# Solar O&M in the Middle East: technical challenges and solutions


**Operations and maintenance |** From sandstorms to extreme heat, solar installations in the Middle East face some unique operational and technical challenges. Experts from Jordan-based developer and O&M specialist MASE describe some of the innovative solutions emerging to keep plants running in the harshest conditions

The Middle East region has over the decade experienced an unprecedented growth in solar energy, with some countries targeting a triple-digit megawatt penetration of solar capacity. Developers, contractors, lenders and consultants now consider the Middle East region as one of the most promising solar energy markets. Pioneering countries such as Jordan, UAE and Morocco have already interconnected over 500MW of solar capacity onto their electricity grids.

However, whilst solar energy sees rapid penetration in the Middle East and more facilities interconnect to the region's grids, solar plant operators and asset management firms are facing unique technical and operational challenges not seen in other regions such as Europe and the United States where solar PV markets are generally more established. Local O&M firms such as MASE with acute knowledge of the operational particulars are pioneering solutions to overcome these challenges and are harvesting valid and reliable data in the process. This feedback is proving essential to stakeholders in the development of a bespoke technical blueprint to cater for the Middle East region's growing demand for solar energy.

**Extremely soiled PV panels in Jordan. Dust is one of the region's biggest challenges**

## Background

Over the past four years, Jordan has interconnected over 200MW of utility solar PV capacity, corresponding to approximately 5% of the country's total power generation. While traditionally Jordan has relied on 3.5GW of diesel- and gas-fired conventional power plants for energy generation, plans are underway to add a further 450MW of solar PV capacity over the next two years, boosting the total solar PV penetration in the overall mix to over 10%. The Jordanian grid is managed by the National Electricity Power Company (NEPCO) and is interconnected to neighbouring Egypt and Syria with plans to connect to Iraq and Saudi Arabia. This article contains data and analysis gathered by MASE, a regional operations and maintenance firm with over 80MW solar assets under care.

As local and international solar O&M firms measure up to manage utility solar PV plants currently operational in Jordan and elsewhere in the Middle East region, they are having to deal with unique technical and operational challenges and innovate bespoke solutions to overcome them. Oftentimes, harsh weather conditions and unstable grid behaviour adversely impact the performance of solar PV plants by a daily factor of up to 40%. Also, soiling and high temperatures are proving to be more significant operational factors than originally anticipated.

## The impact of soiling on plant generation

More than 80% of the Middle East region is desert and receives fewer than 25 centimetres of rainfall a year. This translates to a particular technical challenge for site operators who in many cases are expected to stand behind performance guarantees often benchmarked against less harsh foreign topographical conditions. Whilst soiling is a common concern for solar PV operators around the world, it poses a significant operational concern in the Middle East region, especially given that the majority of solar pants are constructed in remote desert locations, by virtue of the higher levels of irradiation in such locations.

In some extreme cases, soiling losses of up to 30% have been recorded when solar panels are left unwashed over relatively short periods of time (less than 60 consecutive days). The following data was collected from a solar plant located in Azraq, Jordan, a desert city to the north east of the country.

As Figure 1 demonstrates, the severe soiling recorded not only impacts the overall production curve, but also flattens the peak point during which the plant is expected to generate at its full capacity. In the case demonstrated in Figure 1, the plant was left unwashed for two consecutive months during the summer season (August and September) and was fully washed in October using water and specialised mechanical machinery.

Even though soiling can be managed by increasing the frequency at which solar panels are washed, site operators and plant owners must evaluate the economic cost benefit of each additional wash given the scarcity of suitable water sources in most countries in the region.

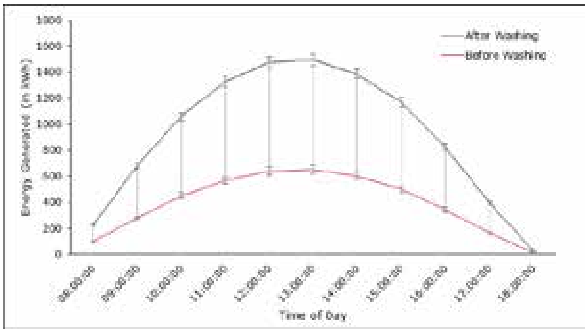



**Figure 1. Impact of soiling on daily energy production**

**Figure 2. A solar PV plant in the midst of a severe sandstorm in Jordan**

In the case above, the performance benefits are unmistakable and the plant is currently washed on average once a month during the summer season.

In addition to soiling, haphazard sandstorm behaviour is another significant weather anomaly common to the region and one that site operators must closely monitor. With its desert conditions, the Middle East region is prone to harsh sandstorms that often last for days and may reappear at random intervals. This poses a particular challenge to site operators, who will need to actively analyse area-specific weather forecasts and track sandstorm behaviour. This may be an alien task to operators in other parts of the world but is extremely relevant to site operators in the Middle East. To manage the impact of sandstorms on performance, local O&M operators use multiple site reference cell data gathered from the site coupled with weather forecasts to decide when it is best to clean. As sandstorms often appear haphazardly, site operators in Jordan refrain from washing solar panels in the days immediately following a sandstorm in order to avoid adverse further escalation of soiling.

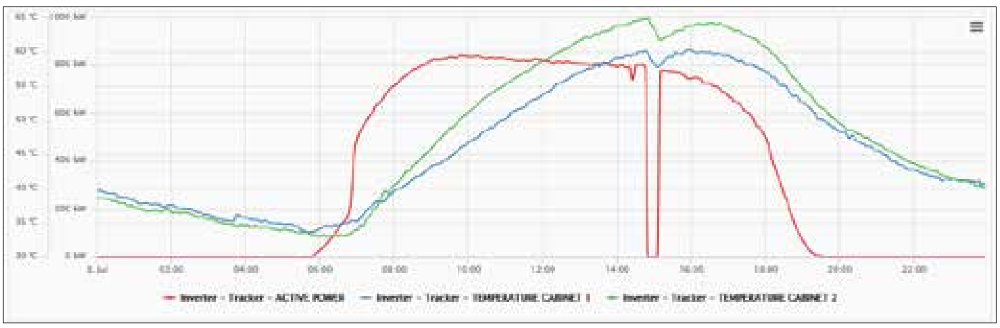


**Figure 3. An event of Inverter shutdown due to high temperature**

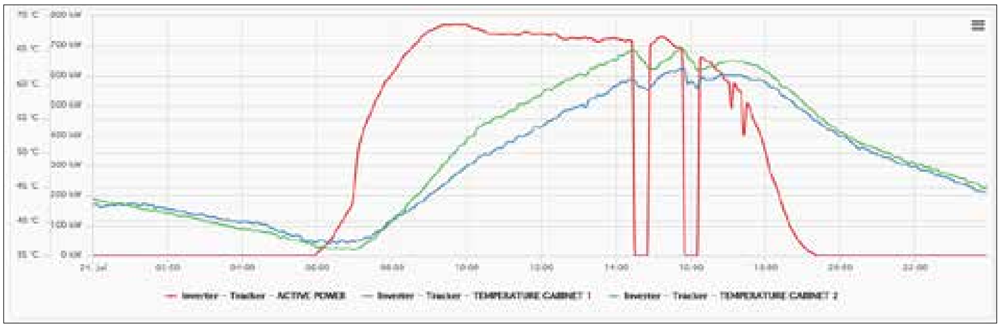
As mentioned earlier, whilst soiling may not pose a significant operational challenge elsewhere, it is a main concern for local operators in the Middle East. MASE's experience is summarised as follows:

- On average, module washing in intervals not exceeding 30 days will maintain soiling losses to below 2%. Longer intervals may result in significant impacts on performance by up to 40%;
- Tracking sandstorm behaviour is essential and must be evaluated by site operators when scheduling washing sequences to avoid adverse impacts;
- Dry cleaning is not recommended, unless coupled with advanced cleaning robots, which are generally yet to prove their effectiveness in the Middle East.

## Power limitation and equipment design

Whereas soiling is mostly an operator-managed concern, equipment manufacturers are responsible for thoroughly evaluating how their products perform when operating in harsh Middle Eastern weather conditions. The case for region-tailored equipment may require commercial evaluation, but PV module and inverter manufacturers need to consider that while their products may be suitable for one region they may not be for others.

Unsuitable inverter design and inadequate heat management have been flagged as two of the main issues curtailing the performance of solar plants in the Middle East. Inverter stations, which are typically designed to

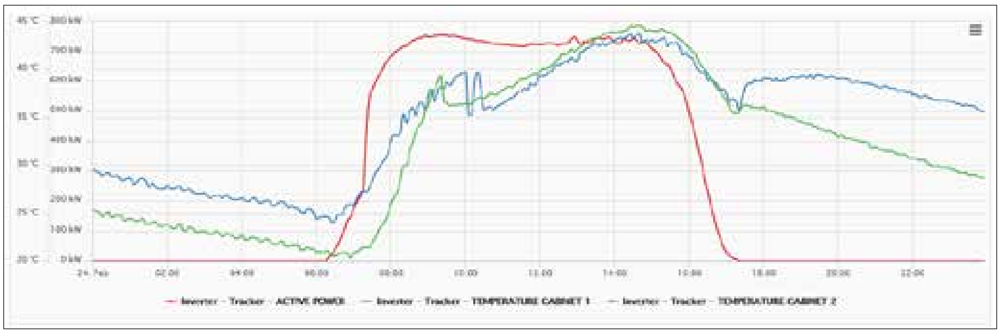


| Total Energy Lost per Day: 462.3 kWh | | | |
|---|---|---|---|
| Period 1 | | Period 2 | |
| Time | Power (kW) | Time | Power (kW) |
| | | | |
| 14:25 | 718.5 | 15:45 | 693.8 |
| 14:30 | 0 | 15:50 | 0 |
| 14:35 | 0 | 15:55 | 0 |
| 14:40 | 0 | 16:00 | 0 |
| 14:45 | 0 | 16:05 | 0 |
| 14:50 | 0 | 16:10 | 0 |
| 14:55 | 700.4 | 16:15 | 661.7 |
| Total Downtime | 20 minutes | Total Downtime | 20 minutes |
| Energy Lost (kWh) | 236.4 | Energy Lost (kWh) | 225.9 |

**▲ Figure 4. Two subsequent events of inverter shutdown due to high temperature**

**◀ Figure 5. Inverter operation data and curtailment analysis**

**▼ Figure 6. Inverter operation when properly cooled and ventilated**



withstand predictable weather conditions of Europe, perform poorly in the Middle East. Consequentially, site operators have had to cope by implementing intuitive but temporary solutions to overcome cooling and ventilation complications.

Data has shown that inadequate internal cooling results in daily plant shutdowns of up to 15 minutes per day during the summer season. For developers and plant owners, this translates to a bearing on their revenue stream and may on occasion hamper their ability to meet financial and contractual obligations. For operators, inverter downtime will directly impact their performance indicators and decrease plant availability.

Inverter stations typically operate within a set range of internal temperature parameters and are also designed to tolerate temperature levels slightly beyond those limits. The power trend in Figure 3 corresponds to a standard inverter station with an internal temperature tolerance of 65 degrees Celsius, after which the inverter shuts down to protect itself and its ancillary equipment from overheating.

The inverter station to which the graph corresponds is of the enclosed type and utilises air flow cooling, which may be adequate in some regions but has proven to be impaired when faced with Jordan's hot summer climate. The graph demonstrates that once the internal cabin temperature reaches 65 degrees Celsius, the inverter shuts down for up to 15 minutes until its internal equipment cools down. On some occasions, the inverter stations shuts itself down more than once a day as demonstrated by the excerpt from the plant's SCADA shown in Figure 4.

For this particular plant, the recorded losses of power due to inadequate temperature tolerances add up to 460kWh per day or 2% of the plant's daily power, a significant concern when it is a daily occurrence.

To overcome this issue, MASE site operators installed separate air conditioning units which feed off the inverter's auxiliary power supply and are only triggered during times of peak heat as recorded by the plant's weather stations. While this solution has eliminated losses due to inverter downtime for the time being, it is understandably temporary and not ideal. A permanent solution requires proper inverter design that takes into account the Middle East's harsh conditions and excessive high temperatures during summer periods. Some inverter manufacturers have taken steps to that end and now offer inverter stations with more powerful cooling systems and also outdoor solutions that are meant to eliminate excessive heat resulting from the containerised enclosure. The benefits of these bespoke solutions include better performance, lower O&M costs and higher plant availability. When properly designed to withstand the region's specific weather conditions, the inverter would otherwise operate as demonstrated by the trend illustrated in Figure 6.

In addition to the inverter stations, ancillary equipment such as array boxes and string combiner boxes also suffer from excessive heat and dust build-up as a result of poor design. Typically, array boxes and ancillary containers ventilate through standard mesh filtration as shown in Figure 7 on the following page. This has been found to be ineffective in harsh desert conditions. Oftentimes, significant amounts of pulsed sands have been recorded, causing the following:

- Array box overheating, thus damaging string monitoring sensors and burning fuses;
- Dust accumulation, requiring more frequent cleaning;
- Degrading of IP protection features.

To solve this significant problem, MASE has worked with array box suppliers on a more potent filtration system that is aimed at avoiding the accumulation of pulsed sand in and around the array boxes. The solution, which is shown in


**Figure 7. Standard versus enhanced array box filtration**

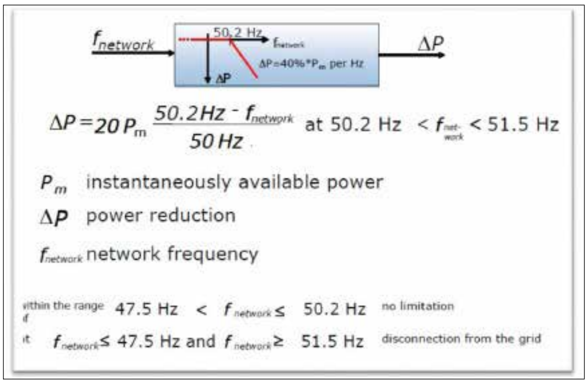



**Figure 8. Active power control requirements – Jordanian Grid Code**

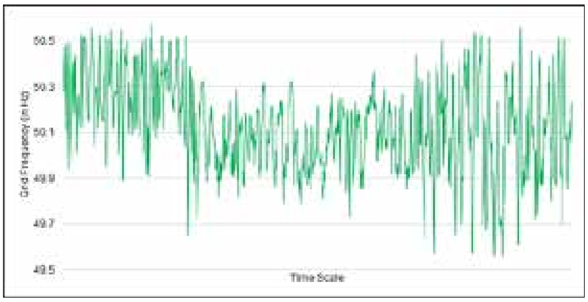



**Figure 9. Recorded grid frequency**

the images shown in Figure 7, is permanent and has proven to be effective in protecting the delicate contents of the array boxes.

In conclusion, the following recommendations form the outcome of these technical concerns:

- Inverter manufacturers and ancillary equipment suppliers must account for extreme weather conditions and topography of the Middle East when designing the equipment;
- Inverter and balance of system suppliers should work on enhancing filtration components to protect equipment from severe sandstorms and the accumulation of pulsed sand;
- Inverter behaviour must be improved to optimise performance and behaviour during periods of excessive heat.

## Grid instability

Data recently analysed by MASE has shown that the Jordanian grid is considerably unstable, with frequency fluctuations recorded on a daily basis. This has been found to adversely impact the daily performance of solar PV plants as the Jordanian grid code currently applied to renewable energy generating units requires compliance with certain active power control covenants as shown in Figure 8.

As shown in this figure, renewable energy generating units (whether solar or wind) are required to gradually reduce their active power, while in operation, in cases of grid frequency exceeding 50.2Hz and disconnect from the grid in cases of grid frequency exceeding 51.5Hz.

Compliance with these grid requirements under Jordan's current grid conditions has resulted in power limitations of up to 15% on a daily basis, the reason being Jordan's unstable grid frequency as demonstrate by the trend in Figure 9. The grid frequency data shown in Figure 9 is recorded by a solar PV plant's SCADA over two days of normal operation.

Site operators have little to no control over the grid frequency. On the other hand, grid management is the exclusive responsibility of the grid operator, the entity which also determines the grid code and operating requirements.

The recommendations arising out of the observations summarised in this section are:

- When assessing the technical feasibility of introducing renewable energy generating units into their network, grid operators need to understand the coherent operational characteristics of these generating units and their potential impact on the behaviour of the grid;
- Project developers and operators must actively evaluate the relevant grid codes and regulations as part of their overall technical due diligence and engage in a discussion with grid operators on the susceptibility of operational parameters and regulations;
- As part of their overarching approach towards renewable energy infiltration, regulators and grid owners must develop long-term plans to ensure the grid's technical sustainability by implementing supplementary projects such as energy storage aimed at stabilising and upgrading the grid. ■

*On p.72 Fraunhofer CSP researchers describe how to determine soiling losses on PV modules in desert regions*


## Authors

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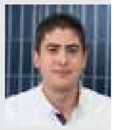

Ady Almadanat has over three years' experience in the areas of solar plant operations, maintenance and management. He is currently responsible for operating solar PV assets of over 15MW in cumulative capacity and manages an array of tasks including preventive, corrective and conditional maintenance as well as analysis and reporting. Ady has a university degree in renewable energy engineering and is a principal member of MASE's O&M team.

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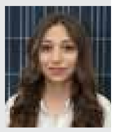

Haya Shahatit is involved in the origination, implementation and operations of MASE's diverse portfolio of retail and utility solar PV plants under management. She holds a degree in electrical power and energy engineering and has extensive experience in project management, technical analysis and reporting. She is an active member of MASE's O&M team.