Mediclinic Rooftop PV Projects

September 2021 Asset Monthly Report

Prepared for:

Moshesh Partners

Reference: HAR\_215\_Moshesh Mediclinic Performance Report

02 November 2022

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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 |

# Introduction

Harmattan Pty (Ltd) (“Harmattan”) has been appointed by Moshesh Partners (the “Client”) to provide asset management support for its rooftop and carport PV assets at various Mediclinic sites across South Africa. The projects were all installed by ACES (Operator/ EPC) who is now acting as the O&M contractor (the “Contractor”).

## Dataroom

Harmattan was provided with reports and documentation by dataroom and various emails and information received up until 20 September 2021 was reviewed as part of this assessment.

Link: <https://drive.google.com/drive/u/1/folders/1mzGbgbADKsgF5-OpjCuji_YpA79gh0k6>

## Scope of Work

The scope of work is fully described in Harmattan proposal “*HAR\_P215\_MOSHESH\_MediclinicAssetManagement \_v2”*, dated 15 July 2021”.

The purpose of this report is to consider the initial operational performance of the projects, highlight any deviations from expectations and make recommendations to improve performance (where possible). The projects under consideration are Durbanville, Hermanus, Highveld, Midstream and Vergelegen (each a “Project”, together the “Portfolio”).

## Site Visits

Harmattan conducted operational site visits to the Vergelegen, Midstream and Durbanville, and Hermanus projects six months after commercial operations began. These reports form Appendices A, B, C and D to this document.

Site visits will be conducted to the Highveld site 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 in 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*‑*1*.

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 © / 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 1‑1: Risk Definitions Key

# Executive Summary

## Portfolio Overview

The following map shows the location of Moshesh Rooftop PV Portfolio operating sites. The sites are in the Gauteng and Western Cape Provinces of South Africa.



Figure 2‑1: Project Locations

Table 2‑1 provides an overview of the Portfolio.

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **COD (Commercial Operation Date)** | **Design Capacity DC/AC (kW)** | **Installed**  **Capacity DC/AC (kW)** |
| Moshesh Mediclinic Durbanville (“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

The following summary describes the performance of the facilities since COD:

### Highveld Solar PV

* Production is {{HIGP}} KWh with a variance of {{HIGPV}} % below the P50 Forecast.
* Irradiation is {{HIGI}} kWh/m2 with a variance of {{HIGIV}} % below P50 Forecast.
* Availability is {{HIGA}} % with a variance of {{HIGAV}} % above the warranted availability.
* PR is {{HIGPR}} % with a variance of {{HIGPRV}} % below warranted availability.

### Durbanville Solar PV

* Production is {{DURP}} KWh with a variance of {{DURPV}} % below the P50 Forecast.
* Irradiation is {{DURI}} kWh/m2 with a variance of {{DURIV}} % below P50 Forecast.
* Availability is {{DURA}} % with a variance of {{DURAV}} % above the warranted availability.
* PR is {{DURPR}} % with a variance of {{DURPR}} % below warranted availability.

### Midstream Solar PV

* Production is {{MIDP}} KWh with a variance of {{MIDPV}} % below the P50 forecast.
* Irradiation is {{MIDI}} kWh/m2 with a variance of {{MIDIV}} % below P50 Forecast.
* Availability is {{MIDA}} % with a variance of {{MIDAV}} % above the warranted availability.
* PR is {{MIDPR}} % with a variance of {{MIDPRV}} % below warranted availability.

### Hermanus Solar PV

* Production is {{HERP}} KWh with a variance of {{HERPV}} % below the P50 Forecast.
* Irradiation is {{HERI}} kWh/m2 with a variance of {{HERIV}} % below P50 Forecast.
* Availability is {{HERA}} % with a variance of {{HERAV}} % above the warranted availability.
* PR is {{HERPR}} % with a variance of {{HERPRV}} % below warranted availability.

### Vergelegen Solar PV

* Production is {{VERP}} KWh with a variance of {{VERPV}} % below the P50 Forecast.
* Irradiation is {{VERI}} kWh/m2 with a variance of {{VERIV}} % below P50 Forecast.
* Availability is {{VERA}} % with a variance of {{VERAV}} % above the warranted availability.
* PR is {{VERPR}} % with a variance of {{VERPRV}} % below warranted availability.

It is noted that all four of the above projects have been subject to numerous loadshedding events which will have contributed to the lower-than-expected levels of production.

## Key Risks and Recommendations

|  |  |  |  |
| --- | --- | --- | --- |
| **Key Risks** | **Description** | **Risk Rating** | **Recommendations** |
| Portofilo Key risk | We have reviewed the plant and have noted the following issues:   * The production of all the plants is below forecast. The Operator has stated that the loss in production was dominated by Eskom load shedding, resulting in inverter downtime due to the anti-islanding function on the inverter. * We have noted that no irradiation data was available prior to April 2022 for Midstream, Durbanville and Vergelegen projects. * We have noted data gaps in the measurement of daily irradiation across the different sites, which makes it difficult to evaluate whether lower irradiation than forecast played a role in the underperformance of the plants and the lower-than-expected PR values achieved. * We have noted that no unscheduled maintenance report, biannual inspection checklist, thermal reports were not provided for Highveld. * No unscheduled maintenance reports were provided for midstream * The underperformance of the plant has resulted in revenue losses due to production losses. | **H** | We recommend:   * Performing a cost benefit analysis of various options that could be employed to allow the PV systems to operate during periods of loadshedding. * Moshesh communicate with Mediclinic on whether they would allow solutions which enable the integration of the PV systems and the backup generators on each site. * We recommend that the Operator provided the missing reports for midstream and Vergelegen. * We recommend that the Operator procure the missing data prior April 2022 for Midstream, Vergelegen, Durbanville * We recommend reloading the missing daily irradiation data to the SCADA |
| Vergelegen  Technical Risk | We also note that the inverters were operating at a high temperature of 50 ˚C, close to the maximum temperature of 60 ˚C. Operating at this temperature for an extended time will result in production losses and increase the levels of wear and tear on the inverters. The inverter’s high operating temperature is due to poor ventilation. Unless this issue is quickly rectified, we expect high losses in summer and possibly reduced inverter lifetimes. | **H** | We recommend ACES to submit specifications for the cooling required to keep the inverter at a safe operating temperature. Harmattan will review the specifications and costings provided. |
| Midstream  Technical Risk | We have noticed soiling on the modules which could have influenced the overall performance. The modules were washed In August 2022 after 10 months operation. The soiling was noted during the site visit on 23 September 2022. | **H** | We recommend monitoring the soiling for at least six months to determine if additional cleaning is needed, as the modules were heavily soiled, as seen during the site visit. |
| Durbanville  Technical Risk | The total production since COD is below forecast which may have been influenced by the shading from nearby trees and the frequent Eskom load shedding due to the anti-islanding function on the inverter. | **H** | We recommend the ACES purchase the missing data from Solcast and cut down or trim trees that shade the panels |
| Performance Guarantee | Harmattan note that Durbanville, Vergelegen, and Midstream started operation in October 2022. However, we were not provided with the irradiance data prior to March 2022. As such we cannot use the formula from the O&M contract 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** | Harmattan recommends:   * Only consider data from April 2022 to November 2022 for generation adjustment. * Inquire whether ACES can use satellite data from another site near the Moshesh projects. |
| Major Spare parts | Harmattan notes that no spare parts are kept on site as agreed in discussions with Moshesh and Harmattan management and will be reflected in the contract. The Operator has stated that minor spare parts are in stock in Cape Town and Johannesburg. Major spares will be kept in Cape Town. We note that only keeping the major spare parts in Cape Town present a problem for plants outside of Cape Town since it would require longer lead time to deliver the spare to site, resulting in higher production losses | **M** | Harmattan recommends keeping some major spare parts in Johannesburg although we note that having spare parts only in Cape Town has had little effect on performance to date. |



Table 2‑2: Key Risks

# O&M Contract

Harmattan notes that the O&M contract between Moshesh and ACES Africa (Operator) has not yet been signed. This poses a risk to Moshesh as it is unable to claim the penalties for underperformance set forth in the contract. Harmattan notes that the Operator submits monthly reports and conducts semi-annual maintenance inspections as specified in the draft O&M contract.

Harmattan has reviewed the draft O&M contract and noted the following:

* Durbanville, Vergelegen and Midstream started operation in October 2022, yet no irradiance data was provided prior to April 2022. We therefore cannot use the following formula in the O&M contract to adjust generation for 12 months of operation.

Equation 1: Generation Adjustment (O&M Contract)

* The draft O&M contract does not include requirements for reporting on:
  + Major spare parts consumed;
  + Spare parts in stock as per the spare parts list and their location;
  + Scheduled maintenance performed monthly;
  + Unscheduled Maintenance; and
  + HSE issues.

Harmattan recommends that the contract is amended to include the above reporting requirements and that ACESACES purchase the missing irradiance data from Solcast to allow completion of the performance assessments.

# Portfolio Finance



## PPA Rates

Revenues are based on actual production and the rate agreed upon between each Mediclinic site and Moshesh under the Power Purchase Agreements (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 4‑1: PPA Rates

The Moshesh/Mediclinic PPA rates increase by 6% every 12 months from COD.

Forecast revenues are based on the P50 Helioscope simulation performed during the pre-construction phase and have not been adjusted to reflect actual irradiation or the installed capacity.

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

## Revenue Year to Date

The following graph shows the revenue against the budgeted revenue.

{{Revenue}}

*Figure 3‑1: Revenue to Date*

|  |  |  |  |
| --- | --- | --- | --- |
| **Revenue (ZAR)** | | | |
| **Plants** | **Actual** | **Forecast** | **Delta (%)** |
| Durbanville | {{DURZARTOT}} | {{DURZARFOR}} | {{DURZARV}} |
| Vergelegen | {{VERZARTOT}} | {{VERZARFOR}} | {{VERZARV}} |
| Highveld | {{HIGZARTOT}} | {{HIGZARFOR}} | {{HIGZARV}} |
| Midstream | {{MIDZARTOT}} | {{MIDZARFOR}} | {{MIDZARV}} |
| Hermanus | {{HERZARTOT}} | {{HERZARFOR}} | {{HERZARV}} |

*Table 3‑2: Project Revenue Overview*



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

In the following sections, we analyse the performance on a per Project basis.

# Technical Portfolio Overview

We have investigated the performance of the Highveld, Durbanville, Midstream, Hermanus and Vergelegen Mediclinic solar PV sites. We evaluated performance by comparing irradiance, availability, performance ratio, and production against forecasts. All sites have underperformed against the forecast. The Operator has stated that the underperformance of each site was dominated by frequent loadshedding which has resulted in curtailment of the sites. This curtailment occurs as the installed grid tied inverters have anti -islanding protection.

Anti-islanding protection is a necessary safety feature which disables PV inverters when the grid enters an islanded condition. This means that the inverter won’t operate during a grid outage event such as Eskom load shedding. 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.

An alternative to this system is to enable the PV systems to operate in an island system and so continue to supply the buildings that the PV system is connected to during time of loadshedding. Under this situation, the PV system would still generate power for direct use in the building, with no export to the external power grid. We note that that the system can only supply part of the load and it must be integrated with a generator, or battery system to allow the invertor to function.

The Operator has suggested installing a genset integrator system, which would connect into the existing Mediclinic backup generator sets. Harmattan has asked the Operator for a quote on the cost of procuring and installing a genset integrator and various other options. Harmattan note that a cost benefit analysis needs to be considered for various options in the market that could be used to solve the problem before deciding whether to install the genset integrator and note that Moshesh would need to communicate with Mediclinic as the genset integrator would be connected to the backup generator.

Harmattan highlights a note of caution here – given the critical nature of Mediclinic’s operations, it is possible that anything that could be seen as interfering with their power supply during a grid outage is a risk. Careful communications will be needed with Mediclinic to allay these fears.

## Data Analysed

Data Analysed

The following sections describes the performance of the system. Harmattan compiled data from the SCADA system and reviewed the monthly operational reports from COD through to August 2022. The Operator did not submit semi-annual reports or unscheduled maintenance reports to verify any issues that may have affected system performance. Harmattan has asked the Operator to provide this information.

The performance data was downloaded from the Higeco SCADA System and processed using Microsoft Excel. Harmattan has reviewed the data and where possible adjusted the production data for gaps in the data based on the following formula:

Based on this data, irradiance, availability Performance Ratio and Production are analysed. The irradiation data is based on the Solcast satellite data, availability and performance Ratio are calculated from the SCADA. The production is measured using a meter installed onsite.

1.1. System Design

The plant is a 258.9kWp system with 540 Wp JA Solar PV modules connected to 100 kW and 50 kW Huawei inverters. The system operates by using PV modules to generate DC electricity. The DC electricity is then converted to AC electricity by the inverters for use in the buildings, offsetting the grid supply during the times when solar electricity is available. The inverters installed by Mediclinic are grid tied with anti-islanding protection. This arrangement prevents the export of power to the grid when the project is load shed.

The plant is a 705.7kWp system consisting of 535Wp JA Solar PV modules connected to 13 Huawei 50 kW inverters. The system operates by using PV modules to generate DC electricity. The DC electricity is then converted to AC electricity by the inverters for use in the buildings. The inverters installed by Mediclinic are grid tied with anti-islanding protection fitted.

The plant is a 227.9kWp system with 535Wp JA Solar PV module connected to 2 Huawei 100 kW inverters. The system operates by using PV modules to generate DC electricity. DC is then converted to AC by the inverters for use in the buildings. The inverters installed by Mediclinic are grid tied with Anti-Islanding Protection.

The system is a 211.7kWp system with 540Wp JA Solar PV modules connected to two Huawei 100 kW inverters. The system operates by using PV modules to generate DC electricity. DC electricity is then converted to AC electricity by the inverters for use in the buildings. The inverters installed by Mediclinic are grid tied with anti-islanding protectionEquation 2:(Provided by ACES)

The system is a 211.7kWp system with 540Wp JA Solar PV modules connected to two Huawei 100 kW inverters. The system operates by using PV modules to generate DC electricity. DC electricity is then converted to AC electricity by the inverters for use in the buildings. The inverters installed by Mediclinic are grid tied with anti-islanding protection.

The system is a 689.6kWp system with 535Wp JA Solar PV modules connected to six Huawei 100 kW inverters and one Huawei 50 kW inverter. The system works with PV modules that generate DC electricity. DC electricity is then converted to AC electricity so that it can be used in the buildings. Inverters are used to convert the electricity for this purpose. The inverters installed by Mediclinic are grid-connected and have anti-islanding protection.

# Highveld Technical Performance

The following table gives a brief overview of the Highveld PV installation.

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

Table 6‑1: 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. We note that some of the irradiation data was not fully captured from April to July 2022.

Harmattan has noted the following after reviewing the daily irradiation SCADA data:

* The irradiance data was not available for 19 days in April 2022;
* The irradiance data was not available for 2 days in May 2022;
* The irradiance data was not available for 25 days in June 2022;
* The irradiance data was not available for 18 days in July 2022;
* The irradiance data was available for the full month in August 2022.

Harmattan adjusted the irradiance P50 forecast by the number of days that data was not available (See Equation 2). Total irradiance is 457kWh with a variance 2.43% below the forecast, as shown in the following table.



We note that the irradiation has been below forecast since COD, except for August 2022 which had a 5.05% above forecast deviation. The August month had no data gaps, this indicates that the irradiation gaps has affected the overall comparison between the forecast and actual performance. Due to high data gaps, it is difficult to tell if the low irradiance is due to poor weather conditions or poor data quality.

|  |  |  |  |
| --- | --- | --- | --- |
| **Irradiation (kWh/m2)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in HIGItable\_contents%} | | | |
| {{item.Date}} | {{ item. HIGIA}} | {{ item. HIGIF }} | {{item. HIGIV}} |
| {%tr endfor %} | | | |

*Table 4‑3: Highveld irradiation and Forecast*

{{HIGIImage}}

*Figure 4‑2: Highveld Irradiation Vs Forecast*

## Availability vs Forecast



The Operator has stated a minimum guaranteed availability of 95 % in their monthly reports. Harmattan has used this guaranteed availability to compare with the actual availability from the SCADA. Harmattan notes that the were no data gaps in the measured data. The average availability since COD is 95 % with a variance of 0.21 % above the guaranteed availability, as shown in the following table.

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 unscheduled maintenance 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 and outage reports for the site to confirm this.

|  |  |  |  |
| --- | --- | --- | --- |
| **Availability (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in HIGAtable\_contents%} | | | |
| {{item.Date}} | {{ item. HIGAA}} | {{ item. HIGAF }} | {{item. HIGAV}} |
| {%tr endfor %} | | | |

Table 4‑4: Highveld Availability and Forecast

{{HIGAImage}}

Figure 4‑3: Highveld Availability Vs Forecast

## Performance Ratio vs Forecast

The performance ratio was calculated by the SCADA system using the measured production and irradiation data. Harmattan has performed a PR forecast adjustment since we have noted the irradiation data gaps. This was performed using Equation 2 and the unavailability days were the same as the irradiation availability. We note that the average performance ratio since COD is 66 % with an average variance of 43.82 % from the forecast. We note that the overall forecast PR is low as it was adjusted due to the high number of data gaps.

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Ratio (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in HIGPRtable\_contents%} | | | |
| {{item.Date}} | {{ item. HIGPRA}} | {{item. HIGPRF }} | {{item. HIGPRV}} |
| {%tr endfor %} | | | |

*Table 4‑5: Highveld PR and Forecast*

{{HIGPRImage}}

*Figure 4‑4: Highveld PR Vs Forecast*



Harmattan notes that due to the data gaps in measured daily irradiation, the performance ratio could not be calculated accurately by the SCADA System resulting in high deviations when compared with the adjusted forecasted as show in Figure 6‑3.

## Production vs Forecast

The following tables describe the production of the plant since COD on 30 March 2022. Production is compared to the P50 Helioscope forecast (Original Forecast) and the weather-adjusted forecast. Harmattan has performed a recalculation of the weather adjusted forecast based on the adjusted irradiation forecast in Table 6‑2 and using Equation 1. We note that the weather adjusted forecast was calculated incorrectly by the Operator as seen below in Table 6‑5.Total production since COD is 119,827.04 kWh with a deviation of 26.21 % below the P50 forecast and 21.41% below the weather-adjusted forecast. The results of the Harmattan forecast simulation shows that the weather adjusted forecast is below the actual production, which indicates that the irradiation of the site was below forecast, but due to high data gaps in irradiation data, Harmattan cannot confirm if the underperformance was due to low irradiation as there is high uncertainty with the irradiation data used to calculate the weather adjusted forecast.







|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | |  | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in HIGPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.HIGPF}} | {{item.HIGPW}} | {{ item.HIGPA}} | {{item.HIGPV}} | {{item.HIGPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{HIGPFTOT}}** | **{{HIGPWTOT}}** | **{{HIGPATOT}}** | **{{HIGPVTOT}}** | **{{HIGPWVTOT}}** |

*Table 4‑2: Hermanus Production and Forecast*

{{ HIGPImage}}

*Figure 4‑1: Hermanus Production Vs Forecast*

To understand the underperformance Harmattan has spoken with the Operator and they have stated that the unavailability of the plant during Eskom load shedding has affected the overall performance of the plant. We note that a genset integrator is required to enable the PV plant to generate power during load shedding and that this would interface with the existing Mediclinic generator. We note that Moshesh need to communicate this to Mediclinic as there are risk involved with the genset integration. For example, if a generator fails because of the PV integration, Moshesh may be liable.

Semi-annual Inspection Checklist, Unscheduled Maintenance, and Thermal Report were not provided by the Operator for review to determine if there were any other issues that may have affected the plant’s performance.

We recommend performing a cost benefit analysis looking at various options that could be employed to improve the performance of the PV facility before implementing any solutions.

# Durbanville Technical Performance

The following table gives a brief overview of the Durbanville PV installation

|  |  |
| --- | --- |
| **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 7‑1: Durbanville Project Overview



## 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.

|  |  |  |  |
| --- | --- | --- | --- |
| **Irradiation kWh/m2** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in DURItable\_contents%} | | | |
| {{item.Date}} | {{ item. DURIA}} | {{ item. DURIF }} | {{item. DURIV}} |
| {%tr endfor %} | | | |

*Table 5‑3: Durbanville irradiation and Forecast*

{{DURIImage}}

*Figure 5‑4: Durbanville Irradiation Vs Forecast*



The above table and figure show that the solar irradiance from April 2022 to June 2022 is above forecast except for the months of July 2022 and August 2022. We note that the overall data quality is good with only 7 days of irradiation unavailability. The below forecast irradiation in July and August cannot be attributed to poor quality of data since there were no data gaps The low irradiation for those months is due to poor weather conditions. In addition, we note that no data was available prior April 2022. Due to the absence of data from previous months, Harmattan cannot confirm whether the site has experienced good or poor solar irradiation since COD.

## Durbanville Availability vs Forecast

The Operator has stated a minimum guaranteed availability of 95 % in their monthly reports, Harmattan has used this guaranteed availability to compare with the actual availability from the SCADA as shown in the following table. Harmattan notes that the were no data gaps noted for the availability. The average availability is 93 % with a variance of 2.20 % below the guaranteed availabilitybe c.

|  |  |  |  |
| --- | --- | --- | --- |
| **Availability (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in DURAtable\_contents%} | | | |
| {{item.Date}} | {{ item. DURAA}} | {{ item. DURAF }} | {{item. DURAV}} |
| {%tr endfor %} | | | |

*Table 5‑4: Durbanville Availability and Guaranteed*

{{DURAImage}}

*Figure 5‑5: 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% below the guaranteed availability.

We also note that the plant did not meet the guaranteed availability in November 2021 because the plant was only in operation for 19 days, resulting in a 68.81 % availability.

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

## Durbanville Performance Ratio vs Forecast

The performance ratio was calculated by the SCADA system using the measured production and irradiation data. Harmattan has performed PR forecast adjustment since we have noted from the irradiation data that there are gaps in the data. This was performed using Equation 2 and the unavailability days were the same as the level of irradiation unavailability since PR is dependent on the irradiation. The average PR since COD is 64 % with a variance of 15.88 % below the forecast, as shown in the following table.



|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Ratio (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in DURPRtable\_contents%} | | | |
| {{item.Date}} | {{ item. DURPRA}} | {{item. DURPRF }} | {{item. DURPRV}} |
| {%tr endfor %} | | | |

*Table 5‑5: Durbanville PR and Forecast*

{{DURPRImage}}

*Figure 5‑6: Durbanville PR Vs Forecast*

From Figure 7‑3 Harmattan notes that the plant’s performance ratio has not improved, and due to a lack of data, cannot confirm whether it has lagged projections since COD. We also note that there were some irradiance data gaps for the month of April and May 2022 which may had an impact on the calculated performance ratio. The overall performance ratio of the plant since COD can’t be accurately calculated due to the lack of data prior April 2022.

## 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. Harmattan has performed a recalculation of the weather adjusted forecast based on the adjusted irradiation forecast in Table 7‑2 and using Equation 1. No weather adjustments were performed prior April 2022 as the irradiation was not available. We note that the weather adjusted forecast was calculated incorrectly by the Operator as seen in Table 7‑5. The total production since COD is 725,443 kWh with a deviation of 21.29% below the P50 forecast and 20.68% below the weather adjusted forecast.



|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in DURPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.DURPF}} | {{item.DURPW}} | {{item.DURPA}} | {{item.DURPV}} | {{item.DURPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{DURPFTOT}}** | **{{DURPWTOT}}** | **{{DURPATOT}}** | **{{DURPVTOT}}** | **{{DURPWVTOT}}** |

Table 5‑2: Durbanville Production and Forecast

{{ DURPImage}}

Figure 5‑1: Durbanville Production Vs Forecast



# Midstream Technical Performance

The following table gives a brief overview of the Midstream PV installation.

|  |  |
| --- | --- |
| **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 8‑1: Midstream Project Overview



## 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 April 2022.

|  |  |  |  |
| --- | --- | --- | --- |
| **Irradiation (kWh/m2)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in MIDItable\_contents%} | | | |
| {{item.Date}} | {{ item. MIDIA}} | {{ item. MIDIF }} | {{item. MIDIV}} |
| {%tr endfor %} | | | |

*Table 6‑3: Midstream Irradiation and Forecast*

{{MIDIImage}}

*Figure 6‑2: Midstream Irradiation Vs Forecast*

## Midstream Availability Vs Forecast

The Operator have stated a minimum guaranteed availability of 95% in their monthly reports, Harmattan has used this guaranteed availability to compare with the actual availability from the SCADA as shown in the following table. Harmattan notes that the were no data gaps noted for the availability. The average availability is 95% with a variance of 0.06% below forecast, we have excluded the 0% availability in January 2022, which was a SCADA error as we have noted that the PV was operating and generating electricity.



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

|  |  |  |  |
| --- | --- | --- | --- |
| **Availability (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in MIDAtable\_contents%} | | | |
| {{item.Date}} | {{ item. MIDAA}} | {{ item. MIDAF }} | {{item. MIDAV}} |
| {%tr endfor %} | | | |

*Table 6‑4: Midstream Availability and Guaranteed*

{{MIDAImage}}

*Figure 6‑3: Midstream Availability Vs Forecast*

We note that the plant did not reach the minimum availability in January 2022, February 2022, and July 2022 with a deviation range of 1 to 32 % below the guaranteed availability. We also note that the plant had a high deviation in February 2022. Harmattan cannot confirm whether the high deviation was 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 solely due to load shedding.

## Midstream Performance Ratio Vs Forecast

The Performance Ratio was calculated by the SCADA system using the measured production and irradiation data. Harmattan has performed PR forecast adjustment since we have noted the irradiation data gaps. This was performed using Equation 2 and the unavailability days were the same as the irradiation unavailability days since PR is dependent on the irradiation.. The Average PR is 77 % with a variance of 18.67 % above the P50 forecast, as shown by the following table.



After adjusting the forecast with the irradiation unavailability days, we note that the actual performance ratio is above the forecast performance ratio. We also note that the PR could not be calculated prior April 2022 since the Operator had not purchased the Solcast satellite irradiance data.

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Ratio (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in MIDPRtable\_contents%} | | | |
| {{item.Date}} | {{ item. MIDPRA}} | {{item. MIDPRF }} | {{item. MIDPRV}} |
| {%tr endfor %} | | | |

*Table 6‑5: Midstream PR and Forecast*

{{MIDPRImage}}

*Figure 6‑4: Midstream PR Vs Forecast*

## 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. Harmattan has performed a recalculation of the weather adjusted forecast based on the adjusted irradiation forecast in Table 8‑2 and using Equation 1. No weather adjustments were performed prior April 2022 as the irradiation was not available. We note that the weather adjusted forecast was calculated incorrectly by the Operator as seen in Table 8‑5. Total production since COD is 286,610. kWh with a variance of 8.18% below the forecast production and 6.43 % below the weather adjusted forecast. Weather-adjusted generation is greater than the actual production, meaning that the plant could have produced more, but it is less than the P50 forecast, indicating that the plant could not meet the overall P50 forecast. We note that due to the uncertainty of the irradiation, the calculated weather adjusted forecast is not fully representative.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in MIDPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.MIDPF}} | {{item.MIDPW}} | {{item.MIDPA}} | {{item.MIDPV}} | {{item.MIDPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{MIDPFTOT}}** | **{{MIDPWTOT}}** | **{{MIDPATOT}}** | **{{MIDPVTOT}}** | **{{MIDPWVTOT}}** |

*Table 6‑2: Midstream Production and Forecast*

{{ MIDPImage}}



*Figure 6‑1: Midstream Production Vs Forecast*

# Hermanus Technical Performance

The following table gives a brief overview of the Hermanus PV installation.

|  |  |
| --- | --- |
| **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 9‑1: Hermanus Project Overview

## 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 the installed pyranometer. The site has been measuring irradiance since April 2022 to the present, and no irradiance data is available prior to that time. We note that some of the irradiation data were not fully captured in the month of April 2022.

Harmattan has noted the following after reviewing the daily irradiation SCADA data:

* The irradiance data was not available for 2 days in April 2022;
* The irradiance data was available for the full months of May-August 2022;

Harmattan has adjusted the irradiance forecast based on the number of data unavailability days (See Equation 2). We have only adjusted the April 2022 dataset, and no adjustments were required for the other datasets. Total irradiance is 542kWh/m2 with a variance of 2.76% above the forecast, as shown in the following table.



|  |  |  |  |
| --- | --- | --- | --- |
| **Irradiation (kWh/m2)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in HERItable\_contents%} | | | |
| {{item.Date}} | {{ item. HERIA}} | {{ item. HERIF }} | {{item. HERIV}} |
| {%tr endfor %} | | | |

*Table 7‑3: Hermanus irradiation and Forecast*

{{HERIImage}}

*Figure 7‑3: Hermanus Irradiation Vs Forecast*

The table and figure above show that the irradiation is below forecast in April 2022 and July 2022 and above in May, June, and August 2022. We note that the overall data quality is good with only 2 days of unavailability since COD. We noted that the overall irradiation of the site is above forecast.

## Hermanus Availability vs Forecast



The Operator has stated a minimum guaranteed availability of 95% in their monthly reports, Harmattan has used this guaranteed availability to compare with the actual availability from the SCADA. Harmattan notes that the were no data gaps noted for the availability. The average availability is 95% with a variance of 0.18% below the forecast, as shown in the following table.

|  |  |  |  |
| --- | --- | --- | --- |
| **Availability (%)** | | | |
| Month | Actual | Forecast | Delta (%) |
| {%tr for item in HERAtable\_contents%} | | | |
| {{item.Date}} | {{ item. HERAA}} | {{ item. HERAF }} | {{item. HERAV}} |
| {%tr endfor %} | | | |

*Table 7‑4: Hermanus Availability and Forecast*

{{HERAImage}}

*Figure 7‑4: Hermanus Availability Vs Forecast*

From the above table and chart, it appears that the plant has not met the minimum availability of 95 % since COD for several months. Harmattan cannot confirm if the unavailability of the plant was due to unscheduled maintenance as only one incident report was provided which does not correspond with the multiple months of lower than guaranteed availability seen in the Figure 9‑2 above. The Operator has indicated that the availability of the plant was mainly affected by load shedding. Harmattan recommends that the Operator submit the unscheduled maintenance reports if available to confirm this.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in HERPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.HERPF}} | {{item.HERPW}} | {{ item.HERPA}} | {{item.HERPV}} | {{item.HERPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{HERPFTOT}}** | **{{HERPWTOT}}** | **{{HERPATOT}}** | **{{HERPVTOT}}** | **{{HERPWVTOT}}** |

*Table 7‑2: Hermanus Production and Forecast*

{{ HERPImage}}

*Figure 7‑1: Hermanus Production Vs Forecast*

From Figure 9‑3 above we note that the irradiation of the plant is consistent with the high and low availability of the plant. As we have noted that the irradiation increases with high availability.

## Hermanus Performance Ratio vs Forecast

The Performance Ratio was calculated by the SCADA system using the measured production and irradiation data. Harmattan has performed PR forecast adjustment since we have noted from the irradiation data that there are data gaps. This was performed using Equation 2 and the unavailability days were the same as the irradiation unavailability days since PR is dependent on the irradiation. The Average The average PR is 81 % with a variance of 5.99 % below the forecast, as shown by the following table.



Harmattan notes that the plant’s performance from April 2022 to July 2022 was below the expected forecast, with a variance of 5 % We note that plant performance ratio improved in August 2022 with a 0.05 % deviation above the expected forecast. This is inconsistent with the above forecast irradiance in May, June, and August 2022, as the irradiance above forecast for these months which should have resulted in a higher than forecast PR. This indicates that the plant has experienced production losses which were not due to bad weather conditions. Harmattan would require unscheduled maintenance to confirm if any equipment failures resulted in the lower performance ratio.

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Ratio (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in HERPRtable\_contents%} | | | |
| {{item.Date}} | {{ item. HERPRA}} | {{item. HERPRF }} | {{item. HERPRV}} |
| {%tr endfor %} | | | |

*Table 7‑5: Hermanus PR and Forecast*

{{HERPRImage}}

*Figure 7‑5: Hermanus PR Vs Forecast*

## Hermanus Production vs Forecast

The following tables describe the production of the plant since 09 March 2022 COD. Production is compared to the P50 Helioscope forecast and the weather-adjusted forecast. Harmattan has performed a recalculation of the weather adjusted forecast based on the adjusted irradiation forecast in Table 9‑2 and using Equation 1. We note that the weather adjusted forecast was calculated incorrectly by the Operator as seen in Table 9‑5. The total production of 112,141.72 kWh with a deviation of 6.48 % below the P50 forecast and -8.52% below the weather-adjusted forecast.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in HERPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.HERPF}} | {{item.HERPW}} | {{ item.HERPA}} | {{item.HERPV}} | {{item.HERPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{HERPFTOT}}** | **{{HERPWTOT}}** | **{{HERPATOT}}** | **{{HERPVTOT}}** | **{{HERPWVTOT}}** |

Table 7‑2: Hermanus Production and Forecast

{{ HERPImage}}

Figure 7‑1: Hermanus Production Vs Forecast



We note that the weather adjusted forecast shows a higher production than the P50 (originally forecast), Which indicates that the plant experienced high enough irradiance to meet the expected P50 forecast, and the irradiation measurement show similar results except for April and July 2022 months where the irradiance was below the expected forecast. Harmattan has only noted one unscheduled maintenance incident since COD which does not explain the high level of underperformance. In Addition, Harmattan reviewed the Thermal Reports and the Biannual Inspection Checklist Report conducted on 24 August 2022. We note that no faults were detected that could have led to the underperformance and the inverters are operating within the expected temperature range.

We have also spoken to the Operator about the underperformance, and they have stated that the underperformance is due to frequent load shedding which results in downtown of grid tied inverter and thus production losses.

We recommend performing a cost benefit analysis to examine solutions that could be implemented to allow the PV system to operate during periods of loadshedding and Moshesh must communicate with Mediclinic as to whether they would accept any installation that interact with their backup generator since this could carry liability risks.

# Vergelegen Technical Performance

The following table gives a brief overview of the Vergelegen PV installation

|  |  |
| --- | --- |
| **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 October 2022 |

Table 10‑1: Vergelegen Project Overview

## 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 based on the installed pyranometer.

Harmattan has adjusted the irradiance forecast based on the number of data unavailability days (See Equation 2). We have only adjusted April 2022 and July 2022 dataset, but no adjustments were required for the other datasets. The irradiation is 488 kWh/m2 since April 2022 with a variance of 5.69 % above the forecast. The irradiance data is not fully representative of the irradiance of the site since no data was available prior April 2022.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Irradiation (kWh/m2)** | | | | | | | |
| **Month** | | | **Actual** | | | **Forecast** | **Delta (%)** |
| {%tr for item in VERItable\_contents%} | | | | | | | |
| {{item.Date}} | | | {{ item. VERIA}} | | | {{ item. VERIF}} | {{item. VERIV}} |
| {%tr endfor %} | | | | | | | |

*Table 8‑3: Vergelegen irradiation and Forecast*

{{VERIImage}}

*Figure 8‑3: Vergelegen Irradiation Vs Forecast*

Harmattan notes that the irradiation is above forecast for each month of operation since COD, the irradiation data availability is good with only 5 days of data gaps. The total irradiation is above the forecast which indicates that the plant had enough solar resource to meet the expected production. We note that due to the lack of data prior April 2022, the measured irradiation is not fully representative of the site conditions. We recommend acquiring the missing data from Solcast.

## 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 %. October only had 4 days of availability; it was excluded from the overall average availability since it would have skewed the data. The overall average availability is 97 % with a variance of 2.00 % above the forecast.

|  |  |  |  |
| --- | --- | --- | --- |
| **Availability (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in VERAtable\_contents%} | | | |
| {{item.Date}} | {{ item. VERAA}} | {{ item. VERAF}} | {{item. VERAV}} |
| {%tr endfor %} | | | |

Table 8‑4: Vergelegen Availability and Guaranteed

{{VERAImage}}

Figure 8‑4: 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. Harmattan cannot confirm whether the power plants unavailability was due to unscheduled maintenance, as only one unscheduled event was reported.

We also note that the plant did not meet guaranteed availability in October 2021, but this is because the plant was only in operation for four days, resulting in a misstatement of 15.83% availability.

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 solely due to load shedding.

## Vergelegen Performance Ratio vs Forecast

The performance ratio was calculated by the SCADA system using the measured production and irradiation data. Harmattan has performed PR forecast adjustments since we have noted from the irradiation data that there are data gaps. This was performed using Equation 2 and the unavailability days were the same as the irradiation unavailability days since PR is dependent on the irradiation. The PR is 74 % with a deviation of 5.93 % below the forecast.

|  |  |  |  |
| --- | --- | --- | --- |
| **Performance Ratio (%)** | | | |
| **Month** | **Actual** | **Forecast** | **Delta (%)** |
| {%tr for item in VERPRtable\_contents%} | | | |
| {{item.Date}} | {{ item. VERPRA}} | {{item. VERPRF }} | {{item. VERPRV}} |
| {%tr endfor %} | | | |

*Table 8‑5: Vergelegen PR and Forecast*

{{VERPRImage}}

*Figure 8‑5: Vergelegen PR Vs Forecast*



From the chart and table above, it appears that the performance ratio from May 2022 to present has fallen short of projections. We note that this is inconsistent with the above forecast irradiance observed since COD. The irradiance is high which should have resulted in a higher than forecast PR. This indicates that the plant has experienced production losses which were not due to bad weather conditions. Harmattan would require unscheduled maintenance reports to confirm if equipment failure resulted in lower performance.

## 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 has performed a recalculation of the weather adjusted forecast based on the adjusted irradiation forecast and using Equation 1. No weather adjustments were performed prior to April 2022 as the irradiation was not available. We note that the weather adjusted forecast was calculated incorrectly by the Operator as seen in Table 8 5. Harmattan points out that October 2022 was not a full month, so production is low. Harmattan adjusted the forecast for the three days of operation. Total production since COD is 840,970 kWh with a variance of 5.22 % below the original forecast and -6.88% below the weather adjusted forecast.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Month** | **Production (kWh)** | | | **Actual vs Original Forecast (%)** | **Actual vs Weather Adjusted Forecast (%)** |
|  | **Original Forecast** | **Weather Adjusted Forecast** | **Actual Production** |
| {%tr for item in VERPtable\_contents%} | | | | | |
| {{item.Date}} | {{item.VERPF}} | {{item.VERPW}} | {{ item.VERPA}} | {{item.VERPV}} | {{item.VERPWV}} |
| {%tr endfor%} | | | | | |
| **Total** | **{{VERPFTOT}}** | **{{VERPWTOT}}** | **{{VERPATOT}}** | **{{VERPVTOT}}** | **{{VERPWVTOT}}** |

*Table 8‑2: Vergelegen Production and Forecast*

{{VERPImage}}

*Figure 8‑1: Vergelegen Production Vs Forecast*



We note that the weather-adjusted forecast is higher than the P50 forecast (original forecast). This indicates that the plant could have met the expected P50 forecast, but we note that due to the gap in irradiation prior to April 2022, the weather adjusted forecast may not be representative of the actual weather conditions.

To determine the cause of the underperformance, Harmattan reviewed the unscheduled maintenance report and found an incident that resulted in a production loss of 68.85 kWh, which is small compared to the high production loss experienced by the project.

We also looked at the semi-annual inspection checklist and Thermal Report to determine if there were any failures that could have led to the underperformance. We noted that no faults were found during the Operator's semi-annual inspection, but the thermal image taken on 30 March 2022 showed that the inverters were operating at a maximum temperature of 50 ˚C, which is close to the maximum inverter operating temperature of 60 ˚C. The high operating temperature of the inverter affects production. Harmattan notes that although the inverter did not exceed the maximum temperature of 60 ˚C. The inverter’s high operating temperature is due to poor ventilation. Unless this issue is quickly rectified, we expect high losses in the summer months.

A picture containing text, electronics

Description automatically generatedFigure 10‑5: Vergelegen Production Vs Forecast

Harmattan notes that the Operator 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.

We have also spoken to the Operator about the underperformance, and they have stated that it is due to frequent load shedding which results in downtown of grid tied inverter and thus production loss.

Harmattan recommends performing a cost benefit analysis to be considered various options in the market that could be used to solve the problem. Harmattan has asked ACES (Operator/contractor) to provide a cost estimate for the procurement and installation of a generator integrator. We also recommend that the Operator provide Mediclinic with a specification for the required cooling of the inverter and conduct further thermal testing at the other sites. Harmattan will review then review specification and costing provided by ACES.

# 

# 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 issues were noted for Hermanus and Vergelegen. At Durbanville, we note 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 in August, but during the site visit it was determined that the modules were dirty after just 1 month, this must be monitored as it has an impact on performance. .

## Unscheduled Maintenance



## Spare Parts



Harmattan notes that no spare parts are kept parts on site. The Operator has stated that minor spare parts are in stock in Cape Town and Johannesburg. Major spares will be kept in Cape Town. We note that only keeping the major spare parts in Cape Town may present a problem for plants outside of Cape Town given the longer lead times to deliver the spare to site, resulting in higher production losses.

# 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 * Inspection\_Hermanus\_24-08-2022 |
| Highveld | * Highveld April 2022 * Highveld July 2022 * Highveld June 2022 * Highveld May 2022 * Highveld August 2022 |

Appendix 1 Unscheduled Maintenance

The following table describes the unscheduled maintenance activities that have been reported since COD:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Date Occurred** | **Plant** | **Events** | **Description** | **Resolution** |
| 9/5/2022 | Durbanville | The communication was down and the inverters were not producing. | Communication between inverters and logger was interrupted and inverters showed no production - idle status.  It has been determined that the UPS for communication on block 3 failed, causing communication to be interrupted. The UPS failed without external causes. | The UPS was repaired on 10 May 2022. The estimated production downtime was 2MWh. |
| 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 failed | On 4 July 2022,  a new part (UPS) was installed  The production loss hour was 1.1MW |
| 23/08/2022 | Durbanville | Theft | The main earthing cable of the solar system was stolen (7 meters) behind the green tanks on the roof slab. | The earthing cable parts that were stolen have been replaced. Harmattan have also submitted the 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 kWh. |
| 25/05/2022 | Hermanus | Main circuit breakers not switching on | The main circuit breakers at the feeder and PVDB did not want to turn on automatically.  It was determined on site that the UFD, which automatically turns the circuit breakers on and off, had failed. | 0n 26 May 2022, the UFD was replaced by another UFD.  The production downtime was 900kWp |