South Africa RE-IPP Round 3.5

Redstone Solar Thermal Power Plant

AUXILIARY LOADS OFFSET WITH PV ASSESSMENT

April 28, 2018
Revision 1.0

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www.SolarReserve.com Tel: (310) 315.2200 Fax: (310) 315.2201
520 Broadway 6th Floor Santa Monica, CA 90401

Document History and Status

Revision	Date	By	Description
1.0	2018.04.28	C. Diep	Provided for permitting purpose

Redstone Solar Thermal Power Plant Auxiliary Loads Offset with PV Assessment

Document Prepared by
SolarReserve LLC

Charles Diep, P.E.
Director, System Engineering

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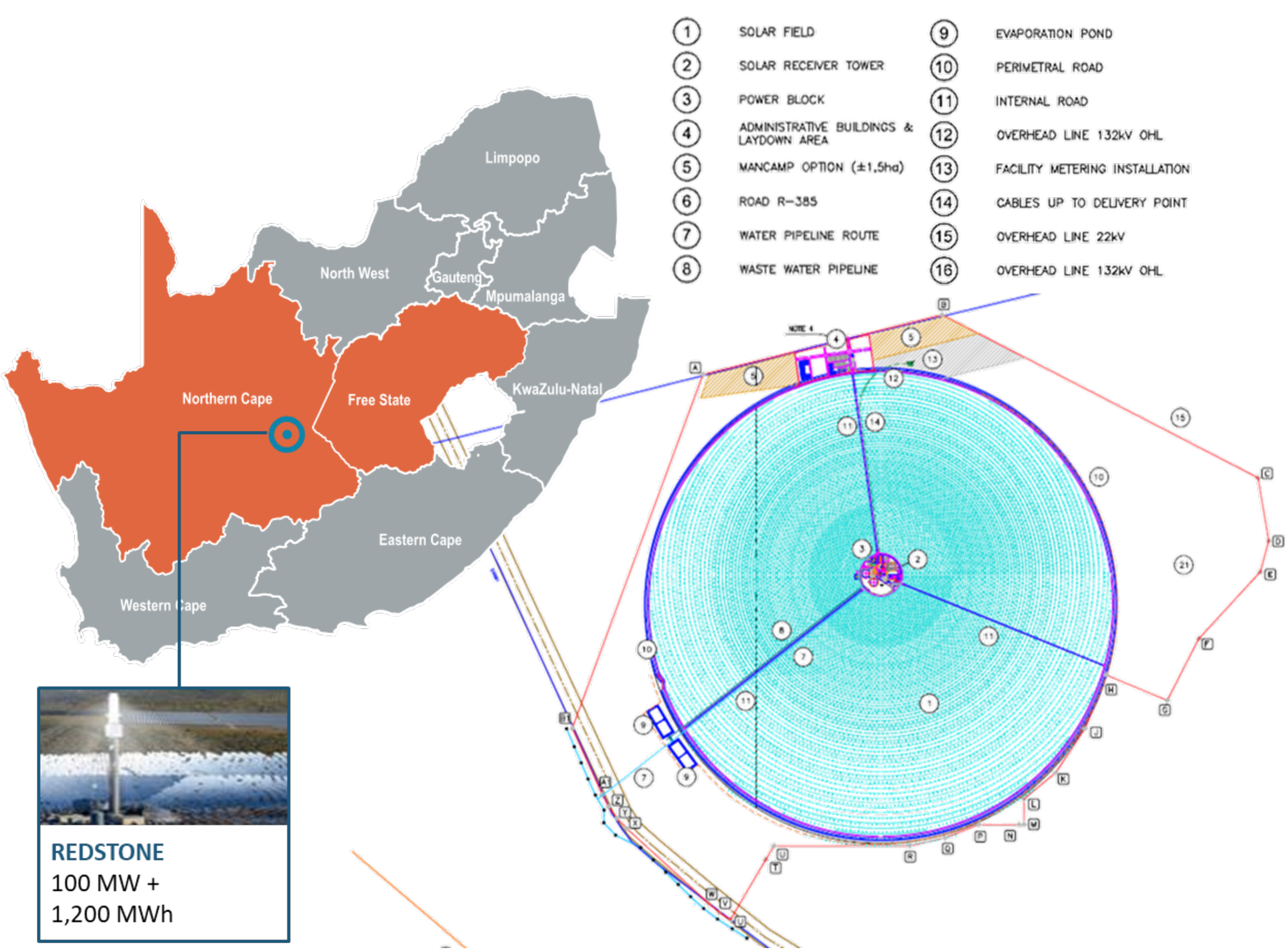
1.0 Background

As the ACWA Power SolarReserve Redstone Solar Thermal Power Plant RF (Pty) Ltd (hereafter the Redstone CSP Project) progresses with its power purchase agreement (PPA) award and at more competitive energy rate, it was proposed that photovoltaic (PV) power be used to offset plant parasitic loads or auxiliary loads. The reason is that the awarded PPA heavily incentivizes night time generation, while solar energy is collected during daytime. It is therefore beneficial to store the solar-thermal energy for night time generation, and rely on PV power to operate pumps, move heliostats and provide heat trace during the daytime energy collection process.

Previously it was suggested that the PV integration project can either be positioned on the Redstone CSP Project heliostat perimeter or potentially embedded in the heliostat field. The purpose of this study is to evaluate these options and to more specifically determine whether it is feasible to embed the PV installation in the heliostat field. The following site plan shows the power island in the center, the heliostat field area (teal), and the property boundary (red).

Figure 1 – High Level Project site plan redition



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2.0 Analyses & Discussions

Other than land and environmental constraints, it is given that the PV installation can be readily implemented in the perimeter areas of the Redstone CSP Project. This study focuses on whether it is feasible to implement PV installation within the heliostat field. For this effort, the following factors are considered: space limitation, performance, cost, system integration and operation and maintenance (O&M).

2.1 Space Considerations

The following figure more clearly shows the larger project site, or lease area available and secured for the Redstone CSP project (magenta line). Adjacent to the Redstone CSP Project are currently two large scale PV power plants in operation – the Jasper and Lesedi PV Power Projects. Taking the environmental constraints of the larger project site into consideration, it is clear that the north-west section of the property appears to be the best suited for the PV installation.

Figure 2 - Project site plan

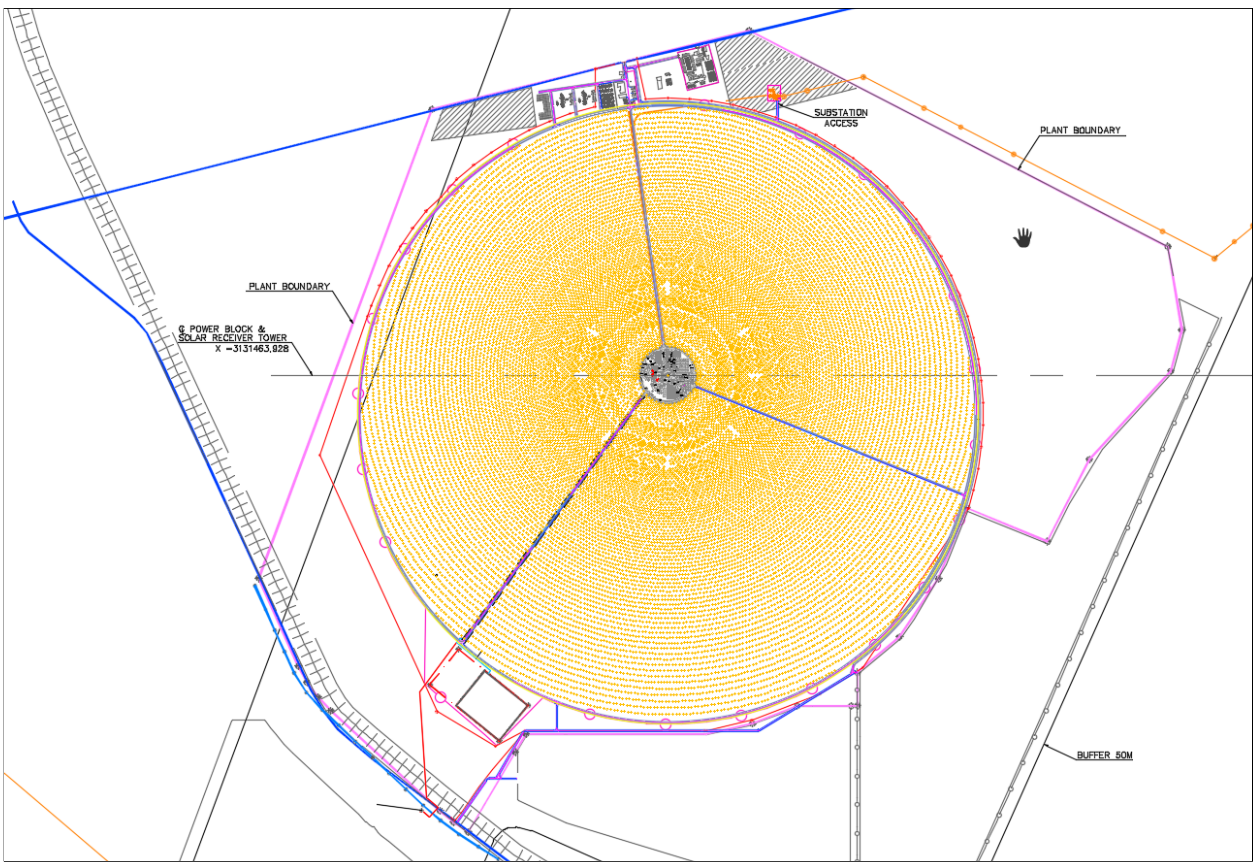
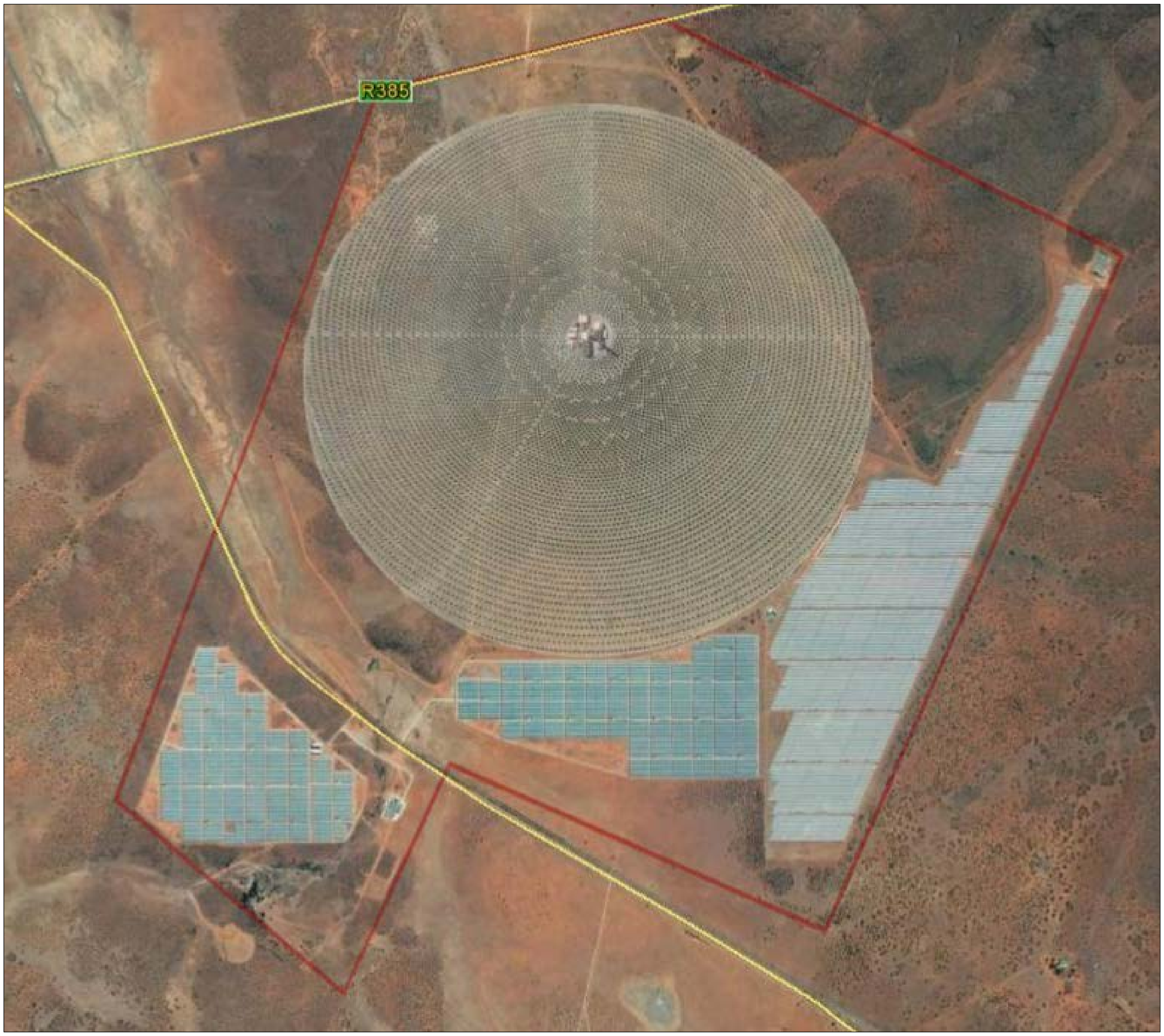
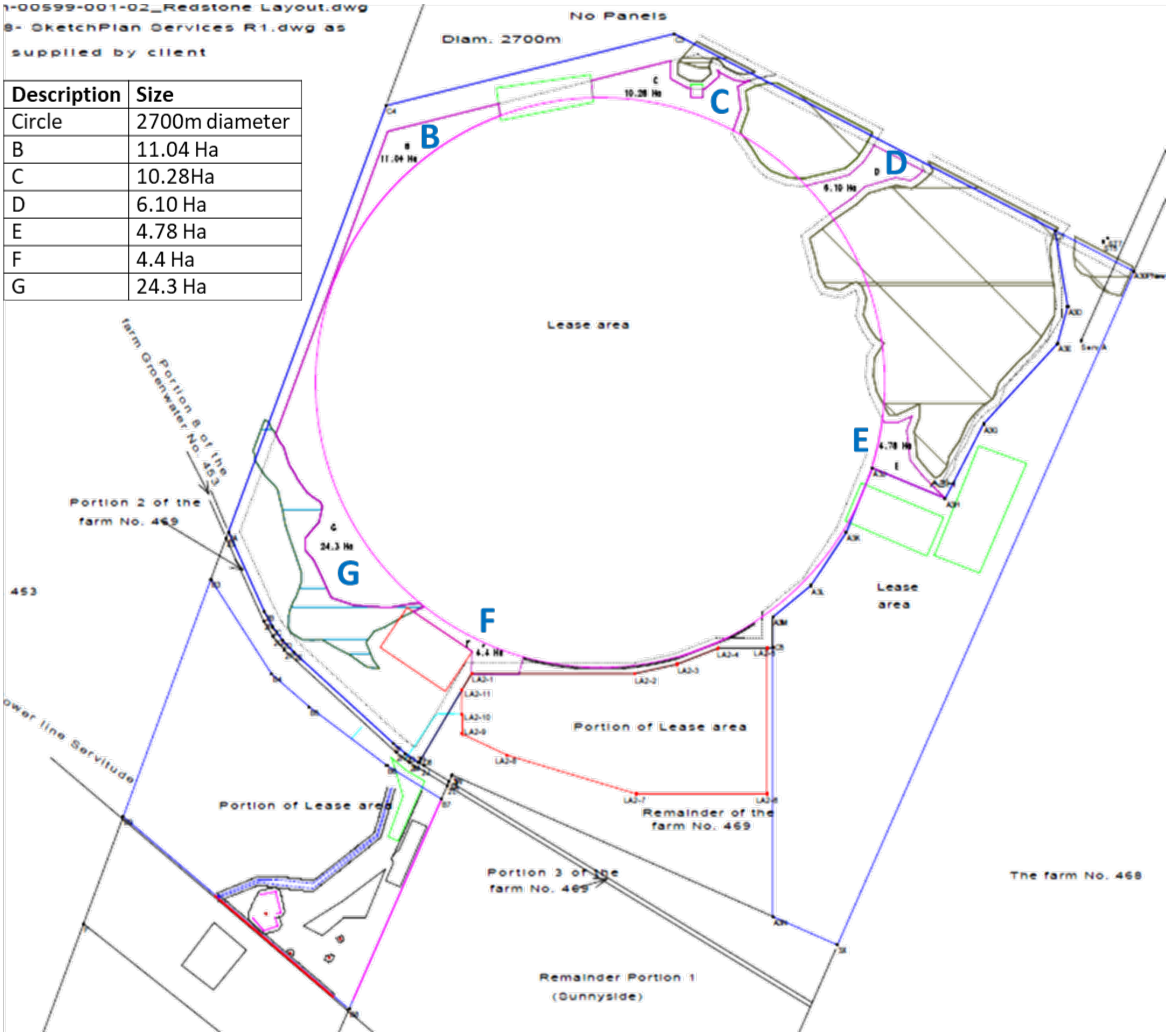


Figure 3 – Rendering the project within the project land boundary & adjacent PV projects.



Again considering the environmental factors and restrictions of the larger site, the only areas available for a PV installation are identified on the figure below (areas B to G). The combination of areas B and G provides just over 34ha for assessment, in order to allow the application of environmental constraints where identifed and also allows for develoment of the PV installation with the required generation capacity of up to 20MW (ideal generation capacity is estimated at 15MW).

Figure 4 – Segments of available land in the perimeter for the PV power block.



With respect to the feasibility of incoporating PV installation inside the heliostat field, several photos of the collector field from a similar power plant in the United States is shown below (Crescent Dunes Solar Energy Project, Tonopah, Nevada). The heliostats are spaced and positioned in concentric circles with sufficient space to avoid physical interference as well as to minimize blocking and shading of one another throughout the operating day of a CSP Plant. Clearance between each row of heliostats are barely sufficient to allow access for wash and maintenance trucks as described in later section.

Incorporation of the PV modules in the heliostat field would therefore have to be in the far field section in between heliostats in a distributed manner. This would essentially limit access in the radial direction, leaving access only azimithally along the circumference of each row.

Figure 5 – Aerial photos of the Crescent Dunes Solar Energy Project

2.2 Performance

In addition to access restriction and potentially hazard due to wiring or support structure, performance of the PV module will be compromised. The basis of the heliostat layout is to pack them as closely together and to the tower receiver possible. The idea is to limit transmission loss (atmospheric attenuation) as the solar rays are reflected onto the central tower receiver. The wider spacing in the far field concentric rings is to reduce shading and blocking amongst the heliostats. PV incorporation in between these heliostats are likely to experience blocking and shading throughout the day.

As shown in the picture below, placing PV in front of the heliostat will be at risk of blocking the reflecting beam as well and be exposed to concentrated flux. The latter could easily be a fire hazard. Placing the PV modules behind would be shaded by the heliostats at various times during the day. In addition to underperformance, the PV modules are likely to degrade faster with this operating cycle.

The heliostats shade the PV panels and this will reduce its efficiency. As such, we will need to add more PV panels to achieve a desired output of 15 MWac. This will further not allow us to maximize the effieicency of the PV supply.

Figure 6 – Far field heliostat radial and azimithal spacing

2.3 Cost

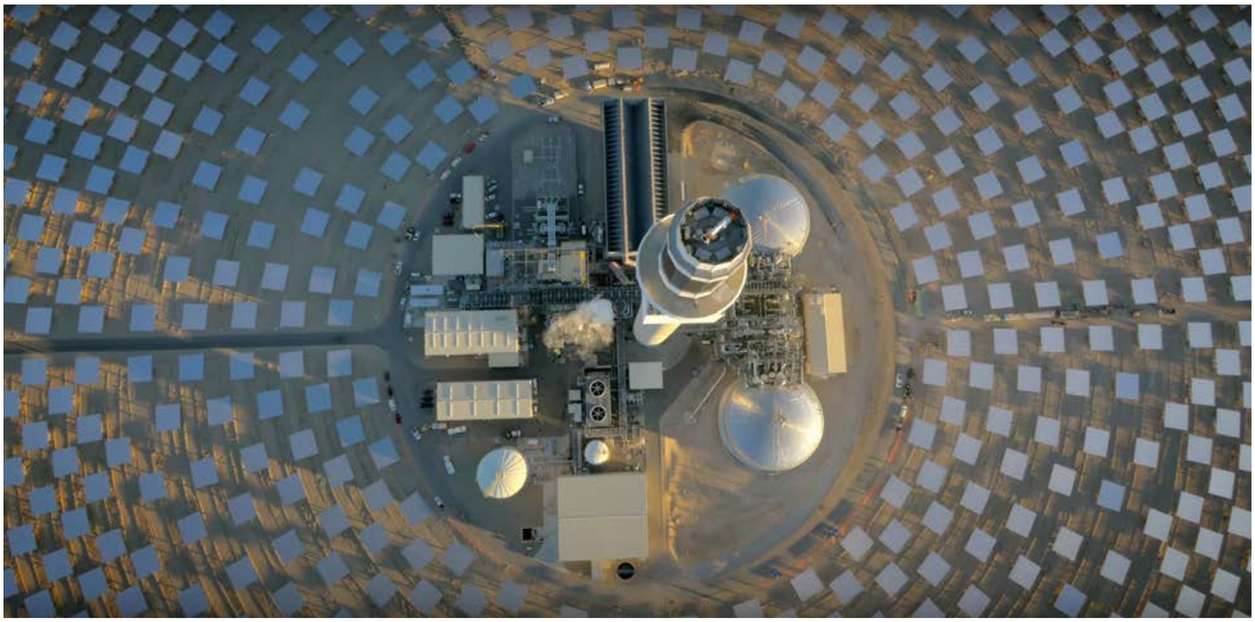
As explained above, incorporation of PV installation in between heliostats is only possible in the far field rings. This implementation requires disjointed/distributed mounting structure as well as additional wiring in between these structures. Intuitively this adds cost to the system, in addition to having greater electric line losses, as well as lower system reliability as the power blocks are smaller and spaced out further.

2.4 System Integration

The goal of PV incorporation is to offset the auxiliary (parasitic) loads associated with the solar thermal energy collection during daylight hours. These loads are mostly in the central power block as shown in the photo below. The loads draw their power from the plant's central medium voltage electric bus. This bus is energized by the grid when the plant does not generate power and any consumption would be netted from the plant's generation amount.

From a system integration perspective, a prudent design would be to aggregate the PV modules in an efficient and closely packed block matter with its energy managed through a smart inverter onto the medium voltage bus.

Figure 7 – Near field heliostats are packed densely surrounding the power block



2.5 Operations and Maintenance

As stated above, the radial roads between concentric rings of heliostats are meant for vehicular access. As shown in the photo below, the heliostats much be routinely washed to maintain the high reflectivity of the mirrors. In addition, the back of the heliostat will have to be maintained occasionally and will require clearance for access. These activities will indivertibly place these PV installation at risk, if not severely limited by them.

The design for the PV installation within the heliostat field showed that the PV equipment will interfere with the operation of the heliostat field. There could also be the high risk of potential fires on site due to the concentration of suns energy by the heliostats. During emergency conditions, the heliostats will be required to reach a stow position, and the PV plant will interfere with such emergency protocol.

Figure 8 – Wash trucks washing heliostats

3.0 Summary of Assessment

Based on analyses and discussions provided in the previous section, it is concluded that the integration of PV be best implemented outside the heliostat field. This is particularly compelling when the PV installation must be sized to offset more significant parasitic loads associated with large pumps and freeze protection electric heating, in additional to the powering of heliostats.

For performance reasons, the heliostat field is packed as closely as possible to avoid physical and optical interference, as well as to minimize atmospheric attenuation losses. The heliostats are positioned in concentric rings surrounding the central receiver, with just sufficient access for wash and maintenance vehicles.

Because the heliostats must track the sun throughout the day and that the PV modules would prefer to face the sun, this limits the placement of the PV module to behind each row of heliostats, either tilted strategically or horizontally with respect to the ground. Such implementation would therefore subject the PV modules to shading by the heliostats at various time of the day. Such placement would require substantially upsizing and potentially lead to shorter module life.

Mounting of PV module on the heliostat structure is also not feasible as this will change the structural loads on the heliostats, which are optimized to track the sun to a high level of accuracy over a wide range of wind loads.

For the above reasons, it is recommended that the project strongly favor the centralization of the PV power block, to be ideally located in the perimeter of the solar field, connected electrically to the medium voltage bus of the Redstone CSP Project that services all auxiliary loads behind the fence of the facility.