

Annual Operation and Maintenance appraisal and its importance

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Summary

This paper is written to fill a void created by lack of knowledge in conducting annual operation and maintenance appraisal and its importance in PV solar power plants. Operation and Maintenance(O&M) appraisal plays a vital role in maintaining the predicted energy yield, by evaluating the existing maintenance methodologies and proposing the remedial preventive maintenance plan to increase the life span of the plant. However, it is often seen that due to budgetary constraints, lack of knowledge of performing the evaluation, annual O&M appraisal are not undertaken. It has been either being skipped or in majority of the operational plant not conducted in stipulated time periods, which had an adverse effect on the plant performance and its life span. Therefore, it is very essential to conduct the O&M appraisal by an independent technical consultant to analyze the plant performance, plant infrastructure status, study the breakdown trends to formulate plans for detailed O&M practice to be followed at site.

The article provides a high-level overview on the importance of Operation and Maintenance appraisal for PV solar power plants, and SgurrEnergy's view to conduct O&M appraisal, key attention areas to enhance the asset life span, energy yield and reduce breakdowns.

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1 Introduction

Power consumption is quickly rising in the modern era around the globe in a wide range of consumer categories-industrial, commercial, and domestic. To ensure the electricity supply meets the market demands, it is not only essential to increase the new generating units adequately but also to maintain the healthiness of existing power generating units. There are numerous power generating sources available, including coal, hydro, nuclear, natural gas, renewable energy, etc. to meet the demands of power.

We are observing a huge addition of power generating units in the renewable energy, especially in PV solar plants due to its quick turnaround construction time and commercial feasibility that is aligned with the plan of transition from non-renewable to renewable energy power generating source.

Financial institution and organizations are deploying their investment and CAPEX in building solar power plants or solar hybrid plants to cater to their ESG requirements and decreasing the carbon footprint. When compared to other power generating plants, investing in solar power has proved to be feasible as maintenance costs for the solar power plants are very low or minimal when compared with other power generating plants. Furthermore, return on the investment is measurably high in these plants.

Generally, PV solar power plants are designed for a lifespan of 25 years, and the majority of PV module manufacturers also offer warranties on the performance of their products. However, investors should consider two major aspects prior to investing in solar plants i.e.

- Good quality of construction for establishing the solar power plant
- Standard procedures proposed to be followed in Operation and maintenance of the plan

➤ **Good quality of construction for establishing the solar plant**

For solar power plants to be established and operational for the specified lifespan, construction methods and standards must be adhered and legislated in accordance with the relevant national or international codes of practice. This results in producing the expected power and ensures the return on investment in a shorter period of time.

When the aforementioned standards and procedures are not followed and activities are carried out with poor workmanship, the plant's lifespan is impacted, the equipment's integrity deteriorates and its performance suffers, which has an impact on the plant's revenue and elongates the time of return on investment.

➤ **Standard procedures to be followed in Operation and maintenance of the plant**

Here, the significance of annual operation and maintenance assessments for solar power plants are highlighted. In order to improve plant performance and protect plant assets, O&M appraisal are crucial. Due to the scarce O&M budget, deployment of less experienced human resource and followed by no independent audits being performed for plant, the operators only follow the standard set of preventive, corrective and condition based maintenance activities, which not only affect the performance of the solar power plant but also deteriorates and decrease the lifespan of the equipment and associated infrastructure.

Nevertheless, it will be challenging to operate plant and simultaneously carry out the regular inspection by O&M team to look in the different area of the plant. In this case, performance falls drastically in non-linear manner and plant doesn't operate till it's designed life span. To avoid and cater to the dynamic changes being observed, energy audits and appraisal of Operation and maintenance shall be conducted by proficient renewable technical consultants to identify and highlight the gaps in performance of the operational plant and suggest remedial actions to be undertaken by the plant operator. The performance of the plant will be improved by having an impartial technical consultant undertaking the site visits to evaluate and assess the effectiveness of the facility's operation and maintenance program

during the annual O&M appraisal.

Following are the benefits of annual O&M appraisal:

Conducting high-level site inspections:

- To assess the quality of constructed infrastructure and find out the deterioration factor of the assets/equipment's.
- Analyze the performance of the equipment and observations/damages if any
- Provide mitigation techniques for the identified observation to increase the life span of the asset.

Assess the condition of plant infrastructure:

- Checking the infrastructure of the plant i.e. roads, drainage system, superstructure, Main control room building, etc.,
- Suggesting remedial actions to increase the life span of the infrastructure.

Module mounting structure and Module inspections:

- Performing visual inspections of Module mounting structure(MMS) to analyze the deterioration of the MMS and suggesting action plan to increase the integrity of the structure.
- Conducting visual inspection on PV modules to ascertain cracks.
- Reviewing the EL test, manual and drone thermography reports to find out snail trails, hot spots, damage of bus bars, junction boxes, terminations of MC4 connectors, etc.,

Inspecting the plant critical equipment's:

- Analyzing the generation of the plant and consumption of the auxiliary equipment's. Furthermore, reviewing the plant performance.
- Studying the breakdown register of the plant, root cause analysis reports etc., and give suggestions to site team for improvement of O&M practice to reduce the breakdowns and increase the plant up-time.

Inspecting the critical spares and reserve maintenance:

- Checking the critical spares of the plant and suggesting for improvement of inventory management of critical spares for PV Solar power plant.
- Checking pre-requisites for plant routine reserve maintenance

Plant performance and breakdowns:

- Reviewing the plant generation reports and assess the performance data to generate the operation trends against the designed parameters.
- Reviewing the breakdown register and preparing models to ascertain the breakdown trends and suggesting the new preventive models for improving the plant performance.

2 Case study

Being an independent technical consultant, SgurrEnergy has performed Operation and Maintenance appraisals for projects and has provided detailed reports entailing all the aforementioned data in detail. Few of the major observations during our previous assignments are made a part of our case study.

Recently, SgurrEnergy has visited one of the plant for undertaking operation and maintenance appraisal, which is operational from past 10 years in the western state of India. During the visit of our representatives, condition of the plant's infrastructure and equipment was found to be highly deteriorated. Most of the module mounting structures were severely corroded. Pile foundations, pile caps, periphery roads, access roads, drainage systems, and boundary fence were washed away at multiple locations due to rain and severe soil erosion. The boundary fence was observed to be collapsed at multiple locations and a significant gap was observed below the boundary fence. Hume pipe culverts were not operational due to rain water not being channelized in proper way. Furthermore, significant hot spots and white precipitation marks were observed over the PV module, which has affected the performance of the PV module and successively led to reduced generation over the years against the predicted values.

➤ Plant periphery boundary wall

SgurrEnergy observed that the quality of chain link fence was degraded at majority of the locations. The lapses at the solar PV plant were highlighted and remedial actions were proposed to ensure the proper security of the plant infrastructure for pending life cycle of next 15 years.



Figure (A)



Figure (B)

- The ISMC channel at majority of the location was observed to be partially or completely rusted in in Figure (A). The rusting of the ISMC channel can lead to corrosion in future. SgurrEnergy has suggested to clean the channel with sand paper or wire brush. Further, a coat of red-oxide followed with an anti-rust paint was suggested to be applied on all the affected ISMC channel.
- In Figure (B), significant gap was observed between the natural ground and wire mesh, due to soil erosion. This is envisaged to be infringement points of the plant in the future. These gaps were suggested to be covered with depositing soil underneath the wire mesh to avoid any passage of the inhabitants.

➤ **Storm water drains**

SgurrEnergy observed that the quality of maintenance performed on storm water drains was not as per the maintenance plan which has led to degradation of the drains at majority of the locations.



Figure (C)

- Figure (C) drainage was observed to be filled with soil or natural vegetation that was blocking the water runoff leading to water accumulation in the PV area which has affected the access to plant thereby increasing the downtime of any maintenance during the monsoon.
- SgurrEnergy could identify that the drainage maintenance was not made a part of regular O&M activity for several years which has resulted in deterioration of the other infrastructure.
- Operator was suggested to survey the existing plant level through DGPS or drone survey, with the input of the site team and local earthen drainage was suggested to be constructed between the rows to channelize and drain off the excess water runoff during the heavy rainfall.
- Further, the drainage filled with soil and natural vegetation was suggested to be cleaned and level of the slope should be maintained after the new drainage survey considering the top level of the drainage at various sections.
- A comprehensive drainage maintenance plan was suggested to be incorporated in the existing maintenance plan to be followed and audited during the annual audits.

➤ **Module mounting structure and its foundations**

O&M plan did not include the maintenance plan of the structures which has led to severe deterioration of the members, operator was suggested to include detailed plan for the structure maintenance for better durability for the remaining life of the plant.



Figure (D)



Figure (E)

- Figure (D) illustrates that the MMS was not made a part of regular O&M activity which has resulted in significant deterioration of the structure members. The mounted modules gradually got affected due to the corrosion of the structures that had inadvertently affected the stability of the mounted PV modules and had also led to hairline cracks that significantly led to the generation loss of the plant.
- Figure (E) illustrates, the pile column post was provided with pile caps; however, they were observed to be eccentric in all the Blocks. Further due to significant water run-off and soil erosion around the pile caps, most of the pile caps were observed to be damaged and cavity could be noticed between the pile cap and the pile foundation making it prone to water stagnation that had led to fissures on the pile foundation.
- SgurrEnergy has reviewed the structures and has observed that severe corrosion was accelerated due to no maintenance plan being observed for the MMS, further, the gaps between the pile caps and pile foundation were not sealed properly in the initial days of maintenance which has led to ingress of water in between the gaps and have helped in creating fissure on the concrete foundations. Pile integrity tests were suggested for the samples to ascertain the defect category and remedial actions were suggested to be performed for increasing the lifespan of the affected piles.
- Since the MMS were significantly corroded, a detailed plan was drawn out for the replacement of the same and a onetime cost was taken in the annual O&M budget to ensure the plant generation are not affected further, the less affected MMS were subjected to reworks by removing the rust and zinc rich paint was applied on all the affected surface.

➤ **Inverter Station**

During the assignment of O&M appraisal of the inverter stations, SgurrEnergy has observed the following points, which were suggested to be rectified on priority basis.



Figure (F)



Figure (G)

- Figure (F) and Figure (G) illustrates that the grade slab of the inverter station was observed to be deteriorated and reinforcement was found to be exposed and corroded from the sides due to fissures in the grade slab, this had led to decrease in the strength of grade slab. SgurrEnergy suggested to perform the hacking of the exposed area till the reinforcement were found of good quality and the affected reinforcement were suggested to be replaced with the new reinforcement as per the approved drawing and followed by re casting of the grade slab.

➤ **String Monitoring Box (SMB)**

The O&M plan for the SMB were prepared at the high level which didn't included points of replacement or wear and tear of any components which significantly affected the operations.

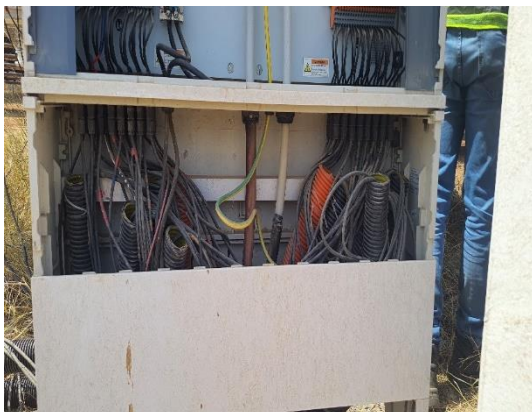


Figure (H)



Figure (I)

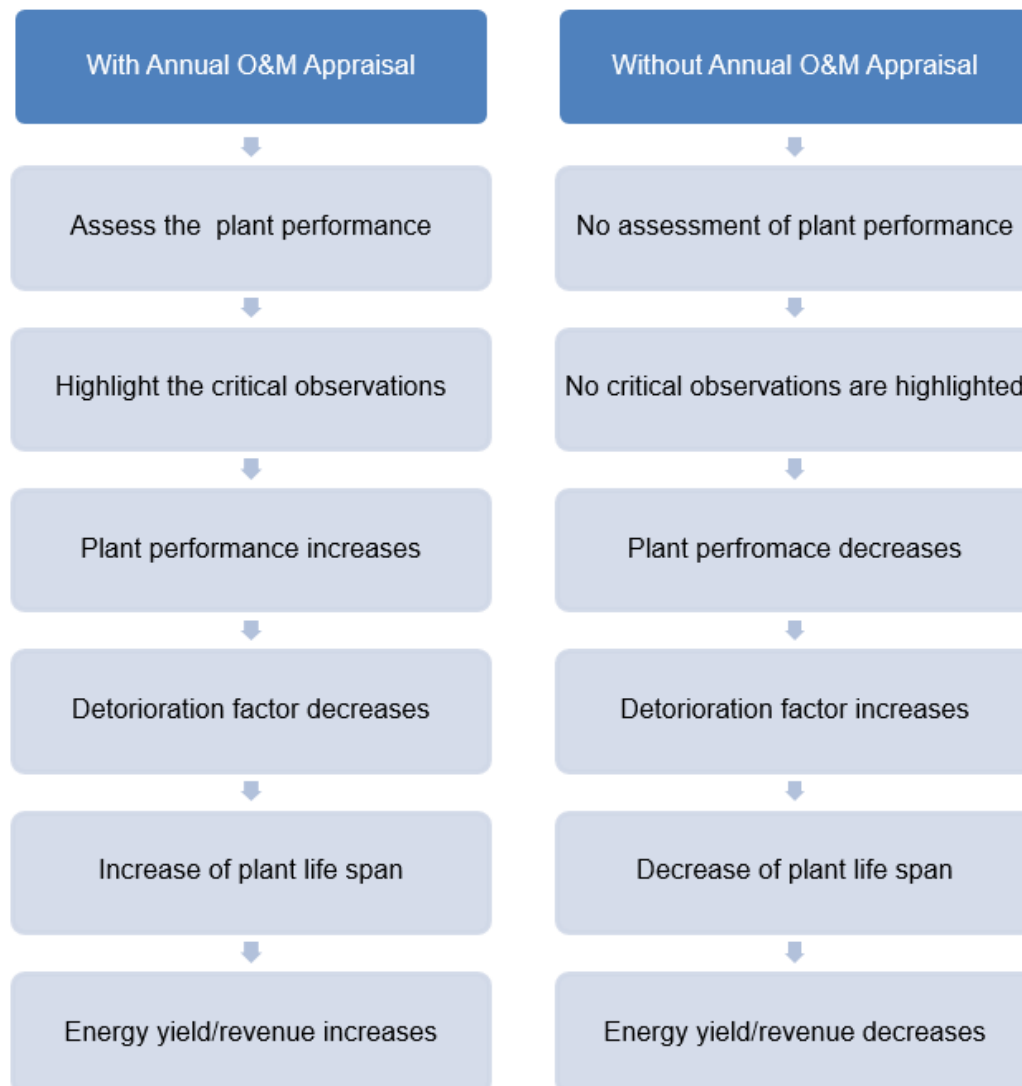
- String identification ferrules were noted to be missing for the strings in the combiner box. These were leading to added time in the fault clearing during the operation of the plants. Ferrules for string cables were suggested to be provided for ease of identification during performance of maintenance activities and fault troubleshooting.
- DC cables were terminated by providing insulation tape instead of heat shrink sleeves which had led to non-linear heat distribution thereby leading to short circuits. SgurrEnergy suggested to replace all the insulation tape with adequate rated heat

shrink sleeves for DC cables at all such locations for protection of cable and allowing for proper heat dissipation.

➤ **Case study conclusion**

- It was noted that performance of the preventive and corrective maintenance was not performed for equipment's, assets and infrastructure as per industrial standards. Energy audits and operation and maintenance appraisal were not being conducted with independent renewable technical consultant which has led to not highlighting the deteriorating asset quality over the years.
- Owing to this, plant could not be operated as designed for its life span efficiently. Not visualizing the key red flags in the individual equipment performance and associated infrastructure had increased the annual O&M budget and have led to reduced returns from the plant with a threat to plant being classified as non-performing asset.
- In the absence of comprehensive preventive and corrective maintenance plan for critical equipment and infrastructure the performance of the major capital goods had deteriorated and the warranties turned void. Therefore, it has reduced the overall performance of the plant. To mitigate the above issues, it is essential for the plant operator, developer, financial institutions to conduct Annual O&M appraisal in stipulated timeframe by independent consultant team so that the assessment of asset can be undertaken.

3 Comparison statement for annual O&M appraisal



4 Conclusion

The above highlighted issues have a significant cost impact, which are ideally identified at a later stage of plant life cycle. Due to the low tariff and high competitiveness in the market the budget for carrying out the O&M activities are very limited. Not identifying and addressing the key operational issues by undertaking annual O&M appraisal puts an additional burden on the developer and the financial institution which leads to increase in the cost overrun on the budget of O&M thereby making the project unviable and tagging the plant to be a non-performing asset.

Therefore it is suggested to perform Annual O&M appraisal of a plant to ensure the timely identification of major problems which can affect the plant performance. SgurrEnergy has performed several assessments for seasonal developers of plants that are operational for more than 10 years and have significantly improved the plant performance by deploying only 2% of their annual O&M budget in such assessments thereby not only ensuring the plant lifecycle but also the increasing the returns from the operational asset.