Mediclinic Rooftop PV Projects: Performance Report

Prepared for:

Moshesh Partners

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Abbreviations

|  |  |
| --- | --- |
| COD | Commercial Operating Date |
| HSE | Health and Safety and Environment |
| kWh | Kilo Watt Hour |
| OPEX | Operating expenses |
| PPA | Power Purchase Agreement |
| PR | Performance ratio |
| SCADA | Supervisory control and data acquisition |
| YTD | Year-to-date |

Glossary of Terms

|  |  |
| --- | --- |
| Actual Production | Production produced in kWh |
| Predicted Production | The forecasted P50 production in kWh |
| PR | Actual production divided by weather adjusted production in % |
| Weather Adjusted Predicted | Predicted production adjusted for actual weather in kWh |

# Introduction



Harmattan Renewables (Harmattan) has been appointed by Moshesh Partners (the Client) to provide asset management support for its rooftop PV assets at various Mediclinic sites across South Africa.

## Scope of Work

The scope of work is fully described in Harmattan proposal “*HAR\_P215\_MOSHESH\_MediclinicAssetManagement \_v2”*, dated 15 July 2022”.

## Site Visits

Harmattan has conducted 6 month operational site visits to Vergelegen, Midstream and Durbanville and the reports are Appendices to this document. The next site visit will be conducted to Hermanus and the Highveld upon confirmation of dates with the contractor.

## Report Layout and Risk Assessment Scale

Key findings and recommendations to the Client are highlighted in a summary table at section 2 of the report The table is colour coded and includes a narrative summary of the overall findings. A detailed summary of the documents reviewed is included in section 9 of the report. Where possible, Harmattan will confirm whether review items are consistent with market norms / standards and across all Project documentation. Where Harmattan identifies an omission, error, inconsistency, or deviation from our expectations, an issue will be flagged, analysed, and assigned a risk rating as outlined in Table 1‑2.

For all items, where an issue is identified, a risk category and colour code are allocated. Categorisation is achieved by making a qualitative assessment of the probability of the occurrence of the issue and the severity of the impact of the issue and allocating a tag Critical (C) / High (H) / Medium (M) / Low (L) / Negligible (N) and associated colour code to each issue (together with a brief explanation of why the tags were chosen). These tags are then multiplied in a range of combinations to yield a qualitative risk categorisation (see graphic below). This categorisation of risk allows for the prioritisation of the issues originally identified and brings a degree of focus to the subsequent mitigation process. If no risk is present / relevant, then the categorisation is summarised as 'Not Applicable' (N/A). Harmattan highlights that a simple, non-numerical, approach has been adopted to maintain the simplicity and functionality of the method and to avoid unproductive debates around the calibration of the categorisation components.

|  |  |  |
| --- | --- | --- |
| **Key** | **Definition** | **Description** |
| **C** | **Critical** | Risk of critical negative influence on project/investment outcome |
| **H** | **High** | Risk of high negative influence on project/investment outcome |
| **M** | **Medium** | Risk of medium negative influence on project/investment outcome. |
| **L** | **Low** | Risk of low negative influence on project/investment outcome. |
| **N** | **Negligible** | Risk of negligible negative influence on project/investment outcome. |
| **N/A** | **Not Applicable** | No risk present/relevant. |
| **TBC** | **Awaiting**  **Information** | Additional information required to enable Harmattan to opine on the risk. |

Table ‑: Risk Definitions Key

# Executive Summary

## Portfolio Overview

Harmattan Renewables (Harmattan) has been appointed by Moshesh Partners (the Client) to provide asset management support for its rooftop PV assets at various Mediclinic sites across South Africa. The projects were all installed by ACES Africa (ACES) who are now acting as the O&M contractor. Table 1‑1 provides an overview of the portfolio.

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **COD (Commercial Operation Date)** | **Design Capacity DC/AC (kW)** | **Installed**  **Capacity DC/AC (kW)** |
| Moshesh Mediclinic Durbanville Solar PV (“Durbanville”) | 11 November 2021 | 704.6 / 650 | 705.7 / 650 |
| Moshesh Mediclinic Hermanus Solar PV (“Hermanus”) | 10 March 2022 | 211.7 / 200 | 211.7 / 220 |
| Moshesh Mediclinic Highveld Solar PV (“Highveld”) | 30 March 2022 | 263 / 250 | 258.9 / 250 |
| Moshesh Mediclinic Midstream Solar PV (“Midstream”) | 27 October 2021 | 227.9 / 200 | 227.9 / 220 |
| Moshesh Mediclinic Vergelegen Solar PV (“Vergelegen”) | 28 October 2021 | 697.1 / 650 | 689.6 / 650 |

Table 2‑1: Project Overview

## Performance Summary

Performance in the month of August 2022 on a per site basis has been as follows:

* + - 1. Vergelegen Solar PV
* Production is 60,653 kWh with a variance of -1.30 % **below** the P50 forecast;
* Irradiation is 109 kWh/m2 with a variance of 1.93 % **above** P50 forecast;
* Availability is 99 % with a variance of 4.65 % **above** the warranted availability;
* PR is 80 % with a variance of -2.99 % **below** warranted availability;
* Revenue is R42,883 with a variance of -1.30 % **below** forecast.
  + 1. Durbanville Solar PV
* Production is 57,793 kWh with a variance of -25.08 % **below** the P50 forecast;
* Irradiation is 131 kWh/m2 with a variance of -4.22 % **below** P50 forecast;
* Availability is 100 % with a variance of 5.0 % **above** the warranted availability;
* PR is 62 % with a variance of 62 % **above** warranted availability;
* Revenue is R40,316 with a variance of -25.08 % **below** forecast;
  + 1. Midstream Solar PV
* Production is 29,575 kWh with a variance of -2.9 % **below** the P50 forecast;
* Irradiation is 107 kWh/m2 with a variance of -35.34 % **below** P50 forecast;
* Availability is 99 % with a variance of 3.97 % **above** the warranted availability;
* PR is 77 % with a variance of -4.13 % **below** warranted availability;
* Revenue is R22,927 with a variance of -2.9 % **below** forecast;
  + 1. Hermanus Solar PV
* Production is 22,528 kWh with a variance of 3.36 % **above** the P50 forecast;
* Irradiation is 121 kWh/m2 with a variance of 3.14 % **above** P50 forecast;
* Availability is 100 % with a variance of 5.22 % **above** the warranted availability;
* PR is 88 % with a variance of 0.05 % **above** warranted availability;
* Revenue is R20,581 with a variance of 3.36 % **above** w forecast;
  + 1. Highveld Solar PV
* Production is 30,455 kWh with a variance of -17.01 % **below** the P50 forecast;
* Irradiation is 186 kWh/m2 with a variance of 5.05 % **above** P50 forecast;
* Availability is 93 % with a variance of -1.78 % **below** the warranted availability;
* PR is 65 % with a variance of -17.31 % **below** warranted availability;
* Revenue is R23,077 with a variance of -17.01 % **below** forecast;

## Key Risks, Recommendations & Actions

The following key risks were identiﬁed:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Key Risks** | **Description** | **Risk Rating** | **Actions** | **Recommendations** |
| Plant Underperformance | All sites have inadequate performance compared to the predicted energy. The Operator has stated that the inadequate performance is due to curtailment during load shedding and poor irradiance due to weather conditions at each site. | **H** | Harmattan has requested the Operator to provide all the unscheduled and maintenance report and also give details on why the plant is curtailed during loadshedding | Harmattan recommends using the emergency generator as a reference to continue operation during a load shedding event. The ace will need to determine if this is possible. Harmattan also recommends running the yield simulation to confirm if the forecasts are correct. |
| Shading | Harmattan have noted that some modules in Durbanville site are shaded by nearby trees resulting in module damage and a loss in production. | **H** | According to the report submitted, no action has been taken to solve this problem. | Harmattan would recommend cutting down the trees nearby. |
| Inverters overheating | The inverter at Vergelegen is overheating due to poor ventilation, causing production losses. Harmattan notes that the inverters were not operated above 60 ˚C at the beginning of the autumn and winter seasons. We note that with the transition to the summer season, the inverter temperature increases and is operated above the maximum temperature. | **H** | The Operators have stated that Mediclinic will install the ventilation system, but this has not happened. | Harmattan recommends that Aces conduct further heat testing at other sites to determine if they are experiencing similar problems. Harmattan recommends that Aces Mediclinic submit specifications for the cooling required to keep the inverter at a safe operating temperature. Harmattan will review the specification and costing. |
| Performance Guarantee | Harmattan note that Durbanville, Vergelegen, and Midstream started operation in October 2022, we do not have irradiance data until March 2022. We cannot use the following formula to adjust generation for 12 months.   * Performance Guarantee after Services Start Date * The Operator guarantees to the Owner that the Facility will reach a minimum of 90% of “Generation Adjusted” in a consecutive period of 12 months. | **H** | No action has been taken | Harmattan recommends:   * Only consider data from April 2022 to November 2022 for generation adjustment. * Inquire if ACES can use satellite data from another site near the Moshesh projects. |

Table 2‑2: Key Risks



# Portfolio Revenue

Revenues are based on actual production and the tariff agreed between individual Mediclinics and Moshesh under the Power Purchase Agreement (PPA) as described in Table 3-1 below.

|  |  |  |
| --- | --- | --- |
| **Plant** | **PPA Rate (ZAR/kWh)** | **Applicable Year** |
| Durbanville | 0.6066 | 11 November 2021 - 10 November 2022 |
| Vergelegen | 0.6148 | 28 October 2021 - 27 October 2022 |
| Highveld | 0.6589 | 30 March 2022 -29 March 2023 |
| Midstream | 0.6741 | 27 October 2021 - 26 October 2022 |
| Hermanus | 0.7944 | 10 March 2022 - 9 March 2023 |

Table ‑: PPA Rates

The tariff rate increases by 6% every 12 months from COD. Projected revenues are based on the P50 Helioscope simulation performed during the pre-construction phase, and have not been adjusted to reflect received irradiation or the installed capacity.

Actual revenue is based upon production as recorded by the SCADA and the PPA rates as shown above.

Weather adjusted forecast is the predicted production adjusted for actual weather in kWh.

## Revenue to date

The following graph shows the revenue against the budgeted revenue since COD.

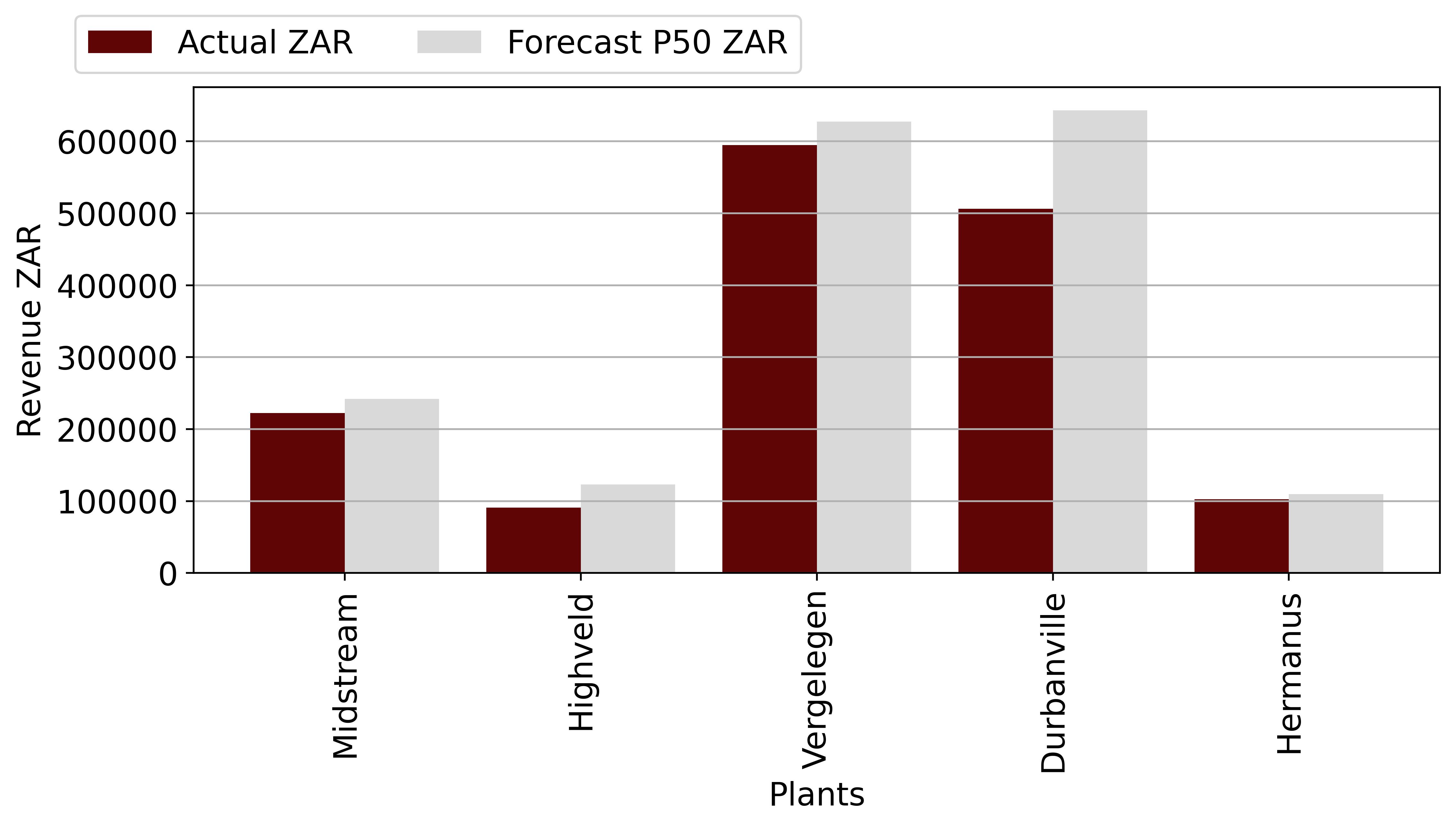


Figure 3‑1: Revenue to Date

|  |  |  |  |
| --- | --- | --- | --- |
| **Revenue (ZAR)** | | | |
| **Plants** | **Actual** | **Forecast** | **Delta (%)** |
| Durbanville | 506,062 | 642,983 | -21.29 |
| Vergelegen | 594,582. | 627,296 | -5.22 |
| Highveld | 90,797 | 123,041 | -26.21 |
| Midstream | 222,184 | 241,974 | -8.18 |
| Hermanus | 102,448. | 109,552 | -6.48 |

Table ‑: Project Revenue Overview

We note that all the plants have been performing below the forecasted revenue, with Durbancville and Highveld showing the most significant deviation from forecast.

# Possible Causes

The possible causes of underperformance are resources, load shedding, and equipment performance. Harmattan has determined that all of the power plants failed to meet the P50 forecast indicated in the Helioscope simulation. We contacted the operator to obtain more information on the possible causes of the underperformance. The operator has stated that load shedding is a major factor in the inadequate performance and low irradiance. No major disturbances were identified that led to the inadequate power. the losses due to load shedding are explained below.

When load shedding occurs, the power plant's inverter shuts down, resulting in production losses. Grid-connected PV systems are typically programmed to shut down during a load shedding event. This is due to international safety standards. Solar modules generate DC electricity, but it must be converted to AC so that it can be used in buildings. For this purpose, solar inverters are used to convert the electricity.

In the event of a grid failure (e.g., load shedding by Eskom), the solar inverters are designed to shut down. This is to protect the grid personnel working on the transmission lines during the outage. If the buildings continue to generate power during a grid outage and potentially feed power to the national grid, this could be fatal to maintenance personnel who are unaware that power is flowing in the lines when the grid is down.

We also note that radiation is below projections, which may be related to the satellite.

In the following sections, we analyse the below-average performance in order from worst to best project.

# Highveld Technical Performance

|  |  |
| --- | --- |
| **Project Overview** | |
| Design Capacity DC/AC (kW) | 263 / 250 |
| Installed Capacity DC/AC (kW) | 258.9 / 250 |
| Technology | Solar |
| Project Company | Moshesh Solar PV 1 (Pty) Ltd |
| Address | 46 Barney Molokwane, Trichardt South Africa |
| Commercial Operation Date | 30 March 2022 |

Table ‑: Highveld Project Overview



## Irradiation vs Forecast

The following table and graph describe the irradiance of the site compared to the pre-construction Helioscope P50 prediction. Harmattan notes that the irradiance data is satellite-based.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Irradiation (kWh/m2)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Apr 22 | 52 | 156 | -66.95 | | May 22 | 139 | 155 | -10.66 | | Jun 22 | 19 | 141 | -86.31 | | Jul 22 | 61 | 154 | -60.58 | | Aug 22 | 186 | 177 | 5.05 | |  |
| Table ‑: Highveld irradiation and Forecast | Figure ‑: Highveld Irradiation Vs Forecast |

The actual solar irradiance is significantly below forecast from April 2021 to July 2022. August 2022 showed a of 5.05% higher than forecast irradiation.

Harmattan therefore recommends that an operating yield forecast of the site be determined to confirm the irradiance.

## Availability vs Forecast

The guaranteed minimum availability of the plant is 95 %.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Availability (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Apr 22 | 95 | 95 | 0.0 | | May 22 | 98 | 95 | 2.75 | | Jun 22 | 95 | 95 | -0.37 | | Jul 22 | 95 | 95 | -0.05 | | Aug 22 | 93 | 95 | -1.78 | |  |
| Table ‑: Highveld Availability and Forecast | Figure ‑: Highveld Availability Vs Forecast |

Between June and August 2022 availability has been slightly below warranted levels. The cause of this unavailability is unclear as the Operator has not submitted monthly reports.

The Operator has indicated that the availability of the power plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports for the site to confirm this.

## Performance Ratio vs Forecast

T

Highveld’s Performance Ratio (PR) has been more than 10% below forecast from COD with a maximum deviation of -21.43 % in July 2022.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Performance Ratio (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Apr 22 | 70 | 79 | -11.56 | | May 22 | 67 | 79 | -14.79 | | Jun 22 | 62 | 79 | -21.43 | | Jul 22 | 64 | 79 | -19.59 | | Aug 22 | 65 | 79 | -17.31 | |  |
| Table ‑: Highveld PR and Forecast | Figure ‑: Highveld PR Vs Forecast |

The Operator has stated that the underperformance of the power plant is due to the bad weather conditions, which have resulted in lower irradiation than expected, as well as load shedding, which leads to production losses because the inverter cannot be put into operation for safety reasons.

## Production vs Forecast

Total production since COD is 119,827.04 kWh which is a -26.21 % deviation from the P50 forecast and -27.07% from the weather-adjusted forecast.

Table 4-2 describes the production of the plant on a monthly basis from 30 March 2022 COD compared to the P50 Helioscope forecast and the weather-adjusted forecast.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** | |  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** | | Apr 22 | 32,408 | 32400 | 21644 | -33.21 | -33.2 | | May 22 | 32008 | 31200 | 28195 | -11.91 | -9.63 | | Jun 22 | 29209 | 31300 | 17910 | -38.69 | -42.78 | | Jul 22 | 32059 | 32100 | 21623 | -32.55 | -32.64 | | Aug 22 | 36696 | 37300.0 | 30455 | -17.01 | -18.35 | | **Total** | **162,380** | **164,300** | **119,827** | **-26.21** | **-27.07** | |
| Table 4‑2: Hermanus Production and Forecast |
| Figure 4‑1: Hermanus Production Vs Forecast |

The weather-adjusted forecast is lower than the P50 forecast, which means that the generation could not meet the P50 forecast due to the bad weather conditions. The higher than P50 deviation from the weather-adjusted forecast also means that curtailment of the power plant during load shedding played a role in the shortfall, as did unplanned maintenance.

Harmattan recommends that the Operator provide unplanned maintenance events to verify losses caused by disturbances.

# 

# Durbanville Technical Performance

The following tables and figures on the technical performance and forecast data provide information on the production, irradiation, availability, and performance ratio of the plant compared to the forecast.

|  |  |
| --- | --- |
| **Project Overview** | |
| Design Capacity DC/AC (kW) | 704.6 / 650 |
| Achieved Capacity DC/AC (kW) | 705.7 / 650 |
| Technology | Solar |
| Project Company: | Moshesh Solar PV 1 (Pty) Ltd |
| Address: | Wellington Road Durbanville South Africa |
| Commercial Operation Date | 11 November 2022 |

Table ‑: Durbanville Project Overview

## Production Vs Forecast

The following tables describe the production of the plant since COD. Production is compared to the P50 Helioscope forecast and the weather-adjusted forecast.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** | |  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** | | Nov 21 | 81,633 | 81,633.33 | 67,695 | -17.07 | -17.07 | | Dec 21 | 130,721 | 130,700.0 | 94,633 | -27.61 | -27.6 | | Jan 22 | 130,944 | 140,000.0 | 100,806 | -23.02 | -28.0 | | Feb 22 | 111,814 | 111,800.0 | 91,370 | -18.28 | -18.27 | | Mar 22 | 111,969 | 112,000.0 | 89,806 | -19.79 | -19.82 | | Apr 22 | 85,868 | 88,500.0 | 70,141 | -18.31 | -20.74 | | May 22 | 68,401 | 66,589.0 | 60,421 | -11.67 | -9.26 | | Jun 22 | 58,422 | 57,700.0 | 48,240 | -17.43 | -16.4 | | Jul 22 | 64,810 | 64,700.0 | 44,538 | -31.28 | -31.16 | | Aug 22 | 77,139 | 71,200.0 | 57,793 | -25.08 | -18.83 | | **Total** | **921,721** | **924,822** | **725,443** | **-21.29** | **-21.56** | |
| Table ‑: Durbanville Production and Forecast |
| Figure ‑: Durbanville Production Vs Forecast |

Total production since COD is 725,443.1 kWh with a variance of-21.29 % below the P50 forecast and -21.56 % below the weather-adjusted forecast. This shows that weather conditions had a minor impact on the failure to meet the P50 forecast since the weather adjusted forecast shows a slightly higher production than the P50 forecast. This means that the weather was favourable for the plant to meet the expected forecast, but due to plant curtailment during load shedding the plant was not able to meet the expected generation.

The loss of production cannot be attributed solely to low irradiance and curtailment, as the variance is high. We note that tree shade and inverter faults may have influenced the high underproduction of the system.

The following image shows the tree shade in Durbanville, which was detected in March 2022 during the on-site inspection.



Figure 5‑2: Durbanville Production Vs Forecast

Harmattan also reviewed the inverter's thermal test to determine if the production failure was caused by the inverter's inefficiency at an operating temperature above 60 ˚C. According to the thermal test conducted on 20 April 2022, the maximum operating temperature is 36.0 ˚C, as shown below. No other inverter was observed to exceed the operating temperature of 36.0˚C.

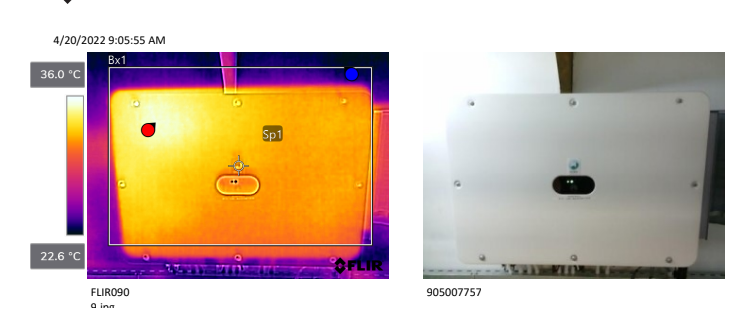


Figure 5‑3: Durbanville Thermal Test

Harmattan notes that the inverters are operating within the expected temperature range, as no inverter was found to exceed the maximum temperature range of 60 ˚C. Harmattan recommends that the temperature also be measured during the summer season, as the inverter's operating temperature may rise during hot weather.

## Irradiation vs Forecast

The following table and graph describe the irradiance of the site compared to the Helioscope P50 prediction. Harmattan notes that the irradiance measurement is satellite-based. The site has been measuring irradiance since April to the present, and no irradiance data is available prior to that time.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Irradiation kWh/m2** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 126 | 157 | -19.62 | | May 22 | 119 | 122 | -2.65 | | Jun 22 | 103 | 103 | 0.36 | | Jul 22 | 106 | 114 | -7.52 | | Aug 22 | 131 | 137 | -4.22 | |  |
| Table ‑: Durbanville irradiation and Forecast | Figure ‑: Durbanville Irradiation Vs Forecast |

The above table and figure show that the solar irradiance from April 2022 to August 2022 is below the forecast except for the month of June 2022. In the absence of data from previous months, Harmattan cannot confirm whether the site has experienced good or poor solar radiation since COD.

## Durbanville Availability vs Forecast

The following tables and figures on the technical performance and forecast data provide information on the production, irradiation, availability, and performance ratio of the plant compared to the forecast.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Availability (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | 69 | 95 | -27.57 | | Dec 21 | 100 | 95 | 5.26 | | Jan 22 | 89 | 95 | -6.74 | | Feb 22 | 99 | 95 | 4.26 | | Mar 22 | 100 | 95 | 5.26 | | Apr 22 | 97 | 95 | 1.86 | | May 22 | 91 | 95 | -4.67 | | Jun 22 | 95 | 95 | 0.27 | | Jul 22 | 89 | 95 | -5.99 | | Aug 22 | 100 | 95 | 5.0 | |  |
| Table ‑: Durbanville Availability and Guaranteed | Figure ‑: Durbanville Availability Vs Forecast |

From the above table and diagram, we can see that the plant has reached the minimum availability of 95 % for several months since COD. We note that the plant did not reach the minimum availability in January 2022, May 2022 and July 2022 with a deviation of 4 % to 7 % from the guaranteed availability.

We also note that the plant did not meet the guaranteed availability in November 2021, but this is due to the fact that the plant was only in operation for 19 days, resulting in a misstatement of 68.81% availability.

Harmattan cannot confirm whether the power plant's unavailability was due to unscheduled maintenance, as only 3 unscheduled events were reported. The Operator has indicated that the availability of the power plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports for the site to confirm that the unavailability was due solely to load shedding.

## Durbanville Performance Ratio vs Forecast

The following table and chart compare the Scada Performance Ratio with the monthly forecast P50 PR of the Helioscope Forecast report.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Performance Ratio (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 60 | 78 | -22.89 | | May 22 | 72 | 80 | -9.59 | | Jun 22 | 67 | 80 | -16.10 | | Jul 22 | 58 | 80 | -28.05 | | Aug 22 | 63 | 80 | -21.88 | |  |
| Table ‑: Durbanville PR and Forecast | Figure ‑: Durbanville PR Vs Forecast |

From the chart and table above, the performance ratio from April to present has fallen short of projections, ranging from -9.59% to -28.05% variance.

Harmattan notes that the power plant's Performance Ratio has not improved, and due to a lack of data, cannot confirm whether it has lagged behind projections since COD.

The Operator has stated that the underperformance of the power plant is due to poor weather conditions that have resulted in lower irradiation than expected, as well as load shedding that results in production outages because the inverter cannot be put into operation for safety reason.

# Midstream Technical Performance

The following tables and figures on the technical performance and forecast data provide information on the production, irradiation, availability, and performance ratio of the plant compared to the forecast.

|  |  |
| --- | --- |
| **Project Overview** | |
| Design Capacity kW DC/AC (kW) | 227.9 / 200 |
| Achieved Capacity DC/AC (kW) | 227.9 / 220 |
| Technology | Solar |
| Project Company: | Moshesh Solar PV 1 (Pty) Ltd |
| Address: | Midstream Drive, Hill Boulevard Midstream Estate, Olifantsfontein. - South Africa |
| Commercial Operation Date | 27 October 2021 |

Table ‑: Midstream Project Overview

## Midstream Production Vs Forecast

The following tables describe the production of the plant since COD. Production is compared to the P50 Helioscope forecast and the weather-adjusted forecast.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** | |  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** | | Oct 21 | 4,608 | 4,607.74 | 4,350 | -5.60 | -5.60 | | Nov 21 | 35,427 | 35,400.0 | 18,454 | -47.91 | -47.87 | | Dec 21 | 37,840 | 37,800.0 | 48,331 | 27.72 | 27.86 | | Jan 22 | 36,357 | 36,400.0 | 34,169 | -6.02 | -6.13 | | Feb 22 | 31,491 | 31,500.0 | 32,937 | 4.59 | 4.56 | | Mar 22 | 32,436 | 35,900.0 | 29,032 | -10.49 | -19.13 | | Apr 22 | 27,152 | 24,200.0 | 23,636 | -12.95 | -2.33 | | May 22 | 26,286 | 27,800.0 | 23,406 | -10.96 | -15.8 | | Jun 22 | 23,828 | 25,900.0 | 21,763 | -8.66 | -15.97 | | Jul 22 | 26,254 | 25,000.0 | 20,957 | -20.18 | -16.17 | | Aug 22 | 30,459 | 31,000.0 | 29,575 | -2.9 | -4.6 | | **Total** | **312,138** | **315,508** | **286,610** | **-8.18** | **-9.16** | |
| Table ‑: Midstream Production and Forecast |
| Figure ‑: Midstream Production Vs Forecast |

Total production since COD is 286,610.1kWh with a variance of 8.18% below the forecast production and 9.16% below the weather adjusted forecast.

Weather-adjusted generation is greater than the P50 forecast, meaning that the power plant could have met and exceeded P50 generation if the power plant had not curtailed during load shedding, which would have resulted in production losses. Another factor that could affect production losses is the soiling of the module in the middle of the river.

During the site visit on September 23, 2022, Harmattan noted that all the panels were covered with dust, possibly due to the windy spring weather. The operator stated that they were cleaned in August and that he cleans the models every 6 months. Harmattan notes that the soiling of the panels may also have affected production losses since COD. The following figure shows the soiling on the module.

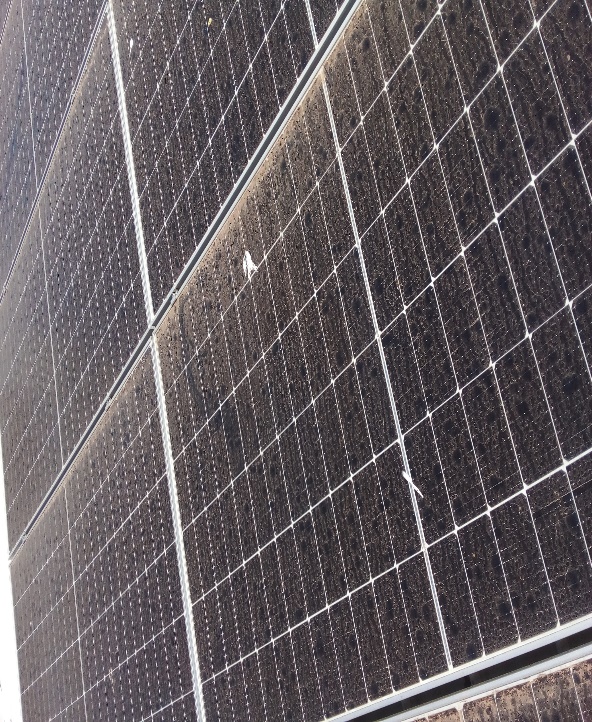


Figure 6‑1: Midstream Soiling.

Harmattan recommends monitoring the soling for 6 months to determine if additional cleaning of the modules is needed for the site, especially in the dry season without rain.

## Midstream Irradiation Vs Forecast

The following table and graph describe the irradiance of the site compared to the Helioscope P50 prediction. Harmattan notes that the irradiance measurement is satellite-based.

The site has been measuring irradiance since April to the present, and no irradiance data is available prior to that time.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Irradiation (kWh/m2)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 117 | 149 | -21.60 | | May 22 | 137 | 142 | -3.19 | | Jun 22 | 92 | 127 | -27.55 | | Jul 22 | 96 | 140 | -31.76 | | Aug 22 | 107 | 166 | -35.34 | |  |
| Table ‑: Midstream Irradiation and Forecast | Figure ‑: Midstream Irradiation Vs Forecast |

The above table and figure show that solar irradiance from April 2022 to August 2022 is below projections. In the absence of data from previous months, Harmattan cannot confirm whether the facility has experienced good or poor solar irradiance levels since COD. We can only state that the irradiance is poor compared to the P50 irradiance.

## Midstream Availability Vs Forecast

The following table and chart describe the availability of the plant since COD, comparing the availability of the plant with the guaranteed minimum availability of 95 %.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Availability (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | 100 | 95 | 5.26 | | Nov 21 | 100 | 95 | 5.26 | | Dec 21 | 100 | 95 | 5.26 | | Jan 22 | 0 | 95 | -100.0 | | Feb 22 | 64 | 95 | -32.35 | | Mar 22 | 100 | 95 | 5.26 | | Apr 22 | 97 | 95 | 1.78 | | May 22 | 96 | 95 | 0.99 | | Jun 22 | 100 | 95 | 5.26 | | Jul 22 | 94 | 95 | -1.29 | | Aug 22 | 99 | 95 | 3.97 | |  |
| Table ‑: Midstream Availability and Guaranteed | Figure ‑: Midstream Availability Vs Forecast |

From the above table and graph, we can see that the plant has reached the minimum availability of 95 % for several months since COD.

We note that the plant did not reach the minimum availability in January 2022, February 2022 and July 2022 with a deviation of -1 to -32 % from the guaranteed availability. We also note that the plant has a high deviation in February 2022. Harmattan cannot confirm whether the high deviation is due to a fault in the SCADA system or caused by unplanned maintenance in February, as no maintenance report and checklist were provided.

The Operator has only stated that the availability of the power plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports for the site to confirm that the unavailability was due solely to load shedding.

## Midstream Performance Ratio Vs Forecast

The following table and chart compare the Scada Performance Ratio with the monthly forecast P50 PR of the Helioscope Forecast report.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Performance Ratio (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 81 | 80 | 1.71 | | May 22 | 75 | 81 | -8.17 | | Jun 22 | 78 | 82 | -5.17 | | Jul 22 | 73 | 82 | -10.86 | | Aug 22 | 77 | 81 | -4.13 | |  |
| Table ‑: Midstream PR and Forecast | Figure ‑: Midstream PR Vs Forecast |

From the chart and table above, the performance ratio from May to date has fallen short of projections, ranging from -4.13 % to -10.86 %. Harmattan notes that the power plant's Performance Ratio has not improved, and due to a lack of data, cannot confirm whether it has lagged behind projections since COD.

The Operator has stated that the inadequate performance of the power plant is due to poor weather conditions that have resulted in lower irradiation than expected, as well as load shedding that results in production outages because the inverter cannot be put into operation for safety reasons.

# Hermanus Technical Performance

Technical performance tables and forecast figures below give details on plant Gross Generation, Irradiation, Availability and Performance Ratio compared against the Forecast/warranted values, then analyse the results and give recommendations.

|  |  |
| --- | --- |
| **Project Overview** | |
| Design Capacity (kW) DC/AC: | 211.7 / 200 |
| Achieved Capacity (kW) DC/AC | 211.7 / 220 |
| Technology | Solar |
| Project Company: | Moshesh Solar PV 1 (Pty) Ltd |
| Address: | Ravenscroft Rd Hermanus – 7,200 – South Africa |
| Commercial Operation Date | 10 March 2022 |

Table ‑: Hermanus Project Overview

## Hermanus Production Vs Forecast

The following tables describe the production of the plant since March 2022 COD. Production is compared to the P50 Helioscope forecast and the weather-adjusted forecast.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** | |  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** | | Oct 21 | - | - | - | - | - | | Nov 21 | - | - | - | - | - | | Dec 21 | - | - | - | - | - | | Jan 22 | - | - | - | - | - | | Feb 22 | - | - | - | - | - | | Mar 22 | 21,376 | 21,376.48 | 17,949 | -16.03 | -16.03 | | Apr 22 | 24,643 | 22,871.0 | 21,947 | -10.94 | -4.04 | | May 22 | 18,855 | 20,381.0 | 19,453 | 3.17 | -4.55 | | Jun 22 | 15,569 | 16,481.0 | 15,026 | -3.49 | -8.83 | | Jul 22 | 17,679 | 15,400.0 | 15,238 | -13.81 | -1.05 | | Aug 22 | 21,796 | 20,100.0 | 22,528 | 3.36 | 12.08 | | **Total** | **119,918** | **116,609** | **112,142** | **-6.48** | **-3.83** | |
| Table ‑: Hermanus Production and Forecast |
| Figure ‑: Hermanus Production Vs Forecast |

Total production since COD is 112,141.72 kWh with a deviation of 6.48 % below the P50 forecast and 3.83 % below the weather-adjusted forecast.

This shows that weather conditions had an impact on the power plant not meeting the P50 forecast, but we note that weather cannot be the only reason for the low production, as the weather-adjusted production is lower than original P50 forecast. The Operator has stated that the high deviation may be due to load shedding that resulted in production outages.

Harmattan also reviewed the inverter's thermal test to determine if the production losses was caused by the inverter's inefficiency at an operating temperature above 60 ˚C. According to the thermal test conducted on 24 August 2022, the maximum operating temperature is 34.9 ˚C, as shown below. No other inverter was observed to exceed the operating temperature of 34.9 ˚C.

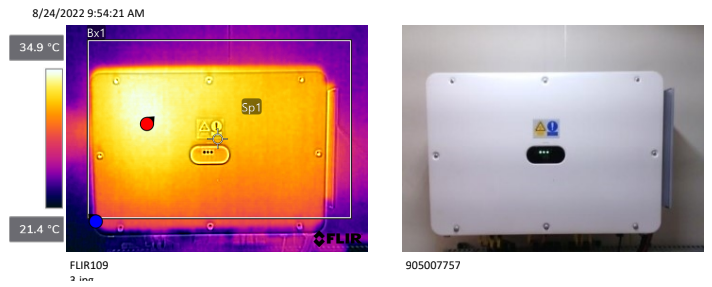


Figure 7‑2: Hermanus Inverter Thermal Test

Harmattan notes that the inverters are operating within the expected temperature range, as no inverter was found to exceed the maximum temperature range of 60 ˚C. Harmattan recommends that the temperature also be measured during the summer season, as the inverter's operating temperature may rise during hot weather.

## Hermanus Irradiation Vs Forecast

The following table and graph describe the irradiance of the site compared to the Helioscope P50 prediction. Harmattan notes that the irradiance measurement is based on a pyranometer installed on site

The site has been measuring irradiance since April to the present, and no irradiance data is available prior to that time.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Irradiation (kWh/m2)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 126 | 135 | -7.19 | | May 22 | 111 | 103 | 8.09 | | Jun 22 | 90 | 85 | 5.86 | | Jul 22 | 94 | 96 | -1.79 | | Aug 22 | 121 | 118 | 3.14 | |  |
| Table ‑: Hermanus irradiation and Forecast | Figure ‑: Hermanus Irradiation Vs Forecast |

The table and figure above show that the irradiation is below forecast in April 2022 to July 2022 and above in August 2022, May 2022 and June 2022.

## Hermanus Availability Vs Forecast

The following table and chart describe the availability of the plant since COD, comparing the availability of the plant with the guaranteed minimum availability of 95 %.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Availability (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | 100 | 95 | 5.26 | | Apr 22 | 93 | 95 | -1.62 | | May 22 | 96 | 95 | 0.97 | | Jun 22 | 92 | 95 | -3.35 | | Jul 22 | 88 | 95 | -7.32 | | Aug 22 | 100 | 95 | 5.22 | |  |
| Table ‑: Hermanus Availability and Forecast | Figure ‑: Hermanus Availability Vs Forecast |

From the above table and chart, it appears that the power plant has not met the minimum availability of 95 % since COD for some months. Harmattan cannot confirm if the unavailability of the power plant is due to unscheduled maintenance as no report has been submitted. The Operator has indicated that the availability of the power plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports for the site to confirm this.

## Hermanus Performance Ratio Vs Forecast

The following table and chart compare the Scada Performance Ratio with the monthly forecast P50 PR of the Helioscope Forecast report.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Performance Ratio (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 78 | 86 | -9.24 | | May 22 | 82 | 87 | -5.8 | | Jun 22 | 79 | 87 | -8.85 | | Jul 22 | 76 | 87 | -12.35 | | Aug 22 | 88 | 88 | 0.05 | |  |
| Table ‑: Hermanus PR and Forecast | Figure ‑: Hermanus PR Vs Forecast |

Harmattan notes that the power plant's performance from April 2022 to July 2022 was below the expected forecast, with a variance of -5.18 % to -12.35 %.

Harmattan notes that the power plant's performance ratio improved in August 2022. The Operator has stated that the inadequate performance of the power plant was due to poor weather conditions, which resulted in lower irradiation than expected, and load shedding, which resulted in production losses because the inverter could not be operated for safety reasons.

# Vergelegen Technical Performance

The following section summarises the Vergelegen project and highlights its technical performance. Key Performance indicators including production, irradiation, availability, and performance ratio were assessed from the SCADA , and compared to the forecast.

|  |  |
| --- | --- |
| **Project Overview** | |
| Design Capacity DC/AC (kW) | 697.1 / 650 |
| Achieved Capacity DC/AC (kW) | 689.6 / 650 |
| Technology | Solar |
| Project Company: | Moshesh Solar PV 1 (Pty) Ltd |
| Address: | Vergelegen, Main Road Somerset West South Africa |
| Commercial Operation Date | 28 Oct 2022 |

Table ‑: Vergelegen Project Overview

## Vergelegen Production Vs Forecast

The following table describes the production of the project. Production was measured from COD to August 2022 and compared to the P50 forecast. Harmattan points out that October 2022 was not a full month, so production is low. Harmattan adjusted the forecast for the 3 days of operation. The resulting variance shows that the plant was above forecasts.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** | |  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** | | Oct 21 | 10,346 | 10,346.03 | 15,876 | 53.45 | 53.45 | | Nov 21 | 124,191 | 124,200.0 | 114,667 | -7.67 | -7.68 | | Dec 21 | 135,649 | 135,600.0 | 126,250 | -6.93 | -6.90 | | Jan 22 | 134,331 | 134,300.0 | 127,625 | -4.99 | -4.97 | | Feb 22 | 108,571 | 108,600.0 | 96,946 | -10.71 | -10.73 | | Mar 22 | 100,729 | 100,729.0 | 94,648 | -6.04 | -6.04 | | Apr 22 | 70,911 | 74,300.0 | 70,139 | -1.09 | -5.6 | | May 22 | 51,576 | 51,700.0 | 52,488 | 1.77 | 1.52 | | Jun 22 | 41,982 | 43,200.0 | 39,238 | -6.54 | -9.17 | | Jul 22 | 47,500 | 45,400.0 | 42,440 | -10.65 | -6.52 | | Aug 22 | 61,453 | 56,800.0 | 60,653 | -1.30 | 6.78 | | **Total** | **887,239** | **885,175** | **840,970** | **-5.22** | **-4.99** | |
| Table ‑: Vergelegen Production and Forecast |
| Figure ‑: Vergelegen Production Vs Forecast |

Total production since COD is 840,969 kWh with a variance of 5.22 % below the original forecast and 4.99 % below the weather adjusted forecast.

The weather-adjusted generation is less than the P50 forecast, which means that the power plant could not exceed the P50 generation.

As the irradiation is low due to cloudy weather conditions since COD. The impact of load shedding is minimal. We have also considered the impact of inverters operating above guaranteed temperature range, as described below.

The following figure describes the inverter temperature at Vergelegen. The thermal image was taken on 30 March 2022, and shows that the inverter is operating at 50 ˚C, which is close to the maximum operating temperature of 60 ˚C. The high operating temperature of the inverter has implications for production. Harmattan notes that the inverter has not exceeded the maximum temperature of 60 ˚C but points out that this could change during the summer months.

A picture containing text, electronics

Description automatically generatedFigure 8‑2: Vergelegen Production Vs Forecast

Harmattan notes that the Operator (Aces) has proposed that Mediclinic provide additional ventilation to the room where the inverters are located. This has not been done because the winter season has allowed for additional cooling of the inverter.

Harmattan recommends that the Operator provide Mediclinic with a specification for the required cooling of the equipment and conduct further thermal testing at the other sites. Harmattan will review the specification and costing provided by ACES.

## Vergelegen Irradiation Vs Forecast

The following table and graph describe the irradiance of the site compared to the Helioscope P50 prediction. Harmattan notes that the irradiance measurement is satellite-based. The site has been measuring irradiance since April to the present, and no irradiance data is available prior to that time.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Irradiation (kWh/m2)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 122 | 127 | -4.25 | | May 22 | 92 | 91 | 1.51 | | Jun 22 | 82 | 73 | 11.81 | | Jul 22 | 83 | 83 | -0.1 | | Aug 22 | 109 | 107 | 1.93 | |  |
| Table ‑: Vergelegen irradiation and Forecast | Figure ‑: Vergelegen Irradiation Vs Forecast |

From the above table and figure, solar radiation was above forecast in May, June, and August, while it was below forecast in April and July. In the absence of data from previous months, Harmattan cannot confirm whether solar irradiation has been good or bad since COD.

## Vergelegen Availability Vs Forecast

The following table and chart describe the availability of the plant since COD, comparing the availability of the plant with the guaranteed minimum availability of 95 %.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Availability (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | 16 | 95 | -83.34 | | Nov 21 | 92 | 95 | -2.95 | | Dec 21 | 100 | 95 | 5.26 | | Jan 22 | 99 | 95 | 4.03 | | Feb 22 | 99 | 95 | 4.52 | | Mar 22 | 100 | 95 | 5.26 | | Apr 22 | 97 | 95 | 1.93 | | May 22 | 99 | 95 | 4.48 | | Jun 22 | 92 | 95 | -3.14 | | Jul 22 | 92 | 95 | -3.53 | | Aug 22 | 99 | 95 | 4.65 | |  |
| Table ‑: Vergelegen Availability and Guaranteed | Figure ‑: Vergelegen Availability Vs Forecast |

From the above table and graph, we can see that the plant has reached the minimum availability of 95 % for several months since COD. We note that the plant did not reach the minimum availability in November 2021, June 2022, July 2022 and August 2022 with a deviation of 3% to 4 % from the guaranteed availability.

We also note that the plant did not meet guaranteed availability in October 2021, but this is due to the fact that the plant was only in operation for four days, resulting in a misstatement of 15.83% availability. Harmattan cannot confirm whether the power plant's unavailability was due to unscheduled maintenance, as only one unscheduled event was reported.

The Operator has indicated that the availability of the power plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports for the site to confirm that the unavailability was due solely to load shedding

## Vergelegen Performance Ratio Vs Forecast

The following table and chart compare the Scada Performance Ratio with the monthly forecast P50 PR of the Helioscope Forecast report.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  | | --- | --- | --- | --- | | **Performance Ratio (%)** | | | | | **Month** | **Actual** | **Forecast** | **Delta (%)** | | Oct 21 | - | - | - | | Nov 21 | - | - | - | | Dec 21 | - | - | - | | Jan 22 | - | - | - | | Feb 22 | - | - | - | | Mar 22 | - | - | - | | Apr 22 | 73 | 80 | -8.40 | | May 22 | 78 | 81 | -4.21 | | Jun 22 | 68 | 82 | -16.58 | | Jul 22 | 72 | 82 | -12.78 | | Aug 22 | 80 | 83 | -2.99 | |  |
| Table ‑: Vergelegen PR and Forecast | Figure ‑: Vergelegen PR Vs Forecast |

From the chart and table above, it appears that the performance ratio from April to present has fallen short of projections, ranging from -2.99 % to -16.58 %. Harmattan notes that the power plant's Performance Ratio has not improved. Due to a lack of data, we cannot confirm whether it has lagged behind projections since COD.

The Operator has stated that the inadequate performance of the power plant is due to poor weather conditions that have resulted in lower irradiation than expected, as well as load shedding that results in production outages because the inverter cannot be put into operation for safety reasons.

# Events

## Health and Safety

No health and safety incidences were reported based on the information provided by the Operator.

## Scheduled Maintenance

Harmattan notes that the operator has only submitted the inspection list for Durbanville, Hermanus and Vergelegen. No problems were noted for Hermanus and Vergelegen. At Durbanville, we noted that nearby trees were shading the panels. The operator did not provide recent reports indicating whether this problem has been corrected.

At Hermanus and Durbanville, module cleaning has not been performed since COD because the modules were clean. For Vergelegen, module cleaning was performed on March 31, 2022. The latest status from the operator is that the modules are still clean. Midstream did module cleaning last month, but during the site visit it was determined that the modules were clean.

## Unscheduled Maintenance

The following table describes the unscheduled maintenance activities that have occurred since COD.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Date Occurred** | **Plant** | **Events** | **Description** | **Resolution** |
| 9/5/2022 | Durbanville | The communication is down in, and the inverters are not producing. | Communication between inverters and logger is interrupted and inverters show no production - idle status.  It has been determined that UPS has failed for communication on block 3, causing communication to be interrupted. The UPS has failed without external causes. | The UPS was repaired on 10 May 2022. The estimated production downtime is 2MW. |
| 9/5/2022 | Durbanville | Inverter 5 - no production - string fault. | The inverter went into fault mode because one string had an abnormal voltage reading to earth.  String 5.4.1 had an insulation fault and there was a voltage leakage into the earth system.  The fault could not be corrected within 24 hours because no team was available at that time to lift the equipment and find the fault. | On 27 May 2022, the faulty string was disconnected from the inverter to resume production, and a new connector was attached to the undamaged piece of cable.  The fault resulted in a production loss of 175 kWh. |
| 3/7/2022 | Durbanville | Inverters 4 to 7 no production | No link between the logger and inverters 4 to 7.  The UPS for the PA link has failed | On 4 July 2022,  a new part (UPS) was installed  The production loss hour is 1.1MW |
| 23/08/2022 | Durbanville | Theft | The main earthing cable of the solar system has been stolen (7 meters) behind the green tanks on the roof slab. | The earthing cable parts that was stolen have been replaced. Harmattan have also submitted incident to the insurer to understand the excess on the claim. The insurer has stated a minimum detectable of R15,000 for theft. Since the total replacement cost for cable was R4,945.00. Harmattan note that the incident cost is too low vs the excess required by the insurer. |
| 22/02/2022 | Vergelegen | Block 1, inverter 2, large DC of output current | Inverter 2 had a string fault that caused a high output DC current.  It was determined on site that inverter 2, string 2.2.1, had an open circuit voltage reading. The MC4 connection on the module array of string 2.2.1 failed due to a hot connection and melted, causing an open circuit connection. | On 23 February 2022, the MC4 was removed, the cables were reconnected, and a new MC4 was installed and properly connected to ensure continuity. The string was retested and found to be functional.  The estimated production loss is 68.85 kWp. |
| 25/05/2022 | Hermanus | Main circuit breakers not switching on | The main circuit breakers at the feeder and PVDB do not want to turn on automatically.  It was determined on site that the UFD, which automatically turns the circuit breakers on and off, has failed. | 0n 26 May 2022, the UFD was replaced by another UFD.  The production downtime is 900kWp |

Table ‑: Unscheduled Maintenance Events

## Spare Parts

The following table describes the required maximum spare parts required under the contract vs the minimum spare parts currently available on site.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Major Parts List – 2022** | **Maximum QTY** | **Durbanville QTY** | **Vergelegen QTY** | **Midstream QTY** | **Hermanus QTY** | **Highveld QTY** |
| SUN2,000 100KTL Inverter | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| SUN2,000 50KTL Inverter | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| 630A CB | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| 200A CB | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| 100A CB | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Motorised Breaker Mechanism | 1 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| JA Solar 540 W modules | 10 | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |

Table ‑: Major Spare parts.

The Operator has not provided a spare parts list for each facility. Harmattan has requested these and is now waiting for the Operator's response.

# Project Budget

The purpose of the following table was to show the plant's monthly expenses compared to the allocated budget. However, Harmattan has not yet received a financial model/operating model from the Operator to complete the following table. Harmattan has requested this information from the Operator, and we are still awaiting a response.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Project Budget** | | | | | | | |
| **Site** | | **Monitoring** | **Satellite Data** | **Site Maintenance & Cleaning** | **Administration** | **Spare Parts** | **Total Cost** |
| Durbanville | Forecast | R7'785.83 | R9'673.89 | R37'191.36 | R15'000.00 |  | R69'651.08 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Vergelegen | Forecast | R7'702.96 | R9'673.89 | R36'879.36 | R15'000.00 |  | R69'256.21 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Midstream | Forecast | R2'518.30 | R9'673.89 | R17'360.64 | R15'000.00 |  | R44'552.83 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Tzaneen | Forecast | R4'492.93 | R9'673.89 | R24'794.56 | R15'000.00 |  | R53'961.38 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Highveld | Forecast | R2'906.15 | R9'673.89 | R18'820.80 | R15'000.00 |  | R46'400.84 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Hermanus | Forecast | R2'339.29 | R9'673.89 | R16'686.72 | R15'000.00 |  | R43'699.90 |
| Actual | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| Delta (%) | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |
| **Totals** |  | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** | **TBC** |

Table ‑: Operating Budget

# Documents Reviewed

|  |  |
| --- | --- |
| **Project Name** | **Documents Reviewed** |
| Vergelegen | * Vergelegen April 2022 * Vergelegen February 2022 * Vergelegen December 2022 * Vergelegen July 2022 * Vergelegen June 2022 * Vergelegen March 2022 * Vergelegen January 2022 * Vergelegen November 2022 * Vergelegen August 2022 * SOIR1\_Site Operational Incident Report-VMC001-22feb22 * O\_M Feedback Report\_Vergelegen MC BL1\_30-03-22 * O\_M Feedback Report\_Vergelegen MC BL3\_01-04-22 * Thermal Report\_Vergelegen MC Block 1\_30-03-22 * Thermal Report\_Vergelegen MC Block 3\_01-04-22 * O\_M Inspection Checklist\_Vergelegen MC B1\_01-04-22 * O\_M Inspection Checklist\_Vergelegen MC B1\_30-03-22 |
| Durbanville | * Durbanville April 2022 * Durbanville February 2022 * Durbanville December 2022 * Durbanville July 2022 * Durbanville June 2022 * Durbanville March 2022 * Durbanville January 2022 * Durbanville August 20,222 * SOIR1\_Site Operational Incident Report - DMC001 - 10-05-2022 * SOIR1\_Site Operational Incident Report - DMC002 - 27-05-2022 * SOIR1\_Site Operational Incident Report - DMC003 - 4-07-2022 * O\_M Inspection Report\_Durbanville MC BL1\_20-04-22 * O\_M Inspection Report\_Durbanville MC BL1\_20-04-22 * OMFR\_O\_M Feedback Report - Durbanville MC Block 1 - 20-04-2022 * OMFR\_O\_M Feedback Report - Durbanville MC Block 3 - 21-04-2022 * Thermal Report\_Durbanville MC Block 1\_20-04-22 * Thermal Report\_Durbanville MC Block 3\_21-04-22 |
| Midstream | * Midstream April 2022 * Midstream February 2022 * Midstream December 2022 * Midstream July 2022 * Midstream June 2022 * Midstream March 2022 * Midstream January 2022 * Midstream November 2022 * Midstream August 2022 |
| Hermanus | * Hermanus April 2022 * Hermanus July 2022 * Hermanus June 2022 * Hermanus May 2022 * Highveld August 2022 * SOIR1\_Site Operational Incident Report - HMC001 - 26-05-2022 * Thermal Report\_Hermanus Mediclinic\_24-08-2022 |
| Highveldf | * Highveld April 2022 * Highveld July 2022 * Highveld June 2022 * Highveld May 2022 * Highveld August 2022 |