business operation at this scale requires a sizable workforce, which is basically addressed in the *additional services* domain of this road map. Employment planning, housing, and related logistics are particularly addressed in this segment. According to the assessment, the BIP will create about 200–250 new employment opportunities in the region and will have to, considering its rural locality, house a community of about 340 residents (70 families of the aforementioned employees) that will be provided with essential services, such as healthcare, child care, schools, etc. A key feature of this planning segment is that the community—and also the BIP—is aimed to be supplied with carbon-neutral energy, *id est* renewable energy (REN), considering the superlative solar energy potential in the region. A utility-scale photovoltaic (PV) plant of the installed capacity of 5 MWp is planned, which will provide electrical energy at the LCoE rate of 1,16 N\$/kWh, that is substantially low compared to the current electricity prices of Namibia.

This road map also presents a comprehensive business plan for the BIP that defines the break-even-prices for each domain of operations and also assesses the business viability based on estimated prices satisfying the market requirements. All critical variables including fuel costs, product prices, raw material specifications, etc. are factored in for financial viability assessment, and accordingly, the project's key financial performance indicators including IRR, NPV, etc. are computed. The IRRs show, that each individual BIP domain is capable to exceed 8.8% WACC and hence create positive net present values (NPV) still including dividend payments.

Further, a sensitivity analysis was performed to understand the relative impact of critical variables. The computations are based on the latest and most accurate market data procured from and by the project stakeholders.

In addition, this road map also addresses a sustainable biomass certification and verification scheme that includes FSC, SBP and PEFC, etc. which is required to satisfy the legal requirements and compliance needs of exporting biomass to the international markets such as the EU.

A BIP with a throughput of 250,000 t per annum would cover an area with a radius of approx. 37km. Based on this assumption and with regard to the affected area, 105 BIPs could be implemented all over the country. With such a capacity, Namibia could have an industry that would significantly contribute to Namibia's GDP, Namibia's rural development and Namibia's sustainability. Because of the potential tax payments, job creation and investments which will be triggered with more BIPs implementation.

Based on the key findings/results, this road map presents recommendations in line with the objectives and the framework of this work. They include, in-depth evaluation of the organization model and the preparation of the certification of the bush biomass to identify the most suitable system, and technical and financial consolidation and fine



tuning. Loan conditions, interest rates, possible funds and availability of technology and resources need to be clarified on the ground and compared to our assumptions. That will enable to get more reliable and accurate numbers by eliminating more and more worst-case scenarios which will become even more attractive to investors and financing institutions. Further, selected technologies should test and adapt to the Namibian condition to ensure a smooth continuous process. Evidently, the project clearly addresses the core issue of the ecological imbalance of the subject through economically and socially optimized sustainable measures. It is also evident that the regional added value of the BIP, brought about through the sustainable utilization of biomass, creates a significant amount of local value chains prompting for new socio-economic ventures not only impacting the target community/stakeholders but also to the national and regional communities those who are facing the negative impacts of the underlying issue of bush encroachment, directly and indirectly. The knock-on effect of creating value chains directly assist the agricultural sector, animal husbandry, tourism sector, etc. to bounce back to their former capacities of operations sustainably which also help augment/strengthen the national economy and help improve the quality of life of the Namibians through the provision of employment, better income, and the creation of wealth.

## 2 Introduction

The present [national] environmental and socio-economic crisis of Namibian Savanna - bush encroachment - has been attributed to the decades of unsustainable land management and animal husbandry. Excessive spreading of native *Acacia* species such as *Acacia mellifera* has thus occurred claiming over 45 million hectares of land tipping the natural ecological balance between the bush and grass. This has disrupted the local cattle industry and small-scale agriculture, severely. This ecological disaster is further intensified as a result of depleting water resources, due to the unprecedented rate (3 to 5% per annum) of bush growth. Adding to the significant loss of biodiversity the native wild fauna has lost substantial territory for hunting, breeding, roaming, etc., in turn, negatively impacting the Namibian tourism industry. Besides the loss of livelihood of small-scale farmers and the significant [unwarranted] pressure on the economy, the sensitive debate on land distribution has surfaced without an apparent sustainable solution.

Counter measures exist. Present bush control is characteristically conventional that creates economic value added through traditional value chains such as charcoal, firewood, wood chips, fence posts, animal feed, et cetera. The current rate of utilization of biomass amounts to approximately 1.4 million t/a of woody-biomass. Opposed to the available 450 million tons that annually grow at the rate of 12 million tons utilization is insignificant, inefficient, and ineffective in restoring the sustainable ecological balance. In particular, it is ineffective in retarding the rate of disappearance of the Savanna biome. Despite the existing massive potentials, large-scale debushing/bush thinning of biomass had not occurred thus far due to issues such as a.) deficiencies in currently employed technologies, such as high wear and tear of machines due to high-silicate bush composition, machine over-heating in harsh desertic-temperatures, etc., b.) lack of demand for the bush-based products, as a consequence of the uneconomical/non-cost competitive, small-scale, inefficient value

chain operations, c.) infrastructural inadequacies for processing/production operations and logistics management, d.) lack of know-how and required skilled workforce along the value chain, and e.) lack of necessary business, policy, marketing, R&D strategies for the perpetuation of sustainable de-bushing at scale.

To that end, during the last 18 month IfaS aimed to develop strategies that systematically, and most importantly, sustainably utilize biomass through optimized value chains, thereby achieve effective bush control while creating regional added value due to the creation of new industries, products and services, employment, tax revenues, etc. and restore the Savanna biome and mitigate the negative ecological impacts. Provided the demand, it is also aimed to create a lucrative international market for the bush-based raw material, specifically for the bio-energy sector, such as biochar, wood chips, wood pellets, etc. with the aim of diversifying the market, and also to enhance the scale and scope of de-bushing operations. Accordingly, the project activities contemplated both concept development and piloting. The principal device; Biomass Industrial Parks [BIPs] - essentially biomass-driven industrial symbiotic sites - shall be piloted at which the effective solutions for the elimination of present technological, logistical, and management barriers shall be demonstrated.

This project is grounded in the principles of Material Flow Management strategy where a bio economy-based strategy for Namibian bush control shall be elicited.

The overarching goal of this project was to retard, stop, and reverse the ongoing bush encroachment of savanna land in Namibia through socially and ecologically optimized measures. These measures include practical models for the use of the bush biomass and piloting of new technical, logistical, and economic value-added chains. Among others, the exchange of applied technical knowledge and technology transfer—also aiming at eliciting necessary policy measures—in the field of sustainable extraction and utilization of biomass to maximize the regional value-added was a cardinal objective. Specific objectives include a.) development of sustainable, cost efficient

harvesting strategies, b.) development and upscaling of bush feed approaches, c.) establishment of partnerships for export of biomass, d.) introduction to Bioeconomy- and Research Centres following the concept of circular economy including a capacity building and further training program both for academic and non-academic education.

Given the complexity of interacting elements (e.g. stakeholders), the level of interactions (i.e. direct, indirect, mild, strong, etc.), the scale (regional, national, international), etc. the present Road Map employed a systems approach in modelling a potentially working value chains, that can be replicated in various geographic locations for small-scale (250,000 t/a) and large-scale (1 million t/a) biomass throughput.

First, an applied material flow management assessment was deployed, in order to assess the status quo of the entire system comprising both technology and economic analyses of each element of the potential value chain at three distinguished levels id est harvesting, processing, and products. Based on these insights and on the basis of the predefined small-scale throughput quantity of 250,000 t/a, a comprehensive scenario analysis was conducted - all scenarios as opposed to the Business as Usual (BaU) - to assess the best operation modes, system leverage points, economies of scale, environmental and social impacts, best return(s) on investment, et cetera. The scenarios are also based on experiences gained through the intensively conducted stakeholder management, which allowed for pertinent technology tests, especially with regard to volume reduction, post-shredding and sieving as well as final manufacturing and assembling with the overall aim of delivering a technology matrix for the decision-making. The results shall be acclimatized, customized, and scaled equipment (ideal/optimized for local conditions) for biomass harvesting and processing for the identified products. Furthermore, the economic feasibility of each technology and product/service combination along the value chain was be assessed (based on the defined KPIs) and unit prices were calculated, which to the current point

of time is done for the first time. The insights allow to clearly detect bottle necks along the value chain and support management decisions. This project's impacts shall be visible along the three dimensions of sustainability, viz environmental, economic, and social, where, optimized value chains will enhance the regional added value at specified quantities and qualities. Furthermore, the information and experience generated through the project can be converted to valuable insights that will subsequently be employed to effectively replicate the BIP model nationally to effectively deploy bush control measures with sustainable outcomes.

The present Road Map summarizes all insights and know-how gained during the entire project phase as a result of the related project activities. The present Road Map is a guideline that provides recommendation for action, with regard to the realization of a Biomass Industrial Park (BIP) in Namibia. It outlines and describes the activities and necessary steps conducted in order to create a decisive business environment that potentially triggers the implementation of a BIP in Namibia. Based on a specific case study, the RM provides information on which realms are relevant and which process steps are necessary to successfully implement a BIP in Namibia.

### **3 Further background**

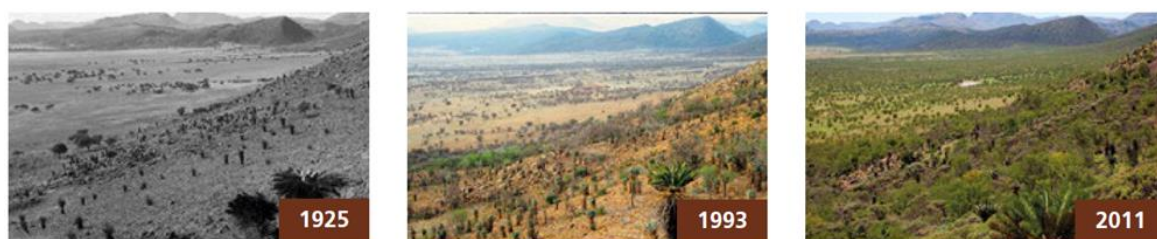
#### **3.1 The encroachment phenomena**

Bush encroachment is currently recognized as an environmental crisis in Namibia with severe social repercussions. It has caused the agricultural productivity to decline by two-thirds in recent decades. In addition to cattle grazing, other land functions such as tourism/wildlife observation and, to a certain extent, Savanna-based, traditional, small-scale agriculture are also severely affected. This decline has caused strong social issues among the native - mostly economically vulnerable - farmers those who are relying on the Savanna ecosystem for small-scale farming. The highly sensitive debate on land distribution is thus surfaced again without an apparent sustainable solution.

In addition to the economic impacts of losing the grazing land for cattle, bush encroachment also poses a major threat to Namibia's biodiversity and water balance. The Savanna biome is increasingly disappearing; along with it, the complete biocenosis adapted to it. The lack of grass is a cause for the significant decline in large grazing animals of the Namibian Savanna. It also intensifies the decline of predators - such as cheetahs - as well as the primary consumers - such as elephants and giraffes - those that depend on bush biomass. These species are increasingly pushed back by the bush encroachment as the thorny and impenetrable bushes hinder their feeding and behavioral routines. While the density of shrub biomass is the major problem in the northeast, preventing access to the watercourses by bush encroachment in the drier south makes it increasingly impossible for the grazing and wild animals to survive.

Since the 1950s, the extensive rearing of grazing cattle has disturbed the delicate ecological balance of Savanna land in Namibia. As a result, bush encroachment of Savanna land had occurred and it has escalated to a crisis level at present. Bush encroachment refers to the excessive spreading of [a] bush species at the expense of

other plant species, especially grasses native to Savanna. In this context, excessive spreading of native Acacia species such as the blackthorn acacia (*Acacia mellifera*) is a serious concern. According to official records, bush encroachment has claimed more than 40 million hectares of land as of now, which amounts to - by conservative estimates - circa 400 million tons of biomass that annually grows at the rate of 12 million tons. The invasive bush species are all native to Namibia and are not introduced ones. Nevertheless, the natural balance between the bush and grass is permanently disturbed. To that end, Figure 1 presents some historical evidence of the increasing bush encroachment in a Savanna landscape in Namibia.



**Figure 1.** Historical evidence: bush encroachment of the Savanna (1925-2011)

Current estimates reveal that around 1.4 million tonnes of woody-biomass of the encroacher species are already contributing to the economic value added in Namibia annually and are used in value chains such as charcoal, firewood, wood chips, fence posts, animal feed, etc. However, proportionate to the available biomass resources, the current usage is negligible (circa 1% of the total availability). Whereas, adding to the concern and intensifying the issue, the annual bush growth at present has reached over 3% per year. The current efforts in bush control are, therefore, far from sufficient in regaining the sustainable balance. In addition, the strategies currently being pursued are considered unsustainable; id est the bush biomass is harvested and burned in the field, rootstocks are killed employing arboricide, and charcoal is produced under poor working conditions, extremely inefficiently, intensifying the national greenhouse gas impact.

It is established that sustainable bush harvest and bush processing lead to positive socio-economic developments that include people receiving work/employment opportunities, especially in rural areas. Furthermore, possibilities exist specifically to include women, especially in the area of processing, logistics, and marketing. The extraction of biomass makes more land available for agriculture, thereby defuses the plight of land distribution. A sustainable supply of biomass establishes new industries in Namibia with appropriate maintenance and support chains/networks. Tourism industry shall also directly benefit as the native wildlife has more land to spread, populate, and also become more visible to the tourists. On the academic and research dimensions, the higher education institutions/universities of Namibia (NUST) in particular - will have the unique possibility to carry out specific pure and applied research in the domain of bio-economy while setting up national examples such as biomass resource parks, research stations, competence centres, etc. As the bush encroachment is a virulent and a prevailing issue in Botswana, Angola, and South Africa, such R&D and academic experience in Namibia can be effectively deployed throughout Southern Africa. Namibia will thus have the possibility to develop into a competence hub for rural bio-economy in the context of Circular Economy in Southern Africa.

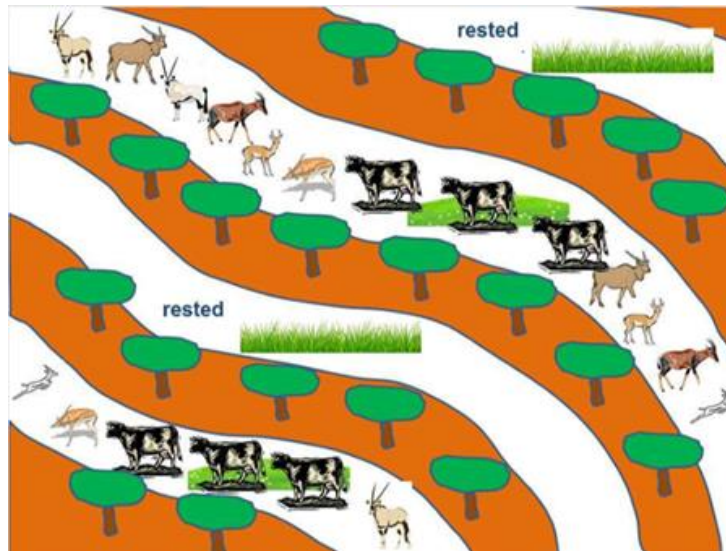
With the public intervention - especially the Ministry of Agriculture, Water and Forestry (MAWF) and the National Planning Commission (NPC) - the criticality of the problem has been recognized and steps have been taken to solve the problem for the last five years with the active support of German Development Assistance (GIZ). As a result, in recent years, numerous studies on ecology, the water balance, the CO<sub>2</sub> balance and the quality of the wood have emerged, as well as clear structures and requirements for sustainable bush thinning. However, unfortunately, it has not yet been possible to translate all this knowledge into a sustainable solution or a strategy for Namibia. The problem lies in the sub-optimal engineering and logistics strategy, which cannot supply the existing markets with competitive products and services.



Mechanical harvesters, shredders and chippers from Europe and the US produce only a fraction of the predicted performance due to the extreme conditions in the Namibian outback. Extensively lignified hardwood, dust, and heat reduce the functionality of equipment by up to 70%. There is a general lack of acclimatized machines/equipment to the local conditions and the skilled local personnel to undertake the maintenance of such machinery. Therefore, there exist a great potential for SMEs in the field of biomass logistics and recycling, harvesting and processing, and mechanical engineering.

Furthermore, the land management/surface management after biomass harvesting - termed hereupon, 'aftercare' - is an unaddressed/unresolved problem yet. If the rootstock of the harvested bushes is not removed using arboricides, burning or mechanical means, an ecologically and economically viable alternative has to be developed to prevent the regrowth of the bushes.

Therefore, the establishment of sustainable mechanism for aftercare, in which harvesting methods for the bush saplings and for the production of new aftercare biomass-based resources (id est fiber and proteins) is of crucial importance. Closing the gap between bush-thinning and aftercare management results in the introduction of a multifunctional land use strategy that will not only ensure a sustainable solution for aftercare but also will provide a portfolio of bio-based raw material for valuable economic processes - such as wood biomass, pasture, grass and animal feed, etc. (see Figure 2). A storable food pellet for cattle and wild animals could be produced when using the bush saplings and shoots by combining the protein components from the grass used for the extraction of fibers. This approach, alleviates the pressure on the Namibian economy to import hay and proteins from the international markets, and also will create a storable emergency reserve/buffer of animal feed for dry seasons.



**Figure 2.** Multifunctional land use according to Zimmermann.

After the shredding different forms of management are combined with different products. The rebuilding of bush for energy use, development of grassland for cattle and wildlife, and grassland for protein and grass fiber.

It is noteworthy that small markets for bush-based material already exist. For example in the field of energy (e.g. coal, and charcoal), in the field of energy wood (local customers such as cement plants, breweries, and energy companies), in the area of feed (id est animal feed — a.k.a. bush feed — from the non-lignified parts of the bush in pellet form), as well as in the area of materials such as wood composites. Furthermore, international demand for wood pellets and woodchips by European power plant operators such as city utilities, or specific companies such as Vattenfall, Uniper, Drax and large-scale traders such as the Brünig Group etc. is going to increase drastically within the next years, as many European countries decided to phase-out coal and fossil fuels within the next decade. Further possible paths of biomass use such as biofuel, wood composites and building materials are not yet intensively pursued for the reasons of capacity and scale. Depending on the region and farm, the biomass to be extracted represents a potential of 15 to 130 t/ha. A very conservative, compliant to MAWF permits and ecologically selective extraction estimate assumes that at least 10

t/ha can and must be extracted, which equals to an extraction of only 30%. This would mean that there is a sustainable standing potential of 450 million tons of biomass in Namibia. The annual increase in bush encroachment is estimated at 3-5%. This means a necessary withdrawal of at least 12 million t/a alone is required to maintain the status quo. As described in the initial situation, currently a maximum of about 1.2 million tons are used. A strong increase in the withdrawal with simultaneous reduction of the costs is absolutely necessary.

### **3.2 Biomass Partnerships with Namibia**

Namibia is offering an exciting opportunity for international cooperation with regards to climate change mitigation, energy transformation, and industrial development. IfaS has been mandated by GIZ to support the development of Biomass Partnerships with Namibia with the overall objective to arrange strategic partnerships with German (European) off-takers.

Due to aforementioned historic land mismanagement, amongst other contributing factors, Namibia is facing a serious problem with invasive bush encroachment. Currently, over 45 million hectares of the savannah biome has become bush encroached, which represents a total extractable resource totaling over 450 million tons of standing excess biomass, sticking closely to the maximum recommended bush-extraction rate provided by the MAWF. Bush encroachment is spreading at a rate of 3% per annum. This means that an estimated 13 million tons of biomass resource is being added to the national resource base, each and every year, with little being done to mitigate this spread. This imbalance of biomass across the Namibian landscape drastically infringes on Namibia's ground water resources, on its biodiversity, and on farming activities, causing estimated economic losses of EUR 100 million per annum<sup>1</sup>.

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<sup>1</sup> Reference year 2016

Moreover, bush encroached land stores less carbon than intact savannah biome systems, whereupon Namibia's national carbon inventories are based.

Considering the aforementioned facts, it is a national objective to utilize this biomass within a sustainable manner, under a targeted value-addition approach, to benefit the local economy through value addition, job creation, and advancing export opportunities. As the local Namibian as well as the regional SADC market demand is relatively limited, in relation to the resource size, it has not yet allowed for meaningful value chain development within the renewable fuels sector.

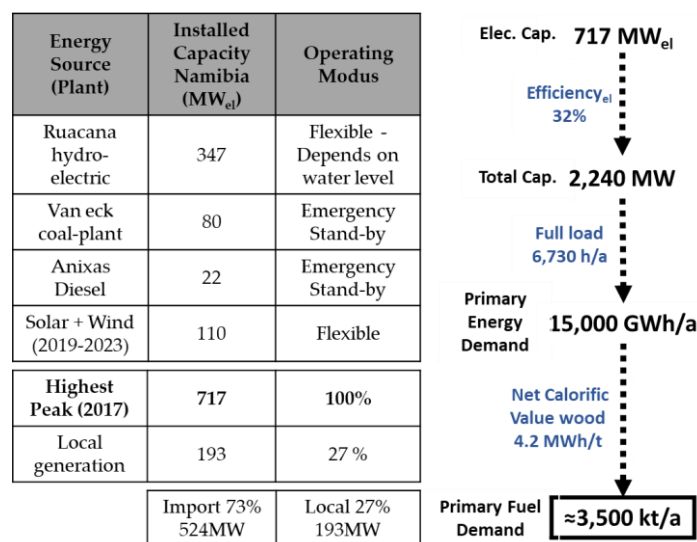
Overall, Namibia, respectively entrepreneurs in Namibia, have not absorbed yet the great national challenge of becoming an important commodity trader. Both renewable fuel exports and biomass feed form trade items high in demand abroad and friendly to the environment. Here, IfaS has opened already great economic opportunities in preparing an innovative energy collaboration between Namibia and Germany. The re-establishment of railroad freight capacities and the extension of loading plants in marine ports are imperative.

In marked contrast to neighboring South Africa where conventional energy sources drive the national power demand, Namibia proved already that bush biomass can be utilized instead. So far, this was implemented in a cement factory and a brewery. Nationally, even a complete switch from fossil to renewable fuels – the bush biomass – would not lead to substantial downsizing of the encroacher bush problem as Namibia's population density of 3 per km<sup>2</sup> could not really absorb more conversion from bush to electricity. Power transmission lines to neighboring states prevent exports.

In the field of charcoal from bush, Namibia is already exporting. Unfortunately, export markets mainly use it for limited leisure time activities. Concerning the use of finer

components of the bush in animal feeding Namibian livestock owners traditionally regard bush feed as an emergency feed. First commercial entrepreneurs sell pelleted ruminant feedstuff only in the immediate vicinity of a rather confined area around production site. This is for two reasons: to date economic transport logistics are not existing and rather improvised production techniques (solar drying on plastic sheets) limit the output and do not allow a considerable reduction of the national bush problem.

Tackling bush-encroachment using bush-biomass for national electricity production of course constitutes a relevant utilisation path, however the real demand in contrast to the needed de-bushing rate is fairly low. Currently Namibia's installed capacity of electricity is around 717 MW, whereof in average only 27% are used. However, if Namibia would base its entire electricity production on biomass, only 3.5 million tons of biomass would be needed to cover even the highest peak demand, whereas 18 million tons of biomass must be harvested in order to stop bush-encroachment. The following Figure 3 illustrates the respective calculation path.



**Figure 3.** Example calculation of biomass fuel demand for Namibia based on the assumption of a 100% coverage rate of electricity production.

Hence, Namibia needs to collaborate with larger international markets, such as Germany, which in order to meet their UNFFFC climate targets, consider to switch their fossil fuel power generation capacity to renewable energy sources. Germany has committed itself by virtue of its environmental policy to withdraw all lignite-fired power plants. With the goal of phasing out coal in 2032, all other coal-fired power plants must be converted or closed. This creates a thermal and electrical energy supply gap. In Germany, 45 lignite-fired power plants are operated with a total capacity of 22,721 MW<sub>el</sub> (23,1%, 2016 of total electricity production) and 66 coal-fired power plants with a total capacity of 26,953 MW<sub>el</sub> (17,2%, 2016 of total electricity production). Germany is a resource poor country and it is not in a position to fill its supply gap with resources from its own country, such as biomass itself. With Namibia there is the possibility of a strategic partnership to close the future supply gap with biomass. At the same time, Germany is participating in investing in the Namibian infrastructure and promoting its prosperity due to the industrial complexes created by this project. The following Table 1 compares fuel prices for Germany on the basis of calorific value. The table clearly shows that wood chips from Namibia could be cheaper than the alternative energy carriers, depending on the carbon tax price.

**Table 1.** Fuel price comparison on energy basis including CO<sub>2</sub> tax

| Category           | Fuel            | Namibian     |              |              |              | Unit                      |
|--------------------|-----------------|--------------|--------------|--------------|--------------|---------------------------|
|                    |                 | Wood Chips   | Hard Coal    | Lignite      | Natural gas  |                           |
| Physical Parameter |                 | 924          | 10,075       | 5,213        | 10.37        | kWh/m <sup>3</sup>        |
|                    | Calorific Value | 15.1         | 29.0         | 15.0         | 47.3         | MJ/kg                     |
|                    |                 | <b>4.20</b>  | <b>8.06</b>  | <b>4.17</b>  | <b>13.13</b> | <b>kWh/kg</b>             |
|                    | Density         | 220          | 1,250        | 1,250        | 0.79         | kg/m <sup>3</sup>         |
| GHG Tax            | GHG Emission    | 0.04         | 0.35         | 0.34         | 0.20         | kg CO <sub>2eq</sub> /kWh |
|                    | GHG Price       | 38.89        |              |              |              | USD/t CO <sub>2eq</sub>   |
|                    |                 | 0.039        |              |              |              | USD/kg CO <sub>2eq</sub>  |
|                    |                 | 0.2          | 2.9          | 1.4          | 2.6          | kg CO <sub>2eq</sub> /kg  |
|                    | GHG Cost        | 0.007        | 0.11         | 0.06         | 0.10         | USD/kg                    |
|                    |                 | 0.002        | 0.014        | 0.013        | 0.008        | USD/kWh                   |
| Prices             | Price           | 115          | 55           | 60           | 312          | USD/t                     |
|                    |                 | 0.12         | 0.06         | 0.06         | 0.31         | USD/kg                    |
|                    | Price incl. GHG | 0.12         | 0.17         | 0.12         | 0.41         | USD/kg                    |
| Costs              | Cost            | 0.029        | 0.021        | 0.028        | 0.032        | USD/kWh                   |
|                    |                 | <b>28.94</b> | <b>20.58</b> | <b>27.59</b> | <b>31.54</b> | <b>USD/MWh</b>            |
|                    | Cost            | 122          | 166          | 115          | 414          | USD/t                     |

The goal is to establish a biomass supply chain. The milestone of a first BIP in Otjiwarongo is to serve as a teaching potential and to test the capacity utilization of the infrastructure in Namibia in order to be able to adapt the infrastructure to future transport masses. In order to ensure profit-ability, buyers and interested parties in the produced biomass products are included in the process from the beginning. According to this, further BIP's with increasing efficiency will be built based on the experience gained in order to upscale the project for the future to get the final result of 6-12 million tons transport mass per year realized.

Here, an obvious win-win opportunity is existent to help each other and create a long-term cooperation. Namibia can improve its climate change resilience, increase biodiversity, and add value in Namibia by harvesting, processing and selling encroacher bush biomass to international markets. Through technological partnerships, Namibia can reach the scale, efficiency and sustainability required to

supply the international market with tailored renewable fuels. Cities, such as Hamburg, could gain access to a sustainable, renewable and clean fuel, supporting their energy transition goals, while in turn, contributing to Namibia's economic development. This opportunity presents a mutually beneficial trade partnership, in producing tailored renewable fuels in Namibia, exported to Europe, on a long-term, and sustainable basis. Products that can add value to Namibia made from bush (for example pellets, wood chips, wood composites, bush feed) are fairly unknown in an international context. Success stories like charcoal however prove that a sound marketing can improve the level of awareness and reduce "wrong" aversion/concerns/reservations. WWF, FSC, SBP, etc. certificates for all kind of products will help, but are no guaranty for international attention. A sound partnership could create the necessary platform to address aforementioned issues. Furthermore, as intrinsic elements of the project, stakeholder management, know-how transfer, dissemination of knowledge, research and development shall be undertaken reciprocal between the partners.

### **3.3 The Biomass Industrial Park Idea**

With the support of GIZ and IfaS, a strategy is being developed to establish bioenergy and raw material centers (Biomass Industry Parks = BIPs) at multiple locations in the country. The advantages of a BIP for biomass customers are the establishment of sustainable supply structures, in particular for the supply of large customers such as biomass (heating) power plants in Europe. In addition, a BIP attracts large amounts of biomass, thus reducing the unit costs for transport, handling and storage. In addition, capacity building, further education and training opportunities are created for the local population.

The BIP in a mid-term perspective offers the practical opportunity to enter into a value adding and resource securing decentral bio-economy. Based on existing, experienced harvesting and processing logistics and technologies new bio-based industries can be



set up. Bushfeed and grass pellets for paper production already are envisaged. New products from woody biomass like wood plastics, wood fuel or wood-based construction material are discussed but not yet in the market.

The overarching goal of a BIPs is to retard, stop, and reverse the ongoing bush encroachment of savanna land in Namibia through socio-ecologically optimized measures combined with **new multifunctional land use**. The focus is also on technology transfer and adaptation to support and expand the careful and climate-friendly extraction of bush biomass. The specific focus here is on the use of the bush biomass as a starting point for the establishment of a **rural bio-economy** to turn a national problem into a sustainable resource with socio-economic development potential. Climate friendliness only can be achieved through a new land use strategy. Instead of removing the bush and killing or excavating the remnants **IfaS scenario** is based on a sustainable harvest of the bush with intermediate use of the land for feed and biomass material. Thus, different applications are combined which consequently create the most climate friendly management of the encroacher bush. Based on existing studies and literature as well as based on local expert knowledge IfaS considers the following scenario with related GHG emissions as valid:

### **GHG Calculation with the assumption**

Namibia has also become a large sink for carbon dioxide bound in wood biomass due to the encroachment, this adaptation must also be carried out as a climate protection measure. In principle, this means that restoration of savanna landscapes must be carried out together with the maintenance of the sink function. This requires intelligent cooperation on a scientific, technical and economic level. That is what the planned partnership with Hamburg is about.

In Namibia, 3% bush biomass grows each year at the expense of savanna biomes or other encroached lands, a total of approximately 1.3 million hectares. Assuming 10 t of

biomass that can be removed per hectare in an environmentally friendly and sustainable manner, 13 million t of biomass are available annually from the growth alone. Only a small part of this would be needed for the partnership with Hamburg. With an exemplary extraction of 1 million t and an increase of 13 million t, the overall system is sustainable.

For the different land use options, currently there are several greenhouse gas emission scenarios, which vary from the development of an additional sink for GHG to the massive release of GHG. In the partnership with Hamburg, land use scenarios that maintain or reinforce the sink effect are clearly preferred. Adapted mixed forms of land use must be developed for this. This is to be achieved in cooperation with the Biomass Industry Parks, since the relevant specialist knowledge and the corresponding logistics options will be available there.

Existing specialist knowledge is combined with the experience of field practitioners. The goal is to enter a bioeconomy with as much cascading use of the existing biomass as possible. One of the developed land use options is harvested by the Busch Biomass and then kept free for 4 to 6 years in order to establish a savannah landscape. The resulting product can be used as an animal feed additive and can partially replace feed imports to Namibia or also enable export. There are currently detailed discussions and a planned research project to test harvesting machines for the harvesting of the canes. After 4 - 6 years, the harvest is stopped on these areas and the bush can grow again. There are currently three usage options for the emerging grass: cattle grass, grass for wild animals (game farming) and material use (e.g. grass paper). These options are also examined in more detail in the prepared research project.

When consider the greenhouse gases of such a multifunctional land use, there are values that fluctuate between sink and light release. Under no circumstances the GHG emissions achieved are higher than those of natural gas or coal. The following graphic

shows a possible, optimistic GHG scenario for a land use option based on an LCA analysis.

The numbers are based on the results of existing studies and concrete calculations, whereby the ongoing scientific discourse on the values paints an initially positive picture. Among other things, it is worth discussing the percentage of carbon bound in the soil. But even if this is lower than the assumed value in the figure, the calorific value-related GHG emissions are still 56% lower than those of natural gas<sup>2</sup>.



**Figure 4: CO<sub>2</sub> balance of bush use for the production of wood pellets based on a 20-year perspective per hectare<sup>3</sup>**

The data is based on specific emission values of a scenario for a biomass industrial park with a throughput of 250,000 t of bush biomass per year (IfaS 2020) as well as specific emission and sequestration values from the expert group from Namibia and the authors of the GHG assessment from Unique (Seebauer et al, Unique 2019).

<sup>2</sup> Specific GHG emissions for natural gas in Germany including upstream chains according to Liebich, (2019).

<sup>3</sup> Seebauer et al, Unique 2019

If the balancing act between adaptation to anthropogenic climate change and the conservation or restoration of the GHG sink (climate protection / decarbonization), which is important from a global perspective, is to be successful, constructive and innovative work must be done on new forms of land use.



**Figure 5: Wood pellets from black thorn (*Acacia meliffera*), IfaS / Amandus Kahl 2020 [calorific value around 5 kWh / kg]**

Depending on the harvest location in Namibia, the biomass will be transported a maximum of 100 km by truck and 600 km by rail. From Walvis Bay to Hamburg there are still around 10,000 km at sea. Including all means of transport, an average of approximately 86 kgCO<sub>2</sub> / t biomass would be emitted (conservative assumption). Based on the calorific value of wood pellets from Namibia (here 5 MWh / t), this results in a transport-related CO<sub>2</sub> load of 18 kgCO<sub>2</sub> / MWh. For comparison: According to the Ecological institute e.V. 2006<sup>4</sup>, the pre-chain-specific emissions (here only extraction and transport, as planned for Namibia) of heating oil are between 15 and 28 kgCO<sub>2</sub> / MWh (respectively from OECD and Russia).

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<sup>4</sup> [http://iinas.org/tl\\_files/iinas/downloads/GEMIS/2006\\_vorketten\\_iwo.pdf](http://iinas.org/tl_files/iinas/downloads/GEMIS/2006_vorketten_iwo.pdf)

The CO<sub>2</sub> emissions caused in Namibia can tend to be even lower due to shorter downtimes and good capacity utilization (biomass industrial parks). The real values of the expected scenario should be discussed and checked in the project in the following months. The table below illustrates the assumption:

**Table 2 : Expected emissions of transport methods**

| <b>Expected Scenario</b> |                       |        |                      |
|--------------------------|-----------------------|--------|----------------------|
|                          | gCO <sub>2</sub> /tkm | km     | kgCO <sub>2</sub> /t |
| Truck                    | 34,0                  | 100    | 3                    |
| Rail                     | 22,7                  | 600    | 13,628571            |
| See                      | 6,9                   | 10.000 | 69                   |
| <b>SUM</b>               |                       |        | <b>86</b>            |

According to current calculations by IfaS, a CO<sub>2</sub> balance per hectare of the entire value chain can be shown as follows over a period of 20 years (see Figure 4 and Table 3 ).

Table 3: IfaS GHG balance for 1 ha over 20 years period

Basic Assumptions

| Item                  | Value | Unit                   |
|-----------------------|-------|------------------------|
| Biomass removal       | 12    | t/ha                   |
| Carbon Content        | 47%   |                        |
| Transport Emissions   | 86    | kgCO <sub>2</sub> /t   |
| Average Soil          | 0.33  | tCO <sub>2</sub> /ha/a |
| Biomass regrowth      | 0.52  | tCO <sub>2</sub> /ha/a |
| Biomass incremental   | 0.00  | tCO <sub>2</sub> /ha/a |
| Restoration Gras      | 0.51  | tCO <sub>2</sub> /ha/a |
| Aftercare             | 0.00  | tCO <sub>2</sub> /ha/a |
| Livestock 100% Cattle | 0.53  | tCO <sub>2</sub> /ha/a |
| Assumed Cattle Share  | 33%   |                        |

| Item                        | Value  | Unit                   |
|-----------------------------|--------|------------------------|
| Calorific Value Pellets     | 5      | kWh/kg                 |
| Calorific Value Gas         | 13     | kWh/kg                 |
| Emission Factor Gas         | 250    | kgCO <sub>2</sub> /MWh |
| Emission Factor Hardcoal    | 350    | kgCO <sub>2</sub> /MWh |
| Biomass to Pellets Effic.   | 80%    |                        |
| Specific Scenario Emissions | -1.27  | tCO <sub>2</sub> /ha   |
| Pellets                     | -0.026 | tCO <sub>2</sub> /MWh  |
| Gas                         | 0.250  | tCO <sub>2</sub> /MWh  |
| CO <sub>2</sub> Saving      | 111%   |                        |

Auxiliary Calculation

| Item                    | Value  | Unit                 |
|-------------------------|--------|----------------------|
| Pellets                 | 9.6    | t/ha                 |
| Calorific Value         | 48     | MWh/ha               |
| Equiv. Gas              | 4      | t/ha                 |
| Gas Emissions           | 12     | tCO <sub>2</sub> /ha |
| Hardcoal Em issions     | 17     | tCO <sub>2</sub> /ha |
| Specific Scenario Emiss | -0.11  | tCO <sub>2</sub> /t  |
| Pellets                 | -0.132 | tCO <sub>2</sub> /t  |

Scenario Hamburg: Multifunctional Land Use with Pellet Export to Hamburg (BIP with 37km Radius for 250.000 t/a removal in a 20 year cycle)

| Year     | Area [ha] | Biomass removal                       | Biomass incremental | Biomass regrowth | Restoration Savanna Gras | Average Soil [SOC] | Aftercare (Bushfeed/Paper) | Livestock - (3/3/3) [Game/Cattle /Gras] | Harvesting | Processing (Pellets) | Transport (BIP to Hamburg) | Total Annual Emissions | Cummulative Emissions |
|----------|-----------|---------------------------------------|---------------------|------------------|--------------------------|--------------------|----------------------------|---|------------|----------------------|----------------------------|------------------------|-----------------------|
| 1        | 1         | 20.7                                  | 0.00                | -0.52            | -0.51                    | -0.33              | 0.00                       | 0.17                                    | 0.28       | 0.44                 | 1.03                       | 21.3                   | 21.3                  |
| 2        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              | 0.00                       | 0.17                                    |            |                      |                            | -1.2                   | 20.1                  |
| 3        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              | 0.00                       | 0.17                                    |            |                      |                            | -1.2                   | 18.9                  |
| 4        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              | 0.00                       | 0.17                                    |            |                      |                            | -1.2                   | 17.7                  |
| 5        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              | 0.00                       | 0.17                                    |            |                      |                            | -1.2                   | 16.5                  |
| 6        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 15.3                  |
| 7        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 14.1                  |
| 8        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 13.0                  |
| 9        | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 11.8                  |
| 10       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 10.6                  |
| 11       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 9.4                   |
| 12       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 8.2                   |
| 13       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 7.0                   |
| 14       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 5.8                   |
| 15       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 4.7                   |
| 16       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 3.5                   |
| 17       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 2.3                   |
| 18       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | 1.1                   |
| 19       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | -0.1                  |
| 20       | 1         |                                       | 0.00                | -0.52            | -0.51                    | -0.33              |                            | 0.17                                    |            |                      |                            | -1.2                   | -1.3                  |
| SUMME 20 |           | tCO <sub>2</sub> /ha                  | 20.68               | -10.40           | -10.40                   | -10.20             | -6.60                      | 3.50                                    | 0.28       | 0.44                 | 1.03                       |                        |                       |
|          |           | tCO <sub>2</sub> /t <sub>Pellet</sub> | 2.15                | -1.08            | -1.08                    | -1.06              | -0.69                      | 0.00                                    | 0.03       | 0.05                 | 0.11                       |                        |                       |
|          |           | kgCO <sub>2</sub> /t <sub>Pell</sub>  | 2,154               | -1,083           | -1,083                   | -1,063             | -688                       | 0                                       | 364        | 46                   | 108                        |                        |                       |

In addition to transport emissions (1.03 tCO<sub>2</sub>/ ha), the overall balance must also include emissions from harvesting and processing as well as possible emissions from increased livestock farming in Namibia (ruminants emit methane), resulting in further emissions of 4.22 tCO<sub>2</sub> / ha biomass. This results in total upstream chain emissions of 5.25 tCO<sub>2</sub> / ha. With an assumed calorific value (here based on wood pellets) of 5 MWh / t and 9.6 t wood pellets per hectare, the energy-specific emissions are 0.088 tCO<sub>2</sub> / MWh.

Contrary to the emission values from the transport and combustion of the biomass, the carbon binding potential is due to the growth and regrowth of the bushes, the increase in soil carbon (SOC) and the grass biomass. It was observed that in the system of multifunctional land use (stripping system) the thinning of the bush leads to a direct growth of grass on the same area. It also makes sense to leave room for regrowth, but in controlled manner. It is assumed that after approx. 5-6 years the renatured grass savannah will again offer space for bush growth. This model is FSC certified, cf. "National Forest Stewardship Standard of Namibia<sup>5</sup>". In the sustainable system of multifunctional land use, however, care is taken to ensure that a renatured area is primarily covered with bush biomass only if another area has been cleared.

Over a cycle of 20 years, the carbon released by the energetic use of the bush biomass is partly bound again by the offspring of the bushes (around 0.52 tCO<sub>2</sub>/ ha / a; or 10.4 tCO<sub>2</sub> / ha / 20a). In addition, the renatured turf binds significantly more CO<sub>2</sub> than the barren soil below of bushed area. This also has an impact on SOC. The amount is 0.33 tCO<sub>2</sub> / ha / a (6.6 tCO<sub>2</sub> / ha / 20a) for SOC and 0.52 tCO<sub>2</sub>/ ha / a (10.2 tCO<sub>2</sub> / ha / 20a) for grass, respectively. The total binding capacity is therefore 27.2 tCO<sub>2</sub> / ha / 20a. All in all, the emission in the model described is minus 1.27 tCO<sub>2</sub> / ha or -0.026 tCO<sub>2</sub> / MWh. In direct comparison with natural gas, which has a CO<sub>2</sub> footprint of around 0.250 tCO<sub>2</sub> / MWh, the use of bush biomass would reduce greenhouse gas emissions by 111%.

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<sup>5</sup> <https://africa.fsc.org/preview.national-forest-stewardship-standard-for-namibiadraft-2-0.a-209.pdf>

## **Namibia's climate policy is expressed through the INDC. (Intended Nationally Determined Contributions 2015)**

The INDC was presented in Paris in 2015 as Namibia's contribution to international climate protection. Among other things, the establishment of 15 million hectares of grassland as a contribution to climate protection. The higher storage capacity of the savannah landscapes compared to the bush landscapes was taken as the reason here. (Seebauer et al, Unique 2019)

## **Further options for GHG reduction through the biomass industrial parks**

In relation to forms of use that are already taking place and that are to be greatly improved, such as charcoal production, the partnership with Hamburg, in combination with the announced biomass industrial parks, offers a significant improvement in GHG emissions.

By using efficient and central technologies, the emissions in the charcoal area per hectare can be reduced from 16t CO<sub>2</sub> to 8t CO<sub>2</sub> (Seebauer et al, 2019). In addition, much more value-adding products are pursued in the coal production sector, such as feed coal and activated carbon. It is expected to have further GHG reductions in the animal feed sector from bush biomass, in the use of grass paper and other material uses.

## **Industrial scaled bush thinning**

Industrial scale bush thinning would reduce the pressure on the existing and steadily growing shortage of land and thus make a decisive contribution to relax the tense land question. The restoration of the savannah biome will allow landowners and land users to return to traditional land use. In addition, by processing the bush biomass in Namibia new opportunities for community added value are generated offering unique chances for rural development especially for the lower income part of the society.



Logistics are one of the mayor challenges, as port, rail and road capacities in Namibia today are insufficient. Exactly here, a biomass partnership with Europe could trigger the set-up of the requested infrastructure and hence allow Namibia to develop a new bio-economy based industry. As part of a biomass partnership between Namibia and Germany, simultaneously environmental, socio-economic and ecological challenges in both countries could be addressed. The aim of the BIP project approach is to promote Namibia's economic and social development by establishing long-term international biomass partnerships. In that regard organizations in similar fields with common goals can be linked together to perform actions as cluster.

### **3.3.1 Why the „cluster“-concept?**

By agglomerating companies in similar fields, they become more competitive and efficient, and create synergies among one another, such as sharing services, sharing their skills pool, sharing logistics infrastructure, among others. The BIP focusses on specific sectors, offering affordable leasing of industrial plots as the main benefit. The grouping of entities with overlapping interests or value chains, the potential for synergisms is intentional, rather than accidental. The benefit of a clustered approach is to leverage these foreseeable synergies between the different BIP tenants, as they share common interests, common input streams, and common challenges. Synergies in sourcing, handling, stockpiling, and processing of biomass, as well as service level synergies will promote increased efficiency within the cluster, and will in turn, improve the competitiveness of the whole cluster, beyond that of a single, stand-alone entity.

#### **This road map adopts a two-pronged approach:**

##### **3.3.1.1 The cluster**

Under the umbrella of a regional cluster the physical localization of specific know-how of the sector, respectively relevant private enterprises, shall be housed to develop their

businesses. Therefore, an organization will be needed that offers land and lots for these enterprises, as well as reliable and attractive conditions to buy, lease or rent appropriate premises. This is directly linked with access, supply infrastructure and, of course, a close vicinity to the encroacher bush land of Namibia as the objective of this roadmap is to provide a recipe on how to move from here to an economic utilization of the encroacher bush biomass. Cluster design and management shall pool all technical and entrepreneurial requirements of involved entities. This includes among others, factory and process facilities, communication lines, fresh water and sewage system, energy, staff accommodation. Criteria for a sound selection of a proper site can be concluded already from this short list of integral aspects.



**Figure 6.** Exemplary Industrial Park Concept (Bird View). A) Manufacturing & Service Businesses; B) Residential Area; C) Energy, Water, and Waste Management; D) Academic and R&D Area.

Flow charts were developed to display main technical objectives and a first sizing of potential biotechnical approaches. The envisioned BIP project aims to process upwards of 250,000 tonnes of encroacher bush biomass per annum, using this raw material and its by-products in a number of different value chains, operated by a host of independent, and yet interconnected entities, leveraging on the available synergies. The BIP developers will concretely identify value chain synergies, and using those unique opportunities, attract specific tenants, whose presence will ensure that the whole is greater than the sum of its parts.

### 3.3.1.2 Constituents of the cluster

Once harvested and brought to the cluster, different biotechnical approaches determine the essence of involved biotech process lines in putting bush to value:

- (1) Chipping / pelleting for regenerative fuel production
- (2) Carbonization for charcoal and briquettes production
- (3) Pyrolysis for biochar production
- (4) Bush-feed pellets for animal feed production

As Namibian encroacher bush forms a challenge for industrial utilization, innovative biotechnological methods had to be developed or adapted to the harsh local conditions. Valuable fundamental data were compiled under the auspices of the bilateral technical cooperation between Namibia and Germany. In addition to former Namibian national efforts to make use of Namibian bush biomass – see “GOVERNMENT OF THE REPUBLIC OF NAMIBIA MINISTRY OF MINES AND ENERGY National Integrated Resource Plan – 2016 for the Electricity Supply Industry in Namibia” – the provision of electrical energy for the country including the country’s biomass as one of the available bioeconomic components, the in-depth survey of bush organic matter resulted in the above mentioned multi-factor utilization of bringing bush to value. GIZ successfully entered the field of institution building on the secondary level. GIZ established DAS (De-bushing Advisory Service) as well as the N-

BIG (Namibia-Biomass Industry Group) organizational group to deal with the defiance of this so far unknown biomass. GIZ successfully supported the genesis of an organizational/institutional umbrella for subsequent industrial settlement and the joining of future companies under the auspices of an innovative association membership. Thus, N-BIG was established under Namibian Company Registration number 21/2015/0482. Important technical data were raised and published. Thus, the base for industrial level solutions of the encroacher bush problem were acquired. IfaS in the role of a technical back stopper was entrusted to compile and develop the technical knowhow needed to remove obstacles in developing value chains. For each of the above-mentioned approaches IfaS has developed and suggested potential business plans. These might serve as guidelines for executive private companies as well as tools in generating financial support. In regard to develop value chains, level of importance in identifying proper locations, catchment areas and respective throughputs over the project time are crucial.

### **3.3.2 Catchment area and BIP size (throughput)**

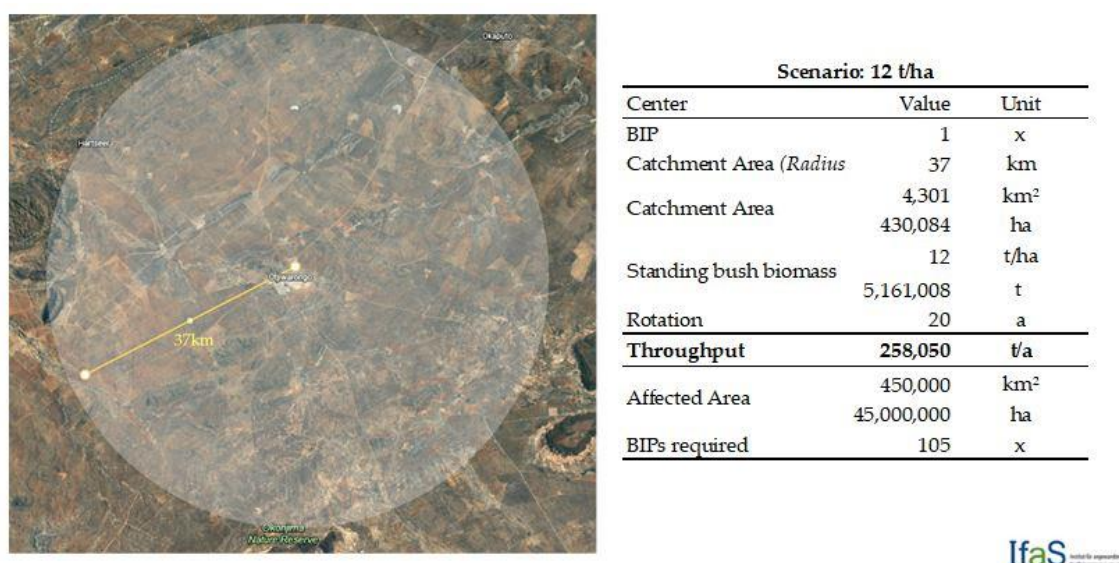
An important question with regard to sizing a Biomass Industrial Park is the question of quantity, respectively throughput. The following sub-chapter describes the approach followed by IfaS with regard to the definition of suitable throughput quantity for a first BIP in Namibia.

As a result of various interviews with experts from the logistical field, existing harvesters and in-field operators, technology providers and biomass traders, it seems meaningful to orientate the set-up of a first BIP on a throughput quantity of approximately **250,000 t/a**. It must be highlighted, that this set point is not cut in stone, rather serves as an anchor value. Depending on individual circumstances of each site, such as adjacent bush-density, applied technology, infrastructure circumstances, topography, etc. the throughput could be lower or larger accordingly.

Most important reasons for pursuing a 250,000 t/a of encroacher bush throughput are established by technology and logistics. After several meetings with technology providers and respective operators from Germany such as AVG GmbH, Vecoplan AG, Arjes GmbH, Haas GmbH, Doppstadt GmbH and DHG GmbH it crystallized that in particular post-harvesting technology, which constitutes the core of a BIP, including stationary chipping, sieving and screening, hammer mills and cyclones is turn-key available, proven in application, economy of scale optimized and recommended by the providers within a range of 150,000 to 300,000 t/a.

From an international sales perspective and shipment options point of view, transport with special wood chip (or pellets) carrier (WCC) which are capable to load up to 50,000 t into a single vessel shall be pursued (see chapter 5). Economy of scale effects using these types of carriers are pertinent, whereas in contrast smaller bulk vessels which can load up to 25,000 t charge threefold higher prices per ton of loading. It has been confirmed by Walvis Bay Corridor Group (WBCG) and MACS that WCCs can enter Walvis Bay harbour. With regard to stock pile necessity at harbour WBCG confirmed free capacities. Exporting 250,000 t/a would demand 5 vessels a year. The transit time plus loading and unloading from Walvis Bay to e.g. Rotterdam and back requires approx. 60 days (+/- 5). Hence, 5 vessels per year seems very realistic. Long-term supply contract would safeguard these assumptions. Even delivery from BIP to stock pile at harbour with containers via truck on road instead bulk in bins via train on rail in this scenario seems feasible, as sending 40 containers to harbour per day is not an exaggerated or too ambitious task. Larger throughput quantities, till infrastructure in Namibia and corresponding sea ways are extended, seem to become difficult for a first BIP, whereas smaller throughput quantities wouldn't proper use economy of scale, one of the major challenges within the current chain of custody of Namibian encroacher bush.

From the logistics perspective and feedstock availability perspective the following Figure 7 illustrates the approach applied to define a suitable throughput. Based on the information provided by on-site logistical companies such as Transworld cargo, Imperial Logistics or MACS, biomass transports from field to BIP should not exceed a distance larger than 50km in order to be cost efficient and guarantee a smooth and continuous material flow. Furthermore, with regard to ‘business certainty’ it should be guaranteed that within a respective catchment area of a BIP sufficient feedstock availability is provided for an operation time of at least 20 years. (Potentially infinitude assuming a controlled regrowth within a rotation time of 20 years.) Otherwise the business risk would be potentially higher and investments would may not occur. Considering the aforementioned arguments, a simple approximation could apply, which helps to define the adequate throughput (see table in Figure 7). Assuming that a standing biomass of 12 t/ha can be harvested during a 20 year rotation, a defined catchment area with a 37km radius (which equals 430,000 ha) would result in a throughput of 258,000 t/a. [430,000 ha in 20 years results in 21,500 ha/a at 220 work days per annum results in 98 ha/d at 7 squads per BIP (c.p. chapter 7.3.3) results in 14 ha per squad and day with a capacity of 4 excavators with hydraulic scissor and a capacity of 6 t/h results in 7 operating hours per day, which is more than realistic and thoroughly a conservative assumption.]



**Figure 7.** Catchment area of 37km radius and associated throughput calculation in a 12 t/ha scenario

Coincidentally, all these numbers indicate towards a common denominator which is 250,000 t/a of throughput. Based on the current affected area of 45 Mio. ha of encroached terrain in Namibia, 105 BIPs all over Namibia could be implemented without causing any serious competition with regard to feedstock availability for a twenty years period. Changing the assumed parameters such as rotation time, catchment area or extractable biomass per hectare results in less common denomination. In summary these are the main arguments why the first BIP model and corresponding business plan is based on this respective throughput accordingly.

### **3.4 BIP Bioeconomy outlook**

Rural Bioeconomy in Namibia - landscape conservation, restoration and regional added value. Development of a Rural Bioeconomy Center (RUBIC) for southern Africa in Namibia

#### **3.4.1 Definition of Bio Economy**

Economy based on renewable resources encompassing all value chains based on sustainable biomass resources and bio-based waste and residues. Rural bio economy as understood by IfaS is focused on decentral, small scale biomass value chains, which create the best regional added value including safeguarding resilience, sustainability and biodiversity. This means IfaS is not promoting large scale biomass use or production with huge amounts of agrochemicals and negative effects on Namibia ecosystems. A countrywide rural bio economy would be a national objective to utilize biomass within a sustainable manner, under a targeted value-addition approach, to benefit the local economy through value addition, job creation, and advancing export opportunities.

### 3.4.2 Differentiation of Bioeconomy to Circular Economy, Green Economy, and Biodiversity Economy

A **circular economy** (often referred to simply as "circularity") is an economic system aimed at eliminating waste and the continual use of resources. Circular systems employ reuse, sharing, repair, refurbishment, remanufacturing and recycling to create a close-loop system, minimizing the use of resource inputs and the creation of waste, pollution and carbon emissions. The circular economy aims to keep products, equipment and infrastructure in use for longer, thus improving the productivity of these resources. **Bioeconomy** is part of this overall cradle to cradle principle of circular economy. Green economy basically describes all economic activities related to protecting the environment. **Green economy** promotes the transition to economies that are low carbon, resource efficient and socially inclusive.

**Biodiversity Economy** underpins economic activity. Agriculture, forestry and fisheries products, stable natural hydrological cycles, fertile soils, a balanced climate and numerous other vital ecosystem services depend upon the conservation of biological diversity. Food production relies on biodiversity for a variety of food plants, pollination, pest control. Looking into the Namibian area we see the third most biologically diverse countries in the world, and therefore has one of the largest natural capital assets. This biodiversity is not only economically viable to the economic wellbeing of many countries but can be used as a vehicle for social upliftment and new economic activities.

### 3.4.3 Rural Bioeconomy in Namibia

Based on the existing bush biomass Namibia has a unique opportunity to develop a model for a rural bioeconomy. Mainly due to historic overstocking, amongst other contributing factors, Namibia is facing a serious problem with invasive bush encroachment. Currently, over 45 million hectares of the savannah biome has become bush encroached, which represents a total extractable resource totaling over 450



million tons of standing excess biomass available, assuming a sustainable off-take. Bush encroachment is spreading at a rate of 3% per annum. This means that an estimated 13 million tons of biomass resource are being added to the national resource base, each and every year, with little being done to mitigate this spread. This imbalance of biomass across the Namibian landscape drastically infringes on Namibia's ground water resources, on its biodiversity, and on farming activities, causing substantial economic losses. Moreover, bush encroached land stores less carbon than intact savannah biome systems, whereupon Namibia's national carbon inventories are burdened. This means without a bio economy approach we have an ongoing negative effect on the economy.

Local Namibian market as well as the regional SADC market demand is relatively limited, in relation to the resource size, it has not yet allowed for meaningful value chain development within the renewable fuels sector. Hence, Namibia needs to partner with larger international markets with high sustainability standards, such as Germany, which in order to meet their UNFCCC climate targets, consider to switch their fossil fuel power generation capacity to renewable energy sources (German coal phase-out).

In here, a unique win-win opportunity for both countries exists to help each other and create a long-term mutual beneficial cooperation. The valorization of encroacher bush can improve Namibia's climate change resilience, increase biodiversity, protect water resources and add value in Namibia by harvesting, processing and finishing encroacher biomass and finally sell renewable fuels to Germany. Through technological and economical partnerships, Namibia can reach the scale, efficiency and sustainability required to supply the German market with tailored sustainable and renewable fuels. Cities, such as Hamburg, Flensburg, Berlin or Rostock are leaving fossil coal and urgently need a new energy source.

### **3.4.4 Bioeconomy in the light of a biomass partnership**

Industrial scaled bush thinning would reduce the pressure on the existing and steadily growing shortage of land and thus make a decisive contribution to alleviate the tense land question. The restoration of the savannah biome will allow landowners and land users to return to traditional land use. In addition, by processing the bush biomass in Namibia new opportunities for community added value are generated offering unique chances for rural development especially for the lower income part of society.

Logistics are one of the major challenges, as port, rail and road capacities in Namibia today are insufficient. Exactly here, a biomass partnership with Germany could trigger the setup of the requested infrastructure and hence allow Namibia to develop a new bio-economy based industry. As part of a biomass partnership between Namibia and Germany, simultaneously environmental, socio-economic and ecological challenges in both countries could be addressed. The aim of the BIP project approach is to promote Namibia's economic and social development by establishing long-term international biomass partnerships.

Products that can add value to Namibia made from bush (for example pellets, wood chips, wood composites, bush feed) are fairly unknown in an international context. Success stories like charcoal however prove, that a sound marketing can improve the level of awareness and reduce "wrong" aversion/concerns/reservations. WWF, FSC, SBP, etc. certificates for all kind of products will help, but are no guaranty for international attention. A sound partnership could create the necessary platform to address aforementioned issues.

Bioeconomy development needs a network of reliable stakeholders from the land use section, to the academia throughout the business community and the politics and government. Politics must define new national targets for the use of biomass materials and must organize a regulating framework for land users, farmers and companies to

create the economy from the biomass material. Especially in Namibia with its 450 million tons of excess/unwanted biomass. bush biomass a new policy focusing on the tremendous options for adding value to the country must be developed and turned into law making.

#### **3.4.5 Bio based value chains**

A bio economy is a continuous search for new products or for the improvement of production process. In Namibia today there are already several clear practical options for enlarged bio-based value chains:

##### **a. The optimization of existing charcoal production**

Production of high-quality biochar or activated carbon in order to create more investment and employment in Namibia. Use of other renewable energy sources for reduction of carbon emission in Namibia. For example, PV and ST for electricity generation and drying process for use in charring and tailor making of different charcoal products

##### **b. Production of bush-feed from bush biomass**

Bush-feed as a side product from bush harvesting for energy and material use is a unique chance to get rid of Namibia's dependence on import of animal fodder especially in times of drought. Moreover, Namibia has the opportunity to develop an export business based on organic animal fodder. Seeing a growing demand worldwide for organic animal feed this is a huge economic opportunity.

##### **c. Production of wood pellets for export**

Compared to wood chips wood pellets offer much more national and regional added value for Namibia's economy. The processing of bush biomass into pellets need large scale investment, large scale maintenance and large-scale employment of skilled labor.

The big demand of process energy can be supplied by cheap and carbon neutral solar and wind energy or by biomass energy.

d. Grass pellets for paper production

Seeing the necessity for a multifunctional land use we need to develop different land use types with different products and markets. Therefore, we also need to make sure that we can sustain open grass-land as part of the new land use mosaic. A part of this grassland will be secured by new cow and game farming. But this will not be enough given the amount of Namibia's biomass potentials. Therefore, in the framework of a bio economy special niches for high end biomass products like grass paper will be developed.

e. Wood composites and others

There are many more options for new products from bush biomass. Aside from wood plastics the extraction of nutrients and sugar from bush biomass is already discussed. The new bio economy center will quickly develop many more product ideas and markets.

### **3.4.6 International perspectives**

Seeing the tremendous biodiversity economy options of southern Africa and considering the trans-national bush encroachment issues in South Africa, Botswana, Angola, Namibia etc., it is an obvious fact that cooperation will help the whole region. By being the first mover, Namibia could establish itself as a center for the whole region in the field of rural bio economy. Based on a strategic biomass and bio economy partnership with e.g. Europe the necessary markets, technologies and capacity building cooperation can be established. This would guarantee to put Namibia in the role of a trading partner adding sufficient value to the nation.

### **3.4.7 Rural Bioeconomy model - Little house concept for the BIP model.**

Based on the bush biomass availability and the large quantity of bush in Namibia, it opens a unique opportunity to develop a model for a rural bioeconomy. Even though it is presented as a bioeconomy, it has several aspects in relation to several other economic and management practices. As this is the initial phase of implementing BIPs, the bioeconomy model must support with conventional economic practices as well as circular economy and green economy practices grounded in the concept of material flow management.

As above explained by the definitions and the differences of multiple concepts, in summary, the circular economy mainly strengthens the eco-efficiency of processes and the use of recycled carbon to reduce the use of additional fossil carbon and replace existing fossil base carbon usage from renewable sources. The bioeconomy substitutes fossil carbon by bio-based carbon from biomass from agriculture, forestry or any other natural environments.

In particular, bioeconomy and circular economy are resource-focused, while green economy acknowledges the underpinning role of all-natural processes. Also, green economy is more comprehensive of some aspects at local level in regard to social activities and measures such as eco-tourism, education etc., Due to the emerging potential of processes in terms of, bush-based value chains, biosecurity and new policies related to the bush biomass utilization; bioeconomy practices are emerged and will be developed. When considering different sustainability visions, all concepts remain limited in questioning economic growth. Although, each concept has its unique strategies and approaches. Using and substituting these concepts to different processes in the BIP model will enable to gain positive ecological and socio-economic outcomes in all possible phases and situations.

Little house concept is an approach to illustrate and explain the integration of different sustainable practices which are integrated in BIP. A house can have several rooms, a kitchen, a hall etc., where each place has a different application with different arrangement. For example, in pellet producing value chain, pellets which are produced by the bush biomass will be used to generate energy and it will replace a certain amount of energy extracted from fossil fuels. That action will reduce the fossil fuel dependency which is an approach towards bioeconomy and circular economy. Similarly, the harvesting of bush biomass will enable the land to revert back to the ideal ecological condition of the country. Which means it creates new ventures for eco-tourism in savanna lands, livestock and agriculture through stable natural hydrological cycles, fertile soils and etc. These practices are oriented toward green economy practices and also it will create regional added values. In the other hand renewable energy provision in BIP will reduce the dependency of fossil fuels for BIP processes which is a practice in relation to circular economy.

Even though, transportation/logistic measure are still not able to move towards eco-friendly or zero emission due to practical issues such as technical limitations and long travelling distances with large quantities. Therefore, transportation phase still remains under the conventional economic practices by consuming fossil fuels.

In conclusion, if the BIP's rural bioeconomy model is considered as a small house, it has several rooms with different processes and each has one or more fundamental sustainable strategies and management methods. To gain the maximum outcome with the most accurate results, it should not be focused in to a single concept. The integration of several sustainable strategies enhances the stability of the project and it eliminates lot of limitations due to the increased level of flexibility.

## 4 BIP Site Selection

Concluded from the above-mentioned considerations utmost caution and sound well balanced procedure was followed to identify a first physical site for the cluster. This process aimed to identify willing and able partners and/or hosts for the development of the first such BIP project in Namibia. The site selection for such a project is critical to its success. The most important factors for consideration for an industrial park of this nature is the availability and suitability of land, the access to logistics infrastructure, the access to basic services, the access to the encroacher bush resource, and the access to secondary and tertiary services, and the peripheral benefits within the greater area.

The most critical site considerations were:

- 1) The site should be located in close vicinity or surrounded by bush-encroached land (see map above).
- 2) A minimum of 30 hectares of land is available for purchase or long-term lease to the BIP project developer, and up to an additional 70 hectares of adjacent land is/and will be available for future expansion phases.
- 3) The current zoning of the potential site is not unduly restrictive to such a commercial development.
- 4) Access to logistics infrastructure, including tar roads, railways, and regional airports, are within a reasonable distance from the potential site.
- 5) Access to power via a suitable grid connection is available or is possible within a reasonable distance from the potential site. The existing or potential grid connection should be a minimum of 100 kVa in capacity.

- 6) Access to potable water is available or is possible within a reasonable distance from the potential site. The existing or potential water connection should be a minimum of 10 cubic meters per day in capacity.
- 7) The site should be within a reasonable distance from a major town, to benefit from its tertiary services and human capital such as;
  - a. Reasonable access to telecoms services
  - b. Reasonable access to existing sewage services
  - c. Reasonable access to existing solid waste services
  - d. Existing improvements of the site
  - e. Distance from the site to existing and future biomass off-takers
  - f. Security and access to the site

#### **4.1 Tentative benefits to site provider**

This road map was compiled under the assumption that the economic success of lucrative businesses in the cluster will represent the driving force in financing the cluster itself and its facilities. Not only will the BIP developers procure or lease the required land from the site providers, offering market related gains, but the BIP project will also attract additional direct investment into the area, and in doing so, also draw in new skills and expertise. With such a development, also comes new services, increased skills pool, local, regional, and international exposure, and infrastructure improvements. The BIP development would also help attract any lacking services in the area, making the general area more attractive for knock-on developments and investments. The ancillary advantage of such a project would be realized by the landowners in the area, who would benefit from a robust off-take market for their biomass resource, and as such, would be further incentivized to harvest and sell their biomass, which would, in effect, support their agricultural productivity. The benefit goes both ways, as the steady supply of biomass from the surrounding area will also lessen supply risks and will increase the overall diversity and quality of the biomass



available to the BIP. The peripheral benefits to the surrounding area would include increased consumer spending, knock-on developments and services being established, new biomass products and value streams being realized, increased research and development taking place, increased commercial and professional visitors, and improved access to new technologies.

In general, the effects of such a BIP development will boost the entire biomass sector in Namibia, and will in turn, become a tipping point for other new developments within the sector. And while it is difficult to place a monetary value on the project at this initial stage, the projected volumes of biomass to be processed per annum by the BIP is equitable to about N\$ 250 million in turnover per annum, on a raw material basis alone, which is then subject to a number of other multiplier effects through the value addition.

Besides contributions of the participating companies, the refinancing of the advance financing of the hub/cluster will be covered by rent or lease payments and charging for provision of facilities (unit cost base) like the weighbridge controlling material going in and out and other central services.

## **4.2 Site selection**

A nationwide tender was published to identify a site that fulfils the above listed technical conditions as well as the willingness of local authorities to engage in the envisaged bio-economic bush-utilization and potentially host the cluster. N-BIG masterminded the selection process and published a call for proposals. Expression of interest, submission deadline was fixed for 25 March 2019. Site proposal submission deadline was planned for the 8. April 2019.

On the 18th of March the municipality of Otjiwarongo expressed their willingness and keen interest to participate in the national fight against encroacher bush. They offered

so far serviced and un-serviced land for this purpose and shortly displayed already existing infrastructural features. Find a letter from Otjiwarongo municipality attached.

### **4.3 Biomass Industrial Park - Site Proposal Request**

#### **4.3.1 Background**

The interested party, Otjiwarongo Municipality, has offered the industrial site (Figure 8) for the development of Namibia's first Biomass Industrial Park (BIP). The site in question has excellent access to logistics infrastructure, services, and it is central to the charcoal sector of Namibia. However, before the final site selection for the BIP development can be made, specific requirements need to be addressed, with regards to potential tenants, local markets, access to land, commitments, and preferred partnership structures.

Of utmost importance, the BIP requires committed anchor clients, either in the form of service providers or processors and manufacturers who are interested in becoming tenants within the BIP. Not only this, but committed local off-take markets for biomass-derived products is also essential, especially in the early stage of the BIP development, before larger, export markets can be targeted. Preliminary and conditional interest from these relevant local stakeholders will help determine the BIP site in question and will also help to ensure the viability of the BIP in more general terms. The importance of these potential tenants and off-take markets can best be assessed through preliminary written commitments, with conditional requirements. In this light, it is imperative that these stakeholders are engaged, to sensitize them and encourage their conditional commitments.

Secondly, the BIP requires a clear roadmap for accessing of the land, be it through a land purchase procedure, long-term lease agreement, or via a partnership structure. The relevant process and timeframes need to be clearly understood, to ensure that the

project can be correctly aligned. In the case of municipal land available, clarity on the authorization process is critical, and buy-in from the relevant line ministries is needed. Lastly, the preferred partnership structure between the BIP management and the site owner needs to be outlined, from the perspective of the site owner. Initial feedback was that a Public-Private Partnership would be preferred, however, this needs to be elaborated on, including the envisaged involvement, role, and stake in the project that the site owner will take.

The BIP Management Forum has agreed that it is now up to the interested party of the potential BIP site to help concretize the case for establishing the BIP at the site in question. The more input and commitment that the management forum receives, the more likely a favorable outcome will be reached.



**Figure 8.** Proposed BIP site near Otjiwarongo, highlighted in green.

## 4.3.2 Proposal Requirements

### 4.3.2.1 Local Tenant Identification

The interested party is hereby requested to assist in the identification of local potential tenants for the BIP. These future entities must ideally be in existence and must be ready to make conditional commitments in reference to relocating or expanding into to the BIP, once developed, based on conditions precedent.

For the Otjiwarongo site specifically, some tenants of special interest have already been identified by the management forum, including, but not limited to

- Namib Green Gold Processing (MITSMED – UNIDO supported biomass value addition project)
- W.Diekmann Charcoal Briquetting
- Makarra Charcoal Processing
- MACS Maritime Carrier Shipping
- Inventec Agricultural and Industrial Designs
- Namibia Charcoal Association
- Cheetah Conservation Fund
- Kilo 40 Charcoal Processing

The above list is not exhaustive, and it is up to the interested party to not only clarify the interest of the aforementioned entities, but also to identify other potential tenants. Obtaining conditional commitments from the above tenants, amongst others, would significantly help sway the site selection decision in favor of Otjiwarongo.

#### 4.3.2.2 Local Market Identification

The interested party is also required to identify local markets relevant to the BIP around the proposed site, within a radius of 100 km. These markets must preferably already be in existence and must be willing to show an interest in receiving services and/or products from the BIP. BIP products will include power, thermal energy (+- 1 km radius from BIP), cooling (+- 1 km from BIP), carbonized products (charcoal, biochar, activated carbon, wood ash, charcoal fines), wood products (firewood, wood chips, wood fiber, wood briquettes, wood pellets) and bush-based animal fodder related products. BIP services will include bulking, storage, packaging, transport, customs clearance, regulatory services, advisory services, training, workshop services, and equipment leasing services.

For the proposed Otjiwarongo site, markets of special interest are the following;

- Cheetah Cement Plant - potential power and/or wood chip and charcoal fines off-taker
- Cenored - potential power off-taker
- Styrotex - potential wood fiber off-taker
- Otjiwarongo Water treatment facility - potential activated carbon off-taker
- B2Gold Otjikoto mine - potential wood chip off-taker

The above list is not exhaustive, and it is up to the interested party to not only clarify the interest of the aforementioned entities, but also to identify other potential off-takers. Obtaining conditional commitments from the above off-takers would significantly help sway the site selection decision in favor of Otjiwarongo.

#### 4.3.2.3 Land Authorizations Process

The interested party is hereby requested to identify and describe, in detail, the necessary procedures, for the land to be handed over to the BIP Development team.

The preferred land procurement process is to be decided by the interested party, whether it is change of ownership, long-term lease, or public-private partnership.

If the preferred structure is still that of a Public Private Partnership, then the interested party is requested to outline the process in detail, and give indicative timeframes of each of the relevant steps, as well as the parties involved along the way.

#### **Partnership**

The BIP project is multi-faceted and inclusive in nature, and as such, it is important that it is built on strong partnerships and relationships. The interested party is hereby requested to outline their envisaged involvement of the BIP project, from development of the project to its management and operations. This does not necessarily require active involvement, but some sort of involvement from the site host is preferable. In order to align the project going forward, a mutual understanding on the level of involvement is required, to ensure the interests are best served.

#### **Commitments**

The aforementioned commitments are extremely important in the final site selection decision-making process. That being said, the expectation at this early stage is not to assume that binding commitments will be made, but rather for conditional commitments to be offered. These can take the form of a non-binding letter of interest, with clear conditional requirements being stipulated. These conditional requirements are essential, acting as a valuable guideline and target for the ongoing BIP development.

#### 4.3.2.4 Otjiwarongo Site

The site proposal development process should be a dynamic one, whereby the interested party is actively engaging with stakeholders, including the BIP Management Forum. The local BIP project coordinator, the Namibia Biomass Industry Group, is available to assist where possible, and may be contacted as such. The interested party is expected to put sufficient effort into the proposal development process, as the proposal will be the document that will decide the final BIP site.

To cut the long selection process short it will be valid enough for the road map to state that Otjiwarongo seemed to be most suited among all other locations that participated in the public tender.

The Otjiwarongo site is the closest site to Walvis Bay, allowing for the best access to international markets. The site also has excellent access to services and logistic infrastructure. Otjiwarongo is also the largest urban centre of all the sites, meaning it will have the best skills available and more comprehensive services to offer. The site is on municipal land, and the preferred option is to develop a PPP with the municipality. While this is not the fastest land acquisition route, it may have the most political buy-in. Otjiwarongo is already the charcoal capital of Namibia, having at least 3 charcoal processors in the vicinity, and a possible wood chip and charcoal fines off taker just across the road from the site, via the Whale Rock Cement Plant.

Other participating sites showed weaker aspects such as longer and more difficult access to infrastructure and traffic/transport options, smaller or less developed urban services or simply less area with encroached bush respectively greater distances to relevant areas.

#### 4.3.2.5 Project and market partners

Focusing on the various technical operations involved in the biotech process inside the BIP cluster, IfaS identified relevant stakeholders along the road. Partly they already committed themselves by issuing a MoU. In dealing with the core problem of Namibia, the economic conversion of encroacher bush vegetation into value, IfaS to date reached a very satisfying level of commitment of potential end-users / buyers of bush biomass. Numerous contacts were made to introduce the material, its properties and economic value. Personal visits and organisation of field trips / participation in on-site visits eventually created interest in Namibian bioenergy. In a next step towards trade contracts contacted companies documented their interest and potential business support by signing a Memorandum of Understanding (MoU). Nevertheless, for a finalization of offtake-contracting the local steering of the sector, executed by the institution-building process of GIZ-management in Namibia, needs to develop and present a fully functional BIP-hub lead by a private business company which will act as the Namibian partner for overseas customers and markets.

#### 4.4 Operators Model

For an efficient long-term operation of the BIP, and to share any possible socio-economic risks, it is essential to have a partnership with multiple stakeholders for the project.

Some concentrate on narrow local targets while others ambitiously try to co-ordinate broad policy areas in large regions where hundreds of people live and work. In the case of BIP, a long-term partnership can be identified as it is a nation-wide multi-sectoral issue where an interdisciplinary team is in action. In general, almost all the partnerships primarily oriented towards business circles and others focused on labour market or social issues. Bottom-up or top-down management/parentship strategies or a combination of those can be applied in the case of BIP. As per the current situation

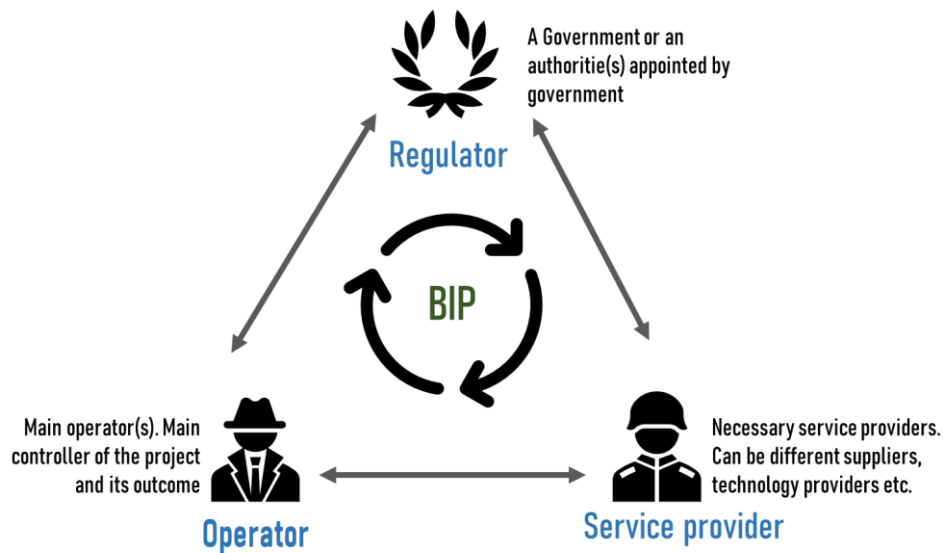


and the awareness about the Namibian situation “Bottom-up” can be seen as a key principle here, but it also important to consider that a decent number of partnerships have been created as part of a central management strategy to support the delivery of programmes at the local and international level.

Therefore, two main partnership options can be identified to operate a BIP. In general, Public-Private Partnership (PPP) and private only partnership are common. In the case of BIP, the involvement of the government is the necessary as this is a national level concern in Namibia. No matter what is the operational condition or partnership arrangement, the political and governmental level involvement is beneficial under existing circumstances.

**Public-Private Partnerships (PPPs)** are partnerships between the public sector and the private sector in the design, planning, financing, management, construction, operation and recycling of alone in government responsibility previously provided public services. Public-private partnerships thus represent a government procurement alternative to conventional self-realization.

Although, a PPP where the government-appointed authority plays the role as a regulator for the project, while the main operator has control over the project with the help of service providers can be identified. These kinds of practices are common in the upstream petroleum industry. When the government has a limited or no capacity to finance the project, the government will be in the regulator role and, the operator has to pay the royalties and related taxes. It is known to be one of the successful types of partnership models in the world. The following figure is a representation of the arrangement of such a cooperation.



**Figure 9.** Organization structure of a partnership where the government act as only the regulator

In such an arrangement, the legal framework of the project will be monitored, regulated by the government, and also it will receive the royalty fees as well as taxes. Service providers are mainly suppliers where they supply different expertise knowledge, technologies when the operator does not have resources or not capable of delivering specific requirements for the project.

**Development partnerships with business;** There is also a special form of cooperation with companies, which is known as developing partnerships with business. It is widely practiced in development projects. It is an organization that provides essential help and money to create new businesses in an area where there are a lot of unemployed people and have little industry. These are short-term to medium-term joint projects by companies and implementing organizations for development cooperation on behalf of related ministries or governments.

These kinds of partnerships thus combine the innovative strengths of the economy with the knowledge, experience, and resources of development policy. They mobilize additional funds for development policy processes. Further, pre-defined core objectives and goals promote the transfer of know-how and modern technology to developing countries. This makes them a great asset for development cooperation.

**Recommendation for Partnership structure for the projected BIP model.** Due to the wide range of sectoral involvement within a BIP, it can be identified as an interdisciplinary group of experts in different fields. Technological experts, academic institutions and research teams, logistics, social services, agriculture, and mainly environmental management and energy-related partners are few of the key partners. In that regard, it is clear that a robust partnership model should be in place for long-term success and to ensure the environmental and socio-economic success of the project.

Due to the novelty character of the project and the herewith associated uncertainties, it seems meaningful to shift any possible risk share to the private sector in order to protect communal and public merits. Therefore, the proposed partnership model for the BIP is a private partnership with development partnership practices. However, government and municipality participation and guidance should be envisaged. It is not only because the bush-encroachment is a nation-wide ecological constrain, but also for the legal formalities on the basis of land rent, lease and provision of electricity, infrastructure water and waste water management. In order to safeguard a BIP endeavour municipality should found task forces or departments that assist in the development of the parks especially with regard to EIA, permits, compliance, etc. In this operational structure, the flexibility of outsourcing non-core activities is another important advantage. Because one of the trending practices in modern governments is to reduce the government involvement and move as much as possible of its tasks over to the private sector<sup>6</sup>.

Also, in general, any state budget is formed of fixed budgets for each ministry and authority. Major investments are temporary modifications of the budget of a ministry,

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<sup>6</sup> Firth, S. (2007). Pacific islands trade, labor, and security in an era of globalization. *The Contemporary Pacific*, 19(1),

and this problem can be difficult to deal with in the budgetary process. To avoid these issues and delays, a partnership headed by private stakeholder(s) seems to be an advantage for all the stakeholders with the regulatory involvement of the government. In this arrangement companies also get benefits in a special way, because there are local partners also involved, they have the support for their projects by experienced development organizations that have country-specific and sector-specific knowledge. Further, they have the opportunity to open up new markets for their products and services in the future.

Furthermore, with the practices of development cooperation, there are more attention to development concerns. As an example, for agricultural projects, the introduction of ecological and social standards will improve working conditions in developing countries. Similarly, techniques are being spread or new farming methods are being tried out due to expertise involvement, etc. Also, measures serve to protect the environment and resources and create jobs - even in rural regions. With these possibilities and by considering BIP characteristics, private led partnership with development partnership practices seems to be a viable operating model.

## 5 Biomass Industrial Park Model

The BIP follows a whole bush utilization approach and the activities are subdivided in five (5) realms (see Figure 10) which comprise:

1. Harvesting
2. Post-harvesting
3. Processing
4. Additional Services
5. Logistics

The **first realm** “harvesting” is subdivided in two branches, namely 1<sup>st</sup> ‘bush pre-thinning’, whereby selectively bush parts, particularly fresh, small and green branches and pots are extracted which serve as feedstock for bush feed production and 2<sup>nd</sup> ‘bush thinning’, whereby whole bushes are extracted in compliance to the MAWF norm which serve as feedstock for further product fabrication. Preferably, bush pre-thinning and bush thinning work in sequence, whereby first special trained bush pre-thinning squads enter the harvesting area to obtain their raw material and subsequently (after a certain period of time) larger machinery is entering the same spot to conduct bush thinning activities. Here a particular advantage for post-harvesting and processing realms can be obtained.

As fuel, charcoal and pellets producers strive for “clean” raw material, whereas leaves, bark and small branches do not belong to this category, premature bush-thinning works as a kind of “screening” increasing the effectiveness of post-processes and augmenting the value (purity) of the raw material. The bush pre-thinning activities strive for a daily harvest of 48 tons of fresh matter. The bush thinning activities strive for a daily harvest of 1,100 tons of dry matter (8-15% residual moisture). The corresponding area demand within the predefined catchment area (cp. chapter 3.3.2) to provide feedstock for 20 years period for both bush pre-thinning and bush thinning is quite balanced, whereby bush pre-thinning area demand lies at approx. 10% of the

catchment area for bush thinning, which guarantees sufficient buffer and constant availability of fresh material and allows for scale-up.<sup>7</sup> Harvesting of bush feed raw material comprises manual removal of biomass, in-field chipping with tractor-PTO driven mobile chipper and haulage with wagons to the BIP. The process starts with selective manual respectively semi-mechanized (chain saws, electric loppers) removal of bush branches in squads. The biomass subsequently is applied into a tractor-PTO driven chipper which blows the chipped material directly into a tractor-pulled wagon which transports the raw material to the BIP.

Harvesting of whole bush comprises the mobilization, drying, primary crushing for volume reduction of biomass and transport to the BIP. The process chain is subdivided into cutting bush above ground with an excavator equipped with a hydraulic shear. The whole bush is piled and naturally air-dried for 4 weeks in field. Afterwards the piles are loaded with wheel loaders or excavators into a mobile chipper in field for volume reduction and directly conveyed into swap-bins and pulled to the nearest street by tractor. Here the swap-bins are loaded onto trucks that transport the pre-crushed raw material to the BIP. Depending on the distance, topography and equipment the swap-bins may be transported to the BIP directly by tractor without entering roads (cp. chapter 7.3.1).

The **second realm** “Post-harvesting” constitutes the “core” of the BIP. Here, a processing line to treat the delivered pre-shredded material is installed. The superior utility of this processing line (procedure) lies in crushing, separation, de-sanding, fractionation and purification of raw material into final (such as wood chips) and intermediate (such as oversize material for charcoal) products. The line consists of a weight bridge to record the delivery. Subsequently the raw material enters an open storage area where wheel loaders agglomerate the material in piles. Between each pile

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<sup>7</sup> Assumed 10% (3t/ha) of standing encroacher biomass (30t/ha) is suitable as feedstock for bushfeed a 50 t/d bushfeed plant requires 43.000 ha of land in 20 years. Catchment area for BIP comprises 430,000 ha in a twenty years circle. Sound aftercare management additionally will increase availability of feedstock for bushfeed production

a mobile electric-driven excavator loads the raw material onto conveyers which enter a rotatory drum sieve to separate both impurities (sand, bark, fines [ $<5\text{mm}$ ]) and oversize ( $>200\text{mm}$ ) material from the main stream. Afterwards, the raw material enters an interim storage and from here it conveyed with conveyer belt to a hammer mill.

Depending on the physical state of the raw material, a stationary electrically propelled shredder is used as upstream process to guarantee a smooth operation of the hammer mill. After milling, material enters into post-sieving process using a flat star screen to separate different fractions. Oversize material ( $>80\text{-}100\text{mm}$ ) is recirculated and wood chip fractions ( $16\text{-max.}100\text{mm}$ ) as well as fine material ( $5\text{-}16\text{mm}$ ) are extracted. The **third realm** “Processing” comprises the refinement of feedstock from the harvesting and post-harvesting realms to final products. Here mainly **five (5)** feedstock fractions are processed. The undersize fraction (impurities  $<5\text{mm}$ ) is used for **composting**. The oversize fraction ( $>200\text{mm}$ ) applies for **pyrolysis** to obtain charcoal, briquettes and biochar. The main fraction ( $16\text{-}100\text{mm}$ ) is considered to be a P100 **wood chip**, which either enters directly market or is post-shredded to downsize factions (such as P30). The  $5\text{-}16\text{mm}$  fraction can be applied in **pelleting**. The bushfeed fraction after weighting enters a dump sump and is sequenced from this place through a belt dryer towards a hammer mill. The dry and fine material subsequently is mixed with supplements and finally pelletized to obtain **bushfeed**.

The **fourth realm** “Additional Services” constitutes the services division. Here a maintenance department, a spare parts & tool storage and a R&D division incl. laboratory centralized serve the BIP in order to allow a smooth operation of the harvesting, post-harvesting and processing realms.

In addition, the fourth realm shall provide electricity by photovoltaic systems to the BIP, provide water, infrastructure, illumination, liquid fuels (fuel station) for the mobile in field equipment and logistics. Last but not least, the BIP provides residential

area, school and kindergarten with playgrounds to the employees and families. The BIP should have a satellite “habitat”, where the residential area including all social services and free time activities are connected.

The **fifth realm** “Logistics” contemplates but not financially integrates all necessary logistic activities associated to the final products distribution, whereas truck, rail and international shipping are observed to the final products distribution, whereas truck, rail and international shipping are observed.



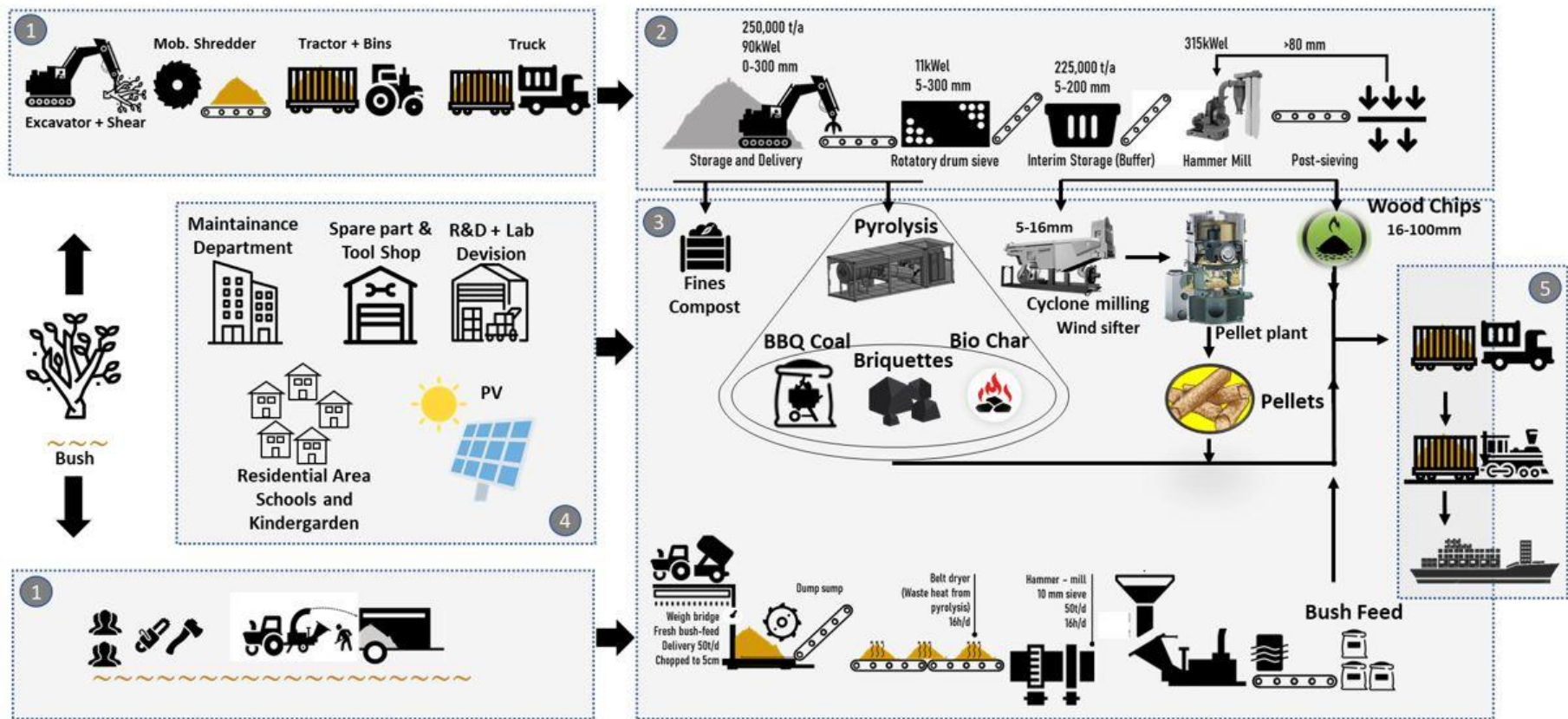


Figure 10. BIP exploded process diagram

## **5.1 Realm 1. Harvesting (in field)**

### **5.1.1 'Bush pre-thinning'**

In the following first part the specs for a bushfeed plant are listed. These specifications all base on offers handed-in from relevant manufacturers and have proven their suitability and quality for the required factory tasks.

This roadmap gives weight to the industrial high output of standardized bushfeed production. Existing local production will be able to produce a 100 kg bag of bushfeed pellets for favorable prices due to mechanical handling in the drying process using solar heat on a plastic sheet laid on to the ground. This results in uneven drying and the incorporation of sand and dust which will reduce the feeding value. Profit earning capacity will be achieved by even process conditions and high reliable daily production output. No wonder that up to date bushfeed producers produced only locally in smaller manageable quantities. On this level, the envisaged conversion of encroacher bush into an international trade commodity will not happen.

A bush-based animal fodder-cost calculation tool had been developed by DAS and published 2017 in a GIZ-financed brochure titled "Animal feed from Namibian Encroacher Bush". The subtitle indicates that "this manual provides guidance for producers". The value of this guide lies in the innovative compilation of necessary production steps. It aims at a farm level improvisation applying a new production approach. Cost calculation presumes that "the farmer will have some of the proposed equipment available on the farm" (p 23). Fixed cost for operating equipment mainly stems on the use of Bos-tot-Kos combination chopper that chops, mills and mixes fresh bush-material with supplements (p13). This applies to preparation of daily fresh feed for animals as "Animal feed produced in this way must be fed to the animals on the same day". Keeping in mind that bushfeed is naturally composed by some 50 % of cellwalls / fibers, bushfeed should be treated with no more than 3 % of NaOH "to make

the bush-based feed more digestible” (p15). On the following page 16, chapter “Drying”, it is stated that “Biomass pre-treated with NaOH must be sufficiently dried before supplements can be mixed in. The mixture can be dried in the sun. If the pre-treated bush is not dried before mixing it with supplements, there is danger that the feed will spoil – even if it is stored for only a few days. Another reason for drying is that the bush fibers lose the smell of the chemicals. Potassium as well as sodium Hydroxide have a very strong odor, not liked by livestock. The drying process alleviates the smell to a great extent.” (p16) This is correct. NaOH on one hand partly cracks the chemical links between lignin and the cell wall macromolecules (cellulose and hemicellulose mainly) and thus increases the digestibility of the fiber fraction but on the other hand leads to reduced feed-intake due to the smell of chemicals.

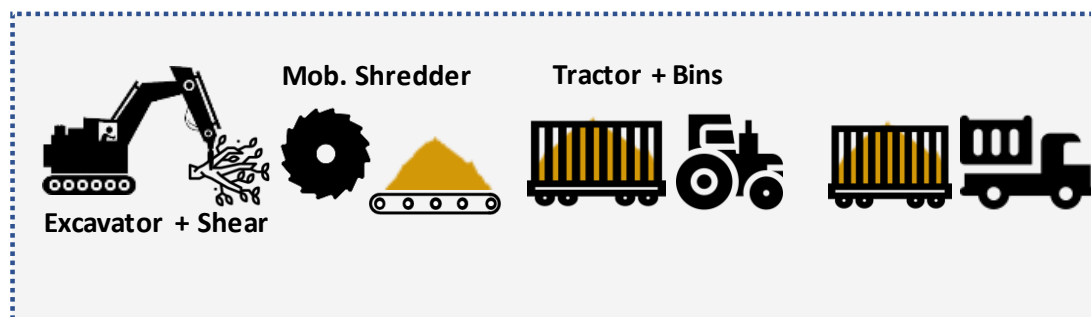
The brochure’s findings on drying contradict the use of Bos-tot-Kos mixing with supplements and feeding on the same day (p13). In general, the total production cost calculation suffers from an incomplete cost base. It assumes the use of already existing machines without cost implementation. It states that chopped feed CAN be dried in the sun (p16). Photographs on pp.22 and 16 illustrate “drying of feed mix on plastic sheets”. Only on very small scale bushfeed production such improvised low-cost drying is advisable. “Drying labor to spread bush” accounts to 0 NAD/kg which means no cost for drying considered.

The machinery component of the cost-calculation tool: for single farm level, amateur level or use every now and then the included Bos-tot-Kos machine might be enough. In terms of nationwide removal of encroacher bush this tool cannot be considered seriously. Its capacity is limited to 2 t per day (pp. 24, 14). Process-units for a high-output industrial setup like continuous drying, hammer mill, pelletizer, computerized mixers and a professional weighing and bagging station are not put into the calculation. From there, a fictitious low price of 450 NAD /100kg of bushfeed is calculated in the brochure. These costs are potentially misleading and can only be

applied on the said improvised farm level. The printed calculation example (p. 24-27) adds only molasses (for palatability) and 2 % urea (to compensate to an extent the relatively low protein / N-content of bushfeed). Such a mix will be covering maintenance level or slightly less. A comparison of this price of 450 NAD / 100kg bushfeed with the price of alternatives, e.g. commercially available feed (p. 27) is inappropriate as commercial feed is offering a complete set of nutrients and enough energy for animal performance. The great advantage of bushfeed is the option of adding all kinds of supplements via the mixer in order to meet all kinds of ruminant feeding objectives. Therefore, the following chapter “realm 3” describes in detail the components of an even industrialized process that mechanizes to a maximum the flow of bush branches from harvest into sales bags.

### 5.1.2 ‘Bush thinning’

Harvesting of whole bush comprises the mobilization, drying, primary crushing for volume reduction of biomass and transport to the BIP. The process chain is subdivided into cutting bush above ground with an excavator equipped with a hydraulic shear. The whole bush is piled and naturally air-dried for 4 weeks in field. Afterwards the piles are loaded with wheel loaders or excavators into a mobile chipper in field for volume reduction and directly conveyed into swap-bins and pulled to the nearest street by tractor. Here the swap-bins are loaded onto trucks that transport the pre-crushed raw material to the BIP. Depending on the distance, topography and equipment the swap-bins may be transported to the BIP directly by tractor without entering roads.



**Figure 11.** Bush thinning harvesting procedure

In order to provide 250,000 t/a of “raw material” to the BIP, it is necessary to work with a multiple number of squads, which all consists of excavators, mobile chippers, tractors and bins, wheel loaders and trucks. In the present scenario, 7 squads are needed to guarantee constant and sufficient supply of raw material to the BIP. It is advantageous to operate more than one squad also with regard to redundancy and buffer if some squads break down due to engine failure or to rain and topography constrains. As every single equipment in the squad has different capacity (here: tons per hour) in harvesting, treating, moving and transporting raw bush material an alignment in capacity is incremental in order to define the necessary units per squad. The following Figure 12 illustrates the approach. It is noteworthy that the smallest capacity per hour is hold by the excavators.<sup>8</sup> In order to provide sufficient material to one mobile chipper, 4 excavators are needed. Note that the assumption is based on 12 t/ha available biomass. If the density of the harvesting area is higher, the harvesting capacity per hour of each excavator increases and less units are needed.

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<sup>8</sup> It is not envisaged to harvest manually; however, it is still an option. So far excavators in the long-run have proven highest capacity in comparison to semi-mechanized or hand harvest and lowest environmental impact. The goal of a BIP is to create rather high qualified jobs over low-skills labor.

| Step             | 1                   | 2                       | 3              | 4                       | 5                                | 6                           |
|------------------|---------------------|-------------------------|----------------|-------------------------|----------------------------------|-----------------------------|
| Equipment        | Excavator + Shear   | Excavator + Grapple     | Mobile Chipper | Front-End-Loader + Bins | Haulage Tractor + Hydr. Tipper   | Truck + Trailer + Hydr. Arm |
| Activity         | Harvesting & Piling | Feeding Pile to Chipper | Chipping       | Loading of Bins         | Transport Bins to Sub (max.10km) | Tranship Transport to BIP   |
| Capacity [t/h]   | 6                   | 14                      | 25             | 1<br>2                  | 8                                | 12                          |
| Units            | 4                   | 2                       | 1              | 1<br>14                 | 3                                | 2                           |
| Availability [%] | 85                  | 80                      | 80             | 85                      | 85                               | 85                          |
| Output [t/h]     | 20.4                | 22.4                    | 20             | 23.8                    | 20.4                             | 20.4                        |

**Figure 12.** Bush thinning harvesting steps, units and capacities

## 5.2 Realm 2. Post-harvesting (at BIP)

The biomass hub comprises different facilities to convert the bush biomass in finale products such as wood chips, pellets and charcoal. The first production stage is the follow-up treatment, which includes a stockpiling for the raw material, a sieving process (to separates impurities such as sand, small organic particle etc.) and at the end a biomass milling process is envisaged. The finale products of this post-harvesting treatment process are:

- Oversize material for the charcoal production,
- Clean woodchips for the market or for an additional treatment process for a pellet production and
- Fines for a directly usage in pellet production

The trial of the HAAS Company (at 17th of January 2020) and also the experts assumptions are the basis of this analyzing process. Depending on these results and also on the technical description and the estimated offer of the HAAS Company

(biomass treatment technics), the follow-up treatment are designed. The illustration below shows a draft design of the infrastructure of the first treatment step inside the biomass hub.

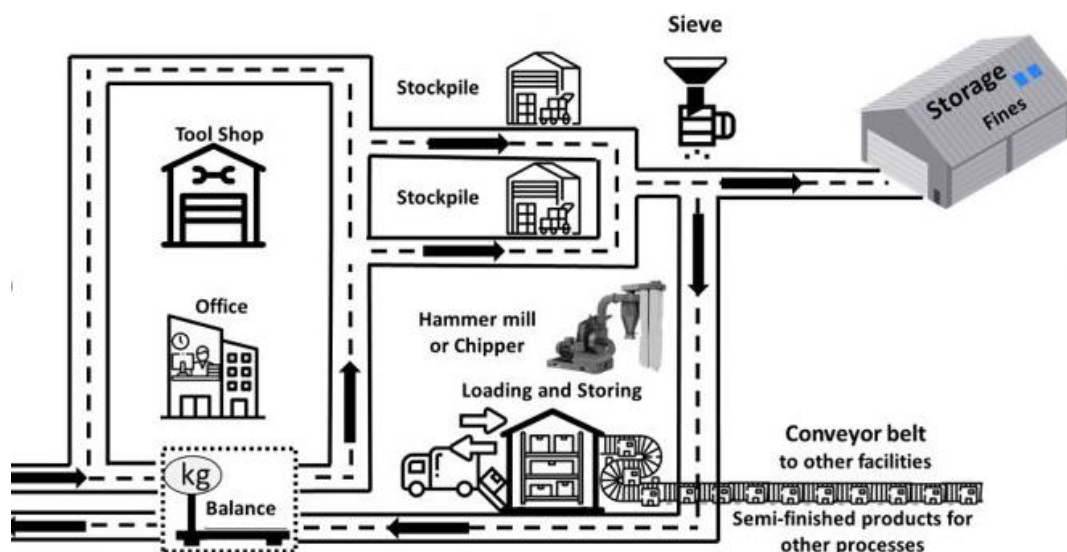


Figure 13. Draft plan of the follow-up treatment facility inside the hub

Furthermore, the infrastructure depends on the biomass potential around the location. The place Otjiwarongo was chosen as the biomass hub. The research method and also the criteria for the selection for this location are described in chapter 4. The limitation of the biomass potential is related to:

- The growth rate of the biomass per year,
- The transport system (e.g. is a reloading point necessary) and the capacity of the pre-treated biomass
- The distances between the point of harvesting and the hub.
- 

In general, it can be assumed that the transport distance should be lower than 50 km for the biomass with a high bulk volume. Based on this radius, the potential is estimated of around 250,000 t/a in Otjiwarongo (cp. chapter 3.3.2). The Transport system to the BIP is described in chapter 7.

### 5.2.1 Infrastructure of the raw material storage

In view of the biomass potential in Otjiwarongo, the treatment facility will be designed for an in-pu t mass of 250,000 t/a. This wooden biomass corresponds to a mass



throughput of 800 – 1.000 t/day<sup>9</sup>, which is equal to around 3,500 – 4,200 m<sup>3</sup>/day. The following figure illustrates the pre-treated Namibian biomass<sup>10</sup>. The production chain, including the stockpiling, are based on raw material illustrated in Figure 14.



**Figure 14.** Final products after grinding in field with a shredder

The treatment and the harvesting process can be interrupted by maintenances or machine failures. For this reason, an open stockpiling is essential for a continuously harvesting and / or treatment process. Hence, it is considered the options to have a raw material storage of around 1 ha net area<sup>11</sup>, which should cover between three to five production days. For the plant feeding it can be utilized an electric driven excavator in combination with conveyor units. In this case, it is assumed that between 3 to 5 excavators are needed. These tools have the advantages of cost efficiency (fuel, maintained) and noise pollution. The technical key indicators for the excavator are listed in the table below.

<sup>9</sup> Assumption of operation time of around 260-265 days/a

<sup>10</sup> (HAAS Holzzerkleinerungs- und Fördertechnik GmbH 2020)

<sup>11</sup> Assumption for the stockpile: 330 – 350 m length; 30 – 35 m wide; 2 – 3 m high



**Table 4.** Technical Data of an electric CAT MH24 excavator<sup>12</sup>

| CAT MH24       | Value | Unit |
|----------------|-------|------|
| Capacity       | 90    | kW   |
| Elec. Connect. | 400   | V    |
|                | 50    | Hz   |

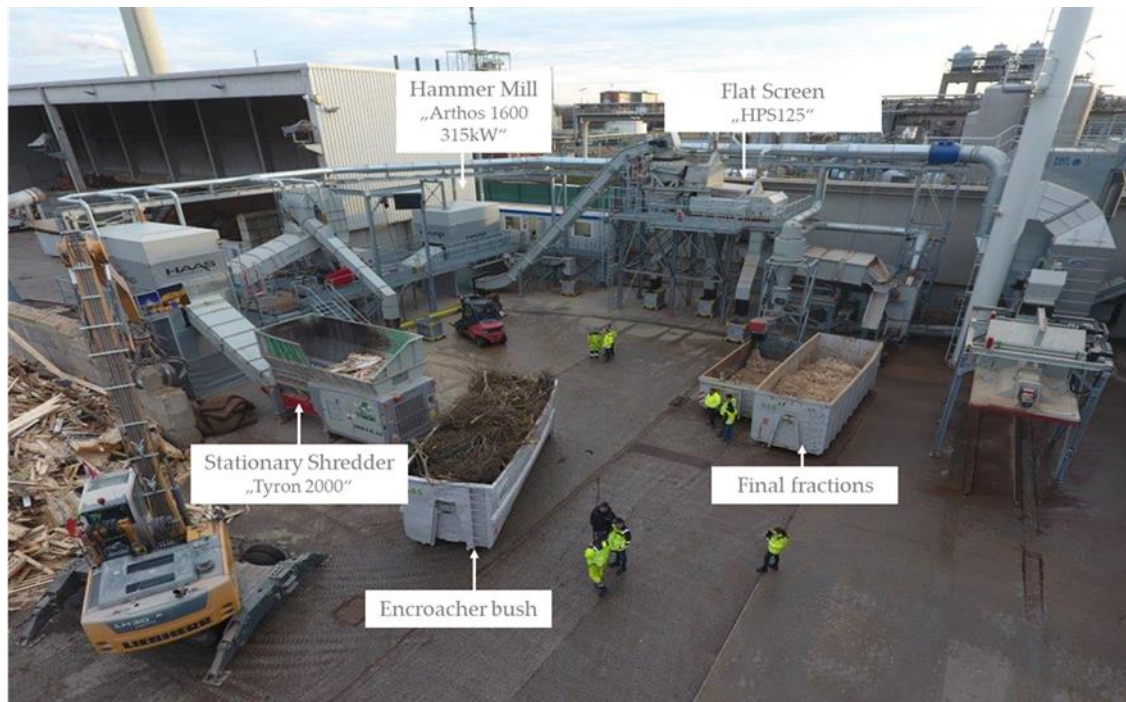
### 5.2.2 Infrastructure treatment facility

The follow up-treatment chain comprised a pre-screening, hammer mill as well as a post-screening. The production chains are chosen to remove at first the impurities (e.g. sand, soil, fine organic fraction) and possibly to extract also oversize wooden material for charcoal production. This separation is needed to reduce the maintenance of the milling process and increase product quality. As a result, there is no need for an additional pre-treatment. It is assumed that the illustrated grind sizes (figure above) are sufficient for this plant<sup>13</sup>. The area for one production chain is estimated at around 1,000 to 1,500 m<sup>2</sup>. The following figure provides an example, from the company AVG Ressourcen GmbH in Cologne, of how a milling facility looks like.

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<sup>12</sup> (ZEPPELIN CAT 2020)

<sup>13</sup> (Haßlinger 2020)



**Figure 15.** Example of hammer mill from the AVG Ressourcen GmbH in Cologne

The following description of the milling process is based on the offer of the company HAAS Holzzerkleinerungs- und Fördertechnik GmbH<sup>14</sup>. This document comprised a pre-screening, a milling process and a post screening with a throughput capacity between 30 – 40 t/h. In addition, the results of the trial in Cologne and machine description from the HAAS-website will be also used.

### 5.2.3 Pre-screening process (flat screen)

For this process stage, a flat-screen can be used. The technic has the advantages to separate up to six fractions in one single operation unit. In the case of the Biomass hub, at this stage is necessary to remove the impurities as well as to separate the oversize fraction for the charcoal facility. Therefore, the flat screen is a flexible unit and a changing of the output sizes can be performed easily through an exchange of the screen decks. For this production chain, the flat screen HPS 125 is sufficient and in addition, a possibility to separates three wood fractions exist<sup>15</sup>. This estimation is based on the following key indicators as

<sup>14</sup> (HAAS Holzzerkleinerungs- und Fördertechnik GmbH 2019)

<sup>15</sup> (HAAS Holzzerkleinerungs- und Fördertechnik GmbH 2020)

**Table 5.** Technical Data of a HPS 125 – Flat Screen<sup>16</sup>

| Flat screen HPS 125              | Value     | Unit              |
|----------------------------------|-----------|-------------------|
| Capacity                         | 11        | kW                |
| Elec. Connect.                   | 400       | V                 |
|                                  | 50        | Hz                |
| Performence                      | 180 - 250 | m <sup>3</sup> /h |
| Numbers of<br>possibel fractions | 1 - 6     |                   |



Moreover, the removal of excess length is also possible with a star screen. These types of screens are also used to separates oversize biomass. In this case, a combination of screens is possible. In the implementation planning phase, the pre-screening options should be discussed in details.

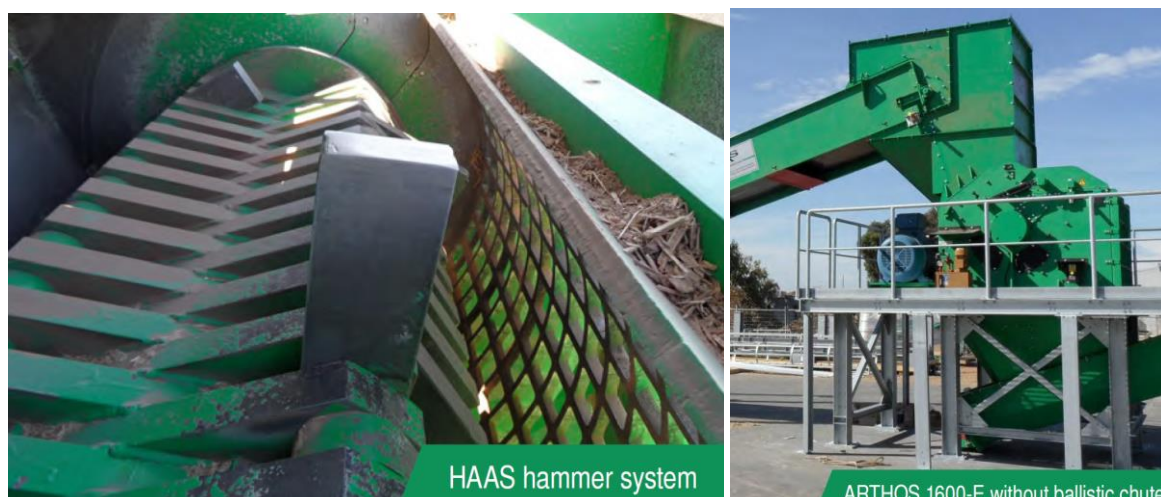
#### 5.2.4 Milling process

In this stage of the treatment, a vertical hammer mill is used. In regards to this specific biomass, the HAAS company recommends to change the hammers by carbon hardened hammers in order to reduce the wear as much as possible, and therefore taking into consideration that the flexibility and hardness of the encroacher bush will challenge the tool's functionality in the long run. The machine AHRTOS 1600 E can be crashed a grind size of 10 – 300 mm of wooden biomass and it can be reduced the grain size to 0 – 80 mm chips<sup>17</sup>. Further-more, an adaption of the set of hammers towards a smaller size would certainly allow to produce e.g. 60 mm chips without any problems<sup>18</sup>. The following figures illustrate the HAAS hammer mill system.

<sup>16</sup> Ibedim

<sup>17</sup> (HAAS Holzzerkleinerungs- und Fördertechnik GmbH 2019)

<sup>18</sup> (HAAS Holzzerkleinerungs- und Fördertechnik GmbH 2020)



**Figure 16.** HAAS Hammer system and the hammer mill ARTHOS 1600 E<sup>19</sup>

The trial in Cologne has shown, that the hammer mill (with a performance of 40 t/h) did not have any problems on milling the received throughput material from the stationary shredder (as was 18 t/h wet material), hence constituting a very promising and reliable operation. Based on these results, for this post treatment facility is assumed a throughput capacity between 30 – 40 t/h for this unit. The ARTHOS 1600-E has an infeed width of 1,600 mm and a height of 1,200 mm. The feeding of this treatment unit occurs with conveyor technologies. The following table shows the key indicators of the hammer mill ARTHOS 1600 E.

**Table 6.** Technical Data of the ARTHOS 1600<sup>20</sup>

| ARTHOS 1.600 E      | Value     | Unit              |
|---------------------|-----------|-------------------|
| Capacity            | 160 - 400 | kW                |
| Elec. Connect.      | 400       | V                 |
|                     | 50        | Hz                |
| Rotor $\varnothing$ | 1,200     | mm                |
| Performance*        | up to 45  | m <sup>3</sup> /h |

\*Depend on the biomass

<sup>19</sup> Ibidem

<sup>20</sup> (HAAS Holzzerkleinerungs und Fördertechnik GmbH 2020)

The wood chips fractions are transported with a conveying system to the post-screening process. The transport can be carried out using a chain conveyor (HMKF 1500), through which the chips are delivered to the flat screen.

#### **5.2.5 Post screening process (flat screen)**

In the post-screening process, a flat screen can be also used. This type of screen is described above. In order to guarantee the success of the treatment, HASS recommends that at this stage the flat screen works smoothly, without any setbacks. Two different fractions of material after milling can be sieved off. The first fraction holds a grain size of <8mm with a share between 7 to 12%. The second fraction holds a grain size of up to 100mm with a share between 88 to 93%. Furthermore, HAAS mentions the option to adapt the sieving equipment further to the material using a star sieving instead of the flat screen, thus depending on the final product requirements, e.g. raw material for pellets<sup>21</sup>.

#### **5.2.6 Performance of the treatment chain**

The performance of the described treatment chain depends on the milling process. This hammer mill can treat around 390 – 520 t/day of biomass.<sup>22</sup> In sum, one treatment chain can be chipped between 105,000 – 135,000 t/a under these assumptions. Based on these results, two production lines are needed to treat around 800 – 1,000 t/d and 200,000 – 250,000 t/a. The following figure illustrates the mass flows in the follow up treatment processes.

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<sup>21</sup> Ibidem

<sup>22</sup> Assumption: Worktime 13 h/d and throughput capacity of 30 – 40 t/h

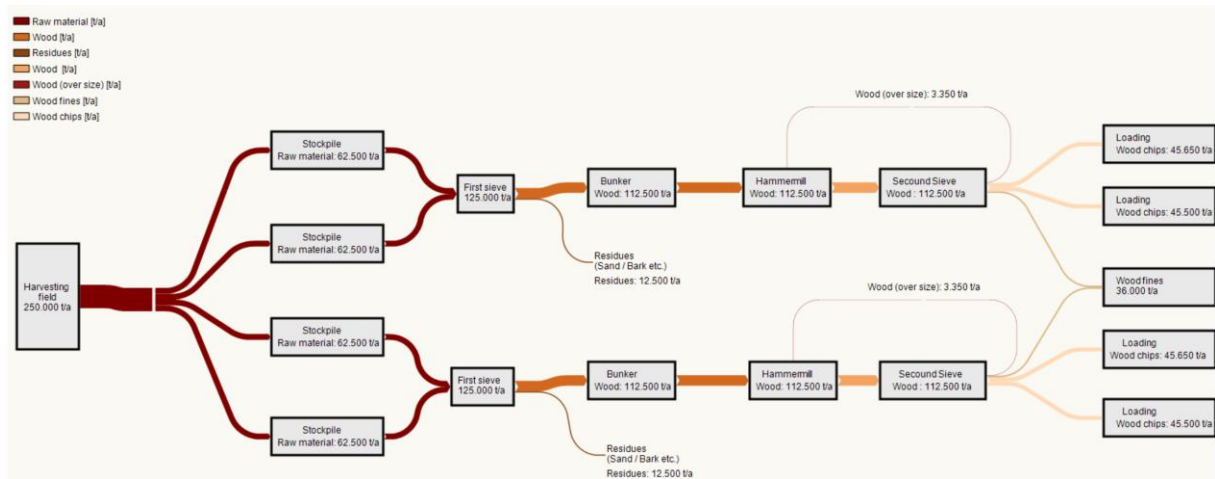


Figure 17: Mass flows in the follow up treatment processes

### 5.3 Realm 3. Processing

The **third realm** “Processing” comprises the refinement of feedstock from the harvesting and post-harvesting realms to final products. Here mainly **five (5)** feedstock fractions are processed. The undersize fraction (impurities <5mm) is used for **composting**. The oversize fraction (>200mm) applies for **pyrolysis** to obtain charcoal, briquettes and biochar. The main fraction (16-100mm) is considered to be a P100 **wood chip**, which either enters directly market or is post-shredded to downsize fractions (such as P30). The 5-16mm fraction can be applied in **pelleting**. The bushfeed fraction after weighting enters a dump sump and is sequenced from this place through a belt dryer towards a hammer mill. The dry and fine material subsequently is mixed with supplements and finally pelletized to obtain **bushfeed**.

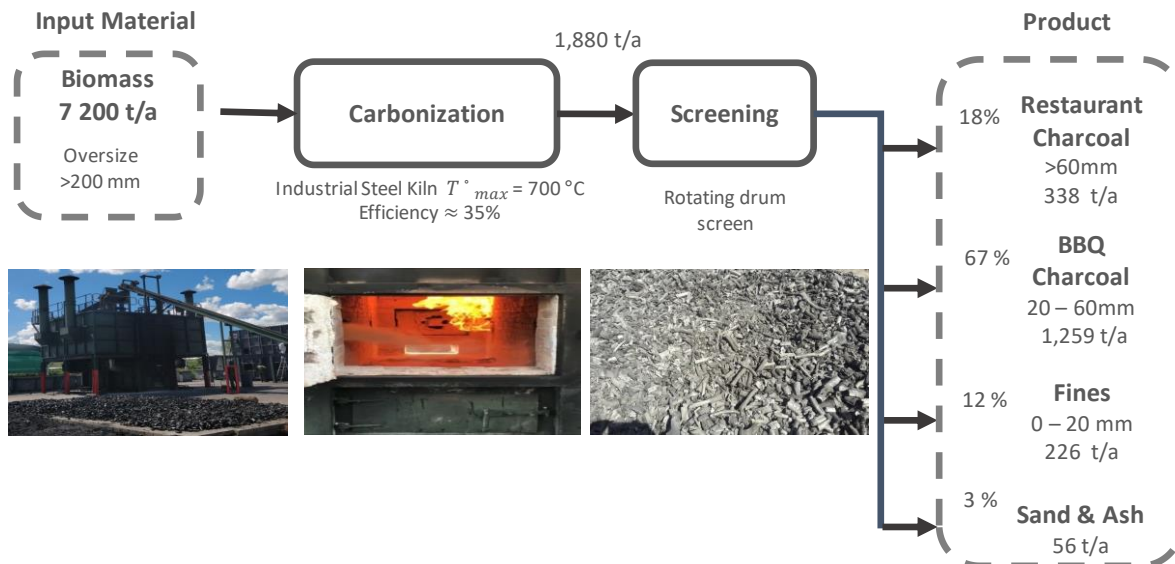
#### 5.3.1 Composting

Fines, bark and ash from the post-harvesting process will be collected and composted. Here no particular treatment is envisaged. It is known that Namibia demands for carbon rich substrates for soil improvement but unfortunately to that point the quality of the material cannot be assessed and selling prices are rather difficult to define. In the present scenario it is assumed that the process and the selling will result in a minus of five (5) EUR/t of compost. However, optimisation potential is given.

### 5.3.2 Pyrolysis (Charcoal, Briquettes and Biochar)

One of the most successful products already made out of bush wood is charcoal, with an annual production of about 85-100 000 t per year (DECOSA 2015). The use of an industrial steel kiln in contrast to the small-scale retorts, offers even higher efficiency rates as of ca. 35 % and utilizes less ignition fuel. A major challenge in charcoal production in Namibia is constant and sufficient fuel supply and final product contamination mainly caused through rain and dust adherence due to the fact the production usually is not in-housed within a controlled environment and the areas are usually not paved. Furthermore, constant heat supply for Briquettes drying is poorly available. All above that, working conditions (shading, controlled air conditioning, etc.) can barely be provide in-field. Some NCA members therefore declared to be willed to operate in the controlled environment such as a BIP were these issues could be addressed. The following figure above describes an industrial steel kiln with the annual input of 7,200 t/a of biomass which produces 1,880 t of carbonized products per annum. The products are then differentiated with a rotating screen drum to yield barbeque charcoal, restaurant charcoal, fines as well as sand & ash. The production of charcoal on a large scale requires less energy input, an increased efficiency and carbon content, in addition to a higher throughput of carbonized products. Another advantage is that the technology can produce high quality charcoal out of bush wood with smaller diameters (> 3 cm compared to >5 cm in mobile kilns), increasing the usable share of the bushes.



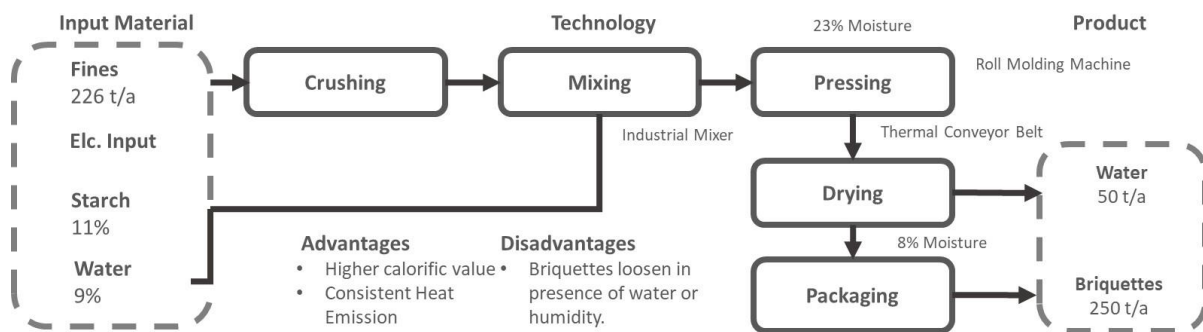


**Figure 18.** Flow Diagram for Large-scale Charcoal Production

A certain amount from the charcoal production, between 10 to 20 %, has a particle size below 20mm and hence is not small and not suitable as barbecue charcoal. The so-called “fines” however can be used to produce charcoal briquettes, which even have a higher calorific value than charcoal. As described in the diagram below, a grinder is used to grind the raw materials’ particle size down to <6 mm, resulting in the homogenous distribution of particles which in turn is responsible for the nearly controlled emission of heat during burning of the final product. The finer particles are then mixed with a binder (starch<sup>23</sup>) and water to activate cohesive forces. The raw product is then pressed in a roll moulding machine, and finally dried to reduce moisture content from 23% - 8%. The quality of the actual briquette production suffers due to inconsistent drying of the product in the open air. In a BIP, the production process could easily utilize waste heat from other production processes (utilizing a thermal conveyor belt) to increase the quality of the product by ensuring thorough dryness.

<sup>23</sup> It is envisaged to gain starch from pelleting. Here a process is currently developed that allows the extraction of sugars from lignocellulose material in pelleting. Furthermore, it is envisaged to obtain starch-similar products from grass paper production using yearlings and saplings from the aftercare management. These are further bio-economic synergies that could develop when the first BIP’s occur.

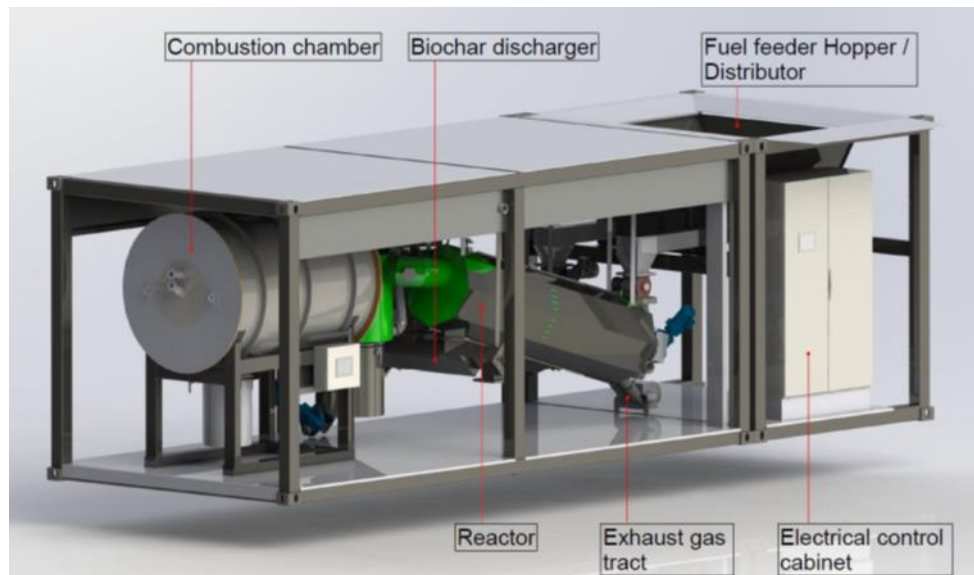




**Figure 19.** Flow Diagram for Briquette Production

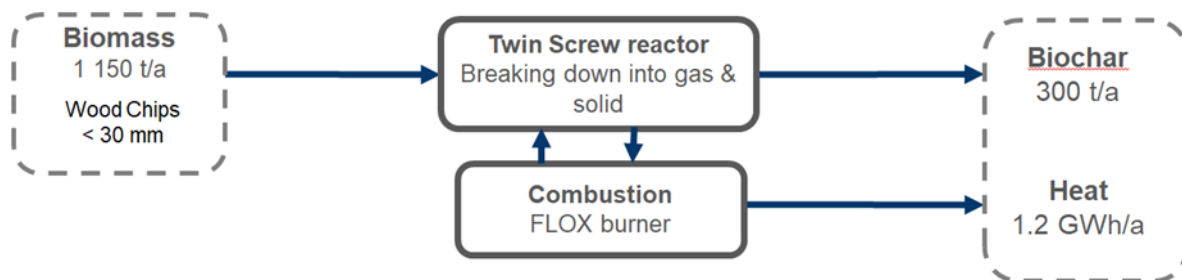
A reliable way to produce EBC proven biochar quality is the PYREG® pyrolysis plant. The PYREG GmbH is a solution provider in the field of environmental technology, and deals with thermal and material recycling of different biomasses as well as the marketing of the produced products. Quality biochar is produced from woody biomass. At the same time excess energy is created for further use. One PYREG-500 module consists of the components shown in the following picture.

The PYREG® system operates according to the principle of dry carbonization. In the two-staged process, the biomass is first heated up to 650 °C in the PYREG® reactor. The biomass is hereby not incinerated, but it is carbonized to biochar, which is easily storable and good for transportation.



**Figure 20.**Components of a PYREG 500-module, source PYREG GmbH

In a second stage the syngas produced in the reactor is completely burnt at about 1,250° C in the combustion chamber. During the PYREG® process, no substances of concern (SOC), such as condensates and tars are produced as the syngas does not cool down, but is thermally oxidized. The generated excess energy of up to 150 kWth can be used for drying moist input material or heating.



**Figure 21.** Material and energy flow PYREG

With one PYREG 500-module approx. 1,150 tonnes of woody biomass can be processed every year. With that biomass, 300 t/a of biochar and 1.2 GWh/a of heat is generated. The heat can be used for briquette and bushfeed drying whereas the biochar is used in bushfeed production as a supplement.

### **5.3.3 Wood chips**

Based on the previous technology scenario it is expected to gain approx. 152,000 t of woodchips annually. The wood chips grain size will be in the range of 16-100 mm, whereby different fractions such as P30, P50 and P100 could be sieved off and individually provided to the traders/customers. For process description cp. chapter 5.2

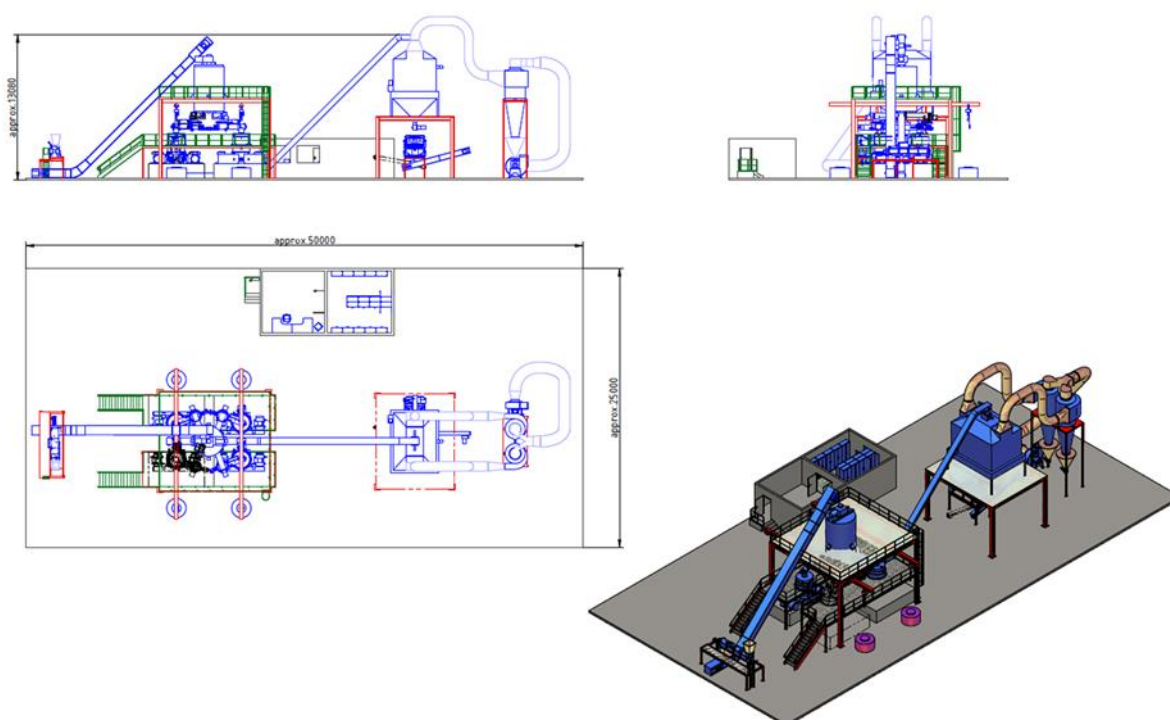
### **5.3.4 Pellets**

Against actual statements from Amandus Kahl Holding GmbH and BPC International Ltd., two internationally leading companies in the pellet business, Namibias Biomass Industry averted from bush-pelletization, due to the fact that several trials with different machinery in the last years resulted in a non-satisfied outcome. The hardness and high silicon content of the material, substantially reduced life time of the equipment and the quality of the pellets was too low to meet international standards such as DIN or I2.

Kahl and BPC in contrast are confident, that Namibian wood is pelletizable. It is obvious that higher wear costs per unit are expected, however are affordable, especially taking into account, that Namibian wood does not need to be dehumidification which saves up to 25% in CAPEX and even more in OPEX, as there is no need to produce heat. To overcome the physical challenge of silicon content, both companies work separately on different solutions to pellet Namibian bush wood. Kahl e.g. concentrates more on de-sanding using improved wind sifters and star sieves, whereas BPC concentrates more on de-sanding with cyclone hammer-mills and softening of the feedstock with vapor. Detailed results are expected soon, however preliminary data have been provided and allow for a first indicative economic assessment.

Pelleting in the present BIP scenario is subdivided into two sections. The first section addresses the feedstock preparation and comprises in-take, defibration, drying,

grinding and sieving (separation). The second section addresses the pelletization process comprising pelletization (die, roller gap, cutting device), cooling and final storage (packaging and loading). Pellet plants can be mounted modular and hence allow for easy scale-up. The present size of a pelletizing plant has been set to approx. 50,000 t/a as this almost equals the expected amount of the undersize fraction (4-16mm) from the post-harvesting realm. The following figure shows a preliminary drawing of a pellet plant.



**Figure 22.** Preliminary drawing of a pellet plant

The biggest advantage, barring the ash and silicate challenges, of Namibian encroacher biomass with regard to pellets is the low moisture content and the price. Generally international pelletizers count 1 Pellet ton (12% moisture) output for 2 tons of raw material (55% moisture) input [feedstock as chip P50-P100], as water needs to be evaporated. Standardized range of purchase price for fresh (FM) raw material is in the range of 50-65 EUR/t<sub>FM</sub> with 20-55% moisture. Calculated on absolute dry matter (a<sub>DM</sub>), this refers to a price of 62-144 EUR/t<sub>aDM</sub>. Comparing these prices with Namibian

encroacher biomass, the potential competitive advantage becomes visible. Encroacher bush wood chips P100 could be supplied in the range of 34-42 EUR/t (8-12% moisture). Calculated on absolute dry matter an equivalent of 37-47 EUR/t<sub>aDM</sub> occurs, which constitutes a delta range of 25-97 EUR/t<sub>aDM</sub> to international common prices.

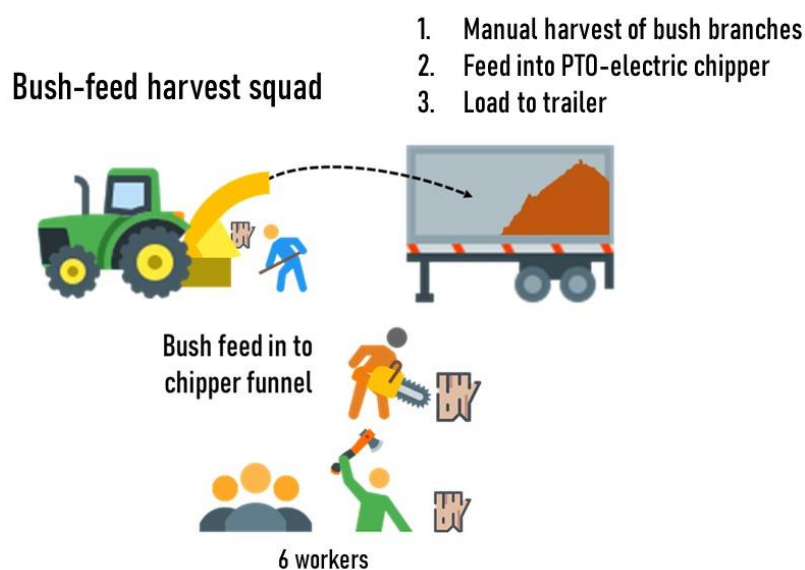
Furthermore, about 20% of CAPEX could be saved and a substantial amount of OPEX as no drying-units are requested and no heat for drying must be produced/purchases. All in all, a tremendous competitive advantage exists in the usage of Namibian encroacher bush for pelleting. Not to forget, that encroacher biomass has a significant higher calorific value than soft woods. Soft wood-based pellets range up to 18,000 MJ/kg, whereas first trials from encroacher bush-based pellets showed calorific values over 21,000 MJ/kg. The savings in drying shall compensate the necessary investments in de-mineralization equipment and improved ash disposal costs for the final customers. The expected tests will prove or deny the assumptions. In contrast to the up-stream realms “harvesting” and “post-harvesting”, where break-even-prices are quite close to market prices pelleting allows for significant higher raw material costs as the delta between market price and break-even-price is much bigger, which could be the key trigger towards the biomass industry in Namibia.

### **5.3.5 Bushfeed**

Bushfeed is a natural product, grown in a clean environment and of great value to the Namibian economy’s livestock production. As huge parts of Namibian farmland are deprived from traditional livestock grazing by encroaching thorny bush vegetation, the removal of invading tree and bush species represents a national challenge.

Bushfeed is a collective term and means the thinner branches, twigs and leaves of trees and bushes. Its feeding value varies according to botanical species, the degree of fineness and the age, respectively the stage of maturation. When harvested from standing vegetation its removal will facilitate the following harvest of more solid parts for producing woodchips

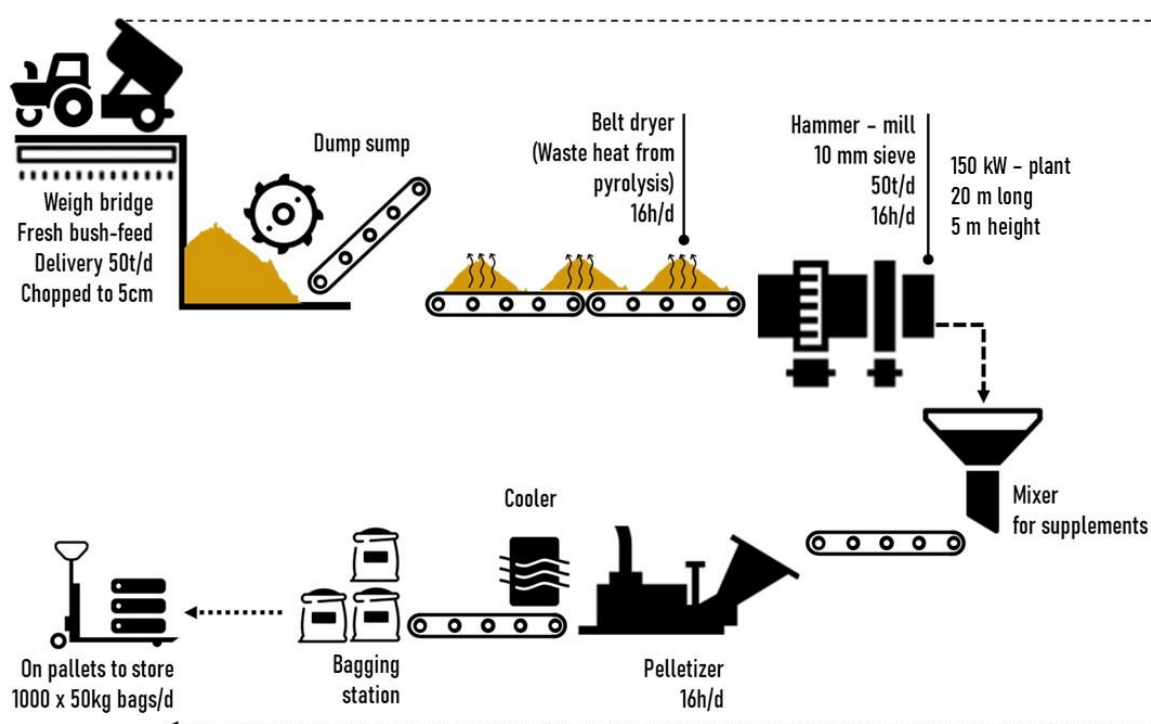
It is understood that mechanical hand-harvest using human workforce plus handheld tools competes with capital intensive big harvest machinery. Focusing on the selectivity of harvesting as demanded by the Namibian authorities and the employment of workers speak in favor of the hand harvest. Research and future modification of the big machinery might modify the harvest method. The following technical setup includes all involved cost and investment for machinery (harvest and process) including building of the bushfeed hub factory. It is understood that only a full-fledged industrial utilization process can serve as a viable tool to remove the vast amounts of encroacher-bush from Namibian farmland. From there a full cost accounting was achieved, necessary for the establishment of a business-plan and a real enterprise.



**Figure 23.** Bushfeed harvesting squad

The following flow-chart illustrates the formation process from delivery of chopped fresh bush branches until bagging of feed-pellets for store and sale. 4 harvest units deliver fresh bush feed and unload into a dump sump. From there, the chopped material is dried on a continuous flow belt dryer which is utilizing heat from the neighboring wood-chip- or charcoal-production. Once dried to 15 % moisture it will

be ground by a hammer mill. This renders the extreme thorns harmless and turns the ground feed into a non-threatening feed. Of course, farmers are afraid of thorns that might penetrate the walls of the animals' rumen and intestinal tract. Once ground, in a mixer feed supplements will be added according to the desired product specifications respectively animal feeding targets. More than 30 mix recipes can be programmed in order to meet all customers' requirements. With focus on the economy of transport the ready-mix loose feed will be pelleted and bagged. The balance of the bagging station will automatically calibrate 25 or 40 kg bags.



**Figure 24.** Bushfeed processing line in BIP

Approximately 10 % of bush dry matter can be utilized for bushfeed. An industrialized production hub will require up to 40 workers who harvest during daytime in four units. Once delivered to the hub, processing of bush biomass will employ 20 more staff working in two shifts. Their daily output of 50 t of bushfeed pellets will provide a bush-based feed to farmers over the whole year. Thus, climatic bottlenecks in continuous supply of good quality ruminant feed will be avoided. To date farmers in

Namibia regarded bushfeed as a means to survive drought periods. Supplementing harvested biomass from encroached bushland with a few nutrient components prior to pelleting will provide a reliable complete feed which can be stored over a period of up to 9 months. Continuous flow harvesting and drying plus mixing it with supplements before pelleting is a great possibility to improve the nutritive value, palatability, digestibility and storability of bush based ruminant feed.

Massive bush encroachment currently affects 30 million ha of Namibian farmland. From estimated 480 million t of dry matter approximately 50 million t are available to be converted into feed. This indicates a bushfeed's hub important upscaling effect in the training of staff. Besides this, first hubs will also serve as field labs to screen and test machinery and its suitability to perform under extreme harsh climatic and environmental conditions.

The great advantage of bushfeed is the option of adding all kinds of supplements via the mixer in order to meet all kinds of ruminant feeding objectives. A very interesting utilization of by products is the supplementation of bushfeed with grass juice from paper production. There, the cell content has to be removed in order to produce paper pulp and in the bushfeed hub this juice serves as valuable source of protein.

The projected production cost of one t of supplemented feed pellets in a continuous flow hub process line clearly underquote the cost and price of a small level or farm level production. The price/t is 210 EUR compared with 225 EUR. Cost advantage would be even greater if also the farm level production would base on full cost calculation. In terms of quality the BIP product will offer better feeding value by avoiding contamination with sand during drying and manual handling on the farm. The bushfeed pellet output per hub will completely cover the roughage feed demand of more than 4,000 cattle. The modern process line will be able to prepare individual nutrient requirements as the voluminous mixers will instantly mix 30 different



ingredients. Thus, the plant will be able to satisfy all potential compositions for all ruminant production systems. The economic interaction of landowners, livestock owners and potential feedstuff producers and exporters might trigger the formation of new rural business entities – cooperatives or associations.

On top of local and domestic utilization of bush vegetation, put into value as bushfeed pellets, Namibia will be in the position to export pelleted feed. By volume this business has got the potential to become Namibias second important export commodity – after meat. As a most welcome side effect, periods of drought and loss of animals as important national production factors do not represent threats to the economy anymore. Also, domestic and safe feed base will turn Namibia independent from imported feedstuff to survive drought periods. Involved logistics will provide even more jobs as the transport of ready-made feed pellets as well as the port facility and capacity will contribute to an improved national employment situation. A projected number of 105 bushfeed hubs in Namibia will provide safe jobs for more than 6,000 people. This forms an extremely valuable support in fighting unemployment. The generation of tax and corporate tax income through general increase of economic activities will generate additional financial means for the public sector in providing services. Around 60 persons will be finding a safe employment in the bushfeed branch of one BIP. Additionally, adequate housing facilities will be provided and – in case enough families with kids are working there – a kindergarten for the little ones can be established on the premises.

150KW PLANT (190 Kva)  
 MAIN BREAKER SIZE - 300 amp 3 pole  
 MAIN CABLE SIZE - 150mm squared 4 core armor core (can handle 335amps)  
 EARTH CABLE SIZE - 125mm squared

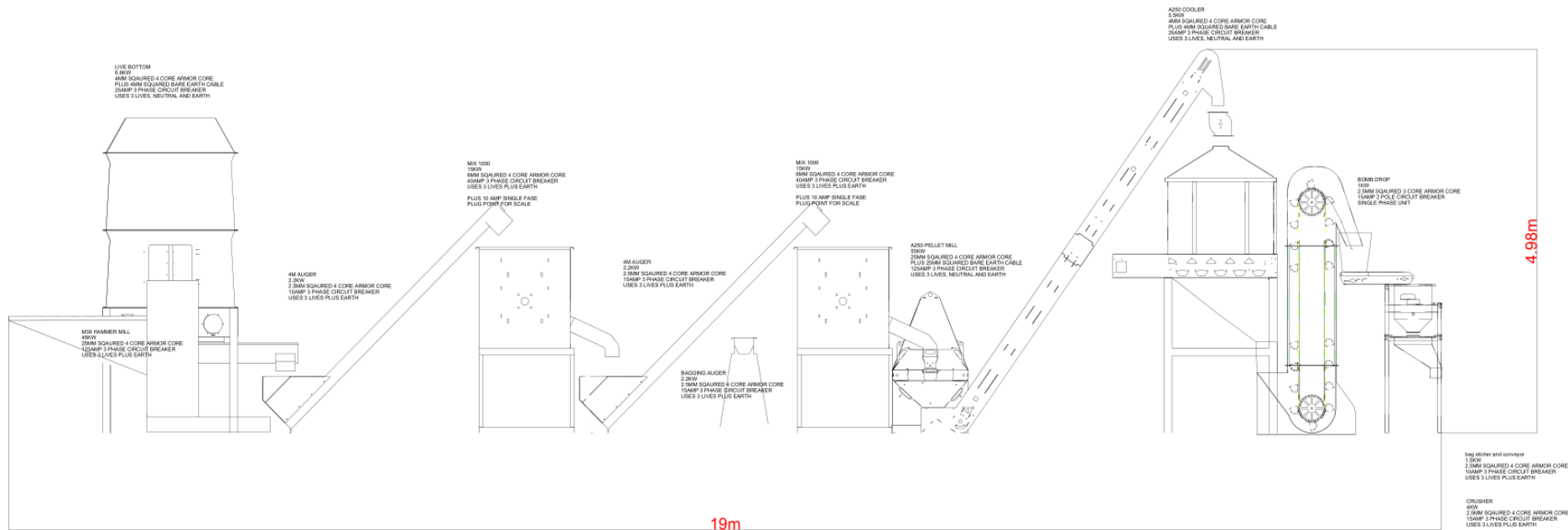


Figure 25. Large-scale bushfeed palletization line

### **5.3.6 Photovoltaic system for electricity provision**

#### **Energy Sufficiency**

In accordance with the BIP's objectives of competitiveness and eco practices, this RM assessed the readiness of the BIP to cover its energy needs from an industrial sized solar photovoltaic (PV) plant. For the better readability of this section, the chapter has been divided to various sections in accordance with the scope of work carried out for this purpose.

#### **Objectives & Scope**

An energy intensive industry like biomass conditioning relies to an extent on energy prices. In light of relatively high electricity tariffs in Namibia, the purpose of this exercise is to calculate the levelized cost of electricity (LCoE) from a PV plant. This is a main performance indicator that allows for comparison between different energy sources. In order to get to this value, the study tests, both the technical and economic feasibility of the plant in order to estimate all relevant parameters required to calculate an LCoE with a very high standard of reliability.

#### **Methodology & Results**

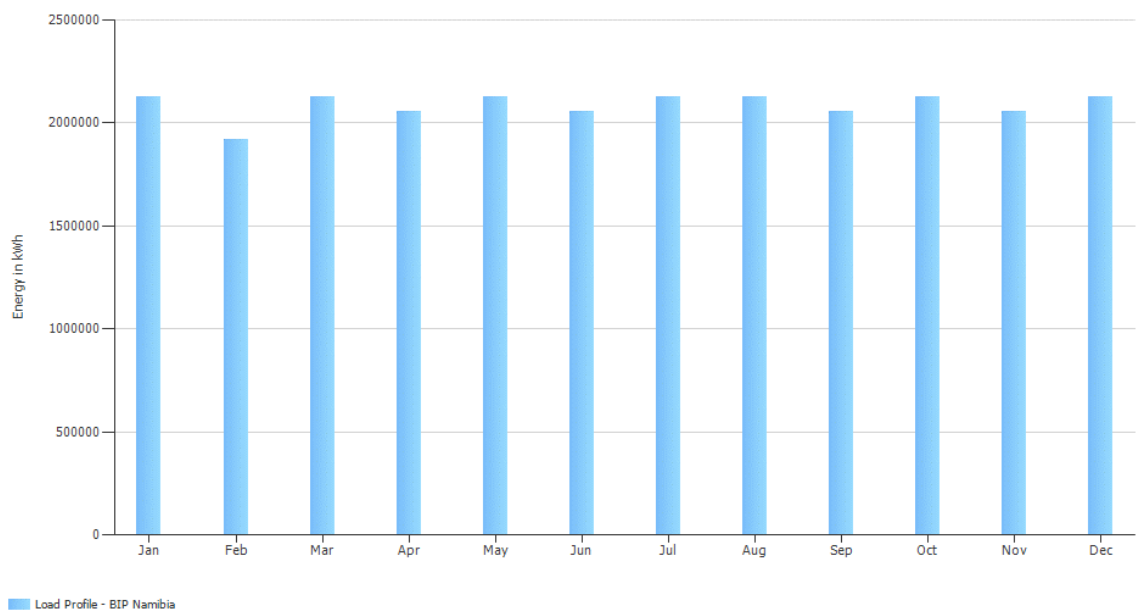
##### **Technical Dimensioning**

This study relies on PV\*SOL<sup>24</sup> as a simulation software to model the load profile and the energy provision as technical feasibility study. In order to model the energy flows of the BIP, the load profile of the BIP has been modelled based on an existing model available in PV\*SOL. The prototype is a modified based on the prototype industrial process load with a constant energy consumption over the whole year totaling 20

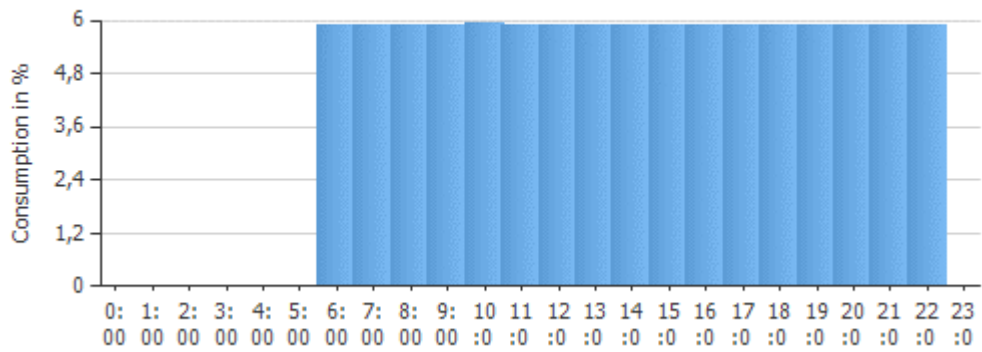
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<sup>24</sup> PV\*SOL is a dynamic simulation program with 3D visualization and detailed shading analysis for the calculation of photovoltaic systems in combination with appliances, and backup systems.

GWh/a. Assuming that the BIP will adopt a two-shift model starting at 6:00 am and finishing at 10:00 pm, the load varies annually as shown in Figure 26 and hourly as shown in Figure 27.



**Figure 26.** BIP monthly modelled electricity consumption profile

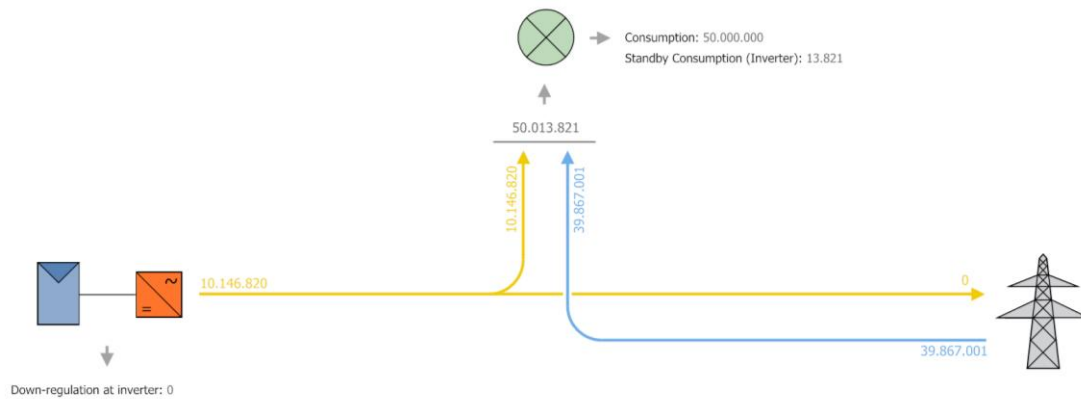


**Figure 27.** BIP hourly load profile in %

To guarantee the injection of the totality of energy, the capacity of the plant has been dimensioned to be lower than the baseline load (in this case 5 MW<sub>p</sub>) which guarantees covering more than 10.146.820 kWh which represents more than the fifth of the energy demand of the BIP in this specific case as illustrated in the energy flow diagram in Figure 28.

## Energy Flow Graph

Project: BIP Namibia



**Figure 28.** Energy Flow Diagram of the BIP, the PV plant, and the Grid

The dimensions and key figures of the plant are summarized in Table 7. Compared to an average 1.700 kWh/m<sup>2</sup> in Germany, the global radiation per square meter in Namibia goes up to 2.480 kWh/m<sup>2</sup> guarantying the production of around 10 GWh/y using around 42 hectares.

**Table 7.** BIP PV Plant Key Figures

| Parameter                      | Value        | Unit               |
|--------------------------------|--------------|--------------------|
| PV Generator Output            | 5,000        | kWp                |
| PV Generator Surface           | 41,916.9     | m <sup>2</sup>     |
| Global Radiation at the Module | 2,480.2      | kWh/m <sup>2</sup> |
| PV Generator Energy (AC grid)  | 10,146,820.4 | kWh/y              |
| Spec. Annual Yield             | 2029.4       | kWh/kWp            |
| Performance Ratio (PR)         | 81.8         | %                  |

## Levelized Cost of Electricity (LCoE)

Based on the simulation results and market financial values surveyed in Namibia, a cost benefit analysis has been conducted to calculate the LCoE from the PV plant. Based on an average specific investment of 23.129 N\$/kWp, accounting for maintenance and operation costs as 2% of the capital expenditures (CAPEX), and an average tariff of electricity from NAMPOWER of 2,3 N\$/kWh, the LCoE is as low as 1,16 N\$/kWh.

**Table 8.** BIP PV Plant overview and economic parameters

| Parameter   | Value           | Unit     |
|---|-----------------|----------|
| Grid Feed-in in the first year (incl. module degradation) | 0               | kWh/Year |
| PV Generator Output                                       | 5,000           | kWp      |
| Start of Operation of the System                          | 18.05.2020      |          |
| Assessment Period   | 25              | Years    |
| Interest on Capital                                       | 2               | %        |
| <b>Economic Parameters</b>                                |                 |          |
| Accrued Cash Flow (Cash Balance)                          | 57,760,683.19   | €        |
| Minimum System Operating Period                           | 3.4             | Years    |
| Electricity Production Costs                              | 0.05            | €/kWh    |
| <b>Payment Overview</b>                                   |                 |          |
| Specific Investment Costs                                 | 1,200.00        | €/kWp    |
| Investment Costs  | 6,000,000.00    | €        |
| Incoming Subsidies  | 0.00            | €        |
| Annual Costs  | 120,000.00      | €/Year   |
| Other Revenue or Savings                                  | 0.00            | €/Year   |
| <b>Loans</b>  |                 |          |
| Loan Capital  | 6,000,000.00    | €        |
| Payment Instalment  | 100             | %        |
| Credit type   | Instalment Loan |          |
| Term  | 10.00           | Years    |
| Grace period  | 2.00            | Years    |
| Interest  | 5.50            | %        |
| Repayment Period  | quarterly       |          |

## Environmental Impact

To determine the GHG abatement potential associated with introducing electricity from renewable energy at the BIP, the large-scale consolidated clean development mechanism (CDM) methodology ACM0002 for Grid-connected electricity generation from renewable sources is employed. Box 1 presents the methodological details adapted from the UNFCCC approved methods<sup>25</sup>. The principal course of action taken herein is the introduction of clean electricity and the replacement of fossil fuel-based systems with renewable electricity PV plant system. Using this method and referring to the Namibian electricity grid factor of 0,91<sup>26</sup> tCO<sub>2e</sub>/MWh, the PV plant would contribute to mitigating 9.233 t CO<sub>2e</sub>/y.

### **BOX 1 | ACM0002: Adapted CDM grid-connected electricity generation from renewable sources**

SCOPE: This methodology applies to project activities that include retrofitting, rehabilitation (or refurbishment), replacement or capacity addition of an existing power plant or construction and operation of a Greenfield power plant.

#### APPLICABILITY:

This methodology is applicable to grid-connected renewable energy power generation project activities that:

- (a) Install a Greenfield power plant;
- (b) Involve a capacity addition to (an) existing plant(s);
- (c) Involve a retrofit of (an) existing operating plants/units;
- (d) Involve a rehabilitation of (an) existing plant(s)/unit(s); or
- (e) Involve a replacement of (an) existing plant(s)/unit(s).

The project activity may include renewable energy power plant/unit of one of the following types: hydro power plant/unit with or without reservoir, wind power plant/unit, geothermal power plant/unit, **solar power plant/unit**, wave power plant/unit or tidal power plant/unit;

#### METHODOLOGY:

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<sup>25</sup> Extracted and adapted from:

[https://cdm.unfccc.int/filestorage/A/G/0/AG07ZJO3EXD42LT5YV9HR16M8KINPO/EB105\\_repan03\\_ACM0002.pdf?t=cFI8cWFxZDdnfDC4HQGWNT5x4ROMfFuCr](https://cdm.unfccc.int/filestorage/A/G/0/AG07ZJO3EXD42LT5YV9HR16M8KINPO/EB105_repan03_ACM0002.pdf?t=cFI8cWFxZDdnfDC4HQGWNT5x4ROMfFuCr)

<sup>26</sup> Extracted from an existing certified UNFCCC project referenced as CLEAN DEVELOPMENT MECHANISM PROJECT DESIGN DOCUMENT FORM (CDM-SSC-PDD) Version 03 - in effect as of: 22 December 2006.

Baseline emissions include only CO<sub>2</sub> emissions from electricity generation in fossil fuel fired power plants that are displaced due to the project activity. The methodology assumes that all project electricity generation above baseline levels would have been generated by existing grid-connected power plants and the addition of new grid-connected power plants. The baseline emissions are to be calculated as follows:

$$BE_y = EG_{PJ,y} \times EF_{grid,CM,y}$$

Where:

|                  |   |   |
|------------------|---|---|
| $BE_y$           | = | Baseline emissions in year y (t CO <sub>2</sub> )   |
| $EG_{PJ,y}$      | = | Quantity of net electricity generation that is produced and fed into the system as a result of the implementation of the CDM project activity in year y (MWh/yr).   |
| $EF_{grid,CM,y}$ | = | Combined margin CO <sub>2</sub> emission factor for grid connected power generation in year y calculated using the latest version of "TOOL07: Tool to calculate the emission factor for an electricity system" (t CO <sub>2</sub> /MWh) |

Emission reductions on annual basis (ER<sub>y</sub>) are calculated as follows:

Note that in this case, emissions from the operation of the PV plant are assumed to be null.

$$ER_y = BE_y - PE_y$$

Where:

|        |   |   |
|--------|---|---|
| $ER_y$ | = | Emission reductions in year y (t CO <sub>2</sub> e/y) |
| $BE_y$ | = | Baseline Emissions in year y (t CO <sub>2</sub> /y)   |
| $PE_y$ | = | Project emissions in year y (t CO <sub>2</sub> /y)    |



### 5.3.7 Residential area, schools, kindergarten and playgrounds

#### **Intended cost structure for essential services and accommodation facilities in BIP for the newly created jobs.**

With the development of the BIP, it is expected to generate around 200 new jobs within the area specifically for BIP processes. Considering the suburb location of BIP, it is essential to deliver the basic accommodation and services for the employees and their families. As a general principle, the competent authorities should, in order to ensure structural safety and reasonable levels of decency, hygiene and comfort, establish minimum housing standards in the light of local conditions and take appropriate measures to enforce these standards. In regard to develop the cost structure, minimum requirements in the ILO convention (also in line with FSC and PEFC certification procedures) was considered. Proposed housing of employees is exceeding the minimum requirements of ILO convention and has more options to select in between houses or flats depending on personal desire. Other than accommodation, the proposed housing scheme will have day care centers, schools, dispensaries, small supermarkets, community centers, fitness centers, gardens and security fleet etc. For the cost calculation, lowest values were determined based on regional observations and online sources. For the final calculation, 15% of unforeseen cost added to the total investment.

It is estimated to have a community about 340 residents with new 200 jobs which includes nearly 70 families (live and work) and 50-80 individual workers. Also, there will be around 100 children in the age of 0-14 years in the premises. To support 340 residents, the following accommodation and social services are identified as a concept to develop in the BIP location. Projected cost structure and combination of different units are listed in Table 9.

**Table 9.** Cost structure for the proposed housing scheme

| Social/Service center and accommodation type <sup>27</sup> | No of families/unit | No of occupants/unit | Required average space/unit | Approximate Building Cost Rates in Namibia (2012) <sup>28</sup> |       |        | Current cost <sup>29</sup>  |         | Requirement of building per community (relation to no. of jobs) |     |     |     |     |     |
|--|---------------------|----------------------|-----------------------------|---|-------|--------|-----------------------------|---------|---|-----|-----|-----|-----|-----|
|  |                     |                      |                             | (Rate per m <sup>2</sup> or unit Excl VAT)                      |       |        | Per building/service center |         | 150   | 200 | 250 | 300 | 350 | 400 |
|  |                     |                      | m <sup>2</sup> or one unit  | Unit  | N\$   | EUR    | N\$                         | EUR     |   |     |     |     |     |     |
| Family Flats (3 floors)                                    | 12                  | 48                   | 864                         | m <sup>2</sup>  | 1200  | 73.2   | 1,523,933                   | 92,960  | 2   | 4   | 4   | 4   | 5   | 6   |
| Houses (2 rooms)   | 1                   | 4                    | 65                          | m <sup>2</sup>  | 3000  | 183    | 286,619                     | 17,484  | 6   | 6   | 10  | 12  | 9   | 10  |
| Houses (3 rooms)   | 1                   | 5                    | 85                          | m <sup>2</sup>  | 3000  | 183    | 374,810                     | 22,863  | 3   | 3   | 6   | 6   | 4   | 6   |
| Flats for single workers                                   |                     | 60                   | 792                         | m <sup>2</sup>  | 1000  | 61     | 1,164,116                   | 71,011  | 2   | 2   | 3   | 4   | 5   | 6   |
| Small Schools  |                     | 100                  | 400                         | m <sup>2</sup>  | 3000  | 183    | 1,763,812                   | 107,593 | 1   | 1   | 1.5 | 1.5 | 2   | 2   |
| Kinder Gardens   |                     | 20                   | 400                         | m <sup>2</sup>  | 1500  | 91.5   | 881,906                     | 53,796  | 1   | 1   | 1   | 1   | 2   | 2   |
| Play grounds   |                     | 200                  | 2000                        | m <sup>2</sup>  | 800   | 48.8   | 2,351,749                   | 143,457 | 1   | 1   | 1   | 1   | 1   | 1   |
| Laboratories   |                     | 0                    | 150                         | m <sup>2</sup>  | 3000  | 183    | 661,429                     | 40,347  | 1   | 1   | 1   | 1   | 1   | 1   |
| Fitness centers  |                     | 20                   | 300                         | m <sup>2</sup>  | 2500  | 152.5  | 1,102,382                   | 67,245  | 1   | 1   | 1   | 1   | 2   | 2   |
| Restaurants  |                     | 50                   | 210                         | m <sup>2</sup>  | 3000  | 183    | 926,001                     | 56,486  | 1   | 1   | 1   | 2   | 2   | 2   |
| Dispensaries   |                     | 350ppe               | 85                          | m <sup>2</sup>  | 2500  | 152.5  | 312,342                     | 19,053  | 1   | 1   | 1   | 1   | 1   | 1   |
| Post offices   |                     | 350ppe               | 50                          | m <sup>2</sup>  | 2500  | 152.5  | 183,730                     | 11,208  | 1   | 1   | 1   | 1   | 1   | 1   |
| Community centers  |                     | 350ppe               | 500                         | m <sup>2</sup>  | 2500  | 152.5  | 1,837,304                   | 112,076 | 1   | 1   | 1   | 1   | 1   | 1   |
| Small super markets  |                     | 350ppe               | 400                         | m <sup>2</sup>  | 3000  | 183    | 1,763,812                   | 107,593 | 1   | 1   | 1   | 1   | 1   | 2   |
| Street lights <sup>30</sup>                                |                     | 350ppe               | 1                           | 350ppe  | 36723 | 2240   | 53,977                      | 3,293   | 1   | 1   | 1   | 1.5 | 2   | 3   |
| Gardens  |                     | 350ppe               | 1000                        | 350ppe  | 400   | 24.4   | 587,937                     | 35,864  | 1   | 1   | 1   | 2   | 2   | 3   |
| Security services <sup>31</sup>                            |                     | 350ppe               | 1                           | 350ppe  | 73200 | 4465.2 | 107,593                     | 6,563   | 1   | 1   | 1   | 2   | 2   | 2   |
| Church(s)  |                     | 350ppe               | 300                         | 350ppe  | 3000  | 183    | 1,322,859                   | 80,694  | 1   | 1   | 1   | 1   | 1   | 1   |

<sup>27</sup> Housing standards - <https://www.ilo.org/dyn/normlex/en>

<sup>28</sup> Construction related costs -<https://www.jonqs.com>

<sup>29</sup> Inflation rate in Namibia - <https://www.statista.com>

<sup>30</sup> Street lighting in Namibia -<https://www.solar-streetlights.com>

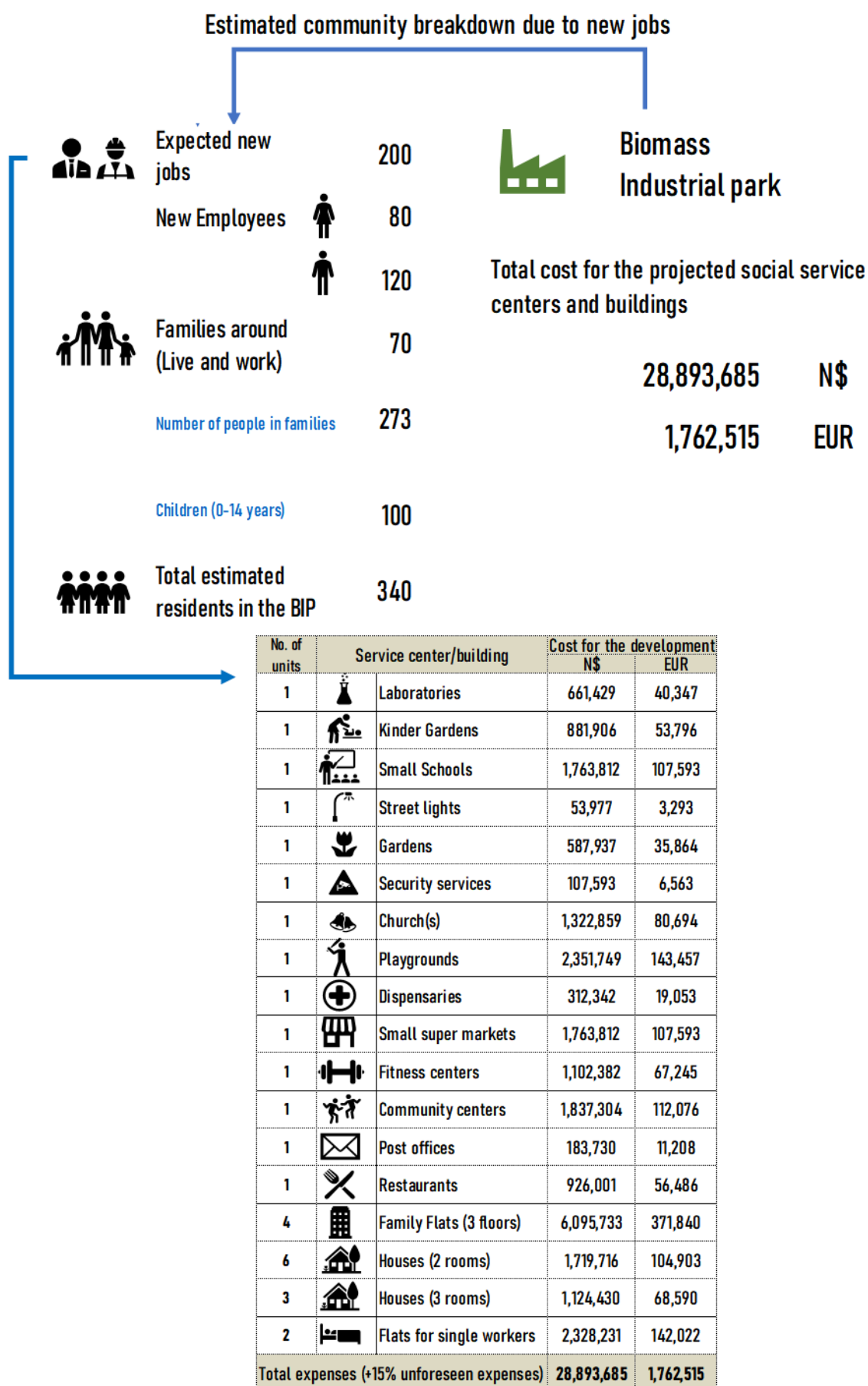
<sup>31</sup> Security services costs -<https://www.namauto.com>

Schools are for primary and secondary education. Dispensaries will have integrated pharmacies. Playground will have basic running tracks, football field etc. Street lights will have 100 sets of solar powered light poles for 350 people equivalent community (7m light pole and 40W LED with 2day backup).

Above cost structure was developed for the illustrative purposes. Also, it is assumed that these facilities will be delivered with basic fittings such as windows, doors sanitary wares, lighting, plug points, taps and other essential fittings but not with furniture. The initial investment for the community development can be subsidized by a share of the profit and a small renting fee from the residents depending on the accommodation type and for essential services such as lighting, water, security etc. The aim should be that adequate and decent housing accommodation should not cost the worker more than a reasonable proportion of income, whether by way of rent for, or by way of payments towards the purchase of, such accommodation. The cost for the infrastructure can be varied due to the place, supplier as well as the materials used for the construction.

As per the ILO convention, employees housing should, in so far as realistic and taking into account available the accessibility within easy reach of places of employment, and in close proximity to community facilities, such as schools, super markets, recreation areas and facilities for all age groups, medical services and religious facilities should be so sited as to form decent and well planned areas, including open spaces such as gardens and parks. Further it is an essential requirement in the design of houses and the planning of new communities for workers, every effort should be made to consult relevant representatives of future occupants and communicate in advance to finalize on the most suitable means of meeting their housing and environmental needs.

By considering all the essential factors mentioned in relevant conventions, a new community which will depend on 200 new jobs at the BIP will have a combination of residents and their projected social centers and accommodation facilities as follows.



**Figure 29.** Projected new community breakdown around BIP

## **6 Business plan**

### **6.1 Objective and applied method of the business plan**

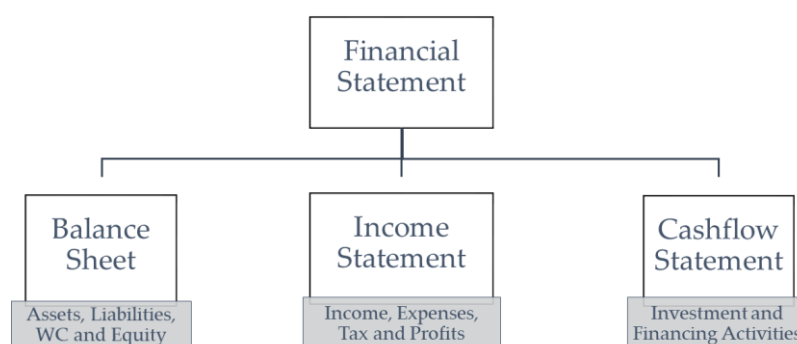
The objective of the business plan was to define break-even-prices for each realm and check if based on these prices the subsequent processes could still reach an economic viability and if the final product prices could satisfy market requirements. Additionally, the determination of the total investment demand was envisaged, in order to get a first insight about CAPEX magnitude with regard to financing a BIP implementation in Namibia. Furthermore, the goal was to identify crucial variables for each single realm and process within the BIP in order to deduce recommendations for action. Finally, the business plan allows to derive socio-economic relevant data such as job creation and corporate tax payments (regional added value creation) which are politically essential for the development of a new industry branch in Namibia. The business plan is based on a two-pronged approach, whereas harvesting and post-harvesting processes are evaluated both to define unit costs and cashflow indicators. Final processing concentrates on cashflow evaluation only as the processes are approved and no need for unit cost hotspot identification is needed. The cashflow evaluation is based on the creation of a financial statement.

#### **6.1.1 Financial Statement**

Within a company (or a project), all relevant financial information is presented in an easily comprehensible manner in the form of a financial statement. The financial statement consists mainly of three financial accounting-related calculations, accompanied by a management discussion and analysis. The aim of the financial statement is to be able to evaluate companies or their projects based on balance sheet figures. Valuation variables can be quite different. For example, the internal rate of interest, the return on equity or the net debt can help to provide economic assessments about the company. Above all, the liquidity, especially in the early years and later for dividend payouts and payment of re-investments, is crucial. The asset balance consists of three parts:

- I. The standardized balance sheet; with the aim of simplifying the balance sheet and thereby making it analysable (cover ratios).
- II. The profit and loss account; used to calculate and judge the operating business.
- III. The cash flow statement; to calculate the liquidity as well as the financial strength and profitability.

The preparation of a financial statement can be carried out retrospective and prospective. In contrast to the retrospective determination where key figures can be analysed based on these annual financial statements, the prospective calculation serves as a financial plan based on planned-, profit and loss accounts for assessing the future ability to meet financial obligations. Companies should therefore always be examined for their solvency. The sheets prepared in this study is prepared prospectively. Figure 30 illustrates the structure of a Financial Statement.



**Figure 30.** Financial Statement set-up.

#### 6.1.1.1 Standardized Balance Sheet

A standardized balance sheet is used by analysts to make comparisons of companies or individual projects comparable and more easily analysable. In doing so, the company's trading balance is structured. The structural preparation means that the large number of listed balance sheet accounts of assets and liabilities are restructured into consolidated balance sheet accounts such as fixed assets and current assets or in equity and debt. This makes the balance sheet easier and more comprehensible and

enables direct determination of economic indicators. There are principles for the restructuring of the balance sheet, but no generally binding rules.

The fixed capital is determined by adding the fixed assets, consisting of property, plant, and equipment (technical equipment and machinery) as well as land and net working capital. In addition, the standardised balance sheet shows the development of equity and debt capital as well as cash. The standardized balance sheet is always linked to the profit and loss account as well as the cash flow statement. The model follows a "roller". The calculations cover periods of up to 30 years.

#### 6.1.1.2 Profit and Loss Account

The Business Encyclopaedia of BPB defines the profit and loss account (P & L) as part of the annual financial statements. By recording and offsetting all income and expenses incurred in a fiscal year, the profit or loss is reported as a net profit or loss for the year. The profit and loss account, therefore, has the task of making the success of the individual success sources identifiable according to the type and amount, thereby providing an insight into the state of the annual result, thus supplementing the balance sheet. For this purpose, the German Commercial Code (HGB) requires the non-balanced comparison of all types of expenses and income. The income statement thus describes the operational performance of the company.

The profit and loss account is based on the requirements of the IFRS. The gross margin is calculated by offsetting the sales revenues with the material costs. The sum of gross margin, personnel costs, other expenses and administrative costs is the gross profit (EBITDA - Earnings before Interest, Tax, Depreciation and Amortization). Gross profit minus non-cash depreciation results in earnings before interest and tax (EBIT). The sum of EBIT and interest result reveals the taxable income (EBT - Earnings before Tax) which, after deduction of corporation tax, shows the profit or loss carried forward (EAT).

### 6.1.1.3 Cash Flow Statement

The inadequate liquidity orientation of a balance sheet prevents an insight into the liquidity situation of the company. Impaired payment bottlenecks and liquidity gaps can only be recognized in a timely manner if a cash flow statement is derived from the balance sheet and income statement.

The German Commercial Code (HGB) currently does not provide for an autonomous, time-related accounting for the financial position that presents the financial flows that are significant for the assessment of the dynamic aspect of the financial situation. Together with the information provided by the annual financial statements, the cash flow statement serves a better assessment of the company. The evaluation of

- the ability to generate payment surpluses,
- the ability to meet payment obligations and to use equity,
- the impact of investment and financing on the financial situation,
- the reasons for the divergence between net profit for the year and net cash flow from operating activities,

comprise the focus of the activity. The cash flow statement can either be created by direct input of the payment flows or derivatively from the annual financial statement data. A cash flow statement, as a period-based accounting for the financial situation, breaks down the relevant financial statements according to factual aspects and divides them into new, independent areas.

The cash flow statement is based on the provisions of IFRS, whereby the cash flows are divided into the following areas:

- operating activities,
- investment activities,
- financing activities.



By subdivision, each activity area can be enriched in its information content, which allows a differentiated analysis. The EBITDA, which is the descriptive value of current business, is cleaned up from taxes and changes in net working capital, the result is the cash flow from operating activities, also known as net OPEX. Investments in property, plants and equipment represent the cash flow from investing activities, also known as CAPEX. The sum of operating and investing cash flow results in the free cash flow. The free cash flow shows how much liquidity is freely available in the financial year after investing.

The free cash flow must be able to repay loans and pay dividends. Equity and debt capital are in-flows in the company. The repayment and interest on borrowed capital are outflows. The total cash inflow and outflow is the cash flow from financing activities. The sum of cash flow from financing activities and free cash flow is called Total Cash Flow. The total cash flow indicates the amount of money remaining at the end of the period (financial year) after payment of all liabilities. This shows how much additional funding (in this case equity) exists to postpone the cooperative. A negative total cash flow leads to a reduction in cash. A positive total cash flow leads to an increase in cash.

#### 6.1.1.4 Projected operational expenditure (OPEX Layout)

Each described realm in the BIP has its own operational expenditure breakdown. Mainly there are variable operational expenses as well as fixed operational expenses. Variable operational expenses are maintenance, fuel and energy costs, essential utilities such as water etc. Salaries, administration expenses, rents and such expenses are categorized as fixed operational expenses. The total OPEX breakdown for Harvesting, Processing of raw materials, Pellets, Bushfeed, Charcoal and Briquettes are as in Table 10 (average for one year -project time 10 years).

**Table 10: OPEX breakdown in BIP**

| <b>BIP Realm</b>               | <b>OPEX<br/>(EUR)</b> |
|--------------------------------|-----------------------|
| <b>Harvesting</b>              | 5,153,052             |
| <b>Raw material processing</b> | 949,068               |
| <b>Pellets</b>                 | 4,916,713             |
| <b>Bushfeed</b>                | 1,050,327             |
| <b>Charcoal and Briquettes</b> | 899,722               |

#### 6.1.1.5 Sensitivity Analysis

Based on the financial statement, different information (results) can be obtained for various target groups using indicators and values. Some information, such as total cash flow or working capital, is primarily used for company management and decision-making, therefore for the internal representation. Other key figures, such as the Internal Rate of Return (IRR) or the Flow to Equity, are used for the external presentation and promotion of the company. Another key indicator for assessing credit worthiness is, for example, the level of debt service and interest coverage. The calculation model serves two target groups. The target groups of active and passive participants. The group of active participants is the operators and owners. The group of passive participants is the borrower. Based on a performance chart, key figures are presented at a glance. The passive group of investors and borrowers is particularly interested in the internal rate of return and the net asset value according to the WACC based free cash flow discounting, the value of equity and its average growth rate.

Each realm in BIP and their performances are much important for the smooth functioning of the complete project. Financial performance is one of the main aspects to maintain and evaluate over the time since the beginning as it is the driving force for the complete project. In that regard, the importance of the understanding and the evaluation of key sensitive factors in each realm is discussed briefly under this chapter.

There are number of variables which effects to the financial aspects of the project. Although, there are few major variables in each realm to affect the outcomes severely. The level of impact towards NPV, IRR and payback period were analyzed. Top 3 – 6 indicators for each realm were defined and listed.

Identification of key variables which effect the highest impact for each realm was the first step. As the methodology; change of each factor by increasing the baseline value from 5%, 10% and 25% as well as the decrement from 5%, 10% and 25% were analysed. Finally, NPV, IRR and payback were calculated for each difference of the identified factors.

As per the illustrative purpose; sensitivity analysis of the Harvesting section in the BIP is described below. In general, there are several variables which contribute to the main indicators such as NPV, IRR etc. To understand the level of impact and how it is important for the proceeding of the project, 5 variables were identified and prioritized them as per the level of impact towards NPV, IRR and payback period.

As per the illustration in Figure 31, Sales price of Biomass (DM) has the highest impact. A 5% increment of sales price can reduce the payback by one year as well as a 32% increase if IRR compared to the baseline scenario. Similarly, Operation time, working days per year, Diesel price have impacts respectively.

|                                   |           | Minus      |            | Base       |         | Plus      |           |
|-----------------------------------|-----------|------------|------------|------------|---------|-----------|-----------|
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 1 Sales Price                     | IRR [%]   | -15.65%    | 2.11%      | 6.31%      | 10.02%  | 13.26%    | 16.41%    |
|                                   | NPV [EUR] | -9,928,418 | -3,216,040 | -1,207,749 | 597,009 | 2,204,744 | 3,795,703 |
|                                   | PBP [a]   | n.a.       | n.a.       | n.a.       | 11      | 10        | 9         |
|                                   |           | Minus      |            | Base       |         | Plus      |           |
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 2 Operation Time                  | IRR [%]   | -2.06%     | 5.53%      | 7.76%      | 10.02%  | 11.98%    | 13.96%    |
|                                   | NPV [EUR] | -6,761,316 | -1,753,854 | -532,725   | 597,009 | 1,495,676 | 2,336,297 |
|                                   | PBP [a]   | n.a.       | n.a.       | n.a.       | 11      | 10        | 9         |
|                                   |           | Minus      |            | Base       |         | Plus      |           |
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 3 Working days per year           | IRR [%]   | -0.80%     | 5.95%      | 7.96%      | 10.02%  | 11.80%    | 13.61%    |
|                                   | NPV [EUR] | -6,010,127 | -1,529,334 | -430,918   | 597,009 | 1,412,628 | 2,177,750 |
|                                   | PBP [a]   | n.a.       | n.a.       | n.a.       | 11      | 10        | 9         |
|                                   |           | Minus      |            | Base       |         | Plus      |           |
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 4 Diesel Price                    | IRR [%]   | 13.24%     | 11.30%     | 10.65%     | 10.02%  | 9.27%     | 8.55%     |
|                                   | NPV [EUR] | 2,191,004  | 1,227,744  | 906,378    | 597,009 | 227,843   | -122,447  |
|                                   | PBP [a]   | 10         | 10         | 11         | 11      | 11        | n.a.      |
|                                   |           | Minus      |            | Base       |         | Plus      |           |
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 5 Envisaged capacity (throughput) | IRR [%]   | 10.13%     | 9.99%      | 10.18%     | 10.02%  | 9.88%     | 10.05%    |
|                                   | NPV [EUR] | 485,298    | 522,291    | 634,733    | 597,009 | 559,284   | 671,726   |
|                                   | PBP [a]   | 11         | 11         | 11         | 11      | 11        | 11        |
|                                   |           | Minus      |            | Base       |         | Plus      |           |
| Variable                          | KPI       | -25%       | -10%       | -5%        | 5%      | 10%       | 25%       |
| 6 Loan period                     | IRR [%]   | 9.48%      | 9.83%      | 9.93%      | 10.02%  | 10.10%    | 10.18%    |
|                                   | NPV [EUR] | 328,783    | 500,774    | 551,535    | 597,009 | 637,951   | 674,980   |
|                                   | PBP [a]   | 11         | 11         | 11         | 11      | 11        | 11        |

Figure 31. Sensitivity of key variables in harvesting

Further, each main section in BIP has several variables which affect to the respective outcomes realm as above described. Identify the key variables in advance is important as well as advantageous to plan and avoid any disturbances for the project progress over the time. It is also an analysis of indicators to overcome and prepare for market changes, price fluctuations and changes in supply etc. Further, the analysis can be beneficial to identify technological developments for necessary processes and functions to reach high level of competencies.

## 6.2 Results

Each BIP realm which was described before has its own outcomes. Most convenient way of presenting the outcome is to showcase the key performance indicators for each function group. Table 11 is a detailed summary of the business plan along with the key performance indicators. Third column in Table 11 is the projected product output of each realm and related subcategory. Calculated key performance indicators (Net Present Value [NPV], Internal Rate of Return [IRR] and Payback Period [PBP]) mentioned in the Table 11 are based on free cashflow discounting in the baseline scenario. Column 4 shows the imputed Break-Even-Prices which is the minimum selling price where the respective process works out. The adjacent column has the actual market values of each product. Sources for each market price are listed next to actual prices. It seems feasible that every single realm along the bush valorisation chain is economical viable, however pellets could levy the pressure on the partially meagre margins (cross-financing) and additionally allow the BIP to provide/finance socio-ecologic activities for employees and nature. The IRRs show, that each individual BIP realm is capable to exceed 8.8% WACC and hence create positive net present values (NPV) still including dividend payments. Simply spoken, positive NPVs guarantee a payback of the invested money including a rate of return that exceeds cost of capital. In this case the project implementation is recommended.

According to the comparison of break-even values and actual market values it is important to mention that some products such as oversize material for pyrolysis, charcoal and briquettes are even and do not show particular unit cost reduction. However, here scale and quality will be improved. Many charcoal producers look for controlled environments to produce charcoal, with steady feedstock supply, access to maintenance and improved working conditions (shading, toilets, etc.). Based on the assumed factors in the planning, heat energy utilization, maintenance as well as the pure economic improvement of the project, there are foreseeable positive potentials. Depending on the quality of the products, internal synergies in between processes,

highly controlled and efficient use of energy can direct to acquire competitive prices in the future.

Also, it is very important to understand that the BIP is whole bush utilization approach. Meaning, there won't be any waste. In terms of economy as well as ecology, the whole bush utilization approach will create set of values within the overall process. For example, utilized bush can have several fractions. Depend on sizes and uses, BIP has the ability to process all the fractions for different predefined purposes while wood chips and pellets are in dominant. Further, exhaust heat of briquettes production is expected to be used to dry the bush feedstock and pellets. Likewise, controlled and efficient material flow management can deliver energy and financial savings.

On the other hand, pellets, wood chips and biochar etc., have break-even prices which are way lower than actual market prices. Those products are highly competitive in export markets in terms of price vs quality. Considering the core approach of the BIP in Namibia, which is to reverse back the existing disturbed ecosystem to a savannah land while creating social, economic improvements to the country, the proposed BIP business plan and BIP realms are inline and fulfilling the core objectives for all stakeholders. Also, BIP functions will contribute to the local government by paying taxes and it creates several value chains and provide work and wealth for logistics and other essential services in the local context.

**Table 11.** Key-Performance-Indicators of the BIP

|                            |                                |                           |                             |                              |                          |      |                     |                |                           |      |              |              | Variable Sensitivity Rank |                                     |                             |                                      |
|----------------------------|--------------------------------|---------------------------|-----------------------------|------------------------------|--------------------------|------|---------------------|----------------|---------------------------|------|--------------|--------------|---------------------------|-------------------------------------|-----------------------------|--------------------------------------|
| BIP Realm                  | Product                        | Product Quantity<br>[t/a] | Break-Even-Price<br>[EUR/t] | Act. Market Price<br>[EUR/t] | Act. Market Price Source | Jobs | Turnover<br>[EUR/a] | CAPEX<br>[EUR] | ø Tax payments<br>[EUR/a] | WACC | IRR          | NPV<br>[EUR] | PBP<br>[a]                | 1 <sup>st</sup>                     | 2 <sup>nd</sup>             | 3 <sup>d</sup>                       |
| Harvesting "Bush-thinning" | Bushfeed feedstock (FM)        | 48,000                    | 13                          | undefined                    | Farm level               | 36   | cp. Bushfeed        | 248,000        | cp. Bushfeed              | 8.8% | cp. Bushfeed |              |                           |                                     |                             |                                      |
| Harvesting "De-bushing"    | Biomass raw material (DM)      | 250,000                   | 26                          | 38                           | N-BiG                    | 86   | 6,880,000           | 13,700,000     | 200,000                   |      | 10.0%        | 597,009      | 11                        | Sales price                         | Operating time              | Working days                         |
| Post-harvesting            | Compost                        | 22,500                    | -5                          | -5                           | n.a.                     | 40   | 9,220,000           | 5,240,000      | 140,000                   |      | 11.0%        | 377,244      | 10                        | Feedstock price<br>(Input material) | Wood chips<br>selling price | Fines for pellets<br>(Selling price) |
|                            | Undersize (for Pellets)        | 52,000                    | 42                          | 87                           | Kahl/BPC                 |      |                     |                |                           |      |              |              |                           |                                     |                             |                                      |
|                            | Oversize (for Pyrolysis)       | 7,500                     | 31                          | 31                           | N-BiG                    |      |                     |                |                           |      |              |              |                           |                                     |                             |                                      |
|                            | Wood chips                     | 152,000                   | 41                          | 46                           | N-BiG                    |      |                     |                |                           |      |              |              |                           |                                     |                             |                                      |
| Pyrolysis                  | Restaurant Charcoal            | 338                       | 290                         | 290                          | NCA                      | 24   | 98,094              | 910,000        | 20,000                    |      | 10.1%        | 22,171       | 11                        | Wood coal ratio                     | BBQ coal price              | Wood price                           |
|                            | Charcoal                       | 1,259                     | 242                         | 242                          | NCA                      |      | 304,693             |                |                           |      |              |              |                           |                                     |                             |                                      |
|                            | Briquettes                     | 226                       | 67                          | 67                           | NCA                      |      | 15,109              |                |                           |      |              |              |                           |                                     |                             |                                      |
|                            | Biochar                        | 242                       | 348                         | 450                          | IfaS                     |      | 84,216              |                |                           |      |              |              |                           |                                     |                             |                                      |
| Bushfeed                   | "BIP" Bushfeed                 | 11,000                    | 218                         | 225                          | DAS                      | 22   | 2,450,000           | 642,000        | 13,000                    |      | 12.2%        | 68,144       | 10                        | Sales price                         | Moisture                    | Heat energy price                    |
| Pelleting                  | Industrial Pellets (I2)        | 49,400                    | 147                         | 162                          | CIF ARA                  | 23   | 4,460,000           | 3,470,000      | 28,000                    |      | 11.5%        | 302,645      | 10                        | Moisture                            | Pellet price                | Feedstock price                      |
| Additional Services        | Social Services                | cp. RoadMap               |                             |                              |                          | 12   |                     | 1,760,000      | n.a.                      |      |              |              |                           |                                     |                             |                                      |
|                            | SEBIP's <i>[here in EUR/a]</i> | 494,000                   |                             | 10                           | per ton pellets          |      |                     |                |                           |      |              |              |                           |                                     |                             |                                      |
| Logistics                  | Truck/Road                     | 236,723                   |                             | 34                           | TWC/Imperial             |      | 8,048,576           |                | 160,972                   |      |              |              |                           |                                     |                             |                                      |
|                            | Train/Rail                     |                           |                             | 26                           | TWC/Imperial             |      | 6,154,793           |                | 123,096                   |      |              |              |                           |                                     |                             |                                      |
|                            | Ship/See                       |                           |                             | 31                           | MACS                     |      | 7,338,408           |                | 146,768                   |      |              |              |                           |                                     |                             |                                      |
| Total                      |                                |                           |                             |                              |                          | 243  | 45,053,889          | 25,970,000     | 831,836                   |      |              |              |                           |                                     |                             |                                      |

Basic KPI interpretation:

When WACC > IRR then NPV is positive. When NPV is positive the project should be implemented! PBP is a risk indicator not a profitability indicator.

## 7 Logistics

The topic of logistics deals with the flow of the raw material from the bush through the BIP's via road/rail to the port and further by ship to the end user. The individual stations are shown to describe the process to obtain data to create business cases in order to know which quantities of raw materials, machinery, plants, road and infrastructure as well as further investments are necessary.

### 7.1 Introduction

The scaling of the raw material flow in the form of different case scenarios, whereby the variable is the quantity (t/a) of the material flow, should show:

- Which quantities can currently be transported (Capacity of the existing infrastructure)?
- What need to happen when the quantities of raw materials scale up?
- How does the transport network could look like?
- Which and how many machines would be necessary?
- How does the cost structure look like?

The supply chain starts in the field where the bushes are cut. After cutting, the bushes are pre-crushed for the first time and loaded into a trailer, which is transported by the tractor out of the field onto a road suitable for trucks. From the road the truck takes over and transports the raw material to the BIP. In BIP, logistics refers to the unloading of the trailer, the storage of the raw materials, and the loading of the finalized products. These internal logistical processes are not part of this chapter as they belong directly to the inner BIP process planning. The final products are preferably transported by train from Otjiwarongo (1<sup>st</sup> BIP as pilot project) to Walvis Bay in the port because truck transport would not be able to meet the demand. A bulk storage facility must be located in the port in order to be able to load the maximum quantity in the short docking times of the bulk freight vessels. From the port of Walvis Bay the raw material



is transported to European ports by vessel. From the European ports, the transfer of ownership can be transferred to commodity traders, who ensure that the raw materials reach the respective end customers by truck, train or vessel. Use of train instead of trucks and assuming 50,000 t/vessel, an average of 300,000 t/a was taken as a realistic guess for the calculations. Rising the valorization from 300,000 t/a to 1,000,000 t/a, it requires sizable investments into infrastructure, logistic machinery, much larger industrial scale bush-thinning activities and a trend-setting blueprint.

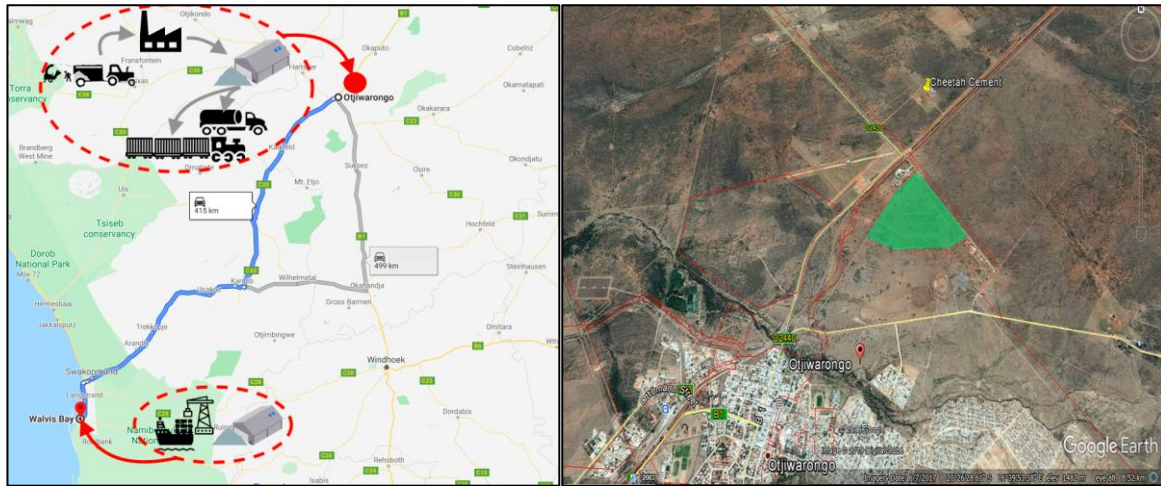
## 7.2 Location

Preferred geographical locations of the first BIP are:

**Table 12.** Distance BIP's to Walvis Bay

| Departure   | Arrival       | Distance (km) |
|-------------|---------------|---------------|
| Otjiwarongo | Walvis<br>Bay | <b>450</b>    |
| Ohorongo    |               | <b>600</b>    |
| Tsumeb      |               | <b>650</b>    |

The distances are measured using Google Maps and refer to the existing road network. The train route and the street course are not identical, which can lead to deviations in the distance. As a result of the selection procedure Otjiwarongo has been elected as a region for the first BIP. Ohorongo and Tsumeb are no longer logistically addressed in the further part of logistics. The following information provided relates to the preferential location Otjiwarongo.



**Figure 32.** The BIP location Otjiwarongo

### 7.3 Chain of Process

The Chain of Process describes the procedure of individual logistical steps, which are explained in technical and monetary terms. Possibilities and disadvantages in the process chain are analyzed in order to derive a way to go. The chapter is divided into 4 sections:

- From Field to Road to BIP
- BIP to Walvis Bay
- Walvis Bay to European Port
- European Port to Final Customer

#### 7.3.1 From Field to Road to BIP

In the field during logging, an initial crushing of the biomass takes place, which then requires collection in trailers for transport. Due to the stumps of the harvested bushes truck tires would get cut, therefore solid rubber tires on tractors are preferred. So, street truck tires can't handle the terrain. The trucks are too heavy and sink because of the nature of the soil, especially in the rainy season, therefore a tractor is used which pulls collection trailers.

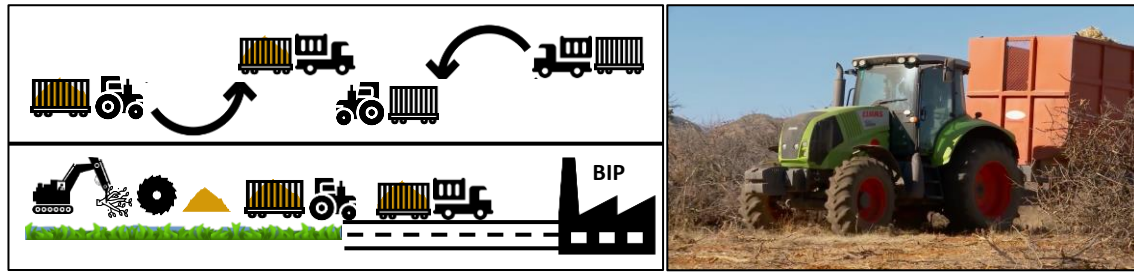


Figure 33. Logistical Procedure from Field to Road to BIP

There are two logistic reloading methods that could be considered:

- a. There is a possibility to change the biomass with the trailer among the vehicles.  
When the truck approaches the field, it carries an empty exchange trailer along so the tractor can drive back into the field with an empty collection trailer.
- b. Small portable transfer centers will be equipped with a mobile crane along the main harvesting areas to empty tractor containers in order to fill larger truck trailers.

Through speed and cost efficiency of a truck on the road compared to tractors, the tractor pulls the full trailers after collection to the nearest road and unload the entire trailer, which is subsequently transported to the BIP by truck. This procedure has an economic break-even point at 5 to 10 kilometers distance from the field to the BIP. If the distances are less than 5 to 10 kilometers, the tractor will drive directly to the BIP. The fleet of trucks, mobile transfer centers and tractors in use varies depending on the distance from the BIP. With the help of agricultural machinery (bulldozers, which are part of the harvesting technology of the BIP) an access road could be established in the course of the harvesting areas.

### 7.3.2 BIP to Walvis Bay

With regard to large-scale export of biomass, it is essential to link the production facility to the infrastructure. The BIP should therefore have a connection to road and rail networks in order to be able to act flexibly on both transport networks. This is the case for Otjiwarongo site, which was one of the main reasons to select this site as preferable for the first BIP in Namibia.

To illustrate the prevailing transport situation by road in Namibia, a case scenario is calculated for one million tons of wood chips to be transported. The average speed of the loaded trucks in Namibia is 60 km/h. Truck trailers can load between 24 - 32 tons depending on the volume of the carts and the bulk density (220 kg/m<sup>3</sup> for wood chips) of the material. There are legally limitations (9 tons per axle) of total weight on a truck. It does not depend on the capacity of the trucks, but on the limitations of the law. A truck has a loading volume of approx. 110 m<sup>3</sup>. The biomass transported so far in Namibia has a bulk density of 230 to 270 kg/m<sup>3</sup>. In order to describe the transport costs in a common value it is calculated in EUR, NAD or \$ per km with 13 NAD/km. Through booking a truck, independent from load or back load empty back loads need to be accounted in Namibia.

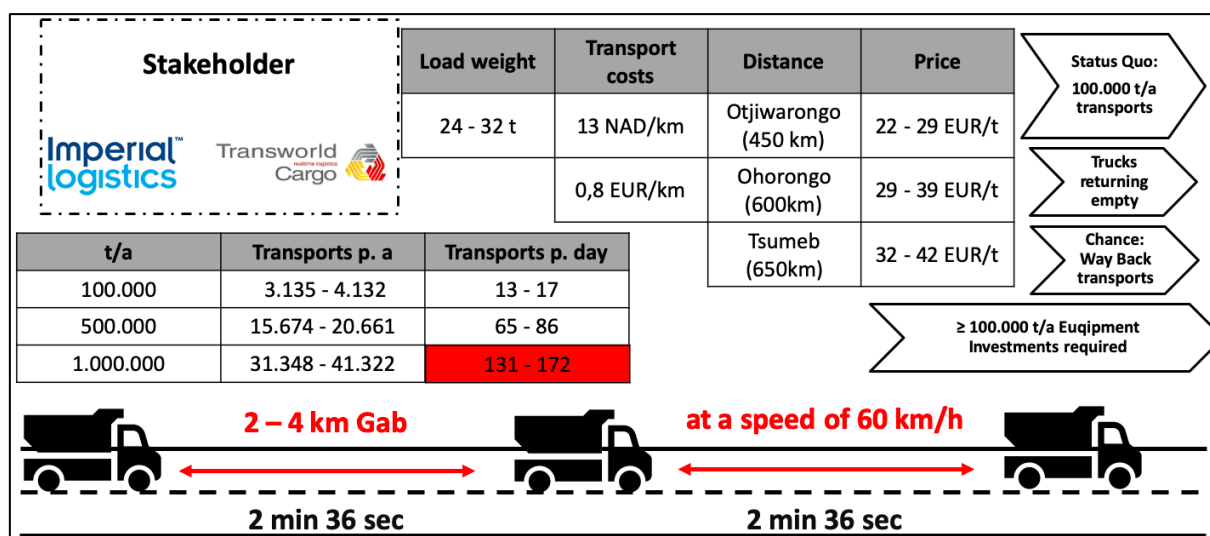


Figure 34. Case Scenarios Trucks only, BIP to Walvis Bay

The number of tons to be transported by truck per year can be calculated on the basis of the possible load weight of trucks on the number of vehicles which have to be in operation per day. In one year, 240 working days are expected. Transporting one million tons of wood chips from the BIP's to Walvis Bay requires between 131 - 172 trucks in operation. In order to drive a transport route at 60 km/h including loading and unloading, a shift of an operator needs to be 10 to 14 hours. Two hours of loading and unloading are included in the calculation. The pure driving time, including mandatory breaks for operators, is between 8 and 11 hours (depends on the BIP location). Since the trucks drive back unloaded, there is potential for cost savings in loading the trucks on the way back with goods. If the return journey requires approximately the same time, the fleet of trucks has to be doubled (262 - 344 Trucks) at full capacity. Due to legal regulations and the movement of animals, it is not intended to drive on the roads at night. At daylight, it would be necessary to clock the trucks at intervals of 2 - 4 km (156 seconds) on the complete route from BIP to Walvis Bay.

In the case of trucks, up-scaling in terms of quantity per transport vehicle is not possible, since the number of trailers cannot be expanded as much as in the case of trains, for example. Thus, the price per truck transport remains relatively constant, as the number of trailers cannot vary. With the increasing amount of biomass to be transported, the realistic transport possibilities decrease, so with units above one million tons per year, rail transport remains the favorable transport option between BIP and Walvis Bay port. The road network without rail networks couldn't handle the traffic of the mass to be transported. In addition to this, it was calculated with optimal conditions and without unforeseen events such as (traffic jams, general traffic, accidents, road works). The more tons are transported, the more important it becomes to use several transport alternatives, including the train route or a conveyor belt. A mix of using roads- and rail network for the purpose of burdening, dependence, alternatives and flexibility could be realistic. The rail network transports up to

two million tons of goods annually and the capacity utilization of rail transport is high due to the industry transports (mines, power plants, etc.). An alliance between Transnamib, BIP-Operator and transport service providers (delivery and loading) needs to be worked out to guarantee the transport of the biomass. An investment in Namibian rail system in exchange of the biomass transports to the port could be a part of the alliance negotiations. The prices on rail transport depend on:

- the route length,
- the date,
- the quantity,
- the material properties (bulk density),
- the un-/loading,
- the current request of transport capacity and
- the already existing supply contracts of Transnamib customers.

Therefore, the price varies and cannot be seen as fixed price for monetary indicator of rail transport costs. The more tons to be moved, the more efficient the rail network could get, if the transport quantity can be guaranteed.

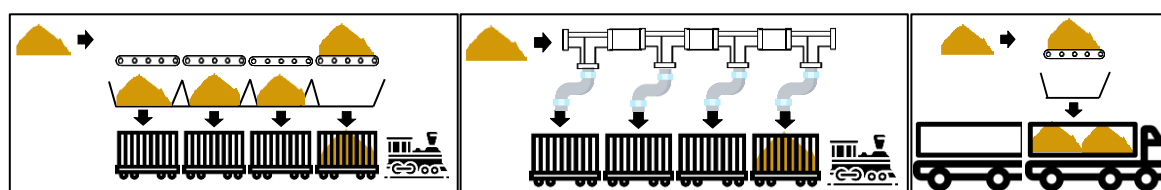
For both truck and rail transport, the question arises which transport units can be used? A distinction can be made between containers and bulk freight. To anticipate the answer, the number of containers needed to ship the desired mass to Europe per year resulted in the statement: the more mass is transported, the larger the transport units must be. If containers were used, up-scaling would not be possible, as the size per container is not variable. To fill the containers a complex filling and loading possibility would have to be created, because the biomass with a tested bulk density (240 to 270 kg/m<sup>3</sup>) would have to be compressed with a container press to improve the loading capacity per unit. However, if the biomass is compressed in containers, the effort in unloading increase. Combined with the docking time of vessels at ports and

the amount of goods to be loaded in time is a factor which leads to bulk freight transport instead of containers. For the sake of completeness, the calculation of container as units is given:

**Table 13.** Container as transport unit for wood chips

| Container type    | Volume m <sup>3</sup> | Safety factor | Max. load   | t/a       | Container per day (240/a) |            |            |
|-------------------|-----------------------|---------------|-------------|-----------|---------------------------|------------|------------|
|                   |                       | 20%           | t/Container |           | 40 FT                     | 40 FT High | 45 FT High |
| 40 Feet Container | 67.7                  | 54.2          | 26.7        | 100,000   | 23                        | 20         | 18         |
| 40 Feet High Cube | 76.4                  | 61.1          | 28.6        | 500,000   | 115                       | 102        | 91         |
| 45 Feet High Cube | 86.0                  | 68.8          | 27.7        | 1,000,000 | <b>350</b>                | <b>310</b> | <b>275</b> |

Bulk freight with the corresponding transport units is given as a more realistic and economical recommendation for action. The connection to rail network allows to fill the carts by using a filling hopper system. The hopper system is coupled to a biomass storage facility, which takes over the loading function of the carts by pressure or conveyor belts. The filling system can be installed in a mobile or fixed position. In case of a rigid construction, several hoppers could be connected in series to allow up to 50 carts to be filled from the top at the same time, so the train would be set off and does not have to start, fill and stop again for each individual cart. The combination of simple construction, low susceptibility to failure and mass loading are advantages of rigid filling systems.



**Figure 35.** The loading variants for trucks and locomotives

The alternative would be mobile systems, for example hose filling (used for unloading bulk freight vessels), which are positioned above the transport units by crane or on a rack. The hose would move and fill the individual carts one after the other. Another option is to load by crane with a shovel attachment, which reduces the efficiency and

automation process and leaves more room for human error. The benefit lies in its flexible application, which means trucks could also be loaded by crane or hose and goes hand in hand with the concept of using different transport networks. A mix of loading possibilities at the BIP would be conceivable in order to compensate failures and to be flexible in loading different vehicles. In Walvis Bay, intermediate storage of the biomass at the level of a maximum ship load (50,000 t) is recommended so when the bulk vessels arrive and loading begins, the required quantity is already on site. The loading capacity of train or truck to bulk freight vessels is extreme so a shipload cannot be transported from BIP to the port within a few days because the infrastructure does currently not allow such a volume without basic investments. A ship has fixed arrival, departure, loading and unloading times, so short-term changes because of Just-in-Time failures could have an extreme impact on profitability.

At the port of Walvis Bay, the transport units (trailer or cart) must be emptied. The unloading techniques vary depending on the choice of vehicle, the system used and the distance to the temporary storage site. Bulk carts from trains are emptied to the side, by conveyor belt or the whole cart is turned. If the intermediate storage site of the biomass can be accessed directly by tracks, a lateral unloading is possible by using hopper wagons, which can open the filling chambers on the left and/or right side by gravity. If smaller distances have to be covered, a conveyor belt is recommended.



**Figure 36.** Locomotive unloading techniques<sup>32</sup> for an interim storage facility at the port in Walvis Bay<sup>33</sup>

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<sup>32</sup> (Agrar Filmteam Austria, 2015)

<sup>33</sup> (Heavy Haul Power International GmbH, 2020)



The most common solution for trucks is the use of tippers, which hydraulically lift the loading area to the side or rear to empty it. The benefit of trucks is the flexible reach of the storage site.



**Figure 37.** Truck<sup>34</sup> unloading techniques for an interim storage facility at the port in Walvis Bay<sup>35</sup>

In the following, the monetary indicators of truck and train are compared. For trains, the cost per cart (16,000 NAD/cart) is composed from Otjiwarongo to Walvis Bay. For trucks, the costs are calculated per km (13 NAD/km). The loading capacity is ~ 32 t for trucks and ~ 44 t for carts. The number of carts on the train is variable up to 50 per locomotive. In contrast, the number of trailers is a limiting factor for the truck. For a mass of 50,000 tons to be transported to Walvis Bay, 1,563 truckloads or 1,136 carts would be needed. To calculate the loads per day, the un-/loading time, working hours and factors such as wild animal accidents by night must be taken into account, which excludes night transport for trucks. With 20 truckloads per day, it would take 78 days to place 50,000 tons at the port. At 22 carts per day (currently confirmed daily availability status 10.12.2019), it would take 52 days to transport 50,000 tons. The next chapter shows a calculation of a ship operating time, which would be ~ 56 days for a 50,000 loaded vessel to Europe and back to Walvis Bay. To transport only with trucks would take too long, but the train with variable carts could deliver the 50,000 tons vessel load to the port in time. The price for truck and train are about same level (22 EUR/t), so both transport routes can be used and an up scaling of the export

<sup>34</sup> (Sturmberger GmbH, 2020)

<sup>35</sup> (Moderner Landwirt, 2020)

biomass to be transported is possible, provided that the utilization of both transport routes is aimed at.

**Table 14.** Compared (50,000 t) Collecting Costs - Truck or Cart - Otjiwarongo to Walvis Bay

|                 | <b>Trucks</b> |           | <b>Transnamib</b> |          |
|-----------------|---------------|-----------|-------------------|----------|
| Tonnage         | 32            | t/Truck   | 44                | t/cart   |
| Total amount of | 1,563         | Trucks    | 1,136             | Carts    |
| Capacity p.d.   | 20            | Truck/d   | 22                | Carts/d  |
| Collecting days | 78            | d         | 52                | d        |
| Truck costs     | 13            | NAD/km    |                   |          |
| Otjiwarongo-WB  | 450           | km        |                   |          |
|                 | 11,700        | NAD/Truck | 16,000            | NAD/Cart |
|                 | 709           | EUR/Truck | 970               | EUR/Cart |
| Sum             | 780           | \$/Truck  | 1,067             | \$/Cart  |
|                 | <b>22</b>     | EUR/t     | <b>22</b>         | EUR/t    |
|                 | <b>24</b>     | \$/t      | <b>24</b>         | \$/t     |

Nevertheless, rail transport is the more exponential system, which should be addressed first for infrastructure investments in terms of the fact that a locomotive can be lined up with up to 50 carts. The daily availability of carts and locomotives is the crucial factor to maximize the mass of biomass to be transported and should be a top priority in negotiations with Transnamib. Therefore, it is recommended in negotiations on infrastructure investments to link the investments to the desired availability of carts and locomotives according to the upscaling export mass of the future.

### 7.3.3 Walvis Bay to European port

This logistics section Walvis Bay to European ports deals with the issue of how biomass can be transported by sea, by which ship, in which masses, for which price per tonne, in which time.

The choice of ship from Walvis Bay to Europe depends on various factors. The required water level in the harbor basin of Walvis Bay and Europe must meet the minimum regulations for the respective vessels and this preferably throughout the year to ensure

continuous delivery. The intended route must be consistent and the frequency of crossings must be guaranteed. The result is a list of vessels whose loading capacity (metric tons of deadweight (DWT)) is used as a selection criterion and has to meet with the number of annual exported biomass. The loading capacity of bulk vessels varies, the largest vessels can carry up to 400,000 metric tons of deadweight (DWT). It is important to check whether and how much storage is available. Furthermore, loading and unloading must be guaranteed at both ports, which means the loading and unloading systems must be compatible with the respective ship. Either the ship already has the gear on board for unloading or the port provides the equipment, if it is available. Physically, the travel time is made up of the speed of the ship and the distance to be covered. The process can be subdivided into crossing, loading and unloading, a buffer and adds up to a period of time, which is in the example of Namibia-Europe 28 days per operation.

**Table 15.** The process of overseas shipping

|      | Transit | Buffer | Loading | Unloading | Total |
|------|---------|--------|---------|-----------|-------|
| Days | 20      | 2      | 5       | 3         | 28    |

If the return trip is taken into account, this ship can carry up to ~ 6.5 transport units every 56 days at maximum capacity. On the basis of the criteria listed above and the initial export mass, a ship in the order of ~ 50,000 tons cargo volume is recommended, which covers the distance from Walvis Bay to Antwerp in approx. 28 days and transports 300,000 tons on 6 trips per year.

The costs for the service of such a vessel are made up of a daily fixed price, the required fuel, the fees at the ports of dock and the loading and unloading process. The daily fixed price can be compared to the rental of a rental car, which is determined by the provider of the service. The cost factor fuel (ship's diesel) is a variable cost element that depends on market prices and the amount of fuel consumed by the ship. The value 600

USD/t was used for the calculation. The ship needs the fuel during the crossing and in port to operate equipment necessary for loading and unloading. The docking fees are set by port operators, who do have price fluctuations. The docking fees are therefore dependent, variable costs of port operators. In the calculation the fees of Walvis Bay and Antwerp (Belgium) have been taken into account. For the loading and unloading of bulk freight vessels two basic loading techniques are used.

The grab-type loading technique consists of different types of cranes using attachments like shovels or spiral hose systems. The alternative are conveyor belt systems, which are lined up to the appropriate intermediate storage place. During the loading and unloading process it is important to coordinate which loading technology is used, which gear is required and whether the gear is provided by the ship or by the port operator (special service provider). The process of loading and unloading can be outsourced by a logistics service provider who will work out and coordinate the details.

The storage costs at the ports must also be taken into account and depend on the availability of storage space, the location of the storage, the storage area, the storage quantity, the nature of the stored material and the conditions under which the material must be stored. The variable cost centre Storage is permanently necessary at the port in Walvis Bay in order to be able to load the ship properly. Taking into account the cost center's, the price scenario for oversea transport from Walvis Bay to the European port is ~ 30 USD/t or ~ 27€/t.

**Table 16.** Costs of a 50,000 tons wood carrier vessel

| Category                     | Number           | Unit  |  |  |  |
|------------------------------|------------------|-------|--|--|--|
| Loading capacity             | 50,000           | t/a   |  |  |  |
| Vessel costs p.d.            | 22,000           | USD/d |  |  |  |
| Vessel costs p. transit      | 616,000          | USD   |  |  |  |
| Bunker (Transit)             | 50               | t/d   |  |  |  |
| Diesel costs per ton         | 600              | USD/t |  |  |  |
| Diesel costs per day         | 30,000           | USD/d |  |  |  |
| Diesel costs per transit     | 660,000          | USD   |  |  |  |
| Bunker (load/unload)         | 3                | t/d   |  |  |  |
| Consumed tons (load/unload)  | 24               | t     |  |  |  |
| Diesel costs load/unload     | 14,400           | USD   |  |  |  |
| Docking fees                 |                  |       |  |  |  |
| Walvis Bay                   | 50,000           | USD   |  |  |  |
| Antwerpen                    | 80,000           | USD   |  |  |  |
| Stowing / loading a ship     | 30,000           | USD   |  |  |  |
| Destowing / unloading a ship | 30,000           | USD   |  |  |  |
| Storage charges              | -                | USD/d |  |  |  |
| Collecting days              | -                | d     |  |  |  |
|                              | <b>1,480,400</b> | USD   |  |  |  |
| Total                        | <b>29.61</b>     | USD/t |  |  |  |
|                              | <b>26.92</b>     | €/t   |  |  |  |

| Wood Chips     | Pellets        |         |
|----------------|----------------|---------|
| 4.3            | 5.8            | MWh/t   |
| <b>215,000</b> | <b>290,000</b> | MWh     |
| <b>6.9</b>     | <b>5.1</b>     | USD/MWh |
| <b>6.3</b>     | <b>4.6</b>     |         |

The bulk density, which is related to the volume capacity, must be considered. Pellets are generally more highly compressed than wood chips, which means that the weight per volume (bulk density) is higher. If the same ship were loaded once with wood chips (270 kg/m<sup>3</sup>) and once with pellets (650 kg/m<sup>3</sup>), the loading volume and the DWT would be exhausted for wood chips, but only the DWT for pellets. To transport the same mass of pellets, ships with less cargo volume but the same DWT could be used. From an economic point of view, if there are differences in the prices for volumes of vessels, it may be reasonable to use vessels with smaller volumes for pellet transport. Smaller vessel loads (DWT) are possible, under the assumption of an increase in prices per ton, which why it should be targeted at the 50kt vessels.

#### 7.3.4 European port to final customers

Before the European port is reached, there would theoretically be the possibility of direct transport by vessel to the end customer. In practice, the following conditions would have to be met:

- a water connection to the end customer would have to exist
- the depth of the basin and the size of the canal to be navigated would have to be sufficient
- the additional expenditure of time would have to be worthwhile
- the service for the direct approach would have to exist
- the unloading options for such masses would have to exist
- the ship would have to be loaded exclusively with the biomass for one customer

As soon as one of these factors is not guaranteed, direct transport must be excluded. Accordingly, the option of traders has become established. If the vessel docks at European ports, the biomass can be transported further by direct transshipment or with intermediate storage. In both cases the biomass is transferred to trains, trucks and/or smaller vessels for further transport. Only the time of further transport differs. It is possible to have the transfer of ownership to traders from the port of arrival, who are then responsible for the logistical effort within Europe to the end customer. It is up to the trader to communicate with the end customer and to agree on delivery quantity, date etc.

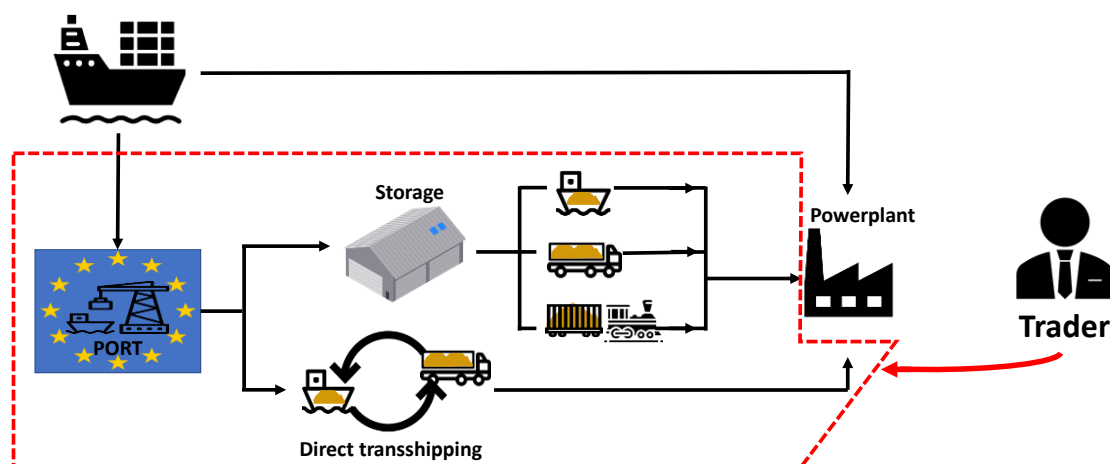


Figure 38. The function of traders

IfaS has imported 14 containers of bush biomass (Acacia: Mellifera, Erioloba, Reficiens) from Namibia to Germany for shredder testing purposes. Therefore, the general European and German country-specific import requirements are explained by the species Acacia.

The type of biomass influences the customs import regulations. Europe-wide and country-specific regulations apply separately. On the basis of the regulations of the European customs, the species of biomass must be defined, which is assigned in the register Electronic Customs Tariff (EZT)<sup>36</sup> to a goods nomenclature (customs tariff number for Acacia: 44039900 000), which must be found. For Germany, the biomass must be checked according to VO 2016/2031 and KontrollVO 2017/625. The „Pflanzenschutzgesetz “and „Pflanzenbeschauverordnung“ do provide specific information.

Depending of the wood species, un-/processed wood to be imported into the European Union must be subjected to a plant health check at the point of import. For this reason, a health entry document (GGED) must be presented for import. This is to be issued via the TRACES system by the applicant or importer. Further information on TRACES in general and on registration can be found on the website of the federal authority responsible for the import of goods of plant origin, the Julius Kühn Institute.<sup>37</sup> The GGED application needs to be handed over at least 24 hours before arrival of the consignment to the EU to the competent plant protection authority. On the GGED the plant entry point confirms the importability of the consignment after inspection of the consignment. Afterwards the goods can be declared for import customs law. The confirmed GGED must be presented for this purpose. In case there must be a phytosanitary certificate because of EZT, the species/variety of plant concerned plays a role in protecting the ecological cycle in the importing country. However, **raw**

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<sup>36</sup> [EZT-Online.de](http://EZT-Online.de)

<sup>37</sup> [julius-kuehn.de](http://julius-kuehn.de)

**material of Acacia bush wood biomass species are not subject to certification and examination**, only on justified suspicion. The biomass must be free from soil and free from insects. In the case of imports from third world countries, non-illegal deforestation is the main test criterion.

#### 7.4 CO<sub>2</sub> Balance Transport

The biomass itself has a CO<sub>2</sub> balance of 0 because it has absorbed CO<sub>2</sub> from the environment up to the day of thinning. This CO<sub>2</sub> absorbed over the lifetime of the plant is released during the combustion process to produce heat or electricity. Therefore, the bush biomass is CO<sub>2</sub> neutral. The CO<sub>2</sub> emission during transport of the biomass to the consumer must be taken into account. For this purpose, the distance to be covered by truck, rail and vessel is added up and offset with their corresponding gCO<sub>2</sub>/tkm equivalent factor. The sum is compared with the combustion value per ton of hard coal/ N-gas in order to be able to compare the CO<sub>2</sub> values for the case of how much CO<sub>2</sub> is produced by one ton of hard coal, N-gas or one ton of biomass (including CO<sub>2</sub> transport balance). If the transport balance for hard coal were also taken into account, the result would develop even more clearly in favor of biomass. Since the vehicle's CO<sub>2</sub> consumption depends on the state of the art of the vehicles, the values must vary, so it is formed an average, worst- and best-case scenario. The distance parameters remain the same for the three scenarios. The result shows even in worst-case scenario biomass has a CO<sub>2</sub> saving potential of 76% compared to hard coal and/or 74% compared to N-gas and in the best-case up to 98%.

**Table 17.** CO<sub>2</sub> emissions in different transport medias

| Mean Value Scenario               |                       |        |                      | Worst Case Scenario               |                       |        |                      | Best Case Scenario                |                       |        |                      |
|-----------------------------------|-----------------------|--------|----------------------|-----------------------------------|-----------------------|--------|----------------------|-----------------------------------|-----------------------|--------|----------------------|
|                                   | gCO <sub>2</sub> /tkm | km     | kgCO <sub>2</sub> /t |                                   | gCO <sub>2</sub> /tkm | km     | kgCO <sub>2</sub> /t |                                   | gCO <sub>2</sub> /tkm | km     | kgCO <sub>2</sub> /t |
| Truck                             | 117                   | 100    | 12                   | Truck                             | 160                   | 100    | 16                   | Truck                             | 75                    | 100    | 8                    |
| Rail                              | 65                    | 600    | 39                   | Rail                              | 120                   | 600    | 72                   | Rail                              | 10                    | 600    | 6                    |
| Sea                               | 32                    | 10,000 | 320                  | Sea                               | 60                    | 10,000 | 600                  | Sea                               | 5                     | 10,000 | 50                   |
| <b>SUM</b>                        |                       |        | <b>371</b>           | <b>SUM</b>                        |                       |        | <b>688</b>           | <b>SUM</b>                        |                       |        | <b>64</b>            |
| Hard Coal                         |                       |        | 2,852                | Hard Coal                         |                       |        | 2,852                | Hard Coal                         |                       |        | 2,852                |
| CO <sub>2</sub> Saving to Biomass |                       | 87%    |                      | CO <sub>2</sub> Saving to Biomass |                       | 76%    |                      | CO <sub>2</sub> Saving to Biomass |                       | 98%    |                      |
| N-Gas                             |                       |        | 2,626                | N-Gas                             |                       |        | 2,626                | N-Gas                             |                       |        | 2,626                |
| CO <sub>2</sub> Saving to Biomass |                       | 86%    |                      | CO <sub>2</sub> Saving to Biomass |                       | 74%    |                      | CO <sub>2</sub> Saving to Biomass |                       | 98%    |                      |



Multiplying the grams of CO<sub>2</sub> emitted by truck (117), locomotive (65) and vessel (32) with the number of kilometres travelled and dividing it by 1000 to arrive at the unit ton, gives the kgCO<sub>2</sub> value per ton. Applying this to each transportation vehicle, in this case Truck, Rail and Sea (Vessel) to add it as CO<sub>2</sub> consumption result for biomass transport vehicles from Namibia to Europe.

This biomass CO<sub>2</sub> balance serves as an equivalent value to show how much more CO<sub>2</sub> is emitted by the equivalent amount of coal or gas. The transport emissions of the harvest with a maximum of 50 transport kilometres (Truck or Tractor) up to the BIP are separately priced in the part harvest. The specific harvest emissions amount to the diesel of the chipper and the excavator are 0.015 kgCO<sub>2</sub>/kg wood chips.

#### **7.4.1 Namport**

Namport (Authority) is a state-owned port operator established by an Act of Parliament in 1994. The headquarter is located in Walvis Bay and from there it manages the southwestern ports of Africa, Walvis Bay and Lüderitz. The port of Walvis Bay connects the transport routes of Africa, Europe, Asia and America. The port of Lüderitz is located approx. 400 km south of Walvis Bay and is responsible for the southern regions as well as providing access to South African markets in the Northern Cape.

**For the project, the port of Walvis Bay and thus Namport is the interface to Europe, where the biomass will be exported. Accordingly, a cooperation with Namport is essential for the logistical planning.**

Namport is responsible for the following tasks<sup>38</sup>:

- Management of port facilities
- Development of ports
- Provision of port services

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<sup>38</sup> (Namport, 2020), [namport.com.na/about-namport](http://namport.com.na/about-namport)

- Regional development
- Support for the development of cross-border trade SADC, Europe and America.
- Minimizing port impacts on the natural environment
- Application of international standards (ISO 14001)

About 2000-2250 vessels dock at Walvis Bay/Lüderitz every year. After the expansion in 2018/2019 the container cargo handling is up to 750,000 TEU per year. The Port of Walvis Bay handled 93.1 percent of total cargo (gross tonnage) transiting to/from the neighboring countries in 2017<sup>39</sup>. Currently, 60 percent of rail freight traffic is generated from the port of Walvis Bay.

Namport and its three subsidiaries

- Elgin Brown & Hamer Namibia (Pty) Ltd,
- Namport Property Holdings (Pty) Ltd and
- Lüderitz Boatyard (Pty) Ltd,

Form together an alliance called the Walvis Bay Corridor Group (WBCG).

The Walvis Bay Corridor is a network of transport routes:

- Trans Kalahari Corridor,
- Trans Caprivi Corridor,
- Trans Cunene Corridor and
- Port of Walvis Bay
- Port of Lüderitz.

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<sup>39</sup> Namibia state of logistics 2018 report

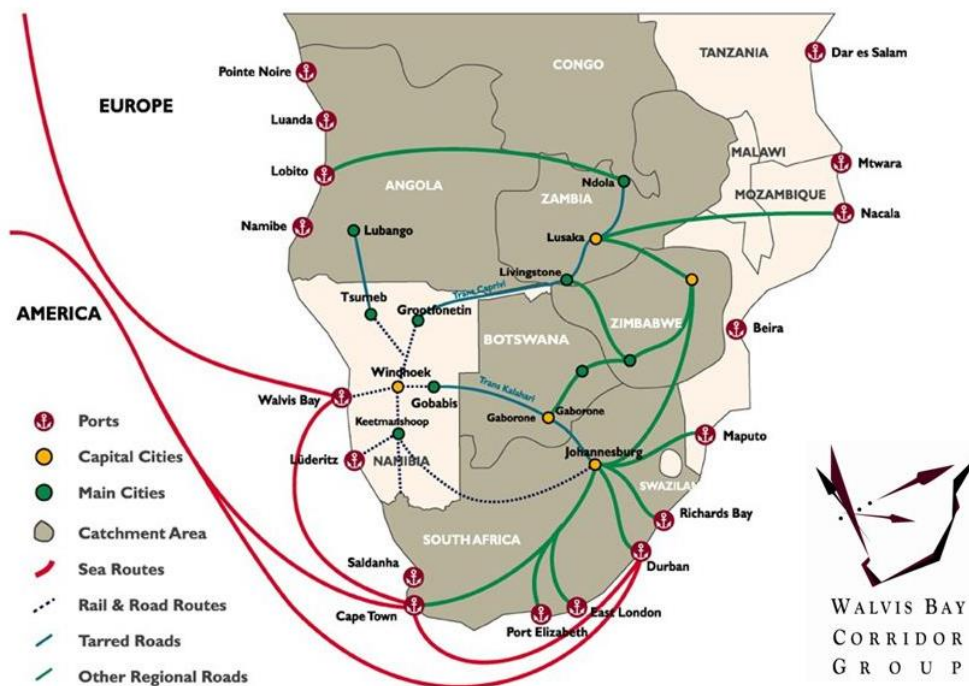


Figure 39. Walvis Bay Corridor Routes

#### 7.4.2 Transnamib

Transnamib is the monopolist in rail transport in Namibia, it is a state-owned company. The company is the point of contact for both passenger and freight transport. According to Transnamib, freight transport is responsible for 95% of its turnover. The rail network transports up to two million tons of goods annually and the capacity utilisation of rail transport are already high due the industry transports (mines, power plants, etc.). The number of two million tons is an indicator for the need of infrastructure investments to ensure an up-scaling effect in the course of the project.

With the increasing amount of biomass to be transported, the realistic transport possibilities decrease, so with units above one million tons per year, rail transport is the main transport option between BIP and Walvis Bay port. To back up this statement, a simulation was made between trucks with trailer or trains with carts. The result, up to 172 truck transports per day with a time gap between each truck of 156 seconds by 60 km/h over 900 km (way to port and back) on 8 – 14 hour shifts for each truck operator. The road network would be overburdened with such a load. In addition to

this, it was calculated with optimal conditions and without unforeseen events such as (traffic jams, general traffic, accidents, road works). The more tons to be moved, the more important the rail network becomes.



**Figure 40.** Rail Network of Namibia

The details of the fleet of Transnamib are (2019):

- 71 locomotives
- 1,658 carts
- 40 tons of max. capacity per cart
- Up to 50 carts can be towed per locomotive
- A max. total weight per locomotive of 1,600 tons
- ~60% of rail freight traffic in Namibia is generated from the port of Walvis Bay.
- ~7% of the rail freight is currently generated from cross-border traffic.
- There is one rail connection to the network of South Africa.

### 7.4.3 Int. logistics

In order to transport the biomass, logisticians with appropriate knowledge and equipment are necessary. With each loading and unloading, an interface is created

which must be organized. It is important to organize a process over a transport network of several thousand kilometers. The question arises which logistics company can cover which parts of the chain of custody. Using a logistics service provider as a BIP umbrella operator, who is the link to participating companies, takes care of the infrastructure, builds up the logistics part and participates in the distribution network to traders, would be a conceivable model for the Biomass Industry Park.

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In order to keep the entry barriers of importing Namibian biomass to Europe as low as possible, a partnership with companies already active in the European biomass market is advantageous. Such partners are characterized by their experience, reputation and trade structures in the European market. With such traders/ logistics service providers the chain of custody can be continued and documented in Europe in order to minimize problems. The brand association of well-known partners can help to build reputation of the Namibian biomass. For example, the Brüning Gruppe trades with energy-supplying bulk raw materials throughout Europe and does already have certifications such as FSC, PEFC, SBP, ISO 14001, EFB and ENplus, which increasingly becoming a requirement for end customers in Europe.

A Memorandum of Understanding (MoU) between Brüning-Megawatt GmbH and IfaS is made to collectively as the “Parties” with a mutual desire to initiate a pro-active cooperation for the development of sales channels and biomass partnerships for

encroacher bush based wood fuels from Namibia within the framework of the development of a Biomass Industrial Park (BIP) in Namibia based on IfaS' Biomass Hub concept co-developed with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The parties will jointly work on the certification of Namibian biomass under the SURE and/or SBP certification scheme, in order to meet international trade requirements for sustainable biomass supply. It is envisaged, that the parties will conduct a fact-finding mission to Namibia in 2020 in order to get first-hand insight about the status quo and create a clear picture about the material flows and involved stakeholders, which is essential with regard to the certification process. Upscaling the valorization of bush biomass into an export-oriented industry requires the mobilization of different stakeholders both locally and internationally.

The parties agree to jointly promote and advertise Namibian biomass as alternative fuel throughout own distribution channels, networks and platforms whenever adequate and possible. In particular the parties tend to conduct a first trial shipment of Namibian biomass as wood chips (or pellets) within the next 18 months. Therefore, a first customer needs to be identified, convinced and supplied. Logistics allowing for an effective operation of a biomass industry is a challenge that needs to be addressed. The logistics required to upscale the valorization of biomass from encroached bush remain a manageable challenge. The existing infrastructure insures a strong resilience with different alternatives.

In fact, the selection of the location of the BIP is highly dependent on logistical considerations like access to the railway and highways as well as reasonable proximity to urban centers and transshipment centers. The country is rapidly developing and improving its transports infrastructure by the day. The parties agree to support to this process with special emphasize of shipping by:

- Triggering supplier-buyer partnerships with European markets.

- Attracting funding and investment required for the development of new biomass-based value chains and utilization pathways.
- Arranging an effective knowledge transfer for the implementation of harvesting-logistics-treatment-export technologies of raw material.
- Modelling traffic and transport scenarios for the optimization of logistical means involved in the export processes.

## 7.5 Up-Shot

- The final products should preferably be transported by train from Otjiwarongo (1<sup>st</sup> BIP as pilot project) to Walvis Bay
- A bulk storage facility must be located in the port in order to be able to load the maximum quantity in the short docking times of the bulk freight vessels.
- Rising the valorization from 300,000 t/a to 1,000,000 t/a it requires sizable investments into infrastructure, logistic machinery, industrial scale bush-thinning activities and a trend-setting blueprint.
- To link in negotiations with Transnamib on infrastructure investments, the investments to the desired availability of carts and locomotives according to the upscaling export mass of the future.
- To start negotiations with vessel operators on cargo capacity

## 8 Certification and fuel requirements

Biomass and its by-products can be used as alternative fuels, contributing substantially to reduce greenhouse gas emissions. However, distinct biofuels affect the environment differently, whereas production techniques, technologies and transport methods can expose negative environmental impacts and, in some countries, biofuel production can compete with local food crops.

To ensure not only sustainable production, but also quality biomass verification is of major importance these days. Depending on the region, there are different verification and certification systems that recognize biomass sustainability. Biomass verifications act as independent documentation that the products are sustainably produced and supplied. It is a proof that the businesses have met all international regulatory requirements. This section of the Road Map will briefly discuss about several certification schemes that apply with regard to Namibia.

The overall certification scheme and the requirement to keep, renew and include new sites and other organizations, the FSC requires certain administrative requirements. Once more, these requirements are slightly different from Single, Multi-Site or Group COC certification procedures and structures. In general, similar to a common quality management standard, (ex- ISO 9001:2015), responsibilities, documentation, training internal audits etc. also available in FSC scheme.



## **8.1 Programme for the Endorsement of Forest Certification Schemes (PEFC)<sup>40</sup>**

PEFC care for forests locally and globally. It works to protect forests by promoting sustainable forest management through certification similar to FSC. This means, PEFC allows to get all benefit from the many products that forests provide now, while ensuring these forests will be managed sustainably. Through the PEFC certification, it provides a mechanism and it ensures that forest-based products reaching the marketplace have been sourced from sustainably managed forests as well as to promote sustainability.

PEFC work through national forest certification systems, allowing countries to adapt their sustainable forest management requirements to their specific forest ecosystems, the legal and administrative framework, the socio-cultural context and other relevant factors. PEFC consider the diversity of the forest as well as the local structure, such as local traditions, cultural and spiritual expectations, average property sizes and support structures etc. This diversity means one size does not fit all when it come to the forest certification. In regard to Namibian situation, this enables much more flexibility. Because it does not set one international standard that all forest owners must follow in order to achieve certification. Instead, PEFC work through national forest certification systems, allowing countries to adapt their sustainable forest management requirements to their specific forest ecosystems, the legal and administrative framework, the socio-cultural context and other relevant factors.

It requires that all the relevant stakeholders are involved in the development of a national system. This means they participate in determining what sustainable forest management means within their country and how it can best be implemented locally. Having stakeholders from several different backgrounds also ensures that one interest cannot dominate the process, as all parties need to agree on the final requirements. Which is the situation already in the intended BIP network at Namibia. There are

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<sup>40</sup> Retrieved from: <https://pefc.org/for-business> | <https://pefc.org>

multiple stakeholders from different backgrounds, academic, research, technological, legal and etc. which make the perfect combination to create a balanced national system.

Nevertheless, while stakeholders develop their national systems locally, they must all meet its international requirements. These set out strict rules on what must be covered within national standards, but also the things to be done during the development process. The aforementioned compliance is one of the main requirements to export sustainable biomass products internationally. It is important to mention that, many national systems exceed PEFC international requirements, going even further to include additional, nationally relevant requirements.

## **8.2 For business- Supply chain companies**

PEFC COC certification provides independent verified assurance that the certified the specific product(s) originates from sustainably managed forests. Also, it enables organizations to demonstrate their legal and sustainable sourcing of forest products to respective customers and provides you with a variety of advantages that help the environment, people, and organization's bottom line, such as access to new markets and compliance with legislation. Further, PEFC available worldwide and open to all companies that manufacture, process, trade or sell forest-based products.

When considering the Namibian situation, there are multiple stakeholders and they have variety of products as well as different market approach. In PEFC, group members are independent of each other and can be from completely different sectors. For example, it is possible that a group certificate includes sawmills, printers and furniture manufacturers etc. The only conditions are the size limitations for the individual group members and that they are located in the same country.

Similar to FSC, PEFC also offers different certification schemes such as multi-site and etc. If organization's activities are in more than one site, PEFC multi-site certification

enables to achieve COC certification for all locations in one certification, without the need to certify each separate location individually. Similarly, for many companies, such as multinationals, franchises and companies with multiple production locations, and traders with many channels, it can be a hard in terms of cost, time and workload to gain PEFC COC certification for every location. To serve that, PEFC multi-site certification, enabling all the different locations (or “sites”) of a company where PEFC COC activities are carried out, to be covered by a single multi-site certificate. The sites can even be located in more than one country. The only condition is that the sites are linked through common ownership or management, or another organization link. In regard to Namibia, single or multiple BIPs can be managed as per the necessity of stakeholders. This prolonged management structure yet to be defined. Never the less, any of the approaches are compatible with the scheme.

Similar to any other international standard or certification scheme, PEFC has some general requirements such as documented procedures, responsibilities and authorities, record keeping, Inspection and control, complaints, nonconformity and corrective action, social, health and safety requirements and etc.

### 8.3 General characteristics of the two major systems for forest certification<sup>41</sup>

Table 18 is a side by side comparison of key elements of FSC and PEFC. In general, there are slight differences in basic requirements, stakeholder scope etc. as well as some similarities such as both schemes need third party verification

**Table 18. General characteristics of FSC and PEFC**

| <b>FSC</b><br>(Established in 1993 at the initiative of environmental organizations.   | <b>PEFC</b><br>(Founded in 1999 in Europe, as an endorsement mechanism for independent, national certification Systems.)  |
|--|---|
| Basic principle  |   |
| <p>FSC is a system of national and regional standards consistent with ten principles of Sustainable forest management (SFM), that cover the following issues:</p> <ol style="list-style-type: none"> <li>1. Compliance with laws and FSC principles</li> <li>2. Tenure and use rights and responsibilities</li> <li>3. Indigenous peoples' rights</li> <li>4. Community relations and workers' rights</li> <li>5. Benefits from the forests</li> <li>6. Environmental impact</li> <li>7. Management plans</li> <li>8. Monitoring and assessment</li> <li>9. Special sites – high conservation value forests (HCVF)</li> <li>10. Plantations</li> </ol> <p>These principles were developed by a global partnership of stakeholders convened by FSC. The principles apply to all tropical, temperate and boreal forests and are to be considered as a whole. All national and regional standards are derived in-country from the ten principles. The principles are expected to be used in conjunction with national and international laws and regulations, and in compatibility with international principles and criteria relevant at the national and sub-national level (FSC Policy and Standards; principles and criteria of forest stewardship) (FSC, 1996, amended in 2002). There is variation in regional standards and in interim standards adopted by auditing bodies.</p> | <p>PEFC is a mutual recognition mechanism for national and regional certification systems. PEFC's environmental, social and economic requirements for SFM build on international guidelines, criteria and indicators for SFM derived from intergovernmental processes such;</p> <ul style="list-style-type: none"> <li>▪ Ministerial Conference on the Protection of Forests in Europe (MCPFE),</li> <li>▪ and the African Timber Organization (ATO)</li> <li>▪ International Tropical Timber Organization's (ITTO) processes for tropical forests</li> </ul> <p>PEFC's SFM standards cover the following aspects:</p> <ol style="list-style-type: none"> <li>1. Maintenance and appropriate enhancement of forest resources and their contribution to</li> <li>2. the global carbon cycle.</li> <li>3. Maintenance and enhancement of forest ecosystem health and vitality</li> <li>4. Maintenance and encouragement of productive functions of forests (wood and no-wood)</li> <li>5. Maintenance, conservation and appropriate enhancement of biological diversity in forest</li> <li>6. ecosystems</li> <li>7. Maintenance and appropriate enhancement of protective functions in forest management</li> <li>8. (notably soil and water)</li> <li>9. 6. Maintenance of socioeconomic functions and conditions</li> <li>10. 7. Compliance with legal requirements</li> <li>11. Endorsed certification systems are assessed to be consistent with international agreements such as</li> </ol> |

<sup>41</sup> Retrieved from: <https://sustainableforestproducts.org/node/90>

|   |   |
|---|---|
|   | <p>12. International labour organization (ILO) core conventions, as well as conventions relevant to forest management and ratified by the</p> <p>13. countries, such as the Convention on Biological Diversity (CBD), CITES and others.</p> <p>All national PEFC standards are independently assessed to ensure that they meet PEFC International's Sustainability Benchmarks. There is some variation with standards exceeding these requirements (PEFC, 2010).</p>  |
| <b>Components, members, extent</b>  |   |
| <p>All component standards carry the FSC brand. National initiatives for forest management certification exist in listed countries and there are also FSC chain of custody certificates in a number of additional countries.</p> <p>165 million have been certified under FSC (as of October 2010). (FSC website, October 2012).</p>  | <p>PEFC endorses certification systems once they have successfully gone through the external assessment process using independent evaluators. Endorsed SFM standards can carry their own brand names. Endorsed standards include listed countries and there are also PEFC chain of custody certifications and PEFC stakeholder members in a number of additional countries.</p> <p>254 million ha have been certified under PEFC (as of October 2012) (PEFC website).</p>   |
| <b>Stakeholder scope</b>  |   |
| <p>FSC is a multi-stakeholder owned system. All FSC standards and policies are set by a consultative process. Economic, social, and environmental interests have equal weight in the standard process. FSC follows the ISEAL Code of Good Practice for Setting Social and Environmental Standards. (FSC website).</p>   | <p>Multi-stakeholder participation is required in the governance of national schemes as well as in the standard-setting process. Standards and normative documents are reviewed periodically at intervals that do not exceed five years. The PEFC Standard Setting is based on ISO/IEC Code for good practice for standardization (Guide 59) and the ISEAL Code of Good Practice for Setting Social and Environmental Standards (PEFC 2010).</p>  |
| <b>Chain-of custody (COC)</b>   |   |
| <p>The COC standard is evaluated by a third-party body that is accredited by FSC and compliant with international standards. COC standard includes procedures for tracking wood origin. COC standard includes specifications for the physical separation of certified and noncertified wood, and for the percentage of mixed content (certified and noncertified) of products. COC certificates state the geographical location of the producer and the standards against which the process was evaluated. Certificates also state the starting and finishing point of the COC.</p> | <p>Quality or environmental management systems (ISO 9001:2008 or ISO 14001:2004 respectively) may be used to implement the minimum requirements for chain of custody management systems required by PEFC. Only accredited certification bodies can undertake certification. COC requirements include specifications for physical separation of wood and percentage-based methods for products with mixed content. The COC standard includes specifications for tracking and collecting and maintaining documentation about the origin of the materials. The COC standard includes specifications for the physical separation of certified and noncertified wood. The COC standard includes specifications about procedures for dealing with complaints related to participant's chain of custody.</p> |
| <p>FSC policy on percentage-based claims, and various FSC guidelines for certification bodies</p>   | <p>COC certificates state the geographical location of the certificate holder; the standard against which the certificate was issued, and identify the scope, product(s) or product(s) group(s) covered PEFC, 2010).</p>  |
| <b>Inclusion of wood from noncertified sources</b>  |   |
| <p>Supply-chain control systems, and documentation to avoid sourcing materials from controversial sources, including:</p>   | <p>The PEFC's Due Diligence system requires participants to establish systems to minimize the risk of sourcing raw materials from:</p>  |

|   |  |
|---|--|
| <ul style="list-style-type: none"> <li>a. Illegally harvested wood, including wood that is harvested without legal authorization, from protected areas, without payment of appropriate taxes and fees, using fraudulent papers and mechanisms, in violation of CITES requirements, and others.</li> <li>b. Wood harvested in violation of traditional and civil rights</li> <li>c. Wood harvested in forests where high conservation values are threatened by management activities</li> <li>d. Wood harvested in forests being converted from forests and other wooded ecosystems to plantations or non-forest uses Wood from management units in which genetically modified trees are planted (FSC,2006)</li> </ul> | (PEFC, 2010). <ul style="list-style-type: none"> <li>a. Forest management activities that do not comply with local, national or international laws related to:             <ul style="list-style-type: none"> <li>▪ Operations and harvesting, including land use conversion, management of areas with designated high environmental and cultural values</li> <li>▪ Protected and endangered species, including CITES species</li> <li>▪ Health and labour issues</li> <li>▪ Indigenous peoples' property, tenure and use rights, payment of royalties and taxes.</li> </ul> </li> <li>b. Genetically modified organisms,</li> <li>c. Forest conversion, including conversion of primary forests to forest plantations.</li> </ul> |
| <b>Verification</b>   |  |
| Requires third-party verification.  | Requires third-party verification.   |

## 8.4 Specific certification schemes for solid biomass fuels

Similar to the forest certification, there are certain specific certification schemes and recognitions for biomass products. Among that, biomass fuels are important as the concerned export value chain in Namibia is focused to solid biomass fuel.

Following two certification schemes are popular and recognized globally (especially in Europe). A valid FSC or PEFC Chain of Custody certificate is a precondition for these chains of custody certification. Organizations must accomplish this in advance or at the same time with these certificates.

### 8.4.1 Sustainable Biomass Program (SBP)<sup>42</sup>

SBP is a UK registered organization which was founded in 2012 by industry partners. It operates as a non-profit organization to have an independent, uniform regulatory system for the certification of solid biomass. So the COC; explicitly producer, trader, end user; is transparent, compliant and documented. It has been setting standards and

<sup>42</sup> Retrieved from: <https://sbp-cert.org/documents/> | <https://sbp-cert.org>

managing a voluntary certification scheme for wood-based biomass for energy production since 2013.

The SBP assures stakeholders sustainably harvested woody biomass (mostly in the form of wood pellets and wood chips) to use it as a renewable energy source. The SBP became a multi-stakeholder organization with a three-chamber board and two advisory expert committees. The three chambers are composed of representatives of civil society, biomass users and biomass producers. SBP is compatible with FSC® and PEFC™ but does not replace them. SBP-certified pellets accounted for 65% of EU pellet consumption for cogeneration and dedicated energy in 2018. It is a certification for RED I (according to the guidelines of RED I) and is already established in the market, so European buyers and international producers can be certified according to SBP. Similar to other schemes organization decides which certification is required and negotiates under individual conditions with the supplier to be certified at the same time.

If the land (area) to be thinned and remove bush biomass is **not** FSC or PEFC certified, a risk assessment or evaluation is necessary (also called supply base evaluation). In Namibia, the area covered by bushes is so widely distributed, the number of landowners can be unmanageable. Many of these owners are farmers who could not manage the documentation and the effort for certification without being taken by the hand.

In addition, it is unlikely a farmer will be able to "certify" his entire farm in terms of harvesting permits, but a scrub clearance is more likely to be announced piece by piece. In this case, the certification process would have to be carried out for each harvesting operation, which would be unbearable for the farmer, small land owners etc. and as well as a harvest service provider. For this reason, a national, regional, group certification solution is recommended by the scheme. The permit of the Namibian

government (in this case MAWF) could be adapted and extended by the SBP guidelines equivalent to FSC or PEFC. The necessary risk assessment would be integrated into the permit and anyone wishing to thin out the bush would need the permit from the ministry which is mandatory.

The aim would be to use the risk assessment to determine whether the guidelines for harvesting the bush are equivalent to the requirements of FSC, PEFC or similar certification, so that certification via SBP can follow. Experience shows that group certification (country risk assessment) costs around €40,000. One takes over the barriers of certification that farmers would have and reduces their effort on documentation to such an extent that a national/regional risk analysis/assessment of the bushy land is integrated into the existing removal legislation.

If the BIP operator would handle the transfer of ownership with the farmer and pay logging companies as service providers, the service provider would not need to be certified. A mass balance must be introduced, but whether this takes place directly during bush thinning or in the BIP itself remains open.

In BIP, leased companies could offer services for the processing of the wood biomass, whereby no transfer of ownership takes place, so wood chip and pellet process steps would not have to be certified. As soon as companies want to buy and resell biomass themselves, certification of the company must take place. At each transfer of ownership, a carbon and energy balance data transfer must be submitted for SBP eligibility. SBP offers the in-house monitoring system DTS (Data Transfer System) for this purpose. Every certified member has access to the block chain-like IT system. The time frame for the transfer of the data should not exceed 3 months.

Similar to other certification, there are few independent auditing companies has approved for SBP certification: Control Union Certifications Bureau Veritas (BV),



NEPCon , SCS Global Services and DNV GL Business Assurance Finland Oy Ab. DNV GL is to be excluded, as international audits cannot be guaranteed. In cooperation with the Brüning Group, which is already SBP certified, the wealth of experience was shared. To determine the suitability of the three remaining auditors, a reference list of already completed international projects can be taken as a comparison criterion.

SBP has developed its own catalogue of 38 sustainability indicators, which are geared to forest-related objectives, among other things: conservation or enhancement of forests; conservation of biodiversity; and conservation of forests with high conservation value. Table 19 is a descriptive summary to showcase if Namibian situation is compatible with the defined indicators.

**Table 19. 38 sustainability indicators of SBP**

| No. | Indicator  | Compatibility   | Remarks  |
|-----|--|---|--|
| 1   | The Supply Base is defined and mapped.   | Yes. In Namibian situation, supply base which is from the ground level (farmers/harvesters) is already mapped. Locations for BIP(s) are identified                    |  |
| 2   | Feedstock can be traced back to the defined Supply Base.   | Yes. As there are different stakeholders are involved with several products and technologies, supply base, feedstock traces, species type has to be defined properly. | Location, species type, and related crucial data should be known but also the mechanism and the logistic procedure still needed to be defined. |
| 3   | The feedstock input profile is described and categorized by the mix of inputs.   | Yes. In line with indicator 2.  |  |
| 4   | Legality of ownership and land use can be demonstrated for the Supply Base.  | Yes. Harvesting permits, transport permits and all other legal requirements are necessary for the overall BIP initiation.   |  |
| 5   | Feedstock is legally harvested and supplied and is in compliance with European Timber Regulation (EUTR) legality requirements. | Yes. Products are intended to export overseas specially Europe. In that regard BIP in Namibia has to align the general/specific requirements for designated markets   | Has to be defined. FSC and PEFC schemes are aligned with EUTR and fulfills it requirements.  |

|    |   |   |  |
|----|---|---|--|
| 6  | Payments for harvest rights and timber, including duties, relevant royalties and taxes related to timber harvesting, are complete and up to date.     | Yes. The complete value chain and intended objectives   |  |
| 7  | Feedstock is supplied in compliance with the requirements of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). | Yes. Namibian context, the overall objective is to protect and reverse back to the savannah base eco-system while protecting regional species and gain social and economic benefits.  | FSC and the CITES are different, but have overlapping, missions. CITES aims to limit and regulate international trade in specimens of wild animals and plants, an overlap clearly exists with the common goal of preventing the extinction of species living in forest-related ecosystems. |
| 8  | Feedstock is not sourced from areas where there are violations of traditional or civil rights.  | Yes. Namibian authorities are the regulators and the civil rights and related concerns are overlooked and controlled.   |  |
| 9  | Forests and other areas with high conservation values in the Supply Base are identified and mapped.   | Yes. In line with indicator 2 and 3   |  |
| 10 | Potential threats to forests and other areas with high conservation values from forest management activities are identified and addressed.            | Yes. In line with indicators 2, 3 and 9. Also, traditional tenure and use rights of indigenous peoples and local communities related to the forest, are identified and well managed with the help of local governmental and non-governmental authorities. | Strength of interdisciplinary team of stakeholders where it can address multi sectoral requirements.   |
| 11 | Feedstock is not sourced from forests converted to production plantation forest or non- forest lands after January 2008.                              |   |  |
| 12 | Feedstock is sourced from forests where there is appropriate assessment of impacts, and planning, implementation and monitoring to minimize them.     | Yes. It falls under the Namibian BIP project management structure under stakeholder requirements where it is a mandatory set of measures to be calculated in terms of social, environmental and economic impacts  |  |

|    |   |  |  |
|----|---|--|--|
| 13 | Feedstock is sourced from forests where management maintains or improves soil quality.  | Yes. In line with 5, 7 and 8 indicators  | Calculations are yet to be defined   |
| 14 | Key ecosystems and habitats are conserved or set aside in their natural state.  | Yes. In line with 5, 7, and 8 indicators. Also, it is also a key objective of the Namibian BIP(s)  |  |
| 15 | Biodiversity is protected.  | Yes, In line with 5,7,8 and 14 indicators  |  |
| 16 | The process of residue removal minimizes harm to ecosystems.  | Yes. Aftercare in approach BIP fulfil this indicator. Also waste management.   |  |
| 17 | Negative impacts on ground water, surface water, and water downstream from forest management are minimized.   | Yes. In line with 5, 7, and 8 indicators.  | Calculations are yet to be defined   |
| 18 | Air quality is not adversely affected by forest management activities.  | Yes. Overall project approach is to mitigate the eco-system imbalance as well as to implement sustainable solutions and consume renewable energies in all possible cases.                                  |  |
| 19 | There is controlled and appropriate use of chemicals, and that Integrated pest management (IPM) is implemented wherever possible in forest management activities.   | Yet to be defined  |  |
| 20 | Methods of waste disposal minimize negative impacts on forest ecosystems.   | Yes. In line with 16   |  |
| 21 | Analysis shows that feedstock harvesting does not exceed the long-term production capacity of the forest, avoids significant negative impacts on forest productivity and ensures long-term economic viability. Harvest levels are justified by inventory and growth data. | As per the requirement of Namibian context and the higher growth rate of bush compared to the current consumption level, the harvest rate has to be increased.   |  |
| 22 | Adequate training is provided for all personnel, including employees and contractors.   | Yes. This is a requirement which has to be fulfilled even without the concern of these kind of certifications. Required level of training and the awareness is a must for an efficient flow of the project | Stakeholders from different background can engage in training and awareness programs for all employees, contractors etc. |
| 23 | Analysis shows that feedstock harvesting and biomass production positively  | Intended value chain development and the regional added value which were   |  |

|    |   |  |                   |
|----|---|--|-------------------|
|    | contribute to the local economy including employment.   | discussed in regard to Namibia bush thinning activities  |                   |
| 24 | The health, vitality and other services provided by forest ecosystems are maintained or improved.   |  |                   |
| 25 | Natural processes, such as fires, pests and diseases are managed appropriately.   |  |                   |
| 26 | There is adequate protection of the forest from unauthorized activities, such as illegal logging, mining and encroachment.  | Yes, In line with 7,8,9 and 10 indicators. Also, the Namibian government authorities are involved and regulates such activities and measures will be implemented.  |                   |
| 27 | The legal, customary and traditional tenure and use rights of indigenous peoples and local communities related to the forest, are identified, documented and respected.                             | In line with 4, 7, 9, and 10 indicators.   |                   |
| 28 | Production of feedstock does not endanger food, water supply or subsistence means of communities, where the use of this specific feedstock or water is essential for the fulfilment of basic needs. | In regard to the Namibian situation, BIP is an approach to enhance several factors. Relation to this indicator, social benefits and specially the water supply will be enhanced. As well as the ground water level will be improved. |                   |
| 29 | Appropriate mechanisms are in place for resolving grievances and disputes, including those relating to tenure and use rights, to forest management practices and to work conditions.                |  |                   |
| 30 | Freedom of Association and the effective recognition of the right to collective bargaining are respected.   |  | Yet to be defined |
| 31 | Feedstock is not supplied using any form of compulsory labour.  |  |                   |
| 32 | Feedstock is not supplied using child labour.   | Yes. There will be no child labor involved.  |                   |
| 33 | Feedstock is not supplied using labour which is discriminated against in respect of employment and occupation.  | Yes. There will be no such events.   |                   |

|    |   |   |   |
|----|---|---|---|
| 34 | Feedstock is supplied using labour where the pay and employment conditions are fair and meet, or exceed, minimum requirements.                                    | Yes. These requirements will be fulfilled with accordance to the national standards and will increase the regional added value. | Insurance schemes for all employees, health and safety standards will be discussed in detail. |
| 35 | Appropriate safeguards are put in place to protect the health and safety of forest workers.   | In line with indicator 34.  |   |
| 36 | Feedstock is not sourced from areas that had high carbon stocks in January 2008 and no longer have those high carbon stocks.                                      |   |   |
| 37 | Analysis demonstrates that feedstock harvesting does not diminish the capability of the forest to act as an effective sink or store of carbon over the long term. |   | Yet to be defined and calculate the impacts precisely.  |
| 38 | Genetically modified trees are not used.  | Yes. Namibian situation is to remove bush which are naturally occurred. There are no genetically modified species are present.  |   |

SBP recognizes existing forest certification systems, FSC and the PEFC schemes, and do not compete with or duplicate them. Nevertheless, there are some limitation which are not yet covered by the aforementioned schemes. Also, SBP is in route to develop short term and long-term solutions, to address these topics and in discuss with both FSC and PEFC to determine how these challenges might be overcome.

Following section describes the fee structure for the SBP certificate holders.

### **Fees for Traders**

If a commodity trader wishes to be certified, an annual fee of

- € for 100.000 - 249.999 tons or
- 25.000 € from 250.000 tons

have to be paid to qualify for the SBP chain of custody.

### **Fee for Producers**

Biomass producers pay a fee of:

- € 0.15 per tons if they produce wood pellets
- € 0.08 per tons if they produce wood chips

The fee is payable at the end of each quarter.

#### **8.4.2 Sustainable Resource Verification Scheme (SURE) <sup>43</sup>**

SURE, is a consortium of REDcert and BIOenergy, who together founded the institution SURE on the basis of the EU Directive for Renewable Energies II (Directive 2018/2001/EU, short: RED II), which according to the preliminary vote of the Commission is to come into force on 01.06.2021.

According to statements, SURE does not want to bring another forest certification system on the market to compete with SBP, FSC and PEFC, instead SURE should act compatibly and concentrate exclusively on the certification of supply chains, which are in connection with solid biomass for power and heat generation.

- As of 04.03.2020, SURE is not recognized by the authorities as an official certifier and is therefore waiting for the future inspection by the authorities.
- According to SURE, the first certification is planned for June 2020 with a test person, although RED II is not yet valid.
- The market entry of SURE is currently still in the future and depends on politics and the Commission decisions on RED II.

If encroacher bush be categorized among the category “agricultural waste and residual materials”, within the SURE system, encroacher bush be handled as landscape conservation material. Under these circumstances, the certification process is

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<sup>43</sup> Retrieved from - <https://sure-system.org/en/documents.html> | <https://sure-system.org/en>

simplified enormously, as the guidelines for agricultural production are not necessary and can be neglected for the project in Namibia, provided that no biomass is replanted, only harvested. Nevertheless, there were doubts about the term "waste", which could be damaging to the project's reputation when marketed.

SURE, has developed a guidance document with instructions of the rules, requirements and action line describe for each certification step and called this "Scheme Principles". The most important steps are listed below

- The certifier must register with SURE online or with forms and submit the appropriate documents.
- SURE checks the necessary documents and proposes corrective measures if necessary or issues the positive registration.
- The certifier must select a SURE-certified auditor out of the free market economy, with whom the terms of the contract and the conclusion of the contract are agreed.
- If the farmer does not have any certifications, a risk analysis is obligatory, which can be carried out by first, second or third parties under the condition of compliance with SURE guidelines.
- If the farmer is already FSC and/or PEFC certified and this is in accordance with the regulations of RED II and the guidelines of SURE, no risk analysis by SURE is required.

### **SURE Mass balance system, Auditors and Costs**

SURE prescribes a mass balance system which requires an incoming and outgoing inventory invoice to be issued at each point in the supply chain at least every three (3) months. It should be possible to understand the incoming and outgoing quantities in a clear and comprehensible manner for the auditor carrying out the audit, It should be

noted the outgoing quantity must be less than or equal to the incoming quantity in order to avoid any doubts, mismatches and frauds. Assumptions on the cost of certification.

According to SURE, the cost structure is divided into three different areas as of 04.03.2020. The three cost centers are the auditors, an annual fee and the fee per ton of processed biomass. All price data are approximate values and not to be regarded as final figures.

As of March 2020, there can't be any certifiers so far. Since SURE is part of a conglomerate, the existing certification partners of the conglomerate are listed on the REDcert website.<sup>44</sup> Some of the certification partners operate throughout Europe.

SURE outsources the certification to authorized auditors who are regularly monitored and trained by SURE. Accordingly, the market-oriented costs of the auditors vary and, according to SURE, are between 800 - 1500€ per day. A certification inspection takes between 1-6 days. Taking into account the accommodation and flight costs, 10,000 € can be a realistic cost per international inspection (outside the EU).

The amount of the annual fee is not fixed as of 04.03.2020. The amount of 1.500 - 2.500 € was put in the room with the emphasis of the annual fee will be eventually cancelled completely. A possible scenario could also be the annual fee is priced in cents per ton. The mentioned fee per ton of SURE is not fixed as of 04.03.2020, 4-6 cents per ton were given as an indication.

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<sup>44</sup> Retrieved from - <https://www.redcert.org/redcertsysteme/zertifizierungsstellen/zertifizierungsstellen.html>



The following information and documents must be provided by the landowner/farmer:

- The landowner/farmer must make a declaration accepting an onsite inspection by SURE
- The landowner/farmer must provide a signed self-declaration confirming and stating the right of harvesting the biomass with his consent on his territory

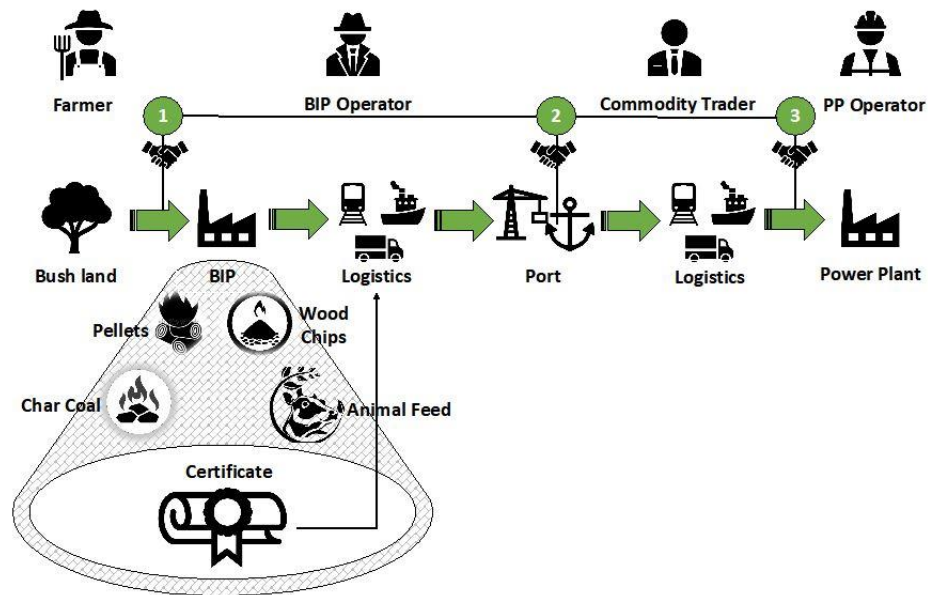
Important for the project in Namibia is the transfer of ownership in the certification chain. After each transfer of ownership, the following party in the chain of custody is obliged to certify itself. For the project in Namibia the transfer of ownership of the solid biomass material flows should be kept as low as possible in order to minimize the certification effort. The first point to be certified is the collection point after harvesting.

### **Recommendation**

To keep the effort and the certification chain as lean as possible, the following proposal is made: A higher-level operator as a screen over the supply/custody chain should act as a client for the BIP, by harvesting biomass, the transfer of ownership passes from the farmer to the operator. The process chains (collection, shredding, preparation, etc.) of the resulting products in the BIP itself are paid for their services to the biomass, but do not acquire the biomass themselves to avoid the transfer of ownership. In this scenario, only the umbrella institution has to be certified and can use or set up its own logistics network or completely outsource the logistics part, since transport is declared as a service rather than a transfer of ownership.

The transport can be organized to Walvis Bay or the European ports, so another transfer of ownership to commodity traders can take place from the ports of destination, who would have to be certified. The European standards already have to be met by traders, because they are mandatory for customers. Therefore, the additional

effort for commodity traders with existing certifications like SBP, FSC, PEFC would be minimal, because the conditions of SURE would already be fulfilled to a large extent. An advantage is the monitoring for the creation of CO<sub>2</sub> and mass balances. One monitoring system should be operated and controlled.



**Figure 41.** Certification scheme with ownership transitions

## 9 Conclusion and way forward

### 9.1 Conclusion

#### **The economic, the technical and socio-economic impacts of BIPs in Namibia**

Namibia cannot effectively tackle bush encroachment without addressing international markets. Namibia's demand for bush very unlikely will exceed 6 Mio. tons per year. At least 13 Mill. tons need to be harvested per year to keep the status quo, which is the minimum requirement. In Namibia the use of solar PV and wind is much cheaper (lower LCOE compared to biomass to power) than the use of biomass. This is due to the lack of demand for heat which is cogenerated in the power production process. Evidently there is a demand to look for other, more value adding strategies and markets to put Namibia's biomass potential into use. In Namibia only those markets should be supplied by biomass which can show an advantage compared to PV and wind. This for example pertains at heating processes in industry, cogeneration in industry, small scale decentral ovens, liquid fuels and baseload coverage.

International demand for biomass energy exists. This is proven by the concrete MOUs created by IfaS within the last 18 month of project work with strategic partners from the international biomass trade and utilization sector. Forced by binding political decisions in Europe and especially in Germany the energy market is decarbonizing and divesting. Whole cities, states, communities and companies are leaving fossil energy sources behind and are searching for sustainable alternatives. Through the economic evaluation, provided in this roadmap it is shown that the Namibian bush biomass can meet the demand to create a new energy market aspect.

As one pre-condition international physicochemical fuel requirements and certification standards must be guaranteed, which can be achieved with FSC or SBP certification. Based on its encroacher bush Namibia owns a unique opportunity to develop solutions alongside the rising international demand for clean energy and fuel. In here, a unique chance for African European partnerships with the aim to get high ecological and social standards in place in Namibia arises. Political support is needed here, as a country certification would benefit all industry players.

However, the reduction of unit cost and increase of volumes are essential to attract the international energy market. Therefore, the industrialization of harvesting and processing via Biomass Industry Park concept (BIP) is recommended in order to reduce unit costs, to guarantee the supply of larger quantities and to set high social and ecological standards. Throughout whole bush utilization and inter-company cooperation and synergies (such as joint maintenance services or waste heat utilization) entire system-costs will automatically be reduced and competitiveness is increased. For Africa this will be the first time to implement the idea of industrial ecology based on bush biomass.

The present economic evaluation shows, that a BIP with an overall estimated investment of 26 Mio. EUR under current market prices could provide requested quantities on competitive scale both quantitative and qualitative and with adequate economic performance. The IRRs show, that each individual BIP realm is capable to exceed 8.8% WACC and hence create positive net present values (NPV) still including dividend payments. Simply spoken, positive NPVs guarantee a payback of the invested money including a rate of return that exceeds cost of capital. In this case the project implementation is recommended. The cash flow models indicate positive 'total cashflows' throughout the business years, meaning that liquidity is reassured all over the project time. The operative performance, expressed by the EAT, except for pellets was relatively low, especially in the first two years, however increases substantially

over period, mainly due to inflation but also to reduction in interest payments given by the relatively low loan credit periods. The payback periods (PBPs) of the projects inherit a moderate risk, as the expected life span of the plants is closely to the calculated payback period. Shareholders could count on a 12 % ROI margin, which constitutes a promising option.

Still there are specific process steps that need improvement on pure technical level, such as essential bush-thinning with excavators, specific refinements such as pellets or improvements on logistics, for instance from field to BIP or from BIP to harbor. For this, a large scale applied research project was organized and approved by German government (BuToVal research grant) which will help to fill in the last missing mosaic stones with regard to field testing and adaption of technology for the harvesting and processing. It is important to highlight, that 50% of a BIPs CAPEX with a proposed throughput capacity of 250,000 t/a account for harvesting activities only. The post-harvesting and processing realms in contrast demand rather small CAPEX. Logistics seem to be the main bottle neck of successful bush thinning. The same counts for unit and sector prices. Wood chips for example could be delivered CIF ARA for 100 EUR/t, whereof logistics cost hold 60% only subdivided in 60% sea freight and 40% national logistic based on FOB prices. The remaining 40 EUR/t that account for production are subdivided in 15 EUR/t for post-harvesting treatment and again 25 EUR/t are needed in field for harvesting. Currently, logistical infrastructure in Namibia is insufficient with regard to mobilizing more than 2 Mio. tons per annum, which is far below the envisaged. Rail and road infrastructure must be improved. Here expected corporate tax payments of around 800,000 EUR/a could trigger further infrastructure development. There is a strong possibility that the revenues of a sustainable, large scale bush thinning will assist the country in further developing its logistical infrastructure.

After many expert discussions, it becomes more and more obvious that pellet production provides one of the keys to a largescale bush thinning. Pellet production in

our opinion will become true game changer. It reduces transportation costs, adds more value to Namibia and makes the use of biomass for the off takers more convenient. The international pellet market will request at least additional 6 Mio. tons of pellets annually by 2024. When this study started Namibian encroacher, bush was known for its “non-pelletizability” due to its high ash and silicon content that depress economic profitability. Throughout this study we could indicate that this “dogma” is no longer substantial, as different wood pellet technology providers surely subscribe the challenge but do not entirely neglect a feasibility. Newly developed hammer mills and cyclones for demineralization as well as steam-based press methods to soften the wood indicate promising results. Sure, the wear costs are higher in contrast to standardized processes using softer woods, but Namibian wood chips as feedstock for pelleting that are manufactured within a BIP are extremely dry and have substantially higher calorific value than soft woods. Here a significant competitive advantage is given as OPEX for drying purposes does not apply and CAPEX for dryers that hold up to 25% of the entire pellet plant are not needed. In this regard, encroacher bush is significantly cheaper than traditional feedstock. Furthermore, BIPs are equipped with PV powered systems providing electricity up to 60% cheaper to the resident processes such as pellet production, whereby electricity counts almost 50% of OPEX. PV systems will even reduce the carbon footprint of BIP products in contrast to fossil fuel-based operations and add more value to Namibian economy. In addition to Namibian biomass, solar energy will be monetarized and exported. The wood pellet market currently inherits the highest potential margins. Transport related emissions, even in export, along the entire chain of custody are negligible as the CO<sub>2</sub> emissions sum up to less than 0.4 g/kg of transported good.

It seems feasible that every single realm along the bush valorization chain is economical viable, however pellets could levy the pressure on the partially meager margins (cross-financing) and additionally allow the BIP to provide/finance socio-ecologic activities for employees and nature. Beside the fact, that a BIP will create up

to 250 new jobs, both for women and men, already there is sufficient margin to shell some “BIP-Pennies” out for residential areas, kinder gardens, schools, parks, playgrounds, laboratories, R&D divisions and other social and public services. Above that, a basic finance for aftercare management research, biodiversity protection and climate change adaptation are available.

Instead of cutting and destroying the bush, which is standard right now, it is instrumental to cut and reuse like in a sustainable forest management. The intermediate time till the bush can be harvested again the land can be used for cattle ranching, game farming, or grass production. Next steps in bush to value practical research will have to deal with the proper use of aftercare material like the re-growing bush twigs and the immediately upcoming savannah grass. First ideas and company contacts exist to develop grass paper business and new largescale bush feed production. Bush feed can benefit from grass paper by using nutrients which can be extruded from the grass fiber production. These aspects will give Namibia the unique chance to enter a rural bio economy strategy based on existing business. More work on markets, technologies and potential investors needs to be done with regard to this. The present study already indicates a technical and economic feasibility for large scale bush feed production alone.

Bush thinning Namibia’s savanna landscape is a tremendous task. A BIP with a throughput of 250,000 t per annum would cover an area with a radius of approx. 37km. Based on this assumption and with regard to the total affected area 105 BIPs spread all over Namibia’s encroached area could be implemented harvesting encroacher bush sustainably in a continuous process and controlled environment. Extrapolating the potential tax payments, job creation and investments that will be triggered when 105 BIPs are implemented, Namibia could really speak of an industry that would significantly contribute to Namibia’s GDP, Namibias rural development and Namibias sustainability.

## 9.2 Way forward

Looking back on the last 18 months with all the problems and networking and new developments the present roadmap clearly shows the remaining issues which need to be tackled. We do have a very promising looking economic and technical feasibility for the Biomass Industry Park as shown in the above tables and figures. These figures can be used to start **interaction with financing institutions, government and entrepreneurs**. This will be done via our so called “**Road Show**” concept in Namibia and South Africa.

In the following month, based on the results of the business plan and the recommendations of the road map individual components with the overall objective of preparatory measurements for BIP implementation, concrete: the first BIP in Otjiwarongo shall be taken up and pursued. It is essential to **further sensitize the European off-take market** with the existing stakeholder network and the implementation bodies in Namibia in order to keep demand for BIP products and proactive participation willingness alive to avoid the creation of a development break. A development stop at the current point of time would be very counterproductive, as the last 18 month of BCBU and IfaS project work created a certain atmosphere of departure which was derided beforehand but is concretizing moreover as producers, processors, traders and customers within the entire chain of custody start believing in an intra-continental biomass industry between Europe and Namibia.

Furthermore, decisive strategic partners with concrete interest in becoming biomass partnership representative have been successfully addressed and committed, such as the city of Hamburg or the Brüning group. However, stakeholder management is time intensive task and reservations against partnering with Namibia are still existent, whereas some specific tasks, such as **international certification** of biomass, tailor-made confection as well as logistics need to be studied in more detail. In order to foster



the existing cooperation and delete all reservations with strategic partners, IfaS expresses its interest in progressing the established work.

It is the clear objective, to support the foundation of a concrete BIP ownership structure respectively partnership structure for Otjiwarongo beyond a gentlemen's agreement (e.g. formally expressed commitment and agreement) within or above the present stakeholder and strategic partner network.

On a different note the feasibility study **needs technical and financial consolidation** and fine tuning. Interest rates, loan conditions, possible grants and availability of technology and resources need to be clarified **on the ground** and compared to our assumptions. Thus, we can eliminate more and more worst-case scenarios, get more reliable and become even more attractive to investors and financing institutions.

One crucially important activity will be the **organization and preparation of the certification of the bush biomass**. In order to be able to sell the biomass products to large scale off takers certificates must be provided. Which system most adequately suits on what scale to whom and who will conduct the certification will be answered in the next steps ahead.

Equally important will be the further testing of specially adapted harvesting and processing equipment. First strong indication exist of possible improvement by the first tests that have been conducted in Germany. Haas GmbH harvester seems to cut costs by half and increase throughput by 50%, DHG guillotine strategy seems to work and the production of wood pellets becomes more and more likely. This is what we strongly believe based on the so far existing evidence! But it is important that the **risk evaluator from the financing bank can be convinced**. And for this we need more trials and more assurance from testing in Namibia under real outdoor conditions. **Selected**

**technologies we have to test and adapt in the field in Namibia** to be sure, to further optimize and to win the trust of the financing institutions.

As shown in the above study the BIP provides opportunities far beyond the production of pellets, wood chips and pyrolysis products. With the multifunctional land use necessary for sustainable aftercare new products can be developed. One of course is bush feed. Another could be material use of grass like grass paper production. Next steps must clearly **develop these new options under the view of entering a new decentral bio economy**. For this the cooperation with universities in Namibia need to be further developed.

During the last 18 months we successfully started the implementation process of the BIP in Namibia. A first mover location in Otjiwarongo was selected and talks to the municipality were initiated. Potential investors from the region like Imperial Logistics from SA were contacted and attracted to the BIP. In any case we need **to follow up on this, while as well promoting the BIP idea to other stakeholders and locations in Namibia**. A BIP roadshow in Namibia to sell the benefits and the procedures of a Biomass Industry Park to financing institutions, government bodies, academia and business world in Namibia and South Africa is needed. In concrete terms this means organizing at least a 2-day workshop/conference in Windhoek and set up meetings with selected stake holders in Johannesburg. The more different potential locations we are planning for more hubs more information on economics and logistics can be added to our feasibility study.

Another benefit and task to deepen from the discussion of new BIP locations and from organizing the “Roadshow” in Namibia will be **the strengthening of local ownership**. In the end it must be a Namibian venture in partnership with international stakeholders. To what extend this will be possible should be shown through a detailed stakeholder questioning at the end of the Roadshow process.

It is of strategic importance to **consolidate the contribution of the academic stakeholders to the BIP strategy**. A detailed BIP brochure should be developed **showing the key research topics connected to the BIP and the idea of a decentral bio-economy strategy**. The more information we spread the newer details we will receive. All this will lead to the **permanent reduction of risks and the elimination of worst-case scenarios**.

Our strategy of approaching German local utilities proved to be very successful. We achieved a written interest from city of Hamburg to look into being partner for Namibian biomass strategy. Hamburg even goes beyond this and will organize 3 working groups to discuss financial, technical and socio-ecological issues. **We need to support and structure these working groups in the time ahead to make sure all information is provided timely and with proper content**.

We as well have to **accommodate the other feedbacks and interests from the first marketing activities**. Various chambers of industry and commerce, other utilities and an increasing number of companies want to be informed about and potentially placed in the BIP hub structure. This must not be neglected.

To summarize the road ahead in a nutshell:

- Roadshow Namibia
- Organization and definition of certification procedures
- Organizing field test for technology adaption
- Fine tuning, economic consolidation and risk minimization in BIP planning
- Strengthening of local ownership of BIP idea, supporting first BIP in Otjiwarongo
- Further developing the academia towards a rural bio economy strategy based on bush biomass using the BIP infrastructure
- Following the international stakeholder network with special focus on Hamburg

We are as close as never to a **real sustainable and resilient interference** with the bush encroachment problem. Not only seems to be possible to intervene on large scale, industrial sized level. It also seems to be possible to maximize the ecological and social benefits as well as the regional added value for rural areas in Namibia. The missing step stones are mentioned above. They need to be organized and stepped on!

## 10 Attachment



### MUNICIPALITY OTJIWARONGO

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OTJIWARONGO  
Namibia

REF. NO. 6/15/1

ENQUIRIES: P. Kuteeue

2019.03.18

**Attention: Colin Lindeque**

Cell: 081 343 3424

Namibia Biomass Group  
5 Von Braun Street  
Southern Industrial Area  
**WINDHOEK**  
Namibia

Dear Sir,

#### **EXPRESSION OF INTEREST TO HOST NAMIBIA'S FIRST BIOMASS INDUSTRIAL PARK**

The above-mentioned hereto refers.

Otjiwarongo Local Authority Council hereby expresses interest to host the envisaged Namibia Biomass Industrial Park, as per your ***"Call for Proposals – Site Selection for Biomass Industrial Park, Namibia,"*** dated 12<sup>th</sup> March 2019.

Otjiwarongo sits at the center of the area mostly affected by bush encroachment, henceforth measures to combat bush encroachment will create positive opportunities for the town's economy, such as animal feed production, electricity generation and value chain development in other sectors.

Otjiwarongo offers extensive infrastructure such as roads, rail, telecommunications facilities, as well as abundance of serviced and un-serviced land for industrial purposes.

Thanking you in advance, while looking forward to the opportunity to submit our detailed proposal for the siting of this exciting project.

For further inquiries kindly contact the above-mentioned at our offices.

Sincerely Yours,

  
**ISMAEL / HOWOSEB**  
**CHIEF EXECUTIVE OFFICER**  
/pk

Figure 42. Scanned copy of the letter from Otjiwarongo municipality.