APPENDIX 38

CONSULTING ELECTRICAL ENGINEERS BULK SERVICES DESIGN REPORT

MARCH 2025

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4 March 2025 Reference: Cape Winelands Airport\17 – v17

PHS Consulting
Environmental, Heritage, Eco-Tourism and Land-Use PO Box 1752
Hermanus 7200

Attention: **Mr. Paul Slabbert**

Dear Sir

Re: Cape Winelands Airport (Erf PA724-10, Paarl 66 Mellish Road, Fisantekraal)
Consulting Electrical Engineers Bulk Services Design Report

The Cape Winelands Airport currently includes an existing 66kVA Eskom supply; however, the intention is to reduce reliance on the Supply Authority as far as possible, and therefore renewable energy alternatives are being considered – specifically bio-digestor plant, wind energy and solar photo-voltaic systems. A comprehensive power plan is currently being developed, as follows:

A. Electrical Energy Design Philosophy

The Design Philosophy for all electrical services is described and defined as follows:

1. The site and facilities housed should be self-sustaining in terms of renewable energy sources and resources.
2. All designs to provide for energy efficient systems and solutions using minimum amount of electrical energy consumption. This will be completed in consultation and coordination with the Project Architects and Mechanical Engineering teams. The systems and solutions employed will be in accordance with Green Star SA (or International Equivalent if required) in accordance with recommended Best Practice/Lowest Emissions. This will routinely deliver energy savings more than 40% in total consumption.
3. Notwithstanding the above, given the critical/aircraft safety/site-security requirements of the airport and supporting aircraft management systems, the electrical systems must include multiple redundant sources of power, including diesel generator plant and uninterruptible-power-supplies.
4. The integration of the various power sources and loads onto a localized micro-grid- system is required to ensure maximum utilization of renewable sources, minimum diesel fuel consumption, and minimum overall electrical energy consumption, especially for non-renewable sources.
5. Lighting systems to include latest generation, high-efficacy LED lighting using ambient light and occupancy sensing to minimize lights-ON time.
6. The inclusion and incorporation of electric vehicle and aircraft charging to be integrated (in future) with bulk mains sustainable and non-sustainable electrical supply sources and systems.
7. The design of all electrical systems and services to be completed in accordance with best-practice, latest generation Green Building Standards Green Star Certifications.

B. Bulk Mains Power Supplies

The ultimate rating of the Bulk Mains Supply connection has been calculated based on (i) individual building total area (ii) building usage classification (i.e., warehouse, hanger, office, retail, etc.) and (iii) diversified load demand (based on Watts/meter^2). This diversified load demand is based on internationally accepted Green Building Electrical Energy Usage models and requires designers and users to use energy efficiently and minimally. Based on the below, the Preliminary Bulk Mains Requirement was assessed to be 5-MVA increasing over time to 10-MVA (Notified Maximum Demand).

Item	Building Areas Description	PAL 1	PAL 2	PAL 3	PAL 4	Power Density	Diversity	PAL 1	PAL 2	PAL 3	PAL 4
		m^2	m^2	m^2	m^2	W/m^2		kVA	kVA	kVA	kVA
1	Air Traffic Control	1676				250	90%	380			
2	Aircraft Maintenance and Refurbishment	19085				20	60%	230			
3	Airside Runway & Apron Lighting					1200	60%	800			
4	Airport Administration	16672	27081	11170		120	60%	1210	1950	810	
5	Catering					200	90%	200			
6	Customs and Immigration	4493				120	60%	330			
7	Firefighting and Rescue	4361				75	50%	170			
8	Fuel Storage					50	30%	15			
9	Ground Support Equipment	4198				50	50%	200			
10	Hangars (Storage of Aircraft)	29082	6400	11078	6400	10	40%	200	30	50	30
11	Heliport	4469				60	40%	200			
12	Parking					60	50%	30			
13	Passenger Services		5928			90	70%		380		
14	Rental Cars	1725				100	70%	200			
15	Security	302				60	80%	100			
16	Terminal Building	27958	20442	22658	31194	80		0	0	0	0
17	Warehouse for handling of airfreight	20252	19900			20	80%	400	320		
18	Warehouse for storage of airfreight	32979	28625	3830		10	30%	100	90	20	
19	Non Airport Use	45719	5508		72486	10	70%	400	40		510
20											
21	**Connectivity per Phase**							**5165**	**2810**	**880**	**540**
22											
23	TOTAL SITE CONNECTIVITY					**kVA**		**10000**			

Bulk Mains Requirement Assessment Schedule

The initial assessed load of 5MVA has been evaluated by Eskom who have confirmed their capability to provide this load. This capacity is sufficient for the PAL-1 stage defined above. The final load required by the site will be determined during the operating and expansion phases of the Airport, as described in phases PAL-2, PAL-3 and PAL-4 above. This increased load can be provided for using sustainable power systems, notably photo-voltaic power with battery storage. It is also noted that alternative sustainable sources including bio-digester generator plant and wind-turbine systems, can be used to supplement battery energy storage for the intended continuous electrical loads above 5-MVA. This will enable a final energy mix of 50% Eskom and 50% sustainable sources, with periods of off-grid power being used as far as possible.

C. Eskom Bulk Medium Voltage Mains Connection

The bulk mains electrical supply will be connected to the Eskom Grid via an overhead 66,000-Volt three phase connection, as follows:

1. The connection will be completed using two feeders, providing a degree of redundancy to the mains supply; this is in accordance with good engineering practice, where critical systems are connected. The (probable) routing of these feeders is illustrated below.
2. The Bulk Mains Supply will be connected to local Eskom High Voltage Substations. The feeders will be routed to the site using 66,000-Volt feeder cables, with the final routing of the Eskom connections confirmed later.
3. The bulk electricity supply will terminate within the Cape Winelands Airport site in the High Voltage Substations on the southwest corner and the mid-west side of the airport facility (as indicated in the diagram below). The connection points will comprise an Eskom high voltage substation, plus a Consumer Substation fitted with 66000:11000 Volt Step-Down Power Transformers, and Medium Voltage Power Distribution Systems.
4. All equipment inside the substation enclosure to be provided by Cape Winelands Airport Owners.
5. The outgoing cable connections will be configured as ring-feed supply ensuring high-uptime maintainability of the CWA Owners Medium Voltage Micro-Grid Electrical Network.

Eskom Bulk High Voltage Feeder Routing

D. Primary Sustainable Energy Sources

As defined above, the bulk electrical services are to include for multiple sustainable electricity supply sources. The provision of a completely off-the-grid source is intended as the ideal solution; the Eskom (coal-fired) mains source is intended and required as a backup source in the event of plant-failure/maintenance operations or unfavourable weather conditions. CWA intends to generate electricity from a renewable source of more than 20MW but less than 100MW considering the available roof space and open areas proposed.

Several types of sustainable energy sources considered, namely, (I) use of energy crop/CWA treated sewerage effluent in bio-digestor plant to run spark-ignition gas-engine generator sets and (II) photo-voltaic power supplies, including optional storage batteries. In the future, the use of water-accumulators can be included as an alternative to battery solutions (which are expensive to buy and manage).

Bio-Digestor Plant

Site and Infrastructure

The Cape Winelands Airport is situated adjacent to the R312, near the northern suburbs of the City of Cape Town in the Western Cape province of South Africa. The airport is easily accessible from the N1 via the R304 from Cape Town.

The proposed site for the biogas is to be determined, but it has been indicated that 450 hectares are available. The biogas plant offers flexibility in terms of placement, and placement will be based on easing waste materials handling. The proposed site has minimal change in elevation and will not require significant earthworks, and the difference in elevation will be utilised to allow gravitational feed through the plant, thereby reducing the works power requirements. The slope of the site will also be utilised for storm water management

Load Profile

The energy consumption is to be defined, but the study is based on a peak electricity demand of 1MWe. The biogas plant itself has been sized to provide 12,000kWh/d. Biogas production will be continuous, and gas will be stored in gas bladders protected by inflated domes for consumption at night. The size of the plant can be increased should there be a higher energy demand. It must be noted that will require a proportional increase in the daily feed to the plant.

Engineering Design

Preliminary concept was to utilise chicken litter sourced from farms in the area as a feedstock for the bio-digester plant. This concept has since been eliminated based on comments received from the bio-digester specialist, who indicated this solution is not viable. The property includes 450 hectares of arable land where an energy crop can be farmed. The following feed streams are recommended:

- Energy crop (Napier grass) (15t/day)
- Treated Effluent/Water (200m^3/day)

It is important that any organic waste material is used as feedstock, and is not contaminated by plastic, wood, metal, etc. The organic waste feedstock will be collected in a designated area and will be fed into a mix tank where the daily feed will be prepared and diluted with effluent/water for further pumping.

The anaerobic digestion process does not affect the fertiliser value of any waste output and only removes the energy available in the organic material as methane. The discharge of the AD plant can be used for irrigation. The bio-digester plant planned will require significant further planning effort, reviewing the viability of the fuel stock sources, the designed rating of the plant in terms of useful electrical output, the required Environmental, Local Authority and National Regulations. The availability and combination of varied bio-mass fuel-stock sources as described will be a key design component of the bio-digester plant to maximize fuel production and provide a viable 24/7 fuel source.

Anaerobic Digestion Facility

An assessment was performed to estimate the waste streams required to generate 1MWe. This was evaluated in conjunction with available data on the identified waste streams in terms of bio-methane potential and used for sizing the reactor vessels (digesters).

The primary function of the biogas facility is seen as the production of electricity and the management of the organic waste can be seen as a value-added byproduct of the process. Biogas production will be constant, but gas will be stored for later consumption so that the generator can operate during load shedding event or at night when solar PV is not available.

The following table details the waste streams required and the resulting anticipated performance:

Design Input							
	t/d0	**% TS**	**Solids**	**Liquids**	**VS/TS**	**VS %**	**t VS/d**
Grass Cuttings	**15,0**	**25,0**	**3,750**	**11,250**	**0,80**	**22,50**	**3,375**
Dilute Water	**200,0**	**0,0**	**0,000**	**200,000**	**0,00**	**0,00**	**0,000**
Total Solid Intake	**15,0**	**4,02**	**3,750**	**211,250**	**0,00**	**0,00**	**3,375**
Total Feed Rate (dilute)	**215**	**t/d**					

Biogas Plant parameters

The following table provides an estimate for electrical production:

Production of CH_4	5944	m^3/d		
	247.6	m^3/h		
CV of CH_4	39820	kJ/m^3	11.06	kWh/m^3
CV of Biogas	23892	kJ/m^3	6.64	kWh/m^3
Total power produced (CHP)	441	kW	397.4	m^3BG/MW
Thermo-Electric Efficiency	34.0%		2.02	kWh/m^3BG
Electrical Output (max)	1000	kWe	3.36	kWh/m^3CH4
Availability	95%		117.1	kWh/t
	11995	kWh/d		

Electricity Generation

The proposed plant will accept waste from storage bins and tanks and dilute water as required. The waste will be transported to the mix tank and dilute water will be added. The content of the mix tank is thoroughly mixed and macerated to a controlled consistency. The dilute water is introduced to control substrate density. The daily digester feed will be pumped, via an accurate positive displacement metering pump, to the primary digester stage. Six primary digesters have a combined volume of 3600m^3, providing a hydraulic retention of approximately 15-days. The primary digesters will be operated in the mesophilic range and will be held at around 37°C using heating coils supplied with hot water from the engine cooling circuit.

The heating of the digesters will utilise approximately 300kW of waste heat during winter and less in summer. The primary digesters will be mixed using circulating pumps with multiple level mixing nozzles operating in controlled cycles. From the primary digesters, the digestate will be transferred to six secondary digesters, with a combined capacity of 3600m^3, providing a further hydraulic retention of approximately 15 days. Digestate in the secondary digesters will be mixed by mixing pumps with multiple level mixing nozzles and this pump will also circulate the digestate between the two secondary digesters to ensure homogeneity. Both the primary and secondary digesters will have gas storage membranes above the tanks for consumption on demand.

Spent digestate will be processed by means of a screw press, to separate the liquid and solid fractions. The solid fraction can be supplied to a suitable off-taker such as a composting facility or be utilised on the property. The liquid fraction, which will have a low COD, can be used on the property for irrigation. It should be noted that the AD process does not alter the nutrient value of the substrate. The fertilising value is retained throughout the digestion process where only the carbon compounds are converted to methane (60%) and carbon dioxide (40%).

The biogas will be fed to a drying and de-sulphurising stage where the temperature of the gas will be dropped by 20°C to remove excess condensate via a knock-out pot and then fed to the biogas generator via a blower, delivering the gas at a minimum pressure of 5kPa. Operation of a single 1000kVA generator will be fully automatic.

<u>Please note the following with respect to these feedstock sources:</u>

Energy crops

Extensive research has been done to determine the viability of growing an energy crop for the specific purpose of supplying the proposed biogas plant with feedstock. The European biogas market was developed largely on grain silage as the primary feedstock due to the high biogas yield potential of this type of feedstock. The market there was however driven primarily by the need for renewable energy and the use of agricultural land to grow energy crops therefore did not raise much opposition. In South Africa with its focus on food production, this practise would not be acceptable. Growing a grass on non-arable land is however not an issue.

For this report, the four most viable grass species have been assessed, namely Napier Grass, Vetiver Grass, Rhodes Grass and White Buffalo Grass. The most cited grasses for the purpose of using it to produce biogas is Napier and Vetiver and the study focussed on assessing these two species.

Napier Grass

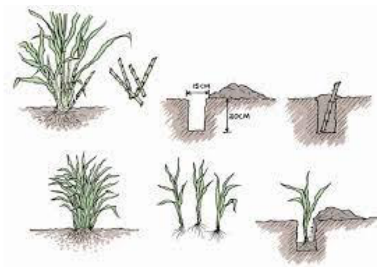
Basic information

Napier Grass (Cenchrus purpureus, synonym Pennisetum purpureum) also known as elephant grass or Uganda grass, is a species of perennial tropical grass native to the African grasslands. It has low water and nutrient requirements and therefore can make use of otherwise uncultivated lands. Elephant grass is a tufted perennial grass that can grow in stands up to 4 m high. It has pale green leaves up to 4 cm in width, with a strong midrib tapering to a fine point. The large flower heads range in colour from yellow to purple and can be up to 30 cm in length.

Napier grass

Cultivation

The cultivation of Napier grass is labour intensive as the plants must be hand planted, as indicated in the picture below. The grass is sensitive in the first few weeks of cultivation but is highly resilient thereafter. It can be harvested regularly, and dryland yields of 40 tons per hectare can be achieved in areas of South Africa. Napier grass is ready for harvesting 3-4 months after planting and harvesting can continue at an interval of 6-8 weeks for 3 - 5 years, whereafter it needs to be re-established. It is estimated that on dry land cultivation in the area, the grass could yield approximately 40t/ha of wet grass. Harvesting can be done with normal silage harvesting equipment.



Planting of Napier grass

Harvesting of Napier grass

Biogas yield potential

Napier grass contains 30.9% total carbohydrates, 27% protein, lipid 14.8%, total ash 18.2%, fibre 9.1% (dry weight). Its organic compositions are an ideal feedstock for biogas production. The fresh grass must be harvested regularly and ground to approximately 1 mm size before fermentation. Research indicated that Napier Grass contains 200tCH_4/tVS with a 30% moisture content and volatile solids at 94%. Biogas typically contains 55% methane. Based on these figures, a ton of fresh grass has the potential to deliver 103m³ of biogas.

Land required

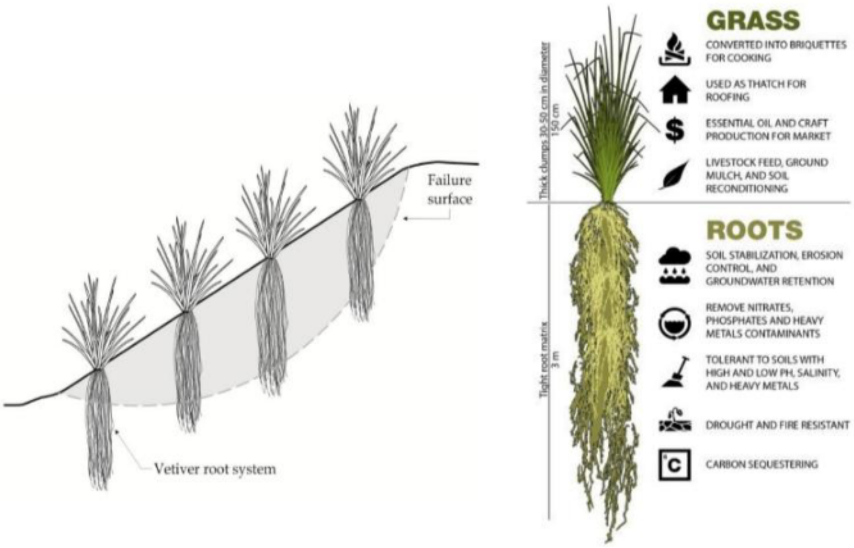
The generation of 4MW thermal energy would require the production of 16 595m³ biogas per day. At a biogas yield of 103m³/ton, this would require a total of 162t/day of fresh grass or 59 130t/year. Assuming that cultivation will yield on average around 40t/ha per year, this would require a total area of 1478ha of land to produce enough grass to feed the 1MW biogas plant.

Vetiver Grass

Basic information

Vetiver (Chrysopogon zizanioides or Vetiveria zizanioides) is a species of aromatic, C4 grass originating from the Tamil Nadu region of Southern India. The grass is tall (averaging 1 to 2m), fast growing, perennial, and has a massive, dense rootstock that can reach depths of 3 to 4m below the soil surface, but possibly to depths of 6m. Vetiver is considered a climax species that can live for decades and, since it generally requires vegetative propagation to expand, poses a low invasive risk.

Vetiver is a hardy grass that can survive in many different environments. The grass can survive in temperatures between -14°c and 55°c, and soil pH levels of between 3.0 and 10.5. It is both flood and drought resistant, can withstand heavy metals and can thrive in saline and sodic soils, as well as soils with high acid sulphate levels. The grass is also resistant to fire, overgrazing, and, when grown within close proximity of each other, can function as an effective sediment trap. Due to its hardy nature, Vetiver can be grown in a wide range of climates from tropical to Mediterranean.



Vetiver Grass Root Structure, Erosion control and environmental benefits

Owing to its deep, dense, and fibrous rootstock, Vetiver is an excellent species to utilise in the prevention of soil erosion and the remediation of contaminated soil. Vetiver grows quickly, with estimates suggesting that up to 2cm of daily rootstock growth can be expected initially, 2 meters of growth within the first 6 months, and up to 6 meters within 3 years. Additionally, Vetiver has been shown to help in remediation of acid mine drainage.

Vetiver rootstock

Vetiver has been suggested as a strong option for carbon sequestration. Carbon sequestration refers to the long-term storage of carbon in plants, soils, geologic formations and the ocean. The storage of carbon takes place in carbon sinks, of which terrestrial soil is a significant example, with estimates suggesting that as much as 1500 gigatons of carbon are contained in the first meter of the earth's soil, and an additional 900 gigatons in the second. The amount of carbon contained in the first meter of soil is estimated to be three times higher than what is contained in the atmosphere, while 80% of total ecosystem carbon is estimated to be contained in the form of soil organic carbon.

Cultivation

Vetiver has shown the potential of generating up to 100 tons of wet material per hectare per year under ideal irrigation conditions. However, this would not be a practical solution for the project. Therefore, our harvesting yield estimates are under dryland conditions without irrigation. The most relevant yield estimates come from a pre-feasibility study done by Clean Energy Consultants, who are working with communities from the Bafokeng Nation to establish a Vetiver based biomass project north of Phokeng, Rustenburg, where they have commenced with the propagation of approximately 2 000 Ha of Vetiver Grass. The results from the initial planting and harvesting work done over the past 2 years has indicated a potential of about 25 tons per hectare per year from 3 harvests per year. Harvesting of Vetiver is simple, and can be done with a normal silage harvester, which also prepares the grass for usage in the digester. This model has been adopted for the planned bio-digester plant feedstock source,

Biogas yield potential

Research indicates that Vetiver leaves, harvested fresh, have a dry matter content of approximately 30% with an organic dry matter content of between 89%. Indicative yield potential is 250 m^3CH_4/t VS and a methane content of 60%. This is based on fresh leaves being processed through a hammer mill. Based on the above, a ton of fresh Vetiver grass processed through a hammer mill has the potential to yield 260m^3 of biogas per ton.

Land required.

The generation of 4MW thermal energy would require the production of 16 595m^3 biogas per day. At a biogas yield of 260m^3/ton, this would require a total of 64t/day of fresh grass or 23 300t/year. Assuming that cultivation in the area will yield on average around 25t/ha per year, this would require a total area of 932ha of land to produce enough grass to feed the 1MW biogas plant.

Current cultivation of Vetiver grass.

As part of the research projects underway, is to investigate the possibility of applying the Vetiver as feedstock to produce biogas as an alternative grass source.

Alternative grasses

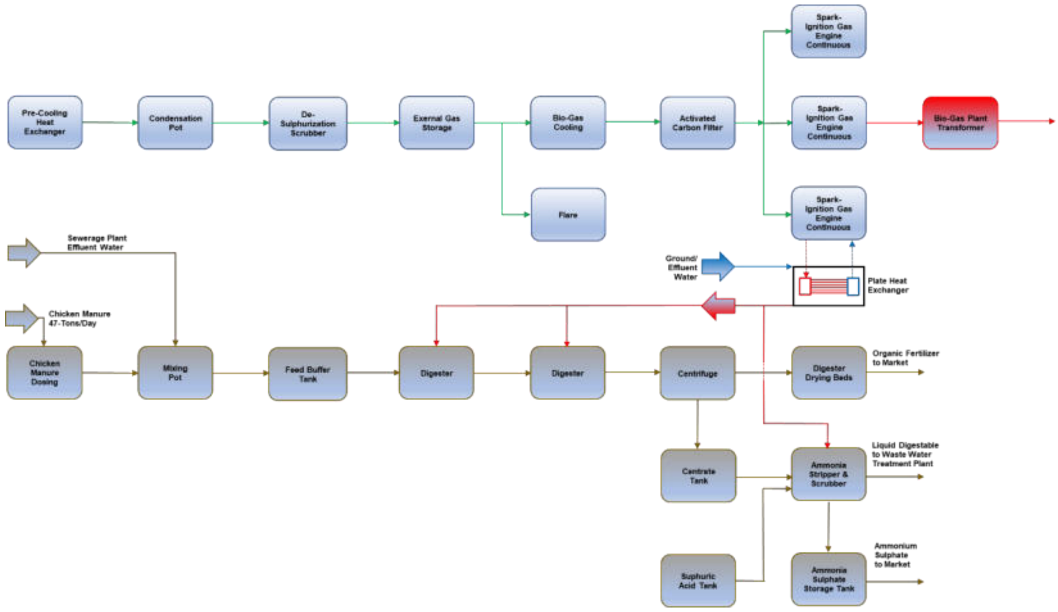
Rhodes Grass and Buffalo Grass are possible options for the primary reason that they are much easier to propagate from seed, whereas both Vetiver and Napier need to be planted by hand. Both these grasses also require more water, and Buffalo is not frost resistant. Although not much information is available on the biomethane yield potential of these grasses, indications are that it is higher compared to either Vetiver or Napier. The fact that the latter is however more drought resistant and can produce higher crop yields per hectare, it is considered Vetiver and Napier Grasses as the most viable for this project.

Treated Sewerage Effluent

The planned plant will take advantage of Cape Winelands Airport sewerage plant treated effluent water, which is ideal for diluting the feedstock for the bio-digestor plant. This provides a good quality sustainable source of fuel using waste products where climate warming methane gas would be wasted under normal decomposition. The reuse of the treated sewerage effluent water further enhances the “waste nothing” principle. The bio-fuel generator plant will require 3-to-5-tons of water/treated-sewerage-plant-effluent-water per ton of feedstock for the bio-digestor plant (≡ to 200 kl/day). If the treated sewerage effluent water is not available, ground water (from borehole sources) can provide the supplementary volumetric requirements. It is worth noting that a significant portion of the daily water “consumption” is cycled through the plant continuously, such that the make-up water required comprises ≥ 10% ≤ 25% of the total water requirements.

General Notes

- The planned plant can provide 24/7/365 continuous electrical power for CWA.
- System designed to provide 1-MW continuous power, at a cost/unit of electricity comparable to Eskom per-unit energy charges.
- The spark ignition engines provide the best fuel-economy and cost efficiency when run continuously at 100% load (i.e., 24/7/365)
- A single biogas fuelled engine should have an availability of around 93.5% (≡ 8200 Hours PA out of total of 8766 hours PA). A second engine can be used to provide the continuous backup if needed.
- The bio-digester plant creates biogas which is accumulated into a (large) bladder system.
- The “waste” from the bio-digester plant comprises “liquid fertilizer” which is planned to distribute to local farms within a 40-km radius of the plant. This will form an income to CWA as well as providing locally sourced/locally used organic agricultural fertilizer.
- It is possible (in the future) to add other types of waste-stream sources, such as food-waste, into the bio-fuel plant. Please see a flow-diagram depicting the plant modules required below.



Bio-Digestor Plant with Gas-Engine Generator


Biogas Bladder Storage

Photo-Voltaic Systems

The entire site comprises an ideal area for the creation of photo-voltaic (PV) power sources, as illustrated below. The following considerations will be applicable to the provision and installation of PV Power Sources:

- Given the primary function and usage of the site as an airfield, any PV Power Source system will be subjected to a Glint and Glare Study to ensure the panels installed will have no impact on air traffic safety.
- CWA intends to generate electricity from photo-voltaic renewable sources of more than 20MW but less than 100MW considering the available roof space and open areas proposed.

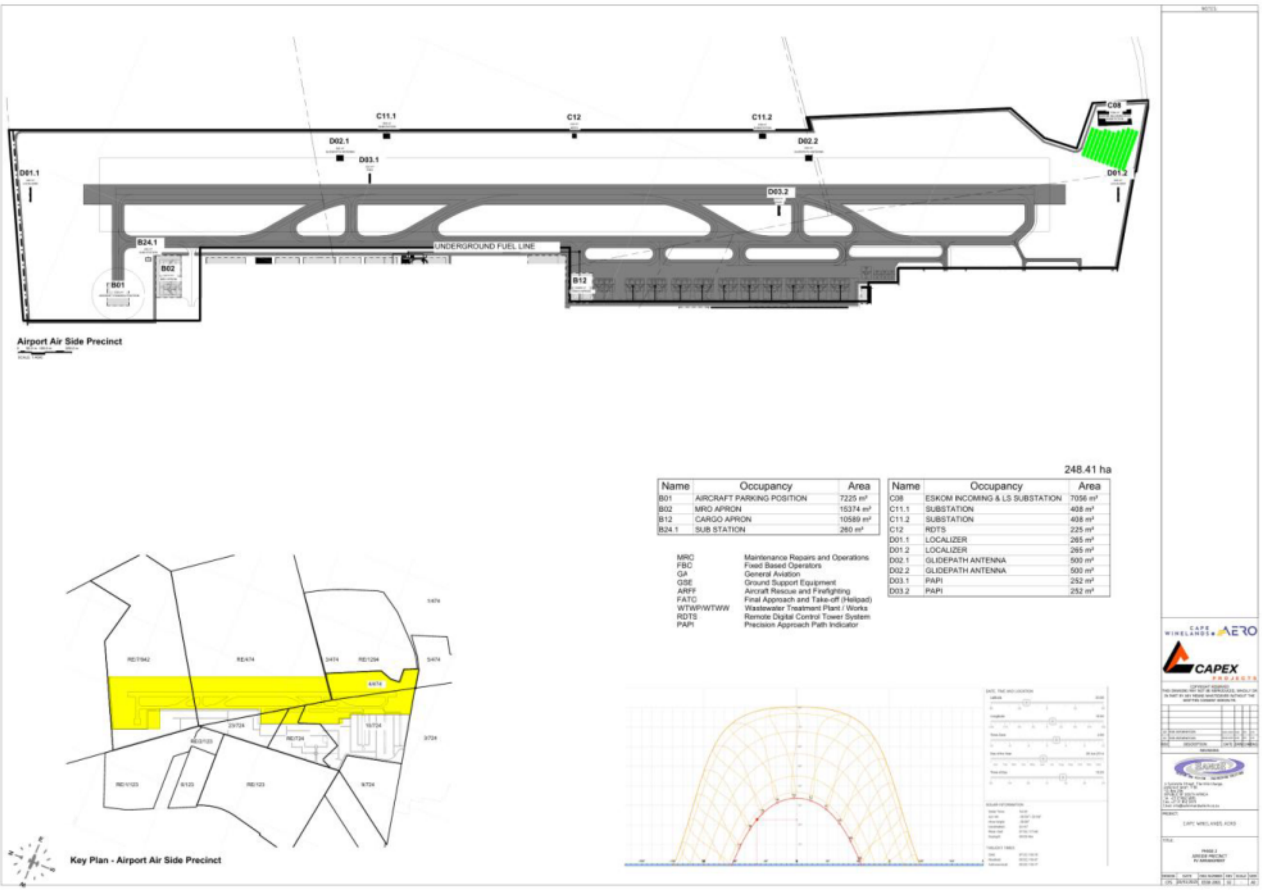
In the drawings and diagrams below, we have marked out the locations of PV panels. On the airside precinct, the only panels planned comprise the panels at the southeast corner of the site, while there are significant opportunities for PV panels placement on the planned landside buildings.

We have adopted a conservative approach in designing the extent of photo-voltaic panels that can be placed on any given building. We have opted to assume a space utilization on the roof of the various buildings at 66% of the gross building area, allowing for placement of other services on the roof plus allowing for access and cleaning to the panels.

Based on the above, we have compiled the following diagrams indicating the PV panel arrays placements:

Airside Precinct PV Plant

The diagram below illustrates the scale of PV arrays installation possibilities on the airfield side.



PV Arrays Capability Illustration (PV arrays in GREEN)

Airside Precinct PV Plant

SANDS

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North End Airside Precinct PV Panel Locations

Services Precinct PV Plant

General Aviation Precinct PV Systems

Based on the above, we wish to advise the following site photo-voltaic installation possibilities:

- Airside Precinct (Southwest corner) 2-MW
- Services Precinct 21-MW
- Airport Terminal Precinct 38-MW
- General Aviation Precinct 14-MW

Total photo-voltaic sources peak rated value ≈ 75-MW. This figure needs to be read in conjunction with the total Mains Supply Connection Rating of 10-MVA. Please note that while there appears to be a wide gap between connection rating and PV peak rating, it must be noted that the PV rating is stated as "peak" – actual power produced is typically a fraction of this total. Excess PV power, when available, will be used for battery storage, EV and EA charging, or returned to the grid.

Please see attached drawings including the above details and information.

The following salient issues relating to the final photo-voltaic design should be noted:

- A detailed Glint & Glare Study is undertaken to ensure the final installation is non-impactive on air movements to and from the airport.
- The orientation of the PV panel arrays on the airfield, facing a north aspect at an inclination of 20° (to the horizontal), would likely provide an optimal solution for air movements in a northerly direction.
- The orientation of the PV panel arrays on the various airside buildings are somewhat dependant on the building roof design but can easily be adjusted to minimize the negative impacts of glint and glare on air movements.

We have completed a preliminary Energy Summary for a 1000-kW PV Power Source, installed on site. This calculation is based on the National Renewable Energy Laboratory (NREL: based in USA) PVWatts® Calculator, which provides a valuable tool assessing the expected total electrical energy output for any given site, considering Site Position, Array Type & Orientation, Panel Type, plus Annualized Weather Data (based on site locale). In this example, a 1000-kW Peak PV Power Source can typically provide ≈ 1,630,000 kWh. The final power available from the PV Power Source will clearly be dependent on the scale of the arrays fitted.

NREL

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data, and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

1,639,258 kWh/Year*

Month	Solar Radiation (kWh / m² / day)	AC Energy (kWh)
January	7.82	187,955
February	7.45	161,025
March	6.42	156,464
April	5.02	119,336
May	4.07	100,797
June	3.24	78,538
July	3.29	81,768
August	4.44	110,793
September	5.38	128,719
October	6.49	157,861
November	7.47	176,128
December	7.56	179,874
Annual	**5.72**	**1,639,258**

Location and Station Identification

Requested Location	durbanville cape town
Weather Data Source	(INTL) CAPE TOWN, SOUTH AFRICA 11 mi
Latitude	33.98° S
Longitude	18.60° E

PV System Specifications

DC System Size	1000 kW
Module Type	Premium
Array Type	Fixed (open rack)
System Losses	14.08%
Array Tilt	20°
Array Azimuth	0°
DC to AC Size Ratio	1.2
Inverter Efficiency	96%
Ground Coverage Ratio	0.4%
Albedo	*From weather file*
Bifacial	No (0)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Monthly Irradiance Loss	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Performance Metrics

DC Capacity Factor	18.7%

NREL Data for a 1000-kW PV Array at CWA

Kindly note that this energy production will be scaled by the relative PV arrays as installed. The PV Power Sources will be integrated onto the Site Micro-Grid electrical infrastructure using the planned medium voltage distribution network. This will enhance the capability of the PV Power Sources to provide power over the entire CWA Site Micro-Grid and will further lessen the impact of rolling cloud cover decreasing PV output. The Site Micro-Grid will be setup, controlled and managed such that the use of Secondary Backup and Primary non- renewable sources is minimized. Given the scale of the site, it will be possible to export PV Power to the Eskom Grid, if appropriate permissions and approvals are provided.

E. **Secondary Backup Power Supplies**

Two backup power supplies have been considered in the Design Proposals, namely diesel driven generator plant and battery backup storage. We wish to make the following observations with respect to these sources.

Non-renewable diesel driven generator plant.

Given the critical/aircraft safety/site-security requirements of the airport and supporting aircraft management systems, the electrical systems must include multiple redundant sources of power, including diesel generator plant and uninterruptible-power supplies. These systems will be designed to operate only when the Primary Renewable Sources, alternatively the Eskom Feeders, are concurrently not available. The diesel driven generator plant, combined with Uninterruptible Power Supplies, will be provided for the following systems and services (as a minimum):

- Airfield and air-control management systems
- Runway and Airside Taxiway lighting systems
- Site Security Management
- Boundary Lighting Systems
- Other miscellaneous critical power systems

The rating of diesel driven generator plant will be ≤ 10-MVA (≡ 8-MW). The opportunity to recover of waste heat from this plant and convert to chilled water or other useful forms of energy is problematic to achieve on this site due to the spread-out nature of the plant and has not been included. If the opportunity arises, this will be reconsidered. Currently, we do not have positions for the backup generators; this is a way off in the design development. With respect to diesel fuel, we would assume that it will be piped to each machine from the central store, with a small tank located or incorporated as part of each engine.

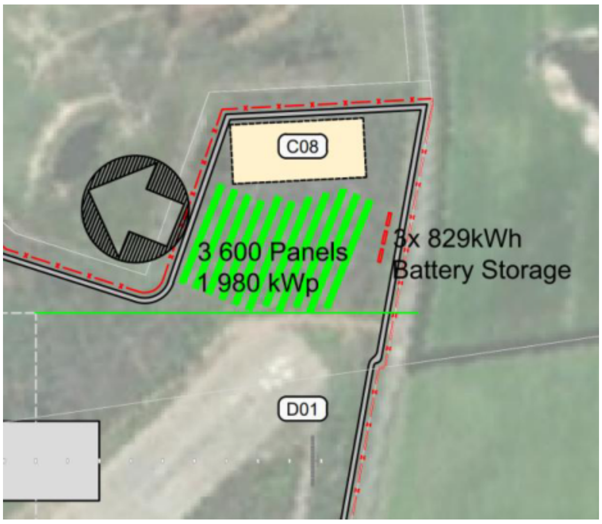
Bulk fuel storage for the generator plant will likely comprise storage of ≥ 80,000-litres, which will be distributed around the greater CWA site to localized generator backup plant.

Renewable Battery Storage

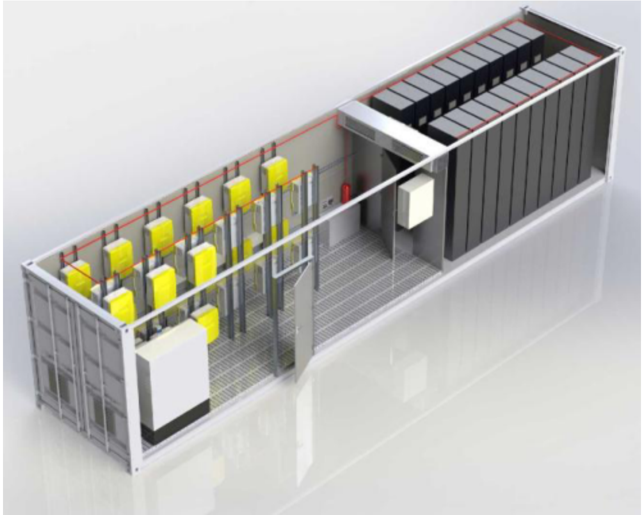
Given the scale of the PV Power Sources possible for the site, separate (below the line) provision has been made for battery energy storage, with Li-Ion batteries to be considered as economies of scale and production costs reduce. Please note the following with respect to this storage:

- It will be preferable to house the battery storage systems in concentrated areas, preferably in containerized outdoor enclosures, close to PV Power Source, on the airfield side as indicated in the diagrams below.
- The inclusion of battery storage for airside buildings will be considered and included as part of the building electrical microgrid design.
- We have considered the use of gel-filled lead-acid batteries plus Li-Ion batteries, with consideration based commercially viability at scale.
- Please note the batteries planned will be fitted in enclosed, fully manufactured units, housed into containerized storage modules. The battery packs are typically rated in relatively small fraction ratings of the overall system rating. We have looked at 830kWh batter containerized modules. The batteries fitted inside these modules are likely to be in the 10-to-20kWh ratings. Therefore, a leak of one unit will compromise a very small fraction of the overall electrolyte volume. The batteries are also individually monitored for over-charge/over-temperature/over-temperature minimizing the risk of individual unit failure. The battery enclosures are all fitted with HVAC cooling and fire suppression minimizing the risk to operators and environment.

- All battery types mentioned above virtually 100% recyclable thus comprising a good environmental solution to energy storage.
- The storage/usage cycle lifetime of the battery options is governed by the permitted discharge level, battery temperatures and number of discharge events. To ensure optimal performance/life cycle the use of battery management will be essential to system longevity.
- The cost/performance capability of battery storage compared to traditional diesel driven generator plant is being considered and will be incorporated and integrated onto the MV electrical micro-grid where required and where possible.



Airfield PV Arrays (with 3*Battery Units)


Typical containerized battery storage unit

Renewable Potential Energy Storage

An alternative to this type of energy storage comprises potential energy storage (large masses lifted with sustainable energy PV Power Sources) and discharging by allowing lowering of the supported mass, generating power using hydraulic fluid turbine generator systems. The commercial viability and availability of these alternatives will be easily integrated into the planned CWA Micro-Grid Electrical Network.

Energy Summary

Based on the above, we wish to summarise site energy needs versus energy sources as follows:

Energy Sources

- The site total demand has been calculated at 10-MVA
- It is possible to provide 24/7 bio-digester plant rated at 1-MVA
- The peak capacity planned for photo-voltaic plant is 79-MVA
- It is likely the total site demand for electricity will be provided off-grid for portions of the working day cycles.
- Provision is to be made for limited battery storage; the electrical network microgrid will be capable of scalable additional battery storage modules as the technology develops.

During the working day cycle at the airport, the primary source of power will be from the Eskom Connections. The site sources planned, including PV sources and bio-digester, will be used to off-set load demand. The portion of the off-sets is largely driven by the time of year, cloud cover, plus bio-digester plant availability,

Critical Loads

- The estimated load for these critical loads is 3-to-4-MVA.
- Backup diesel generator power will be included for airport facility critical facilities, ensuring that applicable safety standards and requirements are achieved for aircraft operations.
- It is envisaged that ≈ 10-MVA of generator capacity will be supplied in support of these critical loads.

Based on a total site load of ≥ 5-MVA and likely ≤ 10-MVA the critical load represents a fraction of this total. Assuming the bio-digester plant is producing a steady 1-MVA, it is likely that PV power produced during daylight hours will replace the Eskom Feed Source entirely. The use of the battery backup during evening and night-time hours will reduce the demand requirement from the Eskom Feeders.

F. Airfield Side: Boundary & Apron Lighting Services

The boundary and apron lighting services for the airfield will comprise the following:

Boundary Lighting including Entrance and Parking Areas

- LED luminaires fitted on 6000-mm high concrete poles at 30-meter centres around the entire site.
- The designed lighting level will be 30-lux.
- A series of 30-kVA mini-substations will be provided around the site, allowing for site-wide distribution at 11,000-Volts, and 400-Volt three phase power supplies for local street lighting connections.

Apron Lighting

- EWO R-System R4 floodlights fitted on 28-m masts with integrated pulley system (to raise/lower mast-top flood lighting mounting).
- High-mast vehicle barrier around each mast light pole.
- The designed lighting level for the apron aircraft parking will be 30-lux.
- A mini-substation will be provided for the apron lighting system, allowing for connection to the site-wide distribution at 11,000-Volts, and 400-Volt three phase power supplies for local mast lighting connections.

G. Airfield Side: Boundary & Apron Security Services

The security services for these areas will include the following typical services and equipment:

- Hybrid daylight/thermal imaging camera system for the security envelope, allowing for automatic intruder alert monitoring.

- Outdoor rated horn speakers, fixed lighting/CCTV camera masts allowing for Security Control voice instructions to Security Staff and Intruders.
- The CCTV cameras will be mounted on concrete poles (for image stability) and connected to the monitoring/image storage headend using a dedicated fibre-optic cable network.
- The field cameras will be powered using the Boundary Lighting Electrical Network, and intruders monitored between the illuminated boundary fencing and the airfield runways using the thermal imaging.
- The CCTV will be linked to the Boundary Electric Fence Monitoring System, such that Security Control Room Operators automatically have TV Monitoring of the affected security breach.
- Electric Fence and associated monitoring system will be provided by the Security Fence Installer Specialist.
- Vehicle entry/exit control to the Cape Winelands Airport Road entrances.

I trust that this is clear and in order. Please contact this office if you require further details or information.

Yours faithfully

Charles Selkirk
(Pr. Eng., S.M. SAIEE)