BIOMASS POWER PLANT FEASIBILITY STUDY

FINAL DRAFT

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ANNEXURE A

RIPARIAN ZONES INFESTED WITH INVASIVE ALIEN TREES OF THE TARGETED SUPPLY BASE AREA – A DESKTOP SURVEY BY THE *COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH* AS PART OF A STUDY BY *NRGen* FOR *AFRICA BIOMASS COMPANY* TO CONFIRM SECURITY OF BIOMASS SUPPLY TO A PROPOSED COMBINED HEAT & POWER FACILITY AT RCL WORCESTER (MARCH 2019)

Compiled by: Dr William Stafford & Greg Forsyth of the CSIR, Stellenbosch

A preliminary assessment to estimate the woody invasive alien plant biomass in the riparian areas of the Breede, Berg, Hex and Riviersonderend rivers for ABC's biomass-to-electricity pre-feasibility study

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1 Introduction

Approximately 750 tree species and close to 8 000 shrubby, succulent and herbaceous species are recorded as having been introduced into South Africa. Of these, 161 are regarded as invasive (Van Wilgen et al., 2001; Nyoka, 2003). The majority (approx. 68%) of these invasive alien plants are woody[i] trees and have been the focus of control efforts. The introduction of invasive alien plants in South Africa has led to the conversion of species-rich vegetation to single-species stands of trees. This conversion threatens biodiversity, water security, the productive use of land, and the ecological functioning of natural systems. Invasive alien trees also intensify the impact of fires and floods, increase soil erosion, and have increasingly negative impacts on ecosystem services (De Lange & Van Wilgen, 2010). The regulations of the National Environmental Management: Biodiversity Act (NEM:BA, 2014) lists invasive alien species which require a range of control measures including removal, permits and appropriate management. The burden of controlling invasive alien trees is largely being led by the government's Natural Resource Management (DEA:NRM) programme established in 1995. While the progress and investment is significant, there are notable missed opportunities. However, to date, very little cost recovery has occurred through the sale of various wood products and bioenergy; including timber, wood-fuels, composite wood products, biochar, mulch, compost, and biomass to electricity.

This report was commissioned by African Biomass Company, ABC, (ChipperSA)[1] who are interested in expanding their operations beyond the supply of wood-chips for mulch, to include a proposed biomass-to-electricity power station in Worcester. **This study is a rapid assessment of the invasive alien tree biomass in riparian areas of the Breede, Berg, Hex and Riviersonderend rivers and adjacent areas of Botriver, Kleintjieskraal and Watervall (Western Cape, South Africa). It should be considered a preliminary, desktop based assessment to estimate the biomass of invasive alien trees in these riparian areas, and should be followed by more detailed feasibility studies that includes ground-thruthing to spatially assess the biomass amounts, verify the species, and determine the costs of extraction based on slope and distance to road-side. Such feasibility studies will also need to develop a management unit control plan for these areas to facilitate partnerships with numerous landowners and ensure that there is effective clearing and harvesting of invasive alien trees, with biomass security of supply established through contractual arrangements and fire prevention measures. These management plans will also need to ensure that cleared lands are maintained and landscapes are restored.**

2 Methods

Since the flood lines have only been extensively surveyed in urban areas for civil engineering purposes and the use of a hydrological model to define the 100-year flood line for these rivers is beyond the scope of this task, we defined the **riparian area** in terms of being functionally accessible for harvesting biomass by ABC machinery by nature of having a gently gentle slope (<20^0) and with **1km buffer either side of the river**. A slope map with several classes was generated and intercepted with the CSIR_biomass data with the **0^0 to 10^0 slope** (from horizontal) selected as preferred slope that enables machinery access so that the biomass can be harvested and chipped. Since there are large areas along these rivers that are agricultural fields with negligible invasive alien plant species, these were masked from the analysis.

The study area of the three rivers and riparian area used in this assessment is shown in Figure 1 and Table 1. The riparian area that we assessed was 149728 m^2 (Table 2).

[1] https://www.abcbanditchippers.co.za/

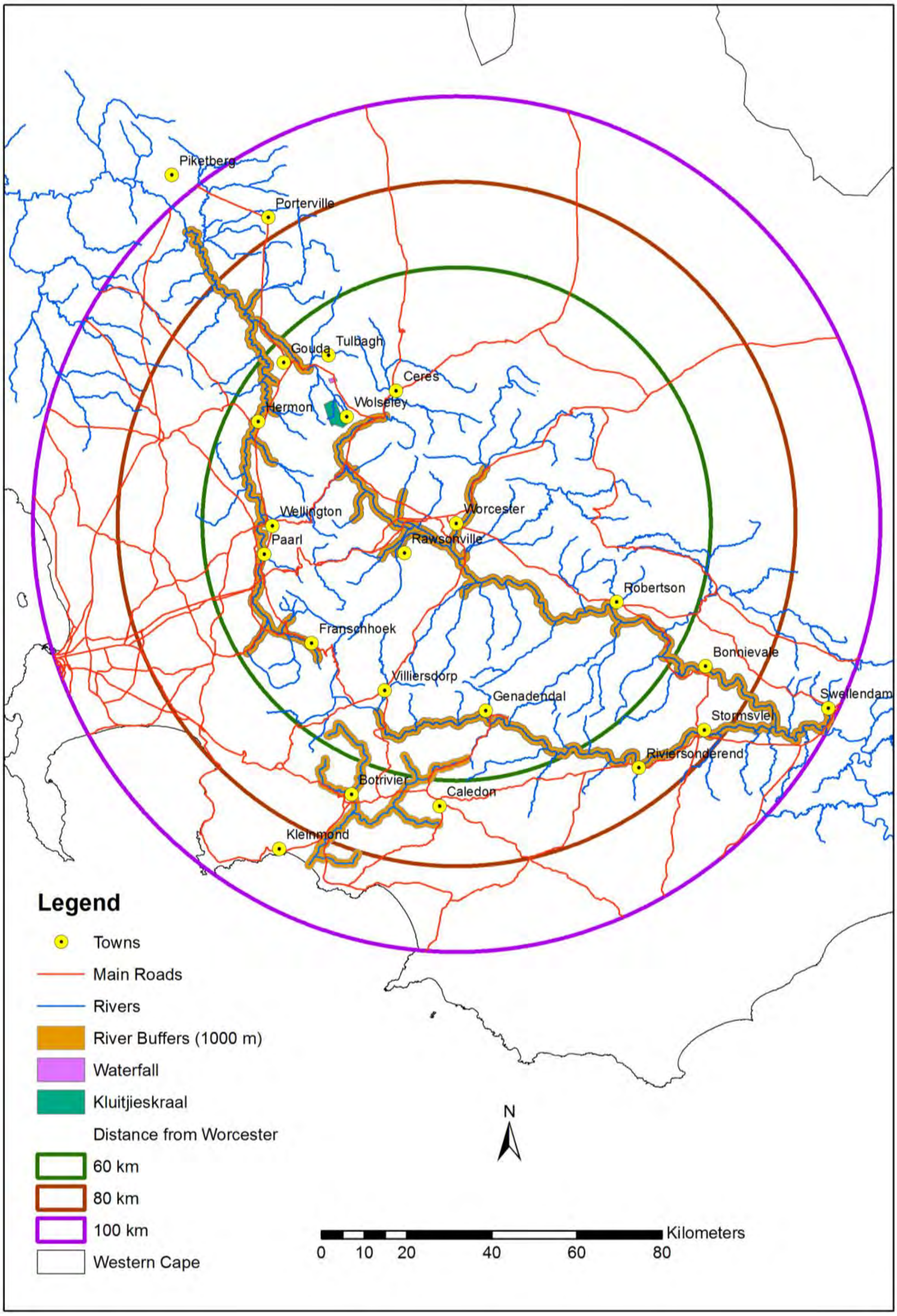

Figure 1. Study area: Riparian areas of the Breede, Berg and Riviersonderend rivers with distance from Worcester

Table 1: Areas described in this study

Riparian Area	Description
Upper Berg	Franshoek to Paarl
Middle Berg	Paarl to Zinkwasdrift
Lower Berg	Zinkwasdrift to Misverstand Weir
Upper Breede	Mictechels pass to Worcester
Middle Breede	Worcester to Van Loerverens estate
Lower Breede	Van Loerverens estate to Swellendam
Riviersonderend	Tierwaterskloof dam to confluence with Breede
Botriver	Botriver system
Kleintjieskraal and Waterfall	Kleintjieskraal and Waterfall plantation exit areas

Using existing data and GIS analysis, we estimated the riparian area, biomass, and extent of invasive alien plants to derive a first order estimate of invasive alien tree biomass in the Breede, Berg, Hex and Riviersonderend rivers and adjacent areas of Botriver and Kleintjieskraal. The CSIR have recently used remote sensing data (ALOS_PULSAR from year 2010) to produce a national map of above ground biomass at 20m resolution (CSIR_Biomass v1.1, beta product 2018, unpublished and in development). The CSIR_Biomass map was used to class the biomass in the areas of interest into **three classes where the slope is <10^0: 30-60 odt/ha, 60-90 odt/ha and >90 odt/ha.** The CSIR biomass map underestimates biomass above 90 odt/ha as the signal begins to saturate. We have therefore adjusted for this saturation by reviewing ABC harvesting data for defined areas and have adjusted the mean for the upper biomass class (90-120 odt/ha) to 105 odt/ha (equivalent 128 t/ha @22% moisture). This is similar to recorded yields of ChipperSA of 53-433 t/ha @22% moisture (average 152 t/ha) during their harvesting and chipping operations.

Note: The CSIR_biomass map uses oven dry tonnes (odt) at 0% moisture. The moisture content is taken into account when expressing the biomass available for the proposed biomass power plant (22% moisture. Aka "as received")

The biomass map has been adjusted for the following:

- The CSIR-biomass map is for the year 2010 so the biomass growth from 2010 to 2019 needs to be included for an up to date estimate. The **mean annual increment** (MAI) of Forestry plantations[2] is typically 2-22 m^3/ha/annum. Based on limited field data, we estimate that the MAI is at least 8m^3/ha/annum which is equivalent to **5 odt/ha/annum** and have adjusted for growth during this period.
- A portion of the biomass identified by the CSIR-biomass map is indigenous trees. Conservatively, we estimate that at lonely **5% of the biomass in these areas is indigenous** (95% invasive alien plants)

[2] Data on Forestry yields: See
https://www.forestresearch.gov.uk/tools-and-resources/statistics/forestry-statistics/forestry-statistics-2016-introduction/sources/timber/conversion-factors/
http://planet.botany.uwc.ac.za/nisl/Invasives/Assignments/GARP/atlas/atlas_236t.htm
http://www.fao.org/3/a-ac121e.pdf
http://www1.udel.edu/johnmack/frec424/424lec16.html

- The biomass available for the power station is therefore the biomass standing stock that can be utilised over a defined time period- which is the **20 year project lifetime** proposed for the biomass power plant. However, during the harvesting of biomass in this time period, the portion of biomass not yet harvested in a given year continues to grow and we have therefore adjusted for the invasive alien plant growth during harvest (5 odt/ha/annum).
- **No adjustments** to biomass amounts of invasive alien plants were made for the **coppicing after clearing or spread** (germination). This is to ensure compliance with NEM:BA legislation
- Since the CSIR biomass map data of 2010, several of these riparian areas have been cleared; particularly along the upper- and mid- sections of Breede and Berg rivers (although most of the clearing has been limited to 30m either side of the river). **No adjustments** to biomass amounts were made to account for the **clearing of invasive alien trees or removal by fire since 2010**.

3 Results and discussion

The GIS analysis of above ground biomass at <10^0 slope as a function of distance is shown in Table 2 and Figure 2 (values as a function of distance are cumulative). An example of spatial data used to calculate these biomass amounts is shown in Figure 3.

Table 2. Cumulative riparian biomass (odt) as a function of distance from Worcester

River	Riparian area (buffer) (ha)	Biomass odt (0% moisture) Distance from Worcester 0 -60 km	0- 80 km	0 - 100 km	Total available biomass
Berg - Lower	12156	13031	58423	83350	83350
Berg - Middle	17945	189540	212226		212226
Berg - Upper	9814	213199			213199
Riviersonderend	24969	115635	240375	272550	272550
Breede- Lower	14833	5694	32042	73797	73797
Breede - Middle	25379	252869			252869
Breede - Upper	15662	7417			7417
Bot River	26895	26446	117938	173188	173188
Kluitjies Kraal	1915	107229			107229
Waterval	161	11952			11952
	149728				**1407776**

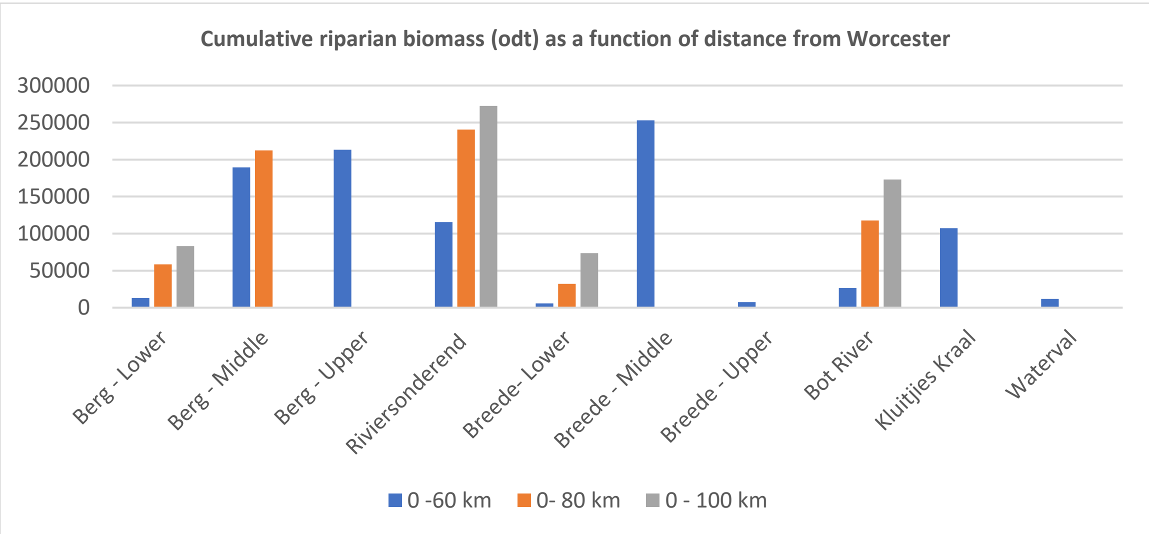

Figure 2. Cumulative riparian biomass as a function of distance from Worcester (total stock as oven dry tonnes, odt)

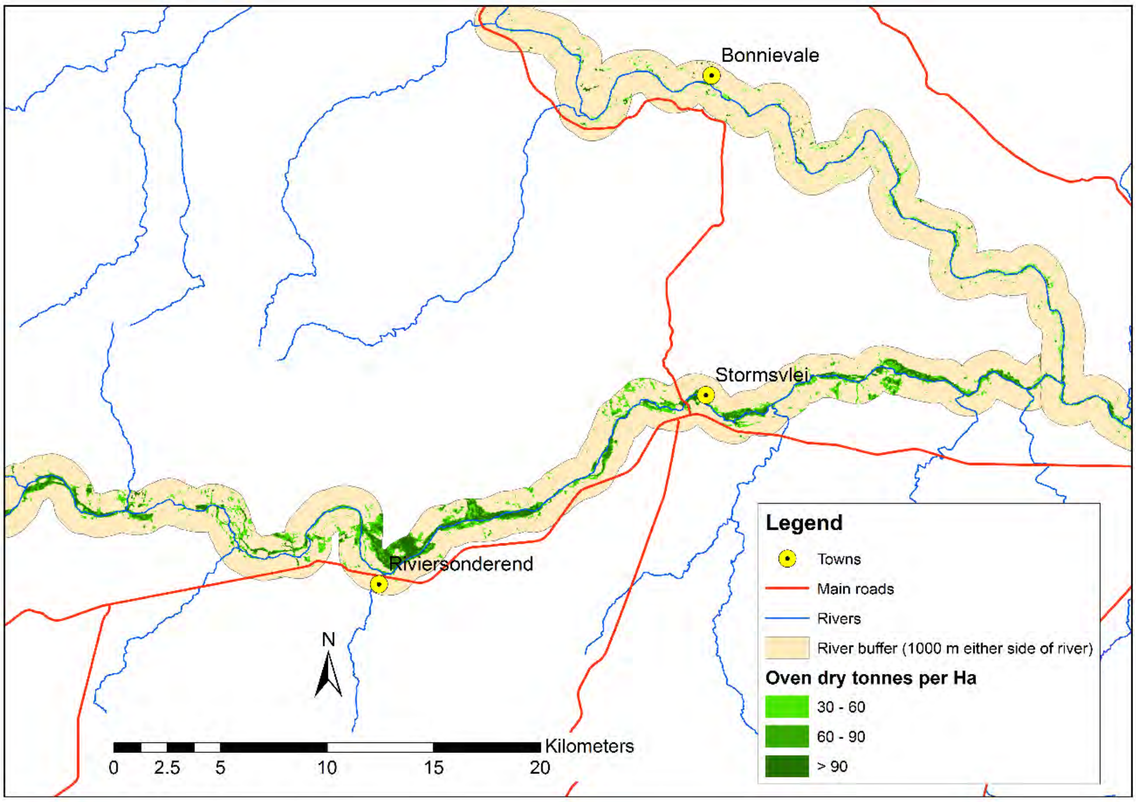

Figure 3. An example of the spatial distribution of biomass in one of the riparian areas assessed in this study

The adjustments made to these above ground biomass standing stocks in terms of the above described factors are presented in table 3.

Table 3. Available Invasive Alien Plant biomass to supply a biomass-to-electricity power plant over a 20 years' time period. Adjustments are as described in the text.

LOCATION	**BIOMASS 2010 STOCK** **CSIR-Biomass** **(odt)** **A**	**INVASIVE ALIEN TREE BIOMASS 2010 STOCK** **Biomass with adjustment for indigenous** **(odt)** **B**	**INVASIVE ALIEN TREE BIOMASS STOCK 2019-** **Biomass after adjustment for indigenous, then tree growth included to get available stock to 2019** **(odt)** **C**	**ANNUAL INVASIVE ALIEN TREE BIOMASS AVAILABLE at 0% moisture** **A 20 year project lifetime and allowing for tree growth during harvest** **(odt)** **D**	**ANNUAL INVASIVE ALIEN TREE BIOMASS AVAILABLE at 45% moisture** **(green tonne)** **E**	**ANNUAL INVASIVE ALIEN TREE BIOMASS AVAILABLE at 22% moisture** **(as received)** **F**
Adjustment equation:	**A**	**B=A*0.95**	**C= B*1.175**	**D=(C*1.87)/20**	**E=D*1.45**	**F=D*1.22**
Berg - Lower	83350	79182	93039	8699	12614	10613
Berg - Middle	212226	201614	236897	22150	32117	27023
Berg - Upper	213199	202539	237983	22251	32265	27147
Riviersonderend	272550	258923	304234	28446	41247	34704
Breede- Lower	73797	70107	82376	7702	11168	9397
Breede - Middle	252869	240226	282265	26392	38268	32198
Breede - Upper	7417	7046	8279	774	1122	944
Bot River	173188	164528	193321	18075	26209	22052
Kluitjies Kraal	107229	101867	119694	11191	16228	13653
Waterfall	11952	11355	13342	1247	1809	1522
TOTAL	1407776	1337387	1571430	146929	213047	**179253**

5 Conclusion

Our preliminary results indicate that, in the riparian area of 149728 ha, there is 179253 tonnes of invasive alien plant biomass (22% moisture) available per annum over 20 years to provide feedstock for a proposed biomass-to-electricity power station in Worcester. This biomass could theoretically supply a 14 MWe power station, assuming biomass is 15.5 GJ/t (22% moisture) and the biomass power station operates with a 25% electrical efficiency, 0.8 capacity factor and 0.8 power factor. However, no adjustments to biomass estimates were made to account for the clearing of invasive alien trees or removal by fire since the CSIR_Biomass map data was acquired in 2010. In addition, there may be risks to access and secure the biomass from landowners and also to ensure the biomass is protected from loss due to future fires. It is also important to note that no re-growth from coppicing, germination from existing seed banks, and incremental growth from young seedlings were included in this assessment- and this could substantially increase future biomass supply.

Furthermore, the biomass from invasive alien trees could also supplemented by biomass from the maintenance or fruit orchards in these areas. Therefore, it is likely that there will be sufficient biomass available to supply a small biomass-to-electricity power station of at least 10 MWe in Worcester for 20 years or more. These biomass-to-electricity power plants are available as turnkey solutions from international and local suppliers[3].

These preliminary estimates should be followed by more detailed feasibility studies that includes ground-truthing to spatially assess the biomass amounts, verify the species, and determine the costs of extraction based on slope and distance to road-side. Such feasibility studies will also need to develop a management unit control plan for these areas to facilitate partnerships with numerous landowners and ensure that there is effective clearing and harvesting of invasive alien trees, with biomass security of supply established through contractual arrangements and fire prevention measures. These management plans will also need to ensure that cleared lands are maintained and landscapes are restored.

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[3] See, for example, the 5 MWe and 10 MWe boilers from John Thompson. http://www.johnthompson.co.za/files/leftpdfs/99_2%20Engineering%20News%20-%20June%20Contribution%20-%20Bio-Mass%20Draft.pdf

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[i] Woody is defined as biomass that has >20% lignin content.

ANNEXURE B

FRUIT ORCHARD AREAS IN THE WESTERN CAPE

Data (2017 Aerial survey) supplied by Ms Joyene Isaacs & Louw Pienaar of the Department of Agriculture, Western Cape Government

PAGE B.1

FRUIT ORCHARDS AREAS IN THE WESTERN CAPE (2017)

Local Municipality	Almond nuts	Apple	Apricot	Avocado	Black-berries	Blue-berries	Cherries	Dates	Figs	Grape-fruit	Grena-della	Guava	Lemon	Lime	Macadamia nuts	Mango	Mul-berries	Naar-tjies	
Beaufort West	2							0										0	
Bergrivier	15	376	12	1	1	91	0		56	3	1	184	168	6		1		783	
Bitou												0			20				
Breede Valley	23	327	92				39		40				59					375	
Cape Agulhas						13			57										
Cederberg	3		119	12						13	16		438	31		101		2 269	
City of Cape Town	0	190				5			0			102	67		1			10	
Drakenstein	5	21	21			99			29			315	278	22		1		394	
George	21	1 409	74	19		198			48	1			1		183				
Hessequa	5	1	13	63		1			1				4		88	2		99	
Kannaland	53	3	536						32				10					1	
Knysna						11									6			2	
Laingsburg	7		86					2											
Langeberg	77	262	1 451	2		62			38	1	3	4	559	115	17			1 009	
Matzikama			1					0	6			1	1		0			2	
Mossel Bay	1			145		54			1			58	1		151	6			
Oudtshoorn			1						1				0		2				
Overstrand		133				33			3										
Prince Albert	8		43			4			15				0						
Saldanha Bay												0							
Stellenbosch	0	8			7	42			2		0	126	126	22			0	138	
Swartland	91	1							19		0	11	131	3				195	
Swellendam	118	162	121	0	60	26			6				96	1	2			740	
Theewaterskloof	1	11 059	34			102					0		33	3	1			146	
Witzenberg	6	7 538	128			81	118	6	16				15					51	
Total	**436**	**21 491**	**2 730**	**242**	**68**	**824**	**157**	**9**	**370**	**17**	**21**	**800**	**1 987**	**202**	**470**	**111**	**0**	**6 214**	
HARVESTABLE FRUIT ORCHARDS IN A 100 km RADUIS FROM WORCESTER [Areas in hectare]																			
Sub-total p B.1		**19 878**	**1 859**									**636**	**1 465**	**159**				**3 831**	**27 828**

PAGE B.2																		
FRUIT ORCHARDS AREAS IN THE WESTERN CAPE (2017)																		
Local Municipality	**Nectar-rine**	**Olives**	**Oranges**	**Other fruit**	**Other nuts**	**Peach**	**Pear**	**Pecan nuts**	**Persim-mons**	**Plums**	**Pome-granate**	**Prickly pear**	**Rasp-berries**	**Straw-berries**	**Table Grapes**	**Walnuts**	**Wine Grapes**	
Beaufort West		111		0		2		3			20	42			0		6	
Bergrivier	31	275	702	1	3	99	190	9	2	24	66	1			1 538		1 062	
Bitou		5									0				5		79	
Breede Valley	70	605	164	0		338	166	5		176	7	3		0	5 787	7	15 807	
Cape Agulhas		30										19			13		246	
Cederberg	31	66	6 202	1		332	36	22			9	14		0	586		910	
City of Cape Town		305		0			170	3		80	44				43		5 049	
Drakenstein	114	1 319	145	1		119	56	15	3	989	77	1		51	1 971		12 297	
George	39	17		0		141	358	25		168	40	4	46	40	10		112	
Hessequa		336	1	1	7	23	10	1	5	2	51	21					56	
Kannaland	9	352	0	1	4	302	66	0		309	77	0		1	125		863	
Knysna		1	12	27					4	1	0							
Laingsburg	13	62	3	5	1	67	12	8		34		0			10		25	
Langeberg	66	374	165	54		2 480	446	37	96	1 471	103	5		10	336		14 141	
Matzikama	3	14	20	1		25		35		0	0	1			1 189		9 490	
Mossel Bay		25	1								2			11			16	
Oudtshoorn		187		2		2		33		34	8	1			19		135	
Overstrand	0	150		1			83			2			63				826	
Prince Albert	1	375	0	1		5		2		16	3	1					70	
Saldanha Bay		47		0							1	1			0		1	
Stellenbosch	33	315	12	1	1	59	136	1	39	795	17		5	61	10		13 040	
Swartland	71	418	55	9		28				13	142	15			1 368		11 058	
Swellendam	15	377	53	4		466	378	9	81	96		0	4	1			190	
Theewaterskloof	35	155	0	5		200	2 572	4	116	214	3	2	4		1		1 450	
Witzenberg	977	294	59	9		2 155	6 018		9	1 219	43	11			85		4 285	
Total	**1 509**	**6 215**	**7 596**	**126**	**15**	**6 843**	**10 698**	**211**	**354**	**5 642**	**715**	**142**	**121**	**176**	**13 095**	**7**	**91 214**	
HARVESTABLE FRUIT ORCHARDS IN A 100 km RADUIS FROM WORCESTER [Areas in hectare]																		
	1 412		**1 355**			**5 944**	**10 045**			**4 997**					**10 749**		**73 330**	**107 832**
Sub-total carried over from page B.1																		**27 828**
Total area of harvestable fruit orchards in the targeted area (2017)																		**135 660**

ANNEXURE C

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

ABBREVIATED WOODY BIOFUEL SPECIFICATIONS

Compiled by: M.J. de Wet	16 June 2023 Updated 30 August 2023

The following specifications should be achievable with felled alien and other trees, left to sundry to < 25% moisture, when chipped into hogfuel[1]. The final chipped/milled/grinded product (fibres) should adhere to the following specifications:

i. *Moisture Content [MC]* between 22% and 25% (by weight) of chips/fibre delivered to the proposed B2E power plant at Idas Valley, Stellenbosch.

ii. A mixture of invasive alien trees, the solid woody part of garden refuse, old fruit orchards, and industrial waste wood may be offered in a mixed format as hogfuel. [Mixing of the various wood types will/or could take place at the on-site wood processing station].

iii. The *Ash Content* (excluding contaminants) shall not exceed 6% and can be further reduced when fines (residual sand/dust) are screened out at a relatively small extra cost per ton. Sand and dust will show as ash in the calorific test results of the on-site laboratory.

iv. The maximum length of single particles/fibres: (250 ± 100) mm.

v. The maximum width of single particles/fibres: (50 ± 10) mm.

vi. 'Fines' are defined as particles smaller than 2 mm in size.

vii. Less than 5% of the biomass (by mass) should be oversized [should not be longer than 350 mm in length].

viii. Less than 5% of the biomass should be 'fines' or undersized material. [Fines can be further reduced to < 4% (by mass) with additional screening at a relatively small extra cost per ton].

ix. Free of contamination e.g., stones, metal pieces, plastic, and other impurities.

x. The *Calorific Value* of the Hog Fuel at an average MC of 24% should be better than 14.0 GJ/metric ton.

[1] Hogfuel refers to biomass fibre for the thermal heating industry, when partially dried aliens (MC < 25%) is chipped/crushed or milled into fibres with a 'chipper' using bit-type cutting and crushing/grinding gear. [Dimensional biomass chips are obtained when partially "wet" bush (MC > 30%) is blade cut with a drum fitted with sharpened blades – Not recommended for this operation].

xi. The proposed medium-term upper reference price[2] per ton ex harvesting site for hogfuel is calculated by using an energy payment of US$ 3.60/GJ, average heating value of 14.0 GJ/t, and an exchange rate of 18.50 ZAR/US$:

∴ Selling price = US$ 3.60/GJ x 14.0 GJ/t (average) x 18.50 [ZAR/US$]

= ZAR 932 per ton (VAT excluded).

xii. To minimise discrepancies re MC, Calorific Value, ash content, and other factors (like Particle Size Distribution), a laboratory analyses will be carried out by an on-site laboratory on a regular basis.

xiii. Consensus needs to be reached between the biomass suppliers and the woodfired boiler operator on the final format including *Particle Size Distribution [PSD]* to the so-called P100 Norm/ISO 17225 as guideline, average *Moisture Content [MC]*, and *Calorific Value [CV]* of the biofuel.

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[2] The selling price is only given as a guideline at this early stage. Eventually, long-term supply contracts will be drawn up with an escalation clause acceptable to both the *Power Station Operator* and the *Woody Biomass Supplier(s).*

ANNEXURE D

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

CHIPPED BIOMASS PRICING CALCULATIONS BASED ON ACTUAL FIGURES OBTAINED FROM AN ABC HARVESTING SITE

Compiled by: M.J. de Wet 12 June 2023 updated 16 August 2023

1. **BACKGROUND**

The ABC harvesting site Skoenmakersfontein can be regarded as a typical average harvesting site, infested with invasive alien trees.

During April - May 2023 a large Bandit Beast horizontal grinder from Africa Biomass Company, Worcester, with the necessary tree harvesting and feeding equipment was used on the 9.31 hectare Skoenmakersfontein site to clear it from invasive alien trees. The following data was recorded:

- The invasive alien trees were reduced to: 6 630 m^3 ①
- At a total cost (plant, equipment, supervision, operators, diesel, etc.) of:

  R2 171 654 ②

2. **APPLICABLE BIOMASS COST CALCULATIONS**

The following calculations were derived from figures obtained in this case study:

- Cost per cubic meter $= \frac{②}{①} = \frac{R2\ 171\ 654}{6\ 630\ \text{m}^3}$

  $= R327.55/m^3$ ③

- Cost per ton with bulk density figures ranging between the two extremes of:

  @ 290 kg/m^3 or 0.29 t/m^3 $= \frac{③}{0.29} = \frac{327.55}{0.29}$ = R1 129.48 ④

  @ 330 kg/m^3 or 0.33/t/m^3 $= \frac{③}{0.33} = \frac{327.55}{0.33}$ = R992.58/t ⑤

- Average cost calculations $= \frac{④ + ⑤}{2}$

  $= \frac{1\ 129.48 + 992.58}{2}$

  $= \frac{2\ 153.07}{2}$

  = R1 061.03/metric ton

  Say = R1 060/t for short-term, small-scale operations

ABC declared their willingness to produce hogfuel at R960/t (ex-harvesting site) for medium- to long-term contracts. (Based on the diesel price and ZAR/US$ exchange rate of 15 August 2023).

3. FINDINGS

The following findings are applicable:

- It would be safe to assume that hogfuel biomass can be produced at between R960/t at typical harvesting sites of the proposed supply base of this project.
- The Skoenmakersfontein site of 9.31 hectares can be regarded as a representative sample of the supply base of alien invasive trees to be harvested for the proposed Idas Valley B2E Power Station.
- For larger scale, long-term harvesting contracts, hogfuel can be prepared at the harvesting site @ < R960/t (VAT excluded).

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ANNEXURE E

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

TRANSPORT COST CALCULATIONS OF CHIPPED BIOFUEL TO THE B2E POWER STATION NEAR STELLENBOSCH

Compiled by: M.J. de Wet 30 August 2023

1. BACKGROUND

To ensure biomass volumes of up to *48 000 metric tonnes per annum* (or ± 50% of the total requirement) delivered to the proposed Biomass Power Station, from remote harvesting sites, it would be wise to look at a supply base which would include the riparian zones of the following rivers:

- Berg, from Franschhoek to Hermon.
- Breede, from Mitchells pass to Robertson.
- Zonderend, from Theewaterskloof dam to Stormsvlei.
- Botriver system.

The large, infested areas of the Napier-Elim-Baardskeerdersbos-triangle (Neighbouring the Strandveld and Nuwejaars Wetland regions) can deliver between 12 000 and 18 000 t.p.a. for many years but are nearly 180 km away from the power station site. (This source is mentioned in Line 10 of Table E.1).

2. THE EFFECT OF TRANSPORT

A *Supply Base* with a road distance limited to 180 km from Stellenbosch, is proposed.

Since transport costs would have a significant impact on the 'delivered cost' of biomass fuel to the Idas Valley Power Station, and since large quantities of biomass would be sourced as far afield as Strormsvlei and from the Strandveld, south of Napier, road distances of 180 km x 2 = 360 km (round trip) are considered in Table E.1. An at-source harvesting and processing cost (See **Annexure D**) of R960/t (VAT excluded) for felling, handling, grinding, and loading of large alien trees with zero by-products were used in Table E.1, and a transport cost of R28/km was multiplied per road trip distance.

A 100 - 110 m^3 (or ± 30t payload for hogfuel) truck system with walking floor is costing R28/km for short-term (< 1 year) contracts. (Quotes obtained from Vallei Organies Transport Co, Worcester – a company which is used to transport low bulk density materials). Separate costings will be done for the so-called billet-type biofuel chunks.

From the logging mill/station (central to the Napier-Elim-Baardskeerderbos-triangle the delivered price of hogfuel would be R1 296/t (VAT excluded). Refer to Line 10, E.1. This high price would limit supply from this area to ± 12 000 t.p.a. Should this area, represented by Mr Leon la Grange [CEO of the Fynbos Logging Mill and Agulhas Biomass Fuel (Pty) Ltd] be prepared to lower the delivered cost of hogfuel to the power station to R1 150/t, their off-take volume could be increased to R18 000 t.p.a. The author is of the opinion that this price can be achieved since hogfuel is a by-product to their logging operation. A long-term solution to the high cost of hogfuel processing could be the implementation of wood billets using an ABC-Billeter. For a more detailed discussion on "wood-billets", please refer to **Annexure H** of this report.

Table E.1: Delivered cost of biofuel to the Power Station near Stellenbosch

Line	Round-trip distance [km]	Transport cost @ R28/km & 30t payload [R/t]	Total cost based on R980/t ex-harvesting site = R980 plus transport [R/t]	Most probable collection mass & frequency [t]	[%]	Moving average (Costs when most probable site are used) [R/t]
1.	20	20 x 28 ÷ 30 = 19	960 + 19 = 979	6 000	12.5	979 x 0.125 = 122
2.	40	40 x 28 ÷ 30 = 37	997	12 000	25.0	997 x 0.25 = 249
3.	80	75	1 035	6 000	12.5	1 035 x 0.125 = 129
4.	120	112	1 072			
5.	160	150	1 110	6 000	12.5	1 110 x 0.125 = 139
6.	200	187	1 147	6 000	12.5	1 147 x 0.125 =143
7.	240	224	1 184			
8.	280	261	1 221			
9.	320	320 x 28 ÷ 30 = 299	960 + 299 = 1 259			
10.	360	360 x 28 ÷ 30 = 336	960 + 336 = 1 296	12 000	25.0	1 296 x 0.25 = 324
11.			**Average = R1 130**	**48 000**	**100%**	**Average = R1 106**

3. DELIVERED PRICE OF BIOMASS IN HOGFUEL FORMAT

From Table E.1 it is clear that the following 'delivered costs' of hogfuel are possible:

- Average delivered price of biofuel = R1 130/t
- Moving average delivered price = R1 106/t
- Work on an average biofuel price delivered to the power station site = R1 110/t (VAT excluded, Aug 2023).

6. FINDINGS

The following findings are noted:

- Hogfuel can be delivered from an area of ± 160 km radius, or 180 km by road (in one direction) by more than one supplier.
- The current average price of hogfuel to the proposed Power Station near Stellenbosch can be assumed at R1 110/t (VAT excluded).
- This price can be reduced by introducing "billeted" logs into the biofuel supply mixture. [See **Annexure H** for further detail in this regard].
- Biofuel cost represents approximately 45% of the final cost of energy, measured in ZAR/kWh, and as soon as the current price for biofuel exceeds R1 200/t, the viability of the project is under threat. This study is therefore aiming to research biofuel production methods and mixes to ensure an average eventual fuel price, at the Power Station of less than R1 000/metric ton in hogfuel format. Early indication is that a significant portion of biofuel from the remote areas will consist of *wood-billets*.

7. SPECIAL NOTE

Because of traffic problems experienced on the R44 between Somerset West and Stellenbosch, and through Stellenbosch town itself, biomass transport from the Bot and Zonderend rivers, as well as from the Baardskeerdersbos area, could experience difficulties – to be addressed elsewhere in this report.

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ANNEXURE F

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

LITERATURE SURVEY[1]: KEY COST INDICATORS FOR BIOMASS-TO-ENERGY PROJECTS IN SOUTH AFRICA

Compiled by: M.J. de Wet 16 August 2023

1. CAPITAL COSTS FOR A 5.0 MW_e OUTPUT POWER STATION[2]

- Organic Rankine Cycle [ORC] system water cooled @ R150 - R160 million
- ORC, air cooled R170 - R180 million
- High pressure steam turbine water cooled @ R160 – R180 million
- HP Steam turbine air cooled @ R190 – R210 million
- All figures above exclude VAT.

2. FUEL CONSUMPTION FOR THE ABOVE POWER STATIONS

- ORC using a step grate furnace of 30 MW_t continuous output @ ± 5.5 t.p.h. of biomass @ 15 GJ/t and < 15% moisture content. [± 44 000 t.p.a. maximum fuel requirement].
- High pressure steam boiler of 25 MW_t continuous output @ ± 4.8 t.p.h. of biomass @ 15 GJ/t and < 15% moisture content. [± 38 000 t.p.a. theoretical fuel requirement].

3. BIOMASS COSTS IN THE EASTERN CAPE (PE AREA MAY 2023)

- Biomass chips delivered over 100 km (May 2023)
  @ 12 - 13 GJ/t @ 25% to 35% moisture content : R550 - R650/t (VAT excluded)
  @ 15 - 16 GJ/t @ <15% moisture content : R800 - R850/t (VAT excluded)

[1] Data obtained from John Thompson, Cape Town and TFDesign Engineering, Stellenbosch.
[2] Capital costs include for plant, equipment, and applicable buildings, but excludes the costs of the industrially zoned and serviced plot.

ANNEXURE G

STELLENBOSCH BIOMASS POWER STATION PROJECT

ABBREVIATED BREAKEVEN ANALYSIS OF AN ON-SITE STATIONARY HEAVY-DUTY WOOD TRUNK, LOG AND BRANCH PROCESSOR

Compiled by: M.J. de Wet Updated 8 December 2023

1. CAPITAL ITEMS

Table G.1 is a summary of the capital goods required for an on-site[1] horizontal grinder station for hogfuel preparation from solid invasive alien tree trunks and other 'unwanted' biomass.

Tabel G.1: Capital Budget for both the 10 MW or the 5 MW Scenario

Item	Description of capital item	R [Million]
1.	Earth and civil works for grinder pit, plinths and pit floor, part of item 5	See item 5
2.	Structural steel works for cladded roof and related structures including dry biofuel bunker buffer store	5.0
3.	Weighbridge (24 m) complete with heavy-duty slab, control room, lighting arrestors. Estimated turnkey cost	1.2
4.	Workshop, ablutions, laboratory, and small office block	1.2
5.	Heavy-duty trunk (50 t/h) grinder, equipped with 400 kW electric power pack	12.0
6.	Three-wheel loggers @ R1 100 000 each (rounded) x 2-off. Each logger has a production capacity of 30 t/h	2.2
7.	Conveyors from grinder station to hogfuel bunkers, allow for	0.8
8.	Motor control centre and electrical works including cabling	0.7
9.	Allow for future PVSolar charged battery system on fuel bunker roof	Phase II
10.	Miscellaneous items (fencing, gates, security guardhouse, security lights, laboratory and workshop equipment, 2 x LDVs, etc.)	0.9
11.	**Subtotal a)**	**24.0**
12.	Contingencies allow for	2.0
13.	**Subtotal b)**	**26.0**
14.	Design and coordination fees including project management costs. Part of main Capital Budget in main Report	See Table 8
15.	**Total capital requirement, VAT excluding**	**26.0**

2. CAPEX

The annual capital expenditure can be calculated as follows:

- With present value [PV] = R26.0 x 10^6
- Interest rate p.a. [i] = 11.5%
- Loan repayment period [n] = 10 years

∴ CAPEX = R4.39 x 10^6 p.a.

Say = R4.4 x 10^6 p.a. ①

[1] On-site' is referring to the proposed Power Station site, which will be equipped with a biofuel receiving complex. This complex will determine the mass and quality of the biomass before processing it further into hogfuel for the boiler plant.

3. OPEX

The operational costs of the on-site grinding station and wood-fuel preparation operations can be calculated as in Table G.2.

Table G.2: Operational costs (Scenario 50 000 t.p.a.)

Item	Description of operational cost	[R'000 p.a.]
1.	Raw material (Tree trunks > 180 mm dia; < 1.2 dia and logs > 25 mm dia < 180 mm dia) at a cost of (50 000 x R270/t) = R13.50 x 10^6. An average cost[2] per ton of raw solid wood @ R270/t delivered to site from an average supply base radius of < 90 km. See **Annexure Q**	13 500
2.	Management and administration at the wood receiving and processing complex	600
3.	Operating staff (1 Grinder operator + 2 logger operators + maintenance and cleaning staff (shared)	480
4.	Maintenance of normal mechanical goods, including regular calibration of weighbridge scale @ 6.5% of applicable capital excluding grinder (1.2 + 2.2 + 0.8) 0.065 = (4.2) 0.065 = R273 000 p.a. (rounded)	300
5.	Maintenance budget of stationary grinder including cutters and screens @ 8.0% of R12 x 10^6 = 960 000	960
6.	Maintenance roads & buildings @ 2.5% p.a. of applicable capital (5.0 + 1.2 + 0.7) 0.025 = R170 000 p.a.	170
7.	Power consumption[3], as supplied by the on-site Power Station to drive all mechanical equipment (400 + 25) kW x 0.60 x 240 d.p.a. x 7.5 h.p.d. @ R2.60/kWh = R1 193 400 (rounded up)	1 200
8.	Diesel for loggers and LDVs, allow for	320
9.	Insurance of mechanical and electrical gear (1.2 + 12.0 + 2.2 + 0.8 + 0.7) x 10^6 x 2.0%	340
10.	Security and miscellaneous items	240
11.	Proposed royalties payable by the Grinder Station OpCo to IPP as a symbolic rental/royalty	600
12.	**Subtotal a)**	**18 710**
13.	Contingencies @ 2.5%	470
14.	**Total operational cost of weighing and grinding plant, VAT excluded**	**19 180**

②

4. BREAKEVEN COST OF PREPARED HOGFUEL

The breakeven costs for the Grinder Station, based on a throughput of > 50 000 t.p.a., can be calculated as follows:

$$\therefore \text{ Total hogfuel cost}^4 = \frac{① + ②}{50\ 000} = \frac{R(4.40 + 19.18)10^6}{50\ 000\ t.p.a.}$$

$$= \frac{23.58\ x\ 10^6}{50\ 000}$$

$$= 471.60$$

Say = R472/t (VAT excluded) ③

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[2] The average payment of R270/t for raw (dry) wood received, will be based on an MC of ± 25% & CV of ± 13.5 GJ/t. See **Annexure Q** for the breakeven calculations of a typical trimmed tree trunk and log supplier.

[3] An equivalent 750 hp diesel driven hogfuel 50 t/h processor would consume diesel @ 120 000 ℓ.p.a. @ R21.00/ℓ = R2.52 x 10^6.

[4] The stationary grinder can produce approximately 40 t/h x 7.5 h.p.d. x 200 d.p.a.= 60 000 t.p.a. (Single shift production). The same grinder and wood processing facility can mill > 110 000 t.p.a. when a double shift is implemented.

5. PROPOSED SELLING PRICE OF HOGFUEL TO THE BOILER PLANT

A mark-up of 15% would be regarded as reasonable for a long-term hogfuel supply contract to the on-site processing company. [Regarding the *Grinder Station Operating Company* as a profit centre, paying royalties/rental to the *Power Station Operating Company* – the Independent *Power Producer [IPP].*

∴ Proposed hogfuel selling price prepared on-site = ③ x 1.15

= R472/t x 1.15

= R542.80

Say = R550 (VAT excluded) ④

6. FINDINGS

The following findings can now be made:

i. From the above calculations, based on an on-site processing facility which can produce > 110 000 t.p.a. (double shift), it is clear that infield chipping of raw wood @ R1 110/t (delivered to the Power Station site. See **Annexure E**) is not viable.
ii. And since a single stationary on-site horizontal grinder can do the full spectrum of raw wood trunks, poles, logs etc. The use of a Billeter (**Annexure H**) is not necessary.
iii. Payloads of raw wood, in trunk, log and pole format, loaded onto a Superlink of 30 to 33t payloads, can easily be achieved. It is therefore more practical and far more economical to convey the raw biomass in trunks, logs, and pole format to the Power Station site where it will be reduced in hogfuel format by an on-site grinder.

7. RECOMMENDATIONS

The following recommendations can now be made:

i. That raw wood should be trucked to the on-site wood processor in trimmed trunk, log or stick format. These pieces of raw wood can be of a wide spectrum of lengths, shape, diameter, but should be free of twigs, growth points and leaves.
ii. Raw wood will be received at the weighbridge of the on-site processing station for laboratory testing to initiate payment of up to R170/t (For wood with an MC < 25%; and GCV > 13.5 GJ/t) excluding allowance for transport. Transport costs will be capped at R160/t for loads from as far afield as 80 km from site. See **Annexure Q**.
iii. The average payment for a mixture of raw wood arriving at the station from a spectrum of nearby (< 20 km one-way) and far away (up to 80 km one-way) harvesting sites, will be approximately: R270/tonne (See §7 of **Annexure Q).**

Photograph 1: Diesel driven BANDIT BEAST CHIPPER with horizontal grinder (Source: Africa Biomass Company [ABC], Worcester)

ANNEXURE H

STELLENBOSCH BIOMASS POWER STATION PROJECT

ABBREVIATED BREAKEVEN ANALYSIS OF THE PROPOSED 'BILLETING PROCESS'

Compiled by: M.J. de Wet Updated 8 December 2023

1. BACKGROUND

One of the more energy efficient ways to reduce small invasive alien trees (wet or dry) – trees with trunk diameters of < 180 mm diameter, as well as branches of < 180 mm dia is to billet it. Billets can be produced from freshly felled smaller trees or branches of taller trees. A typical 90 kW Billeting machine can produce billets (small chunks of wood) at a tempo of > 20 t/h (or approximately 120 t/day) when fed correctly with tree trunks/poles/branches of up to 180 mm in diameter.

See photographs of billeters, manufactured by ABC, Worcester, at the end of this Annexure.

2. CAPITAL COSTS TO INSTALL A BILLETING PRODUCTION UNIT

See Table H.1 for a summary of the estimated capital required to design, built and commission a 120 ton per day billeting plant at the Power Station site with related infeed and outfeed screening system.

Table H.1: Capital Requirement Budget – Billeting Production Unit of 25 000 t.p.a.

Item	Description of capital items	[R'000]
1.	Horizontal infeed conveyor to accommodate trunks and poles from both sides of the infeed conveyor, feeding straight into the mouth of the Billeter, allow for a 10 meter long loading system (excluding civils). Also refer to Item 6	400
2.	Billeting machine (90kW) with electrical power pack and 450 mm high x 300 mm wide infeed aperture, capable of producing > 120 t.p.d. of billets	2 100
3.	Elevating conveyor from the discharge end of the Billeter to the infeed site of drum screen (Item 4). Elevating conveyer fitted with slatted belting	180
4.	Elevated (all weather) drum screen assembly, complete with fines removal, middlings and oversize sections built on top of dividing bunker walls, with: • Fines removal conveyor (Fines to compost stockpile) • Middlings to main biofuel bunker (by others) • Oversize return to on-site chipper/grinder (as per **Annexure G)** for further reduction	1 100
5.	Materials handling system to main biofuel bunker (by others). Allow for materials handling conveyors	900
6.	Civil (earth- and wet-works) for the above including approach and departing road sections. Allow for	400
7.	Cabling, motor control centre for the plant and power supply connection	340
8.	**Subtotal a)**	**5 420**
9.	Contingencies @ ± 10% (rounded)	540
10.	**Subtotal b)**	**5 960**
11.	Facilitation, design and project management fees on the system (excluding the Billeter) @ ± 10% of R4.0 x 10^6	400
12.	Recoverable costs of the professional team, allow for	30
13.	**Total, VAT and escalations excluded**	**6 390**

3. CAPEX + OPEX

The total cost of the plant, capable of 25 000 t.p.a. of billets, can be calculated as per Table H.2.

Table H.2: Total cost summary

Item	Description of cost items	[R'000]
1.	CAPEX calculation with PV = R6.39 x 10^6; i = 11.5% and n = 5 years ∴ Instalment = R140 533 p.m. x 12 = R1 686 393 p.a. (rounded)	1 700
2.	Raw wood supply costs: 120 t.p.d. x 200 d.p.a. x 1.05 (for waste) @ R270/t[1] (average cost delivered to the plant by local harvesters) = R6 804 000 (rounded down)	6 800
3.	Electrical energy costs: 100 kW x 66% x 7.5 h.p.d. x 200 d.p.a. @ R3.00/kWh = R297 000 p.a. (rounded)	300
4.	Maintenance of plant and equipment @ 6.5% of 4.0 x 10^6 (rounded)	260
5.	Allow for cutter blade sharpening and replacement	80
6.	Insurance @ 2.0% of total plant of R5.0 x 10^6	100
7.	Operator salaries [rest of HR costs included at central chipper/grinder complex (**Annexure Q**)]	240
8.	**Subtotal a)**	**9 480**
9.	Contingencies @ ± 5% (rounded)	470
10.	**Total cost to pay the plant off in 5 years and to operate and maintain the plant (VAT & escalation excluded)**	**9 950**

①

4. TOTAL COST OF BILLETS PRODUCED AT THE POWER STATION

The costs ex works to produce billets:

$$= \frac{①}{120\ t.p.d.\ x\ 200\ d.p.a.}$$

$$= \frac{R9.95\ x\ 10^6}{24\ 000\ t.p.a}$$

$$= 414.50$$

Say = R420/t ②

5. CONVERTING THE BILLETS INTO HOGFUEL/REDUCED PSD[2]

A re-grind action is required to reduce the chunky billets to hogfuel. This can be done by putting the billets through the stationary grinder at the Power Station site. It is estimated that this operation would add approximately R120/t to the final costs of the billeting route, bringing the total cost to:

= ② + R120/t
= R420/t + R120/t
= R540/t (VAT and escalations excluded)

[1] Fruit farmers can expect a ± 30 to 40 t/ha biomass yield from most of their fruit orchards @ R170/t x 35 t/ha = R5 950/ha (farm gate). At an average round trip of 50 km @ R1/t-km the total cost of biomass = 170 + 50 = R220/t. However, from **Annexure Q** a higher figure of R270/t is proposed to allow for biomass from the riparian zones, See **Annexure Q.**

[2] Most boiler manufacturers are of the opinion that the billets can be used as is for their boiler operations, provided the billets are smaller than 60 x 60 x 60 mm.

6. INITIAL FINDINGS

The billeting operation appears to be the most cost-effective solution to process smaller invasive trees and logs of less than 180 mm diameter into acceptable biofuel chunks for wood-fired boilers.

Billeting would however require screening to remove those billets too large for effective burning in the boiler. After a worksession with the design engineer, Mr Charl Oosthuizen and the CEO of ABC, Worcester (5 December 2023) it was found that the majority of billets would be regarded as 'oversize' and would need to be grinded down to hogfuel specifications.

7. RECOMMENDATIONS

The following recommendations can be made:

i. It is recommended to not incorporate any form of billeting into the biofuel supply line of the proposed Power Station. This would eliminate double handling for further reduction, additional noise, and dust.

ii. The proposed on-site horizontal grinder, capable of a production tempo of > 40 t/h can do the full spectrum of wood logs, trunks, poles, branches – from 25 mmm dia to 1.2 m dia. It is therefore unnecessary to introduce further wood reduction machinery onto the central wood processing site.

Photograph 1: Handfed Billeting Machine (Source: Africa Biomass Company, Worcester)

Photograph 2: Machine fed heavy duty Billeter capable of tree trunks and logs up to 200 mm diameter. See typical billets on discharge conveyor (left) [Source: ABC]

Photograph 3: Three typical dry eucalyptus billets of 200 mm diameter (Source: Africa Biomass Company, Worcester)

Photograph 4: Diesel driven 15 t/h Billeter in action (Source: Africa Biomass Company, Worcester)

ANNEXURE I

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

LONG-TERM BIOMASS SUPPLY FORECAST PER AREA

Researched and compiled by: M.J. de Wet 30 August 2023

1. **BACKGROUND**

For a 10 MW_e biomass Power Station, roughly 100 000 t.p.a of dry biomass would be required for a typical supply period of 20 to 25 years.

As said earlier in this report, see **Annexure E**, approximately 50% of the biomass would be sourced from areas as far away as Napier, Elim and Baardskeerdersbos – areas up to 180 km away from Stellenbosch.

The other 50% (or say 48 000 t.p.a) of the biomass would initially (For the first ± 12 years) be harvested from the immediate surroundings (± 90 km inner circle) of the supply base. Including the invasive alien infested areas of the *Cape Winelands District Municipality [CWDM]* as well as its fruit farms[1]. Fruit farmers typical renew and replant their orchards every 25 to 50 years or every 30 years (3% p.a. of orchards) on average. This would mean that say 3% p.a. of 135 000 ha at an average dry biomass yield of 25t/ha could produce:

$$0.03 \times 135\,000 \times 25 = 101\,250 \text{ t.p.a.}$$

However, only ± 100 000 ha of the above orchards are within the 90 km inner circle of the Power Station and say only 50% of these old orchards would be economically harvestable. Assume further that only a small percentage of farmers would make their biomass available for downstream use in the proposed power station [most farmers would bulldoze these orchards in windrows to dry and burn it, while a relatively small number would recycle the orchards as mulch]. In Table I.1 the author has assumed that only 6 000 t.p.a. (or < 16%) of the available old orchard biomass of the inner circle would reach the Power Station. The rest of Table I.1 is self-explanatory.

2. **A LONG-TERM BIOMASS SUPPLY FORECAST**

See Table I.1 for a long-term forecast of the targeted biomass resources for the proposed Power Station near Stellenbosch.

[1] A survey conducted by the Department (See **Annexure J**) indicates that in 2017 approximately 135 660 hectares of harvestable fruit orchards exists in the province.

Table I.1: Long-term biomass supply forecast per area (August 2023)

Line	Biofuel supply type & area	Estimated dry mass available			Average distance from Power Station near Stellenbosch	Potential supply mass (dry) during *Years 1 - 12* [t.p.a.]	Potential supply mass (dry) during *Years 13 - 25* [t.p.a.]	Remarks re long-term supply situation
		Hectare [ha]	Average yield [t/ha]	Total estimated dry mass potential [t]				
1.	Hogfuel ex Strandveld	> 10 000	40	400 000	180	12 000	-	Distance from the Power Station will eventually make this source too expensive
2.	Billets ex Strandveld				180	6 000	-	
3.	Hogfuel ex Breede & Berg riparian zones	> 50 000	80	4 000 000	100	24 000	12 000	Sources of invasive aliens will eventually become smaller
4.	Billets ex Breede & Berg				100	6 000	-	
5.	Hogfuel ex Bot & Zonderend rivers	> 30 000	80	2 400 000	120	24 000	12 000	Sources will eventually become smaller and too expensive to harvest
6.	Billets ex Bot & Zonderend rivers				120	6 000	-	
7.	Cape Metro tree waste ex garden refuse transfer stations[2]	-	-	12 000 t.p.a. x 25 yrs. = 300 000	60	12 000	12 000	A continuous source of waste wood
8.	CWDM tree waste ex garden refuse transfer station	-	-	300 000	60	12 000	12 000	A continuous source of waste wood
9.	Billets ex old orchards of the fruit sector	> 100 000 @ 3% p.a. = 3 000	± 25	75 000 t.p.a. x 50% x 25 yrs. = ± 900 000	90	6 000 [3]	6 000	A continuous source of waste wood
10.	Wood from the Helshoogte and surrounding Woodlots	± 300	80	24 000	10	(For ± Yrs.) 6 000	-	This area could be restored to a well-managed 'Fringe Forest'
11.	Wood from newly established Woodlots of CWDM as from year 10 onwards	± 3 000	250	750 000	90	-	60 000	New woodlots will become a key source as from *Year 13* onwards
12.	**Totals**	**See above**	**> 90**	**Excluding wood waste from CCT & CWDM 8.30 x 10^6 t**	**± 100**	**108 000 t.p.a x 12 yrs = 1.29 x 10^6 t**	**114 000 t.p.a x 13 yrs = 1.48 x 10^6 t**	**> 2.7 x 10^6 t ÷ 25 yrs = 108 000 t.p.a (average)**

[2] The CoCT's transfer station at Kraaifontein for example is handling approximately 30 000 t.p.a. of garden refuse of which an estimated 12 000 - 15 000 t.p.a. consist of solid wood waste like tree trunks, larger branches, and other wood waste.

[3] From Table I.1 the licenced Woodlots of the Stellenbosch Municipality and CWDM would play a key and significant biomass supply role in the future of the Biomass Power Station near Stellenbosch/Klapmuts.

ANNEXURE J

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

SURVEY OF POTENTIAL WOOD WASTE AVAILABLE FROM THE LARGER SURROUNDING GARDEN REFUSE TRANSFER STATIONS

Compiled by: M.J. de Wet & H.A Calitz 5 September 2023

1. **BACKGROUND**

   Approximately 70 000 to 90 000 t.p.a. of garden refuse is handled by the *City of Cape Town* [*CoCT]* and the *Cape Winelands District Municipalities [CWDM]*. This figure can be regarded as fairly accurate, since all eight of the *Refuse Transfer Station [RTS]* sites surveyed are equipped with weighbridges. Larger *Garden Maintenance Contractors* who wish to dispose of garden refuse at any of these sites are bound to pay a tipping fee (ranging from R80/t to R170/t) to dispose of their garden refuse. [Small amounts of garden refuse are generally excepted free of charge, provided loads are < 1 000 kg per day].

   k

2. **ESTIMATED POTENTIAL TO DIRECT WASTE WOOD TO THE STELLENBOSCH B2E POWER STATION**

   The professional team is of the opinion that if a small fee – to cover the costs of loading and transporting of solid wood waste – is offered at the above Power Station site to waste wood handlers, that a fair percentage of the waste wood currently being dumped at the listed transfer sites, would be directed to the above wood-fired Power Station. See Table J.1.

3. **INCINERATING INFESTED TREES**

   The percentage of trees currently being infested by the *polyphagous shot hole borer beetle* is gradually increasing across the Cape Metro and CWDM. The wood-fired boiler plant at the proposed new Power Station can be regarded as an incinerator to assist in the control of this new pest. Infested trees can be felled and brough directly to the on-site chipper/grinder at the Power Station to be converted into hogfuel for the boilers (running at a near constant temperature of > 450°C) to be burned to ash.

4. **INITIAL RESULTS FROM THE RTS SURVEY**

   From Table J.1 it is estimated that >12 000 t.p.a. of solid waste wood can be directed from listed nearby transfer stations to be processed into biofuel for the Power Station. This is ± 12% of the planned biomass volumes required by the Power Station to produce between 8 and 10 MW of electrical energy.

5. **WASTE WOOD VOLUMES FROM THIS SOURCE TO THE B2E POWER STATION LIKELY TO GROW**

   The waste wood volumes referred to above will most likely grow further as the wood and timber industry becomes more and more aware of this option. In other words: instead of paying a tipping fee at the Refuse Transfer Stations or Landfill Sites, they could be paid a small fee (± R150 - R250/t depending on the biofuel quality of the waste wood) by the Power Station for their waste wood.

   It is forecast that the waste wood delivered to the Power Station could grow from an initial ± 12% (or 12 000 t.p.a.) to > 20% (or > 20 000 t.p.a.) within a few years. These volumes still exclude any of the waste wood generated by the industries with broken wooden pallets and wooden crates used as packing material. Some surveys indicate that this fraction of waste wood timber can be as high as 100 000 t.p.a. in the Cape Metro.

Table J.1: Approximate mass of solid wood waste currently being handled at the 'nearby' Garden Refuse Transfer Stations[1] of the Cape Metro [CoCT] and Cape Winelands District Municipality [CWDM] (September 2023)

Item	Metro/ Municipality	Adress of Garden Refuse Handling/Transfer Station	Estimated mass of Garden Refuse handled [t.p.a]	Estimated usable solid wood waste portion by mass		Current contractor in charge of this site (& destiny of solid waste)	Road distance from this site to Idas Valley [km]	Estimated mass of solid wood waste which could be directed to the proposed Idas Valley Power Station [t.p.a.]
				Total] [%]	Wood portion [t.p.a.]			
1.	CoCT	Kraaifontein *Refuse Transfer Station [RTS]*, N1	> 30 000	± 30%	9 000	TBC	24	± 6 000
2.	CoCT	Athlone RTS, N2	± 8 000	± 30%	2 400	TBC	45	± 1 600
3.	CoCT	Swartklip RTS, Khayelitsha	Carted to Coastal Park	N/A	N/A	N/A	30	N/A
4.	CoCT	Bellville RTS	± 4 000	± 20%	800	TBC	30	± 500
5.	CoCT	Vissershok Regional Landfill, Garden Refuse, N7	± 6 000	± 30%	1 800	TBC	60	± 1 200
6.	CoCT	Coastal Park, Baden Powell Rd, Muizenberg	± 7 000	± 30%	2 100	TBC	44	± 1 400
7.	CWDM	Paarl RTS, Distillery Street	> 20 000	± 30%	6 000	TBC	33	± 4 000
8.	CWDM	Stellenbosch, Devon Valley Rd	> 12 000	± 30%	3 600	TBC	8	± 2 400
9.	**Totals**		**> 87 000**		**> 25 700**			**> 17 100**

[1] The 'nearby' transfer stations, refer to those larger garden refuse handling sites within 60 km (by road) from the proposed Power Station near Stellenbosch/Klapmuts.

ANNEXURE K

STELLENBOSCH 10 MW BIOMASS POWER STATION PROJECT

REVIVING THE WOODLOTS OF THE WESTERN CAPE

Compiling by: Prof Ben du Toit and team at the Department of Forest & Wood Science 30 October 2023

Abstract

The biomass feedstock to run the proposed energy generation plant can be sourced from (a) thickets of invasive trees in the area and (b) from purposely grown woodlots. The establishment of woodlots are strongly advocated because it could yield a readily available and sustainable biomass supply in close proximity to the energy plant. Transport of biomass from invasive thickets in far-away places carries with it some hidden liabilities [an increase in CO_2 emissions (fuel use), as well as increased investment requirements for vehicles and road infrastructure]. The former state-owned plantations in the Boland region would be an ideal area to establish woodlots for bioenergy, and approximately 7 000 ha of land is potentially available for this purpose, plus some additional private land. The estimated growth rates on these lands range between 10 and 20 tons of wood (6-weeks air dry) per hectare and year. The establishment of dedicated woodlots with non-invasive, but fast-growing hybrid tree crops can be a fully sustainable operation with numerous ecological and societal benefits, e.g. job creation, carbon sequestration, infrastructure maintenance, forage for honey bees and other pollinators, and landscape-scale fire protection. At the same time, it will have very modest impacts on biodiversity and water use. The site types of higher quality that are potentially available for woodlot establishment in the Boland region can be economically viable in their own right (given the envisaged prices of woody biomass delivered to the plant of maximum R980/ton). The lower quality sites in the region will be economically viable if a small additional income (between R50 and R250) can be generated per ton of timber produced, through carbon sequestration credits and/or ecotourism or agroforestry activities on the land holdings (a target that can realistically be reached).

The potential role of managed woodlots in providing a sustainable and reliable supply of wood for the biomass-to-energy project, Stellenbosch district.

Ben du Toit and Anton Kunneke

Introduction

The biomass-to-energy (B2E) project in the Stellenbosch District can comfortably be run for approximately one decade on biomass procured from thickets of invasive woody plants in the region (referred to as Phase one in the B2E document). However, as easily accessible biomass sources are exploited, leaving only sources in difficult terrain positions or far-away locations, the reliability of biomass supply may deteriorate, and the cost will go up. Biological control by insect pests/parasitoids and/or fungal pathogens, coupled with eradication strategies, has also cause the invaded area to shrink substantially in some districts over the last two decades (Van Wilgen et al., 2021). It is therefore essential to investigate the potential use of purposely grown woodlots (in close proximity to the power generation plant using non-invasive hybrid trees) during the second decade of this project. An analysis of the feasibility of woodlots for biomass supply needs to answer the following five key questions:

1) How much biomass can be produced per hectare under local climatic and soil conditions?
2) What are the economic considerations to establish and maintain such a system of woodlots?
3) How much carbon is emitted during harvesting, timber extraction and transport of woody biomass from woodlots, and how does this compare to C sequestration in the biomass?
4) Are sufficient areas of land available for the establishment of woodlots and what are the legislative implications of growing tree biomass crops?
5) What are the environmental and social impacts and/or benefits of the proposed woodlots?

These five questions will be addressed systematically below in the results section.

Results and findings

1. *Potential productivity of woodlots in the Boland region*

During the last two decades, the Silvicultural research unit in the Department of Forest and Wood Science, Stellenbosch University, has established several woodlots to test species/hybrids and silvicultural management systems for optimal production systems in woodlots and shelterbelts. The experimental woodlots are situated across a range of climate and soil types in the Boland region (and some in the greater Western Cape Province). The average growth rates of fast-growing eucalypt hybrids in experimental woodlots of the Boland Region are shown in Table 1. The average of the three fastest growing hybrids or treatments per experimental woodlot site are shown in each case, and their productivities range between 7.3 and 20.2 tons of utilizable timber per hectare and year. Most of the experimental woodlots are planted on areas with slightly drier climates than the former plantation lands of the Boland area. It is thus likely that plantations grown on slightly higher rainfall areas may yield between approximately 10 and 20 tons of utilizable air-dry timber per hectare and year.

Table 1. Rainfall and growth rates recorded for three best treatments in experimental woodlots in the Boland Region (du Toit, 2023).

Experimental Site	Annual Rainfall (mm)	Stand density (Stems/ha)	Trial age (yrs)	Avg. volume for 3 best tmt's (m^3/ha)	Tonnage MAI (t/ha/a)
Mariendahl dry site	647	1187	8	83.7	7.3
Coetzenburg	740	943	10	118.7	8.3
Mariendahl med. dry site	647+	1328	8	125.1	10.9
Backsberg Spacing trial	800	1583	8	154.5	13.5
Backsberg Species trial	800	1198	13	261.35	14.1
Mariendahl wet site	647++	1392	8	212.2	18.6
Backsberg wet site	800+	1211	13	374.9	20.2

Notes: MAI = Mean annual increment; + refers to some additional seepage water at the site location, and ++ refers to substantial quantities of additional seepage water from upslope positions. Note that most plantation areas in the region have slightly moister climates than the experimental sites tested to date (i.e. mean annual rainfall values from 750 - 1000 mm for plantation areas).

2. Economic feasibility of woodlots for energy in the Boland region

To answer this question, we calculated the present value of all forestry operations that are needed to establish and grow woodlots, as well as the costs of harvesting and shorthaul to roadside (using the model of a greenfield operation). A second costing scenario was constructed where an existing woodlot is harvested and replanted after harvesting (*i.e*. a sustainable management scenario). This was done to assess feasibility if donor money can be accessed to get the woodlots back into production after two decades of government neglect, and then expecting the B2E project to pay only for sustainable management of the system from then on *(i.e.* start of Phase 2 onward). From these data sets, we could calculate a roadside price that will be needed to make the establishment of woodlots a profitable operation. The results are shown in Table 2. The input costs for Table 2 were sourced as industry averages for short-rotation plantations, as follows: Woodlot establishment costs R10 555/ha; Tending costs R1 290/ha per operation; Annual overheads (for infrastructure maintenance, firebreaks, conservation costs, and management/office costs), R4 033/ha; Harvesting (i.e. clearfelling & shorthaul costs, R270/ton; Transport over an average 50 km lead distance (plus 50 back to site) as well as conversion of roundwood to hogfuel was estimated at R300/ton. We emphasize that the proposed woodlots on former plantation land should be treated as a greenfield operation: It will require a large capital investment to establish the woodlots and get them back into a sustainable production cycle, over the timeframe of approximately 10 years.

It is clear from Table 2 that only the high productivity sites (> 18 t/ha/a MAI) can break even with the current price structure. We will demonstrate in in Section 4 that approximately 1 000 ha of the Boland plantations in the northern supply sector (centred around Klapmuts) may indeed come close to this this level of productivity. If additional revenue can be earned from carbon sequestration (See Section 3) or ecotourism activities, this could also improve the profitability the lower productivity lands in the VECON package (approximately 6 000 ha).

Table 2. Prices for timber per air dry ton [delivered as roundwood on roadside, (ROR)] or prepared in a use-ready state [hog fuel at the mill] that will allow plantation managers to recover costs of

establishment, tending and protection for 10-year rotation woodlots yielding average MAI's of 12 – 18 t/ha/a, Boland region.

Tonnage MAI (t/ha/a)	Greenfield operation		Maintenance operation	
	ROR	Use-ready	ROR	Use-ready
12	R941	R1 241	R857	R1 157
15	R801	R1 101	R734	R1 034
18	R708	R1 008	R652	R952

3. *Carbon emissions and sequestration in biomass plantations*

When a forest is established, carbon in sequestered in the living biomass, the soil, and the forest floor (dead organic matter). It follows that the carbon sequestration in the system usually increases dramatically when vegetation with low biomass per hectare (*e.g.* grassland or scrubland) is afforested. Once a sustainable forest system is established, standing biomass will reach a steady state. At this point, only the annual increment is usually harvested to ensure sustainability, and this is typically accounted for as the sum of the harvested wood products. Individual wood products have different lifetimes, e.g. they can be burnt to generate energy (and offset fossil fuel burning), used in paper making, or used in structural applications where they will trap carbon for several decades. The specific use of the harvested wood products is thus important in calculating the net effect on the carbon balance. Finally, the harvesting and transport of biomass my emit some carbon dioxide through the use of fossil fuels.

If we assume an average growth rate among the low-productivity sites in the Boland Region of 12 t/ha/a (air-dry timber), then the carbon sequestration rate will be approximately 4.2 ton C (or 15.4 ton CO_2) per ha/a. Prices of €20 per ton sequestered CO_2 may be achieved by selling carbon credits through well-established carbon credit brokers. If we assume that only €10 per ton CO_2 can be used toward co-payment for the growing of the trees, this will boost income per hectare by approximately R 3 000 per annum. When expressed per unit of biomass harvested, it brings an income of R 256 per ton of air-dry timber used to offset fossil fuel burning. Additional income of R 256 per ton of air-dry timber will mean that the power generator will be able to procure timber from even low productivity sites (MAI 12 t/ha/a) at a cost of less than R1 000/ton.

The carbon emissions produced per unit volume of timber (*i.e.* harvesting and transport costs) have been estimated as an average from several published studies by Cosola et al., 2016. We present the most relevant values for the proposed short-rotation woodlots, namely (a) harvesting and extraction in plantations using semi mechanised harvesting operations (typically used in short-rotation crops with individual tree volumes < 1 m^3/tree), and (b) Secondary transport in log form over 100 km (50 km loaded and 50 km unloaded). Table 3 shows that the CO_2 emissions associated with harvesting and transport of one m^3 of timber is a small fraction (approx. 2.2%) of the CO_2 sequestered in this volume of timber. A sustainably managed woodlot system supporting the annual harvesting of one m^3 of wood will have several age classes (cohorts) to support the annual cut, and therefore, the harvesting and transport costs makes up an extremely small fraction (0.33%) carbon sequestered in the living biomass in field supporting it.

Table 3. Carbon dioxide fluxes due to harvesting and transport operations of one m^3 of timber with an assumed density of 500 kg/m^3, contrasted to carbon dioxide equivalents sequestered (negative sign) in said piece of biomass (values from Cosola et al, 2016; du Toit et al, 2016; Dovey et al, 2021).

Operation	Average CO_2 flux (kg CO_2 m^{-3})
Harvesting and extraction in plantations using semi-mechanised operations at clear felling.	2.73
Secondary transport of timber in log form over 100 km (50 km loaded & 50 km unloaded).	17.40
Sum of emissions to harvest, extract and transport timber to an energy plant 50 km away.	20.13
Sequestration in one m^3 of timber with bulk density of 500 kg m^{-3}.	-916.67
Estimate of C stored in living biomass of sustainably managed plantation system on 10-year rotation cycle producing one m^3 of wood per annum*.	-6 187.50

4. Land available for the establishment of woodlots

Priority areas earmarked for the re-establishment of woodlots are shown in Figure 1 and Table 4. Importantly, these are areas where woodlots or plantations had been grown before, most commonly in mountainous areas with poor soils that have low agricultural potential. The fact that they harboured trees before makes it easier to re-forest as a new afforestation license would not be necessary for re-planting. Note that any new area earmarked for land use change to an afforested state ,will (if larger than 1 ha) be subjected to the procurement of an afforestation license (issued after due process by DWAF and DFFE). The DFFE has indicated during September 2023 that tenders will be put out before December 2023 for the re-forestation of the so-called VECON areas (state forest land with higher production potential in the Western Cape (LHA, 2014). It would be an ideal opportunity to bid for reforestation and use of this land for sustainable biomass supply using woodlots (Table 4). The potential biomass production rate from fast-growing eucalypt hybrids have been estimated, based on the pine growth rates achieved in previous decades (1990 – 2010 period). Figure 1 and Table 4 shows state forest land under sustainable 80-year lease (Jonkershoek plantation) as well as the VECON holdings (higher productivity potential and the Exit areas (generally lower production potential). Other woodlots and plantation under municipal management are also indicated. The two circular sectors with midpoints in Klapmuts and Grabouw show potential locations of power generation plants with a 65km radius drawn around each, showing transport distances. Trucks from woodlots to the north and east of Stellenbosch do not have to enter town and will thus not markedly increase traffic within the town.

Figure 1. Location of the former plantation lands and miscellaneous smaller woodlots in the study area. Circles indicate a northern sector around the centre point of Klapmuts and a Southern Sector around Grabouw industrial area as centre point.

Table 4. Areas earmarked for re-forestation with sustainable woodlots. Rows 1, 2, 3 and 7 are the VECON areas of former state-owned plantations in the Boland region.

Plantation or woodlot name	Re-forestable area excluding buffers (ha)	Avg Pine volume MAI (m^3/ha/a)	Average eucalypt tonnage MAI estimate per plantation (t/ha/a)	Biomass production potential (Tons/a)
Kluitjieskraal	1118	10	8.6	9655
La Motte	914	13	13.5	12310
Jonkershoek	630	16	18.3	11538
Stell. Municipality	270	16	18.3	4945
Misc. Woodlots north	450	10	8.6	3887
Sub-total Northern sector	3381			42334
Grabouw	3875	10	8.6	33464
Misc. Woodlots south	900	10	8.6	7773
Sub-total Southern sector	4775			41238

5. Environmental impacts and benefits

Water use and stream flow reduction by woodlots.

Concerns of excessive water use by woodlots/ plantations are generally based on selective and unscientific reporting in the popular media. The hard scientific facts are that Western Cape pine plantations have been estimated to reduce stream flow with a mere 3.2% (on average) in those areas where the entire sub-catchment has been afforested (Gush et al., 2002). Given that the reduction in stream flow will only be on 7 000 ha if all the VECON areas are re-forested (*i.e.* 0.054% of the Western Cape Province), the impact is demonstrably small. The conversion to short rotation-eucalypts in some areas may slightly increase the stream flow reduction *while the tree crop is growing* (more rapid leaf area index development occurs in gum stands, thus more rapid development to maximum transpiration rates) but the short rotations will lead to more periods per decade when the crop is harvested and re-planted (with zero to very low levels of leaf area). For these conflicting reasons, the stream flow reduction rates may increase slightly (but not appreciably) when converting some of the pine forests to short rotation gum woodlots (du Toit et al, 2014). Interestingly, of all trees tested to date in South Africa, pine and gum species and hybrids have the highest water use efficiency (*i.e*. they grow more timber per litre of water transpired) than all indigenous species tested to date (Gush and Dye, 2009). The aforementioned genera are therefore indeed a water-wise choices for biomass plantations. Importantly, none of these woodlots will be planted in riparian zones as this is forbidden by law, and this is another reason why the impact on stream flow will be modest (3.2% average reduction on approximately 0.054% of the total land area of the province).

Potential of woodlot trees becoming invasive.

To limit possibilities of trees in woodlots becoming invasive, only non-invasive hybrids and carefully selected pure species should be considered for planting in woodlots. Appropriate choice of species/hybrids for both the production compartments as well as the edge areas (ecological corridors) and buffer zones (fuel load reduction zones to stop wildfires) are of paramount importance. In fire protection zones on the edges of woodlots, *Pinus elliottii* or can (for example) be grown as this species is fire resistant from a young age and does not seed well in the Western and Southern Cape. So much so that the seed orchards for MTO forestry company cannot be established on their Cape holdings but are instead located in the KwaMbonambi area (near Richards Bay) to allow for adequate seed production. The majority of the pine and gum interspecific hybrids on the market today are not invasive, although most of them do flower and may even produce some seed.

Biodiversity conservation

Samways and co-workers (2010) have done a large body of work on the biodiversity in ecological corridors in timber plantations. They concluded that these ecological corridors (on mountain slopes, riverine areas, spurs, around wetlands, etc.) give excellent biodiversity conservation options provided they are wider than approx. 60 m, and interconnected (Samways, 2010; du Toit et al, 2014). Generally speaking, about one third of all forestry holdings in South Africa are not planted to commercial trees and are left for biodiversity purposes. This model can also be used for the Biomass plantations in the Boland region. On the VECON areas considered for re-planting such a system of ecological buffers is already in place.

Additional ecosystem services

Eucalypt trees provide forage for honeybees during critical periods in summer when other nectar and pollen sources are low. The flowers sustain healthy bee populations that act as important pollinators in the agricultural and horticultural sectors. In addition, tree plantations sequester significant quantities of carbon in both above-and below ground biomass.

The ash residues from biomass power generation plants can be disposed of on woodlot soils if other uses are not envisaged, thereby assisting to recycle nutrients contained in the ash. This practice is beneficial to tree crops especially if supplemented by additional N and P fertilizers and promising results have been achieved with this practice, even in sandy soils with low organic matter contents. (Scheepers & du Toit, 2017).

Social benefits

The plantations have the potential to create sustainable employment in the region, on land areas where few, if any other land uses are economically feasible. Using Forestry South Africa's multipliers, it is estimated that approximately 540 permanent jobs can be created in tree growing plus additional jobs in processing and transport.

If woodlots were to be re-established on former plantation lands, the presence of active land management will make a significant positive impact on fire protection, environmental management, and prevention of illegal activities. Since the exit of commercial forestry from plantation areas in the Boland region, illegal hunting, illegal dumping, arson, illegal occupation, and general lawlessness have escalated in the affected zones. Re-forestation of these lands will go a long way towards re-establishing law and order with a responsible community where more people are in formal employment.

Conclusions

1. The growth rate of woodlots on former plantation lands is conservatively estimated to range from 10 to 20 tons timber per hectare and year (6-weeks air dry timber).
2. The economics of growing truly sustainable plantations is feasible in areas with a tonnage MAI of 18 or more but becomes marginal where the tonnage MAI is below 18 and timber is the only income source. In these areas, additional income from C sequestration, agroforestry or recreation activities may make the reforestation of former plantation areas for biomass production a feasible option.
3. The annual carbon sequestration rate resulting from stand growth could generate at least R250 per ton of air-dry timber at current prices. CO_2 emissions from harvesting and transporting timber to the proposed electricity generation plant is less that 2.5% of the CO_2 sequestered in each ton of wood and is thus fairly insignificant in the greater sequestration/emission balance.
4. There is sufficient forestry land to supply a significant part of the biomass base load needed for electricity generation. An estimated 15 000 tons can be produced from former plantation lands in an economically feasible way without additional income sources. An additional 65 000 tons per annum from the former plantation lands can probably be produced on a sustainable economic model if additional income can be generated from the annual carbon

sequestration through stand growth (and offsetting fossil fuel burning in electricity generation), or if additional income can be generated from ecotourism and agroforestry on the land holdings.

5. The re-forestation of plantation lands will have modest impacts on water use and biodiversity. Non-invasive interspecific hybrids should primarily be deployed, along with carefully selected pure species. However, reforestation will have large positive benefits for beekeepers (and hence fruit farmers), people seeking safe recreation spaces, fire management in the region, carbon sequestration and in the creation of permanent employment.

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ANNEXURE L

IDAS VALLEY B2E POWER STATION[1]

A FIRST ANALYSIS OF FOUR JOHN THOMPSON BOILER TYPES – BASED ON PRELIMINARY, THEORETICAL AND GENERIC INFORMATION (FOR ILLUSTRATION PURPOSES ONLY) RECEIVED FROM ETIENNE DE VILLIERS OF JOHN THOMSON (JULY 2023)

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1. FINDINGS (FIRST ROUND)

- **Option I:**

  2 x Firetube Boilers @ 94.8% is outperforming the other three options by a significant margin – See Table L.1, Line 10.

- **Option II:**

  1 x Torripac Boiler; Obtained the second place @ 74.8% – A full 20% lower than the firetube boilers @ 94.8%.

See our Second round, when figures and ranking factors are adjusted to illustrate the workings of the Selection Matrix-model further.

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[1] During the initial stages of the project, it was called the 'Idas Valley B3E Power Station'. As the project evolved the name became 'Stellenbosch 10 MW Biomass Power Station'.

TABLE L.1: THEORETICAL SELECTION ANALYSIS MATRIX ONE BASED ON JT DATASHEET ROUND ONE

Item	Decision influencing factor	Weight per factor			OPTION I: Power Station with 2 x firetube boilers 13.16 t/h each @ 16 barg & 290 °C				OPTION II: Power Station with 1 x Torripac b oiler 25.31 t/h @ 27.5 barg & 355 °C				OPTION III Power Station with 1 x Microgen boiler 25.31 t/h @ 45 barg & 440 °C				OPTION IV Power Station with 1 x Microgen boiler 25.31 t/h @ 67 barg & 485 °C			
					Ref & Calculation	Mark			Ref & Calculation	Mark			Ref & Calculation	Mark			Ref & Calculation	Mark		
1.	Capital required – EPC/Turnkey project [R million]	30			171.5	30			225.0	15.6			383.3	9.3			400.00	8.7		
			35				35		$\frac{117.5}{225}$ = 0.52		18.2		$\frac{117.5}{383.3}$ = 0.31		10.9		$\frac{117.5}{400}$ = 0.29		10.2	
				40				40				20.2				12.4				11.6
2.	Output cost of energy = f (R/kWh)	20			2.63	18.8			2.48	20			2.64	18.8			2.48	20		
			20		$\frac{2.48}{2.63}$ = 0.94		18.8				20				18.8				20	
				15				14.1				15				14.1				15
3.	Net electrical power output = f (MWh p.a.)	15			34 794	10.4			38 807	11.6			45 967	13.7			50 648	15		
			10		$\frac{34\ 794}{50\ 648}$ = 0.69		6.9		$\frac{38\ 807}{50\ 648}$ = 0.77		7.7		$\frac{45\ 967}{50\ 648}$ = 0.91		9.1				10	
				10				6.9				7.7				9.1				10
4.	Maintenance intensity = f (maintenance cost p.a.)	10			3.6	10			4.7	7.7			8.1	4.4			8.4	4.3		
			10				10		$\frac{3.6}{4.7}$ = 0.77		7.7		$\frac{3.6}{8.1}$ = 0.44		4.4		$\frac{3.6}{8.4}$ = 0.43		4.3	
				5				5				3.9				2.2				2.2
5.	Complexity of the overall power station system = f (HR costs p.m.)	5			592 K	5			607 K	4.9			662 K	4.5			679 K	4.4		
			10				10		$\frac{592}{607}$ = 0.98		9.8		$\frac{592}{662}$ = 0.89		8.9		$\frac{592}{679}$ = 0.87		8.7	
				10				10				9.8				8.9				8.7
6.	Fuel consumption = f (t.p.a.)	10			54 057	9.4			50 884	10			52 724	9.7			54 214	9.4		
			5		$\frac{50\ 884}{54\ 0574}$ = 0.94		4.7				5		$\frac{50\ 884}{51\ 724}$ = 0.97		4.9		$\frac{50\ 884}{54\ 214}$ = 0.94		4.7	
				10				9.4				10				9.7				9.4
7.	Turbine durability = f (water treatment costs)	5			3.4	5			4.1	3.8			5.4	3.2			6.5	2.6		
			5				5		$\frac{3.4}{4.5}$ = 0.76		3.8		$\frac{3.4}{5.4}$ = 0.63		3.2		$\frac{3.4}{6.5}$ = 0.52		2.6	
				5				5				3.8				3.2				2.6
8.	Redundancy factor = f (number of boilers)	5			2 x boilers	5			1 x boiler	2.5			1 x boiler	2.5			1 x boiler	2.5		
			5				5				2.5				2.5				2.5	
				5				5				2.5				2.5				2.5
9.	**Totals**	**100**				**93.6**				**76.1**				**66.1**				**66.9**		
			100				**95.4**				**74.7**				**62.7**				**63.0**	
				100				**95.4**				**73.5**				**62.1**				**62.0**
10.	**Average [Ranking Position]**					**94.8 [1]**				**74.8 [2]**				**63.6 [4]**				**64.0 [3]**		

2. FINDINGS (SECOND ROUND)

- **Option I:**
  2 x Firetube Boilers; From Table L.2 Option I still outperforms *Option II*, the Microgen Boiler, by 7.2%, which is significant. See Table YL.2, Line 10.

- **Option II:**
  1 x Torripac Boiler: Table L.3 gives an indication that Option II can become a winning option when emphasis is placed on:

  (i) The net electrical power output capacity.
  (ii) Biofuel requirement per annum/Fuel efficiency.
  (iii) This Option is sensitive to cost of maintenance and water treatment costs.
  (iv) For this Option to succeed the cost of capital and cost of biofuel can be regarded as key factors and would need to be kept as low as practically possible.

3. CONCLUSION

The selection of the final boiler type will be done in greater detail in future, when boiler suppliers and potential EPC Power Plant Contractors have had the time and budget to hand in their detailed RfP.

The information contained in this Annexure can only act as a generic sample of how a boiler-type can be selected, based on a range of decision making criteria. For illustration purposes only.

TABEL L.2: DECISION ANALYSIS MATRIX TWO – BASED ON REVISED FIGURES FOR OPTION I

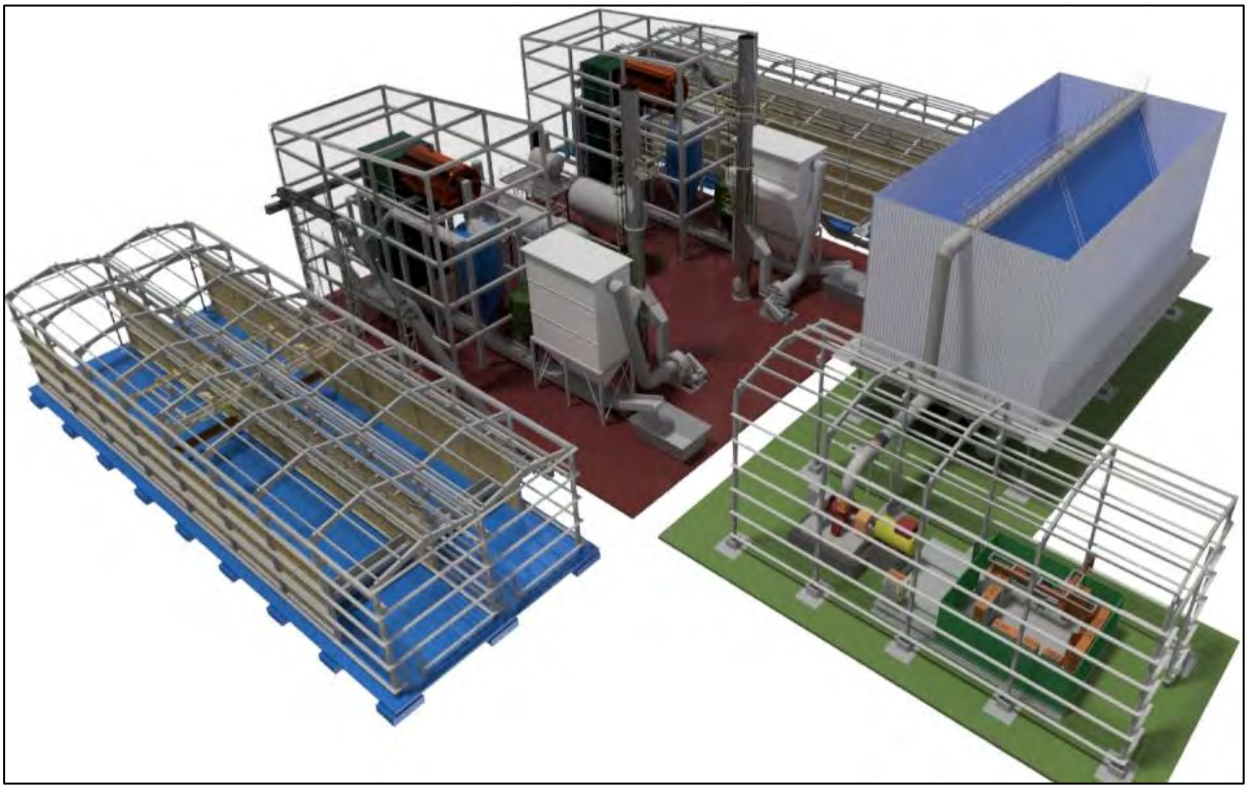
Item	Decision influencing factor	Weight per factor			OPTION I: Power Station with 2 x Firetube boilers 13.16 t/h each @ 16 barg & 290 °C					OPTION II: Power Station with 1 x Torripac boiler 25.31 t/h @ 27.5 barg & 355 °C				
					Ref	Calc	Mark			Ref	Calc	Mark		
1.	Capital required – EPC turnkey project = f (Capital costs)	20					20					15.2		
			30		R171.5 m	$\frac{171.5}{171.5}$ = 1.00		30		R225 m	$\frac{1\,71.5}{225}$ = 0.76		22.8	
				50					50					38.0
2.	Output cost of energy = f (R/kWh)	20				$\frac{2.48}{2.78}$ = 0.89	17.8					20		
			15		R2.78/kWh			13.4		R2.48/kWh	= 1.00		15	
				20					17.8					20
3.	Net electrical power output = f (MWh p.a.)	20					15.7					20		
			20		30 377 MWh	38 8074 = 0.78		15.7		38 807 MWh	= 1.00		20	
				10					7.8					10
4.	Maintenance intensity = f (maintenance cost p.a.)	10					10					7.6		
			10		R3.60 m	= 1.00		10		R4.73	$\frac{3.60}{4.73}$ = 0.76		7.6	
				8					8					6.1
5.	Complexity of the overall power station system to operate = f (HR costs p.m.)	10					10					9.8		
			10		592 289	= 1.00		10		606 889	$\frac{592}{607}$ = 0.98		9.8	
				6					6					5.9
6.	Biofuel consumption = f (t.p.a.)	10					10					9.3		
			5		47 202 t.p.a.	= 1.00		5		50 884 t.p.a.	$\frac{47\,202}{50\,884}$ = 0.93		4.6	
				4					4					3.7
7.	Turbine durability = f (water treatment costs)	6					6					5.0		
			8		R3.40/t stm	= 1.00		8		R4.10/t stm	$\frac{3.40}{4.10}$ = 0.83		6.6	
				2					2					1.7
8.	Redundancy factor = f (number of boilers)	4					4					2		
			2		2 boilers	= 1.00		2		1 boiler	$\frac{1}{2}$ = 0.50		1	
				0					0					0
9.	**Totals**	**100**	**100**	**100**			**93.5**	**94.1**	**95.6**			**88.9**	**87.4**	**85.4**
10.	**Average mark**	**100**					**94.4**					**87.2**		

TABLE L.3: DECISION ANALYSIS MATRIX THREE – BASED ON REVISED FIGURES FOR OPTION I AND FACTORS FAVOURING OPTION II

Item	Factor	Weight	OPTION I: 2 x Firetube boilers			OPTION II: Torripac		
			Ref	Calculation	Mark	Ref	Calculation	Mark
i.	Net electrical power output capacity	25	3.86 MW_e	$\frac{3.86}{4.66}$ = 0.83	20.7	4.66 MW_e	= 1.00	25.0
ii.	Total cost per hour	25	R10 712/h		25.0	R11 563/h	$\frac{10\,712}{11\,563}$ = 0.93	23.2
iii.	Biomass fuel per annum ①		47 202 t.p.a.			50 884 t.p.a.		
iv.	Net electrical power output per annum ②		30 377 MWh/p.a.			38 807 MWh/p.a.		
v.	Fuel efficiency ①/②	25	1.55 t/MWh	$\frac{1.31}{1.55}$ = 0.85	21.2	1.31 t/MWh	= 1.00	25.0
vi.	**Technical complexity**							
	a) Maintenance costs	10	R3.60 m	= 1.00	10.0	R4.73 m	$\frac{3.6}{4.73}$ = 7.6	7.6
	b) HR costs	10	592 K p.m.	= 1.00	10.0	607 K p.m.	$\frac{592}{607}$ = 9.8	9.8
	c) Water treatment cost	5	R3.4/t stm	= 1.00	5.0	R4.1/t stm	$\frac{3.4}{4.1}$ = 8.3	4.1
	f (a + b + c)	25			25.0			21.5
vii.	**Total (i + ii + v + vi)**	**100**			**91.9**			**94.7**

-oOo-

Idas Valley Biomass Power Generation



Summary – Cost and Operating Parameters

Prepared by:

TF Design Engineering (Pty) Ltd
Stellenbosch
Republic of South Africa

September 2023

1. Introduction

TF Design was approached to provide a budget costing for a biomass to power generation solution in Idas Valley, Stellenbosch. A comprehensive technical and cost proposal was compiled. This document summarises the main operating and cost parameters for the proposed biomass power plant.

2. TF Design Capability Statement

Established in 1993, TF Design has firmly established itself as a prominent leader in delivering turn-key projects across diverse industry sectors. Our extensive experience, coupled with a client-centric approach, enables us to offer innovative and dependable solutions that actively contribute to your success. Within the TF Design group, we employ a workforce exceeding 150 individuals, of which approximately 50% are qualified engineers.

We proudly serve a wide array of industries, with a primary focus on the Renewable Energy sector, alongside the Automotive, Timber, Medical, and Military Industries.

Experience Pertinent to This Specific Project:

TF Design stands as the foremost supplier and integrator of biomass boilers, biomass combustion, and advanced biomass handling systems within South Africa. Our expertise in this field is deeply rooted in our extensive involvement in the Timber Industry spanning over three decades. Additionally, we have successfully executed a notable turnkey biomass-to-steam turbine power generation plant installation in South Africa, specifically at MTO George in 2015. In 2017, TFD further contributed as the local contractor, overseeing the comprehensive replacement of the steam turbine control system on behalf of the OEM supplier at Sappi Saiccor.

Below, you will find a list of turnkey biomass-fired boilers recently installed by TF Design in South Africa:

Biomass boiler systems supplied by TFD in recent years

- **MTO – George:** 2x Boilers & Steam Turbine
- **Iswepe Timber - Panbult:** 1x Boiler
- **PG Bison – George:** 2x Boilers
- **Bracken Timber - Greytown:** 1x Boiler
- **Lawa – Lothair:** 1x Boiler
- **A.P. Green Sawmill - Queenstown:** 1x Boiler Kettle
- **Woodlands Dairy – Humansdorp:** 2x Boilers
- **Pallet Supply Co. - Blackheath:** 1x Boiler Kettle
- **FTI - Montagu:** 1x Boiler Kettle
- **Rance Timber – Stutterheim:** 3x Boilers
- **York Timber – Sabie:** 2x Boilers
- **AC Whitcher - Tsitsikamma:** 5x Boilers
- **York Timber – Jessievale:** 1x Boiler
- **UCL Kusel – Glenside:** 1x Boiler
- **Busby Sawmill - Panbult:** 1x Boiler
- **TWK Sawco – Swaziland:** 1x Boiler
- **Timrite Yaverland - Whiteriver:** 1x Boiler Kettle
- **New Forest Co. - Rwanda:** 1x Boiler Kettle
- **WRSM – Whiteriver:** 1x Boiler
- **Busoga Mill – Uganda:** 1x Thermal Oil Boiler

Total **biomass fired boilers** installed: **30**

Biomass Power Plant supplied by TF Design

Figure 1: A Turnkey Biomass Power Plant, successfully delivered as a turnkey project by TF Design.

TF Design with experience in the field of biomass-to-power generation systems within the country, combined with our geographical location in Stellenbosch, where the Idas Valley Biomass-to-Power Project is planned, places our company in an advantageous position. We are enthusiastic about the opportunity to contribute actively and play a pivotal role in the design and realization of this project, collaborating closely with relevant equipment and technology suppliers and the funders to ensure its success.

Figure 2: Top loader biomass storage facility supplied by TF Design.

3. Proposed plant

The proposed plant layout can be seen in Figure 3 and Figure 4.

It consists of:

- **Steam generation:** Two John Thompson Torripac TO2500 boilers each delivering 25 tph superheated steam.
- **Biomass storage and handling:** Four top loader biomass storage and extraction systems as well as biomass feed conveyors to each boiler. Total biomass storage capability = 1438 m^3.
- **TG set**: Steam turbine and generator set with a gross output of 9200 kW with the available steam.
- **Air cooled condenser:** Air cooled condenser (ACC) to condense the turbine exhaust steam. Note that the ACC does not consume any water. A similar wet cooling system will consume at 75-100 m^3 of water per hour.
- **Control system:** Control room with integrated control system for the entire plant.
- **Civil works and building:** All the civil works and building for the depicted plant.
- **Services and Auxiliaries:** Services such as water treatment systems, compressed air etc.

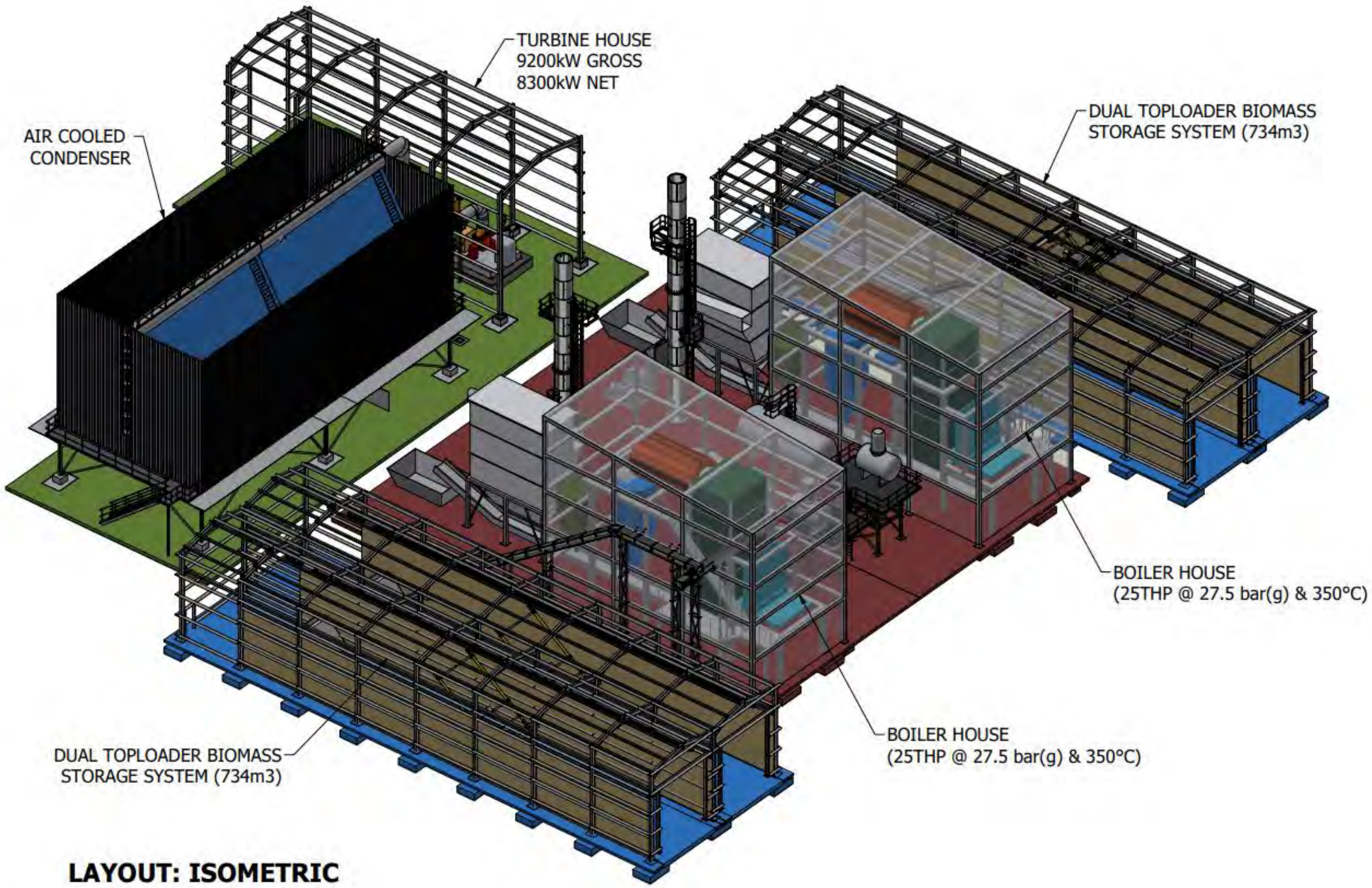


Figure 3: Proposed Layout

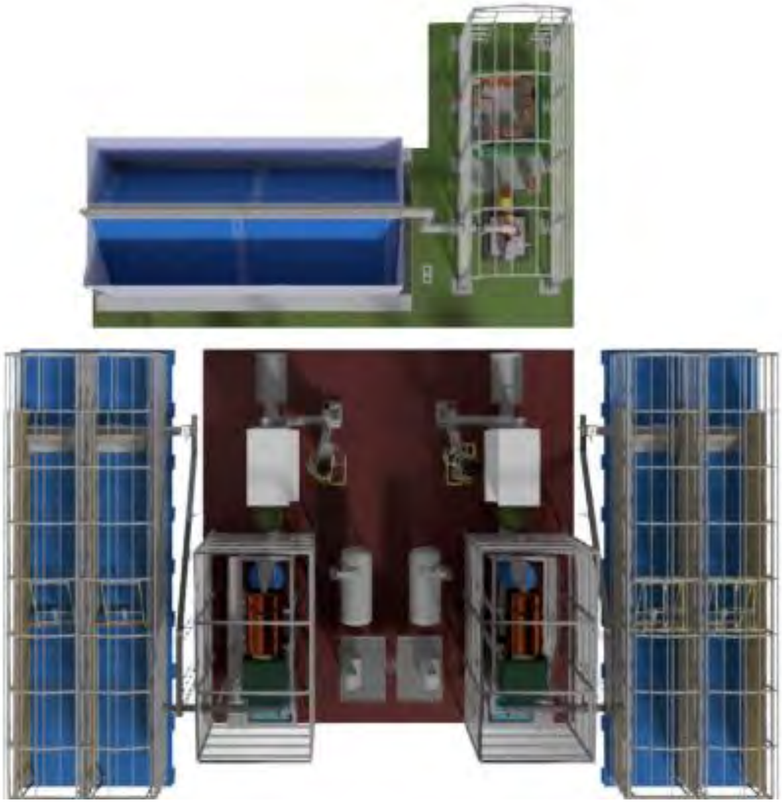


Figure 4: plant footprint relative to < 1 ha requirement.

4. Costs

Capital Cost:

Idas Valley - Budget Proposal for 9200kW (gross) Steam Turbine and Boiler Solution 2023/09/11			
Idas Valley- Power Plant			
#	**ITEM DESCRIPTION**	**REF TO RFP**	**TOTAL COST [EXCL VAT]**
PROPOSAL SUMMARY			
1	**Power Generation (2-off 25tph @ 27.5 bar(g) & 350°C supplying 9200kW (gross))**	iii,iv	**R243 067 000**
2	**Biomass Storage & Conveying (1.75 days of Storage)**	i,ii	**R35 869 530**
3	**Civil works & Buildings**	vi	**R45 288 544**
4	**Electrical**	v	**R15 074 220**
5	**Services (compressed air, RO plant)**	v	**R5 424 500**
6	**Design, Engineering & Project Management (Civil & Mechanical)**	vii	**R62 358 000**
TOTAL (EXCLUDING VAT)			**R407 081 794**
CONTINGENCY (5%)			**R20 354 100**
TOTAL INCLUDING CONTINGENCY (EXCLUDING VAT)			**R427 435 894**

System specifications and OPEX costs:

Idas Valley 9200kW (gross)		
Description	**Unit**	**Specification**
Required Annual Biomass	TPA	108500
Boiler Steam Temperature	°C	350
Boiler Steam Pressure	bar (a)	28.5
Boiler Net Heat Input	MW	48
Turbine Installed Generating Capacity (Gross)	kW	9200
Total Parasitic Load (Turbine, Boiler, ACC, Biomass Feed)	kW	900
Turbine Operational Generating Capacity (Net)	kW	8300
Annual Gross Power production (95% availability)	MWh	76562
Annual Net Power production (95% availability)	MWh	69073
Biomass Feed rate	TPH	13.04
Project Present Value (Capital Expense + contingency + PM)	Rands	R427 435 894

CAPEX p.a (Cost of credit @ 20 year and 11.5%)	Rands	R54 699 636
Estimated OPEX p.a	Rands	R132 319 868
Total Cost of electricity (Biomass Cost of R 980/ton)	R/kWh	**R2.71**
Biomass Contribution to Total Cost (R 980/ton)	R/kWh	R1.54
Biomass Fraction Contribution to Total Cost (R 980/ton)	%	57%

OPEX/CAPEX Breakdown					
Expense type	Description	Gross Generating Capacity		8300	kWhe
		R/Annum	R/months	R/h	R/kWhe
OPEX	Biomass Expense	R106 330 000	R8 860 833	R12 138	R1.54
	Operating Expense	R8 750 000	R729 167	R999	R0.13
	Maintenance Expense	R10 685 897	R890 491	R1 220	R0.15
	Water Expense (Blowdown)	R553 971	R46 164	R63	R0.01
	Unforeseen Expense	R6 000 000	R500 000	R685	R0.09
CAPEX	Financing Cost (11.5%, 20 Years)	R54 699 636	R4 558 303	R6 244	R0.79
COST(R/kWhe)					**R2.71**

Projected project timeline:

- Detailed design: 6 - 8 months
- Project execution: 18 - 24 months

Operation & Maintenance:

TF Design is situated in Stellenbosch and is keen to play a major role in the operation and maintenance of the proposed power plant. We however believe that a proper operating and maintenance team should also involve the major equipment suppliers such as the Boiler- and TG set suppliers. Certain maintenance aspects are specialised and should only be carried out by the OEM suppliers.

A proper health monitoring system coupled with regular inspections (daily, weekly, monthly etc.) are crucial to the successful operation of a plant of this nature.

Your One-Stop Global Energy Supply Partner

KN/END 23 7869 **Rev** 0

15th September 2023

MRSS CRSES & NRGEN
Stellenbosch

Attention: Mr. Matthys J de Wet and Professor Wikus van Niekerk

Dear Sir,

Re: NEW 45tph (10MWe) BIOMASS FIRED POWER PLANT FOR IDAS VALLEY

We thank you for your email enquiry and request for quotation (RFQ) dated 13th September 2023, as addressed to our Mr Etienne de Villiers, and we have pleasure in submitting our indicative budget tender as follows:

1 EXECUTIVE SUMMARY

This indictive budget offer shall provide the Client with a broad view of the capital costs, CAPEX and OPEX expenditures, cost of energy and a preliminary project programme. This will provide the Client with an overall view on the feasibility of the required project they wish to undertake, namely the design, supply, manufacture, delivery, erection, commissioning and testing of one 45tph biomass fired boiler plant and operation of a 10 MWe Power Plant at Idas valley, Stellenbosch South Africa. The proposed power island footprint is attached for reference.

In the brief, it was requested that we investigate two options:

- OPTION 1 – Turbo-Alternator (TA) with a water-cooled condenser
- OPTION 2 – Turbo-Alternator (TA) with an air-cold condenser

2 CAPABILITY STATEMENT

Our Industrial Watertube Boiler business unit designs, installs and maintains boilers and associated equipment for customers in both local and international markets. Designs for steam outputs, pressures and temperatures up to 350 t/h, 110 bar and 540 °C respectively, are available for both process steam and power generation applications. In addition, we provide a wide range of boiler and steam related services and combustion equipment for fibrous biomass-, coal-, oil- and gas-fired boilers in industries such as:

- sugar,
- food and beverage,

4 Belfast Road, Bayhead, 4052
P.O. Box 32292, Mobeni, 4060
Tel: +27 (031) 408 9700
Fax: +27 (031) 408 9722
www.johnthompson.co.za

- chemical,
- petrochemical,
- steel,
- metallurgical,
- textile,
- pulp and paper.

We have the following capabilities related to various types of boilers at our disposal:

- Engineering and Design capabilities
- Construction Operations
- Fabrication and manufacturing facilities
- Boiler services
- Product range for your specific needs

3 CAPITAL COST

Our indicative total pricing in accordance with the following capital costs as per your attached RFQ is:

TABLE 1 – CAPITAL COST BREAKDOWN

NO.	ITEM DESCRIPTION	BUDGET PRICING	
		OPTION 1	OPTION 2
1	Boiler plant including pre-boiler, fuel handling and 3 days undercover storage	R 214 164 392	
2	Turbo-Alternator c/w condenser	R 112 500 000	R127 500 000
3	Balance of plant	R 188 041 825	
4	Design, construct, project management and commissioning of a turnkey project	R15 000 000	
5	**TOTAL CAPITAL EXPENDITURE**	**R 529 706 217**	**R 544 706 217**

4 OPERATIONAL EXPENSES (OPEX) COST

Our indicative total pricing in accordance with the following OPEX costs as per your attached RFQ is:

TABLE 2 - SERVICES & UTILITIES AT BOILER MAXIMUM CONTINUOUS RATED CAPACITY

NO.	ITEM DESCRIPTION	UNITS	BUDGET PRICING	
			OPTION 1	OPTION 2
1	Boiler Fuel	R/hr	12 312.59	12 312.59
2	HR Cost	R/hr	1 044.05	1 044.05
3	Diesel	R/hr	550	550
4	Financing Cost	R/hr	8 254.74	8 488.53
5	Maintenance Cost	R/hr	1 336.49	522
6	Boiler Feedwater Treatment	R/hr	246.04	246.04
7	Water Cost	R/hr	183.86	2.85
8	**Total Cost**	**R/hr**	**23 927.78**	**23 166.06**

TABLE 3 – BASIS FOR OPERATIONAL DATA

NO.	DESCRIPTION OF PARAMETER	UNIT	VALUE
1	Planned annual shut days	days	11
2	Unplanned annual shut days	days	7.5
3	Assumed availability of power plant	%	95%
4	Financed period	years	20
5	Interest rate (assumed as fixed)	%	11.5%
6	Fuel Gross Calorific value	MJ/kg	13.5
7	Moisture content in woody biomass fuel	%/kg	25.0%
8	Ash content in woody biomass fuel	%/kg	5.5%
9	Fuel price delivered to the power station	R/t	1 020.00

5 OPERATIONAL PERFORMANCE

The anticipated operational performance aligning with your RFQ is:

TABLE 4 - PLANT PERFORMANCE AT BOILER MAXIMUM CONTINUOUS RATING

NO.	ITEM DESCRIPTION	UNITS	BUDGET PRICING	
			OPTION 1	OPTION 2
1	Fuel consumption	t/year	100 456	100 456
2	Fuel consumption	kg/h	12.07	12.07
3	Steam output	tph	45	45
4	Plant loading	%	100	100
5	Plant availability	%	95	95
6	Running time	hours	8 322	8 322
7	Gross electrical power output	MWe	10.68	10.28
8	Parasitic load	MWe	0.73	0.72
9	Net electrical power	MWe	9.95	9.56
10	Net electrical power per year	MWh	80 804	79 558

6 COST OF ENERGY (R/kWh)

The following utilities are required in order to operate the boiler plant within the defined parameters:

TABLE 5 – OPERATIONAL COSTS AT MAXIMUM CONTINOUS RATING

NO.	ITEM DESCRIPTION	UNITS	BUDGET PRICING	
			OPTION 1	OPTION 2
1	Boiler fuel consumption	R/kWh	1.24	1.29
2	Personnel costs	R/kWh	0.1	0.11
3	Diesel for front end loader	R/kWh	0.06	0.06
4	Financing costs	R/kWh	0.83	0.89
5	Maintenance cost	R/kWh	0.13	0.05
6	Boiler feedwater treatment cost	R/kWh	0.02	0.03
7	Water cost	R/kWh	0.02	0.00
8	**Total cost**	**R/kWh**	**2.40**	**2.43**

Note:
The operational costs are not based on a full accounting assessment of the operational costs, calculated over the financed period of 20 years, but only a snapshot of the tangible operational costs that will be incurred if the plant should be started up at this point in time.

7 PROJECT PROGRAMME

We anticipate requiring between 20 to 30 months from order placement for the completion of manufacture, delivery, erection and commissioning.

This program is to be mutually agreed between John Thompson and NDG prior to the commencement date and is based on the assumption that all technical and commercial issues will have been finalized by the commencement date. The program is also subject to factory loading at the time of commencement.

This program assumes no unforeseeable material delivery problems or labour issues due to external factors such as, but not limited to, steel shortages and / or strikes. Should any such problems arise, our program is subject to review.

8 PRICE BASIS

This indicative budget proposal gives a preliminary indication of the basis of which services / deliveries can be undertaken and does not constitute an offer to carry out those services / deliveries. In particular, any prices, delivery times, or performance figures mentioned are given without commitment at this stage. Furthermore, this budget offer is based on current pricing. We suggest that some provision is included in the client's budget in order to cater for possible price escalation.

Should there be a Project Labour Agreement (PLA) established for the site work, we reserve the right to claim for all labour costs where the PLA rates exceed our normal labour rates.

9 TAXES AND DUTIES

The prices given in this tender exclude South African Value Added Tax.

10 CONFIDENTIALITY

The information in this tender and documents attached hereto are intended as indicative budget costing to evaluate the feasibility of a 10MWe, woody biomass fired power station, located within Idas Valley area, Stellenbosch. If this information is included in a report and distributed to other parties, this document should be included in its entirety to ensure the intent and the date of this executive summary will be maintained in such report.

11 CONDITIONS OF CONTRACT

This quotation is non-binding as it contains indicative prices and is not open for acceptance. Only once a formal request with detailed requirements for quotation is received from you, will a binding quotation be provided to you.

In the event of a Contract resulting from this offer, the Contract shall be subject to ACTOM's Standard Conditions of Sale and Tender, which can be provided on request or can be accessed from our website (https://www.actom.co.za/legal-info/). Alternatively, we would be willing to work to a FIDIC based Contract, with special conditions negotiated and agreed prior to Contract award.

12 SALES RESPONSIBILITY

To ensure continuity and to assist communications, we would advise that the Sales Responsibility for this project is in the hands of Krinolen Naidoo, who can be contacted on Telephone No. 031-4089749 / +27 (0) 79 256 1307.

We trust that we have interpreted your requirements correctly and hold ourselves available for any discussion you may wish to have regarding this Tender.

Yours faithfully,

INDUSTRIAL WATERTUBE BOILERS BUSINESS UNIT
JOHN THOMPSON
A Division of ACTOM (Pty) Ltd

F. Marais
Engineering Manager

Steam House Western Cape (Pty) Ltd
Company Reg. 2021/387117/07
Vat Registration No: 4510295654
5 Bradford Close
Airport Industria
Cape Town

10th September 2023

Ref: SON5054-Rev2

To: Matthys de Wet

NRGen Advisors (Pty) Ltd

Re. New 10MWe Biomass Power Station – Feasibility Summary

Dear Mr de Wet,

Herewith a summary of the estimated CAPEX and OPEX required to establish a turnkey biomass fueled power station for the generation of power to the grit.

We hope that this submission aligns with your expectations, and through our collaborative efforts, we can fine-tune these numbers to ensure that this endeavor significantly contributes to the Western Cape's goal of achieving energy independence from the national power utility supply.

Best Regards,

Matthys du Toit

082 893 3298

Steam House Western Cape (Pty) Ltd

Index

1 Capability Statement

The owners of Steam House Western Cape boast a distinguished track record of active engagement in the development and operation of diverse biomass-fired steam generation and power generation systems. Our deep involvement in this sector underscores our unwavering commitment to sustainable and eco-conscious energy solutions.

We firmly believe in our responsibility to make a significant contribution to reducing greenhouse gas emissions and fostering a greener and more sustainable energy landscape. To this end, we have successfully executed several biomass projects and are presently immersed in the construction phase of a turnkey biomass project for an esteemed international corporation.

Our invaluable partnership with Vyncke, a fourth-generation Belgian global family enterprise, with a presence spanning Belgium, Brazil, China, Czech Republic, Germany, Malaysia, Spain, and Thailand, positions us at the forefront of cutting-edge technology. This collaboration ensures that the equipment and technology we deploy are rigorously tested and optimized, guaranteeing the highest standards of efficiency and effectiveness.

The strategic location of Steam House Western Cape's manufacturing facility in Cape Town empowers us to produce a substantial portion of the equipment in-house. This approach not only serves to minimize the overall project cost but also maximizes the utilization of local resources. Additionally, it enables us to seamlessly integrate internationally designed and rigorously tested technology into our projects, ensuring the highest quality standards and cost-effectiveness.

2 Costing Summary

Operation parameters

Electricity exported		10	MWe			
Yearly uptime		8000	hrs/year			
Total hours per year		8760	hrs/year			
Availability		91.3%				
Plant operational life		20	years			

Steam Generation

Feedwater temperature	105		°C
Steam Flowrate	55		t/hr
Steam Pressure		65	bar
Steam Temprature		455	°C
Boiler combustion efficiency		81%	
Boiler turndown ratio		40%	
Availability		**8000**	hrs per year

Fuel

Fuel Type	Wood chips						
Moisture content		25%					
Fuel CV		13.5	MJ/kg				
Fuel Required		14.40	ton/hr				
Fuel Required per 24hrs cycle		346	ton/day				
Fuel Required per year		**115 197**	tons/year				
Fuel Price	**R**	**980.00**	R/ton				
Fuel Cost	R	14 111.61	R/hr				
Fuel Cost per year	R	112 892 841	R/year	R	1.41	R/kWhr	53%

Operational Cost

Labour	R	8 714 235.20	per year				
Maintenance	R	11 139 705.92	per year				
Water Treatment	R	1 822 275.00	per year				
Ash removal	R	1 935 349.31	per year				
Total	**R**	**23 611 565.44**	R/year	R	0.30	R/kWhr	11%

Capital Cost

ZAR per Euro	**R**	**22.00**					
Boiler Plant	R	231 079 200.00					
Fuel System	R	30 407 520.00					
Turbine Island and Condenser	R	77 689 920.00					
Emission abatement Equipment	R	22 264 000.00					
Balance of Plant	R	45 760 000.00					
Shipping and import	R	19 800 000.00					
Installation	R	33 662 200.00					
Civils and Building costs	R	46 810 104.00					
Fuel Preparation plant	R	42 000 000.00					
Solar PV system for supplement operation power	R	35 320 000.00					
Total	**R**	**584 792 944.00**					
Interest rate		**11.5%**					
Term		**20**	years				
Montly Payment	R	6 236 405.24					
Total Cost of Loan	R	1 496 737 257.07					
Cost of Capital per year	R	74 836 862.85	R/year over lifetime	R	0.94	R/kWhr	35%

Electricity generation

Total Generated	11	MWe
Total Exported	10	MWe
Units per year exported	80 000 000	kWhr per year

Total Cost	R	211 341 268.97	R/year	**R2.64**	R/kWhr

3 Fuel Specification

Vyncke biomass combustion equipment is designed to burn a wide variety of fuels, including wood chips, agricultural waste, sunflower husk, barley husk, corn cobs, saw mill waste, pruning's, RDF and spend coffee grinds to name a few. Even though there is no one-size-fits-all approach to biomass combustion, the boiler design will be adjusted to the specific fuel available. The Vyncke design grate and combustion system allow for a large range of variation in the supplied fuel, and the combustion control system can be configured to ensure efficient combustion of a variety of fuels.

The following will be a typical specification for a wood chip fuel.

Parameter	Unit	Min.	Average	Max.
Fuel analysis				
LHV	kJ/kg (wb)	9.518	10.615	13.879
Moisture content	wt.% (wb)	25	40	45
Ash content	wt.% (db)	-	2	4
Volatile matter	wt.% (db)	75	-	-
Carbon (C)	wt.% (db)	-	50,4	-
Hydrogen (H)	wt.% (db)	-	6,3	-
Oxygen (O)	wt.% (db)	-	43,1	-
Nitrogen (N)	wt.% (db)	-	0,2	
Sulphur (S)	wt.% (db)	-	0,02	
Chlorine (Cl)	wt.% (db)	-	0,02	
Fluorine (F)	wt.% (db)	-	-	0,010
Ash analysis (values on ash base)				
Potassium (K) as K_2O	wt.%	-	5	10
Sodium (Na) as Na_2O	wt.%	-	1	5
Silicon (Si) as SiO_2	wt.%	-	20	40
Ash fusion temperature (under reducing conditions)				
DT	°C	1.100	-	-
Physical properties				
3,15<P<100 mm	wt.% (wb)	65	-	
100<P<350 mm	wt.% (wb)	-	-	10
P<3,15 mm	wt.% (wb)	-	-	10
Fuel dimensions	mm	-	150x50x20	300x50x20
Bulk density	kg/m³ (wb)	200	280	350

Figure 1: Wood Chip fuel specification

4 Plant layout

The power plant layout will be customized to the available space that is available. The following images shows typical power plant installations from previous projects.

Figure 2: Biomass power stations under construction

File Name.: AWEC 1051

Environmental Planning
Impact Assessments
Management Plans
Environmental Audits

Tel.: 083 658 8744
aubreywithers@mweb.co.za
6 Santa Rosa St.,
Die Boord, 7613

5 November 2023

REQUEST FOR AN EXPERT OPINION ON THE REQUIREMENT FOR AN ENVIRONMENTAL IMPACT ASSESSMENT FOR THE PROPOSED STELLENBOSCH BIOMASS-TO-ENERGY POWER STATION PROJECT LOCATED ON THREE POSSIBLE SITES WITHIN THE STELLENBOSCH MUNICIPAL AREA

1. BACKGROUND

A feasibility study for the proposed **Stellenbosch Biomass-to-Energy Power Station Project** is currently being undertaken by the Stellenbosch University. As part of this feasibility assessment, Aubrey Withers Environmental Consultant has been appointed to assess whether:

(i) an Environmental Impact Assessment (EIA) in terms of the Regulations (2014, as amended) of the National Environmental Management Act, 1998 (Act 107 of 1998) (NEMA) will be applicable or not; and
(ii) the project will require any other environmental approvals in terms of the Statutes of South Africa.

The total area of the required infrastructure for the power station plant will be about 8 ha. The planned continuous net output of the Power Station will be 9.0 MW_e and the net electrical energy output per annum is estimated to be > 76 x 10^6 kWh.

The biomass supply base will be sourced as follows:

- **Primary supply** from the riparian zones of the Berg, Bot, Breede and Zonderend rivers;
- **Secondary supply** from old fruit orchards and windbreaks from the surrounding agricultural sector; and
- **Tertiary** supply from solid wood wastes from municipal garden refuse transfer stations, timber industries, and others.

The Biofuel/"Hogfuel" required will be approximately 100 000 dry tons per annum.

The aim of the project is to:

- Add value to invasive alien trees and other ‘unwanted’ wood.
- Produce dispatchable power of ± 9.0 MW_e from renewable biofuel and sulphur free emissions.
- Improve the rainfall run-off within the above river catchments with the Western Cape Province.
- Create sustainable long-term jobs by introducing labour-based LED projects for the surrounding communities, with specific reference to the harvesting of invasive aliens and the establishment and maintenance of woodlots for future biofuel to the power station(s).

Three locations for the proposed biomass facility have been put forward, namely: Idas Valley, Stellenbosch Waste Water Treatment Works and the Klapmuts area.

1.1 Idas Valley

1.1.1 Location

Sited on the northeast of Stellenbosch Municipality dams in Idas Valley Krom River catchment area (**Figure A1**). The Municipality refers to this area as the Helshoogte and Botmanskop “Nature Reserve”, albeit that a “nature reserve” status has not formally been promulgated with any of the statutes of South Africa. The Municipal landholdings within this catchment area are still zoned Agriculture Zone I (Schalk van der Merwe, pers. Com. 6 September 2023). The Stellenbosch University has a *Letter of Support* from the Stellenbosch Municipality to complete a Feasibility Study to evaluate the long-term viability of the project.

The benefit of this site would be to reduce the wildfire hazard of the Helshoogte, Botmanskop, Tokara, Delaire Graff, Rustenberg, Glenelly and other farms bordering this area.

1.1.2 Access to the site

Access to the site will be problematic in that large interlink trucks would need to travel through the southern portion of Idas Valley along the Old Helshoogte Road. Access to the Biomass to Energy plant by trucks bringing in the biomass (tree logs) from the north along the N1 would be off the R310 Helshoogte Pass road and R44 and from the south via the N1 and the R44.

1.1.3 A Preliminary Environmental Assessment of the Krom River Catchment Area

Vegetation of the Krom River Catchment

The vegetation growing within the catchment area is classified as Boland Granite Fynbos (FFg2) and Cape Winelands Shale Fynbos (FFh5), both of which have an “endangered” conservation status (**Figure A2**).

When assessing the vegetation type and the relevance to the NEMA EIA Regulations (2014 as amended) it does not matter whether the inundation of invasive, exotic vegetation is lightly invaded or heavily invaded, the vegetation is still considered to be “endangered”.

Historic-Cultural Aspects within the Krom River Catchment

The gum trees that line the old Hellshoogte road pass may well be considered to represent “historic tree” status by Heritage Western Cape, and as such may need to be retained.

There are also historic ruins of a possible historic farmstead within the Krom River catchment area which may not be disturbed (**Figure A3**).

1.2 Stellenbosch Waste Water Treatment Works

1.2.1 Location

The Stellenbosch Waste Water Treatment Works (WWTW) is located to the southwest of Onderpapegaaiberg to the west of Stellenbosch. The location of the Biomass plant will be towards the west, in the old locality of the compost area to the west and the old de-sludging plant in the northwest sector of the site (**Figure B1**).

The benefit of this site is firstly the location of the Municipal Substation to the northeast of the WWTW, the use of the compost area to again produce compost from green waste which will be added to the sewage sludge from the WWTW. This sludge is currently removed to the Vissershok Toxic Waste Disposal facility off the N7 to the north of Dunoon, at great cost to the ratepayers of Stellenbosch.

1.2.2 A Preliminary Environmental Assessment of the Stellenbosch WWTW Site

The land available for the Biomass to Energy facility is a disjointed area of about 8.5ha. The Veldwagters River runs along the western portion of the WWTW site, between the waste disposal facility to the west and the WWTW to the east. The disused sludge pond is separated from the rest of the site by the Veldwagters River.

Access to the WWTW by trucks bringing in the biomass (tree logs) would be off the Devon Valley Road. Transport routes for the logs would be from the N1 via the R44 and R304 and N2 via the R44 and R310.

The proposed site is not environmentally sensitive and contains no locally indigenous vegetation. The prevailing winds are from the south and southeast during summer and from the northwest during winter, i.e. away from sensitive receptors such as the industrial to the east and residential areas of Onderpapegaaiberg.

Other than conducting a specialist air quality investigation by a suitably qualified and registered engineer or scientist, no other environmental studies will be required in terms of the National Environmental Management Act, 1998.

1.3 Klapmuts Site

1.3.1 Location

The Klapmuts Site is located to the west of the Klapmuts WWTW which is located to the northwest of Klapmuts on Stellenbosch Municipal land (**Figure C1**). The area is currently used by informal farmers and an informal plastic recycling enterprise.

The current WWTW would probably need to be expanded once the Stellenbosch Bridge mixed-use development to the south of the R101 Road (the old Paarl road) gains momentum, and as such, vacant land to the immediate west of the WWTW will need to be left for such expansion. An area of about 17ha could be made available for the proposed Biomass to Energy facility.

The benefit of this site is firstly the location of the Eskom Substation to the south of the WWTW and secondly for the ease of transporting the biomass to the site. A third benefit of this site would be the composting of green waste which will be added to the sewage sludge from the WWTW and the ash from the energy plant.

Transport routes of the biomass would be from the N1 along the R101 old Paarl road; from the R43 from Ceres; the R304 from Malmesbury; and the R44 off the N2 to the south.

1.3.2 A Preliminary Environmental Assessment of the Klapmuts Site

The land available for the Biomass to Energy facility is about 17ha and comprises Swartland Alluvium Fynbos (FFa3) to the east and Swartland Granite Renosterveld (FRg2) to the east (**Figure C2**). Both of these vegetation types are critically endangered. The site is currently inundated with the invasive Port Jackson trees (*Acacia saligna*).

Easy access to the site will be from the N1 which would services the biomass areas to the north and east, whilst the N2 would service the site from the South Cape via the R44.

There is an abundance of staff for the operation of the energy facility from Klapmuts which has a high percentage of unemployed residents.

The power generated from the facility would be used by Klapmuts, the emerging Stellenbosch Bridge mixed-use development and the possibly the proposed Distel industrial hub development to the north of the N1.

2 Relevance of the Environmental Statutes of South Africa

2.1 EIA Regulations (2014 as amended) of NEMA, 1998

2.1.2 In terms of Regulation R983 of 4 December 2014:

2.1.2.1 Listing Notice 1, Activity 1 states the following:

The development of facilities or infrastructure for the generation of electricity from a renewable resource where-

(i) The electricity output is more than 10 megawatts but less than 20 megawatts; or

(ii) The output is 10 megawatts or less but the total extent of the facility covers an area in excess of 1 hectare;

Excluding where such development of facilities or infrastructure is for photovoltaic installations and occurs within an urban area.

In terms of the above, the electricity output is less than 10 megawatts, but the power station facility will cover an area greater than 1 ha, and as such **Activity 1 will be triggered at all three facilities, i.e., an EIA process in terms of the NEMA EIA Regulation R983 of 4 December 2014 will be required.**

3.1.1.2 Listing Notice 1, Activity 12 states the following:

The development of-

(x) buildings exceeding 100m² in size;

(xii) infrastructure or structures with a physical footprint of 100m² or more;

Where such development occurs-

(a) within a watercourse;
(b) in front of a development setback;
(c) if no development setback exists, within 32m of a watercourse, measured from the edge of a watercourse.

It is more than likely that the buildings and infrastructure for the proposed Idas Valley and the proposed Stellenbosch WWTW facility would trigger the above, and as such, **an EIA process in terms of the NEMA EIA Regulation R983 of 4 December 2014 will be required.**

My recommendation is to ensure that buildings or structures are more than 32m from a watercourse (Krom River in Idas Valley site and the Veldwagters River on the Stellenbosch WWTW site) or above the 1:100 year floodline, whichever is the greater, and that a registered freshwater ecologist is appointed to determine a setback line or the 1:100 year floodline that will need to be approved by both the Department of Environmental Affairs and Development Planning (DEADP), who is the Competent Authority in terms of NEMA application, and the Department of Water and Sanitation (DWS) in terms of the National Water Act, 1998 (Act 36 of 1998).

3.1.2 In terms of Regulation R985 of 4 December 2014:

3.1.2.1 Listing Notice 3, Activity 12 states the following:

The clearance of an area of 300m² or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a Maintenance Management Plan.

(a) In the Western Cape province:

i Within any critically endangered ecosystem or endangered ecosystem listed in terms of section 52 of the NEMA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004;

ii Within critical biodiversity areas identified in bioregional plans;

In terms of the above, the vegetation growing within the Krom River catchment area is classified as Boland Granite Fynbos (FFg2) and Cape Winelands Shale Fynbos (FFh5), both of which have an "endangered" conservation status. Similarly, the proposed Klapmuts facility has Swartland Alluvium Fynbos (FFa3) and Swartland Granite Renosterveld (FRg2) growing on the site, both of which are "critically endangered". The proposed facilities at both these sites would trigger the above, and as such an EIA process in terms of the NEMA EIA Regulations (2014) (as amended) will be required. A specialist botanical assessment would be required for this site.

2.2 NEM: Air Quality Act, 2004 (Act 39 of 2004)

Section 21 of the National Environmental Management Air Quality Act, 2004 (Act No. 39 of 2004) lists activities and associated minimum emission standards which would apply to the operation of a solid biomass combustion installation, which may have a significant detrimental effect on the surrounding environment and, as such, a specialist air quality investigation will need to be undertaken by a suitably qualified and registered engineer or scientist for all three prosed sites (please refer to **Annexure A** appended herewith).

2.3 National Water Act, 1998 (Act No. 36 of 1998)

As this Act is founded on the principle that National Government has overall responsibility for and authority over water resource management, including the equitable allocation and beneficial use of water in the public interest, a person can only be entitled to use water if the use is permissible under the Act.

In terms of Section 21 of the National Water Act (NWA), water use includes-

(a) **taking water from a water resource** (*you will require water to generate steam to drive the turbine(s)*);

(b) **storing water** (*you may need to store water on the site of the power station*);

(c) impeding or diverting the flow of water from a watercourse (*this is a "catch all) phrase and the siting of a facility within 500m or a water resource is triggered*);

(d) engaging in a stream flow reduction activity contemplated in section 36 (*your will be doing the opposite*);

(e) engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);

(f) discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;

(g) disposing of waste in a manner which may detrimentally impact on a water resource;

(h) disposing of waste in a manner which contains waste from, or which has been heated in, any industrial or power generation process (*this may apply to your facility*);
(i) altering the bed, banks, course or characteristics of a watercourse (*this is also a "catch all" phrase and you will need to address it*);
(j) removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
(k) using water for recreational purposes.

The above highlighted words may be applicable to the running of your proposed power station and as such, a General Authorisation in terms of the National Water Act will be required [e.g., (a) and (b)]. A freshwater ecologist will need to be appointed to undertake such an application.

It will need to be established whether you can use treated effluent from the WWTW or whether you will require another source of water (such as groundwater or potable Municipal water) can be used in your plant to generate steam to drive the turbines.

2.4 National Heritage Resources Act, 1999 (Act 25 of 1999)

Section 38 of the National Heritage Resources Act deals with **Heritage Resources Management**.

In terms of section 38:
(1) Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as—
- (a) the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;
- (b) the construction of a bridge or similar structure exceeding 50m in length;
- (c) any development or other activity which will change the character of a site—
  - (i) exceeding 5 000m² in extent; or
  - (ii) involving three or more existing erven or subdivisions thereof; or
  - (iii) involving three or more erven or divisions thereof which have been consolidated within the past five years; or
  - (iv) the costs of which will exceed a sum set in terms of regulations by SAHRA[1] or a provincial heritage resources authority (*such as Heritage Western Cape-HWC*);
- (d) the re-zoning of a site exceeding 10 000 m² in extent; or
- (e) any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority,

must at the very earliest stages of initiating such a development, notify the responsible heritage resources authority and furnish it with details regarding the location, nature and extent of the proposed development.

Such applications are undertaken by a Heritage Consultant by submitting a **Notice of Intent to Develop** (NID) a project and if requested to do so, a Heritage Impact Assessment (HIA) may be required. As far as the proposed Idas Valley site is concerned I believe that a Notice of Intent to Develop (NID) will only be required, while the proposed Klapmuts site will require

[1] SAHARA-South African Heritage Resources Authority

a full Integrated HIA study because the Old Paarl road (R101) is considered to be a "scenic route" Such a study would require a HIA and a Visual Impact Assessment (VIA) to be undertaken.

3 CONCLUSIONS

3.1 Idas Valley Project Area

3.1.1 A Basic Assessment process will need to be undertaken in terms of the NEMA EIA Regulations (2014) (as amended) to obtain environmental authorisation from DEADP since Listing Notice 1, Activity 1 and Listing Notice 3, Activity 12 of the EIA Regulations (2014) (as amended) will be triggered.

3.1.2 As part of this Basic Assessment, a specialist Botanical Impact Assessment would need to be undertaken by a registered Botanist.

3.1.3 A specialist air quality investigation will need to be undertaken by a suitably qualified and registered engineer or scientist in terms of the NEMAQA.

3.1.4 A General Authorisation in terms of the NWA to run your facility will be required from DWS.

3.1.5 A Notice of Intent to Develop (NID) will need to be submitted to HWC in terms of the NHRA.

It would appear as though the Idas Valley site is the least favourable site because of steep slopes, transporting the logs through a residential area and the absence of a nearby substation site.

3.2 Stellenbosch Waste Water Treatment Works

3.2.1 A Basic Assessment process will need to be undertaken in terms of the NEMA EIA Regulations (2014) (as amended) to obtain environmental authorisation from DEADP since Listing Notice 1, Activity 1 of the EIA Regulations (2014) (as amended) will be triggered.

3.2.2 A specialist air quality investigation will need to be undertaken by a suitably qualified and registered engineer or scientist in terms of the NEMAQA.

3.2.3 A General Authorisation in terms of the NWA to run your facility will be required from DWS.

This site is not ideal because of the disjointed land available for the plant and the fact that the excess land within the site of the WWTW may well be required in the future for its expansion.

3.3 Klapmuts Site

3.3.1 A Basic Assessment process will need to be undertaken in terms of the NEMA EIA Regulations (2014) (as amended) to obtain environmental authorisation from DEADP since Listing Notice 1, Activity 1 and Listing Notice 3, Activity 12 of the EIA Regulations (2014) (as amended) will be triggered.

3.3.2 As part of this Basic Assessment, a specialist Botanical Impact Assessment would need to be undertaken by a registered Botanist.

3.3.3 A specialist air quality investigation will need to be undertaken by a suitably qualified and registered engineer or scientist in terms of the NEMAQA.

3.3.4 A full Integrated Heritage Impact Assessment (HIA) study because the Old Paarl road (R101) is considered to be a "scenic route" Such a study would require a HIA and a Visual Impact Assessment to be undertaken

The Klapmuts site is the best of the three sites for the development of a biomass to energy plant, given its accessibility to good road infrastructure, the positioning of the Eskom substation, the proximity to a labour resource and to an off take of power source. The negative impacts could be the visual impact of the plant and the presence of informal farmers on the Municipal land.

4 APPROXIMATE COSTS FOR UNDERTAKING THE ABOVE APPLICATIONS

4.1.1 A Basic Assessment Process will cost in the region of R250 000 to R300 000 and should be approved within 9 months.

4.1.2 A botanical impact assessment would cost in the region of R48 000.

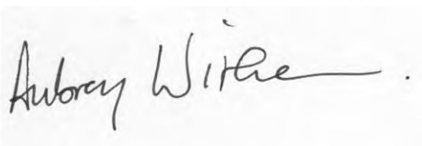
4.1.3 An air quality investigation could cost up to R300 000 to R350 000[2] and would take about 1 month to complete. Further investigation would need to be undertaken once the plant is up and running in terms of the NEMAQA (e.g., measurements of particulate matter) and any modelling that may be required for smoke impacts.

4.1.3 Depending on the source of water, a General Authorisation may be required to be undertaken by a freshwater ecologist and will cost in the region of R40 000.

4.1.4 An Integrated HIA, comprising a HIA and a VIA, will probably be required from heritage and visual impact consultants. The cost of the two specialist studies will be in the region of R50 000 and R80 000, respectively.

The total cost of the above studies could be as much as R868 000.

I trust the above will be of use to you in your feasibility study being undertaken by your team.



A.W.WITHERS
Aubrey Withers Environmental Consultant
EAPASA Reg. No.: 2022/5105 and SACNASP Reg. No.: 400112/89
SACNASP Reg. No.: 400112/89

[2] This figure is based on the escalated study undertake for the recycled steel waste plant at Kuils River where reinforced steel bars were made some 10 years ago.

ANNEXURE Q

STELLENBOSCH BIOMASS POWER STATION PROJECT

ABBREVIATED BREAKEVEN ANALYSIS OF AN INFIELD ALIEN INVASIVE TREE HARVESTING OPERATION TO PRODUCE TRIMMED TREE TRUNKS AND BRANCHES FOR THE CENTRAL WOOD PROCESSING PLANT AT THE B2E POWER STATION SITE

Compiled by: M.J. de Wet 8 December 2023

1. ASSUMPTIONS

The following assumptions can be made:

- For a fulltime invasive tree harvester, the critical mass for cut and trimmed tree trunks and large branches would need to exceed 20 000 t.p.a. to sustain itself financially.
- The alien invasive trees [AIT] will be given to the above harvester free of charge by the landowner in exchange for the clearing operation by said harvester.
- No financial assistance by the *Working for Water* or *Working on Fire* programmes were considered in the calculations below.
- Because of the low work intensity on the mechanical plant, rebuilt and/or second hand equipment can be used.

2. CAPITAL ITEMS REQUIRED

See Table Q.1:

Table Q.1: Capital budget to harvest 12 000 t.p.a. of IAT trimmed trunks[1]

Item	Description of capital item	[R'000]
1.	One three wheel logger (rebuild) to handle and load > 100 tonnes of logs per day onto side tipping trailers	900
2.	Second hand/rebuild haulage tractor (4 x 4) to fetch side tipping trailers from the harvesting site to the depot for transport to Power Station wood processor (Hauling not to exceed 10 km (one way) from harvesting site to transfer station	800
3.	2 x purposely build side tipping offroad trailers @ R450 000 each	900
4.	2.5 m^3/4t Front-end-loader [FEL] to load batch loads of trunks, logs and prepare roads for haulage	2 400
5.	Loading of on-road transport trucks at transfer station by the above FEL	included
6.	Chain saws, and related spares + sharpening tools. Allow for	80
7.	**Subtotal a)**	**5 080**
8.	Contingencies	220
9.	**Total capital requirement, VAT excluded**	**5 300**

3. CAPEX

The annual capital instalment can be calculated as follows:

- PV = R5.30 x 10^6
- i = 11.5%
- n = 5 years

[1] The equipment selected above can do > 24 000 t.p.a. on a single shift operation.

∴ Instalment = R1 398 730 p.a.
Rounded up to say = R1 400 000 p.a. ①

4. OPEX

The operational cost for this operation can be summarised as in Table Q.2.

Table Q2: Operational cost to prepare 20 000 t.p.a of IAT trunks and logs to nearby transport depot

Item	Description of operational cost[2] item	[R'000]
1.	Chainsaw team of 5 operators @ R600/day x 16 day d.p.m. ∴ (5 x 600 x 16) 12 = 576 000 (rounded up)	580
2.	Three wheel logger operator @ R9 000 p.m. x 13 = 117 000 (rounded up)	120
3.	2 x Tractor & FEL operators @ R9 000 p.m. x 13 x 2 = 234 000 (rounded up)	240
4.	Fuels and oils, allow for R18 000 p.m. x 12 = 108 000 (rounded up)	220
5.	Maintenance costs of mechanical gear (900 + 800 + 900 + 2 400) 0.065 = (5 000) 0.065 (rounded up)	330
6.	Additional allowance for chainsaw maintenance and safety gear	60
7.	Insurance @ 2.0% p.a. of R5.00 x 10^6	100
8.	**Subtotal a)**	**1 650**
9.	Contingencies @ 2.5% (rounded up)	50
10.	**Subtotal b)**	**1 700**
11.	Allow for management & admin fees + profit for the above operation @ 17.5% of subtotal b) ∴ 0.175 (1 700) = 279 000 (rounded up)	280
12.	**Total OPEX (VAT excluded)**	**1 980**

②

5. BREAKEVEN COSTS

The breakeven cost for the above including profit before tax:

∴ Total harvested and trimmed tree trunks logs at loading depot

$$= \frac{① + ②}{12\ 000\ t.p.a}$$

$$= \frac{R(1\ 400\ 000 + 1\ 980\ 000)}{20\ 000\ t.p.a}$$

$$= \frac{R3.38\ x\ 10^6}{20\ 000\ t.p.a.}$$

= R169/t

Say = R170/t ③

[2] Operational costs were checked by the management team of ABC, Worcester, during a worksession on 5 December 2023.

6. ALLOW FOR TRANSPORT TO THE POWER STATION SITE

6.1 Worst case

- Transport cost, including loading of link-truck at transfer point @ R1.00/t.km over an 80 km x 2 (for round trip) distance and an average payload of 32t/truck

= 32 x 1.00 x 160 km

= R5 120/ load

÷ 32t/load = R160/t ④

6.2 Most economical case

- Transport over 40 km round trip = R40/t (For close by sites) ⑤

6.3 Average transport costs of trimmed logs

- Average costs of trimmed logs arriving at the Power Station

$= \frac{④ + ⑤}{2}$ (when evenly spread over the supply base area)

$= \frac{160 + 40}{2}$

$= \frac{200}{2}$

= R100/t ⑥

7. PROPOSED RAW WOOD COST DELIVERED TO THE POWER STATION

Raw material and transport cost:

∴ Raw material + average transport cost

= ③ + ⑥

= R170/t + R100/t

= R270/t (VAT excluded) ⑦

It can therefore be concluded that the average cost for raw wood harvested in the riparian zones within an 80 km (one-way) radius supply base, delivered to the Power Station would be R270/tonne (VAT excluded, Dec 2023).

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