2 PROJECT DESCRIPTION

The following chapter provides an overview of the proposed 1GW Upington Solar Park and include a description of the planning/design, construction, operation and decommissioning activities.

The proposed 1GW Upington Solar Park development consists of the following infrastructure development but not limited to:

- Construction of the Solar Park bulk infrastructure (e.g power blocks and turbines; collector substations and interconnection substations, power lines, auxiliary fossil fuel boilers, salt or direct stream storage vessels)
- Solar panels of different solar technologies;
- Workshop area for maintenance and storage of equipment;
- Building infrastructure;
- Construction of pipelines for water supply;
- Stormwater, drainage and sewage;
- Telecomunications;
- Subsoil stockpile area;
- Topsoil stockpile area – where possible foundations need to be constructed;
- Water treatment works ,water storage and evaporation ponds;
- Access/Haul road network.

It is envisaged that the proposed Solar Park will make use of different Solar Technologies such as *Concentrated Solar Power (CSP)* which include; Parabolic Trough (PT) and Central Receiver (CR) and *Photovoltaic (PV)* which include; fixed and tracking crystalline PV, fixed thin film PV and Concentrated PV (CPV) with a total generating capacity of 1GW. The proposed Solar Park development is on the remaining extent of Farm Klipkraal 451 which covers an area of approximately 5011 hectares. The actual footprint for the Solar Park (will be confirmed during the EIA Phase) in terms of the various technologies will be smaller than the total extent of the site. In other words the development will be smaller than 5011 ha.

The spatial detail layout is subject to change depending on the outcomes and findings of the EIA. Taking into consideration the current information, the spatial constraints of the site as well as the various objectives of the Solar Park, three layouts (design alternatives 2.1.1) is proposed by the feasibility study done by ARUP.

In terms of the EIA Regulations published in Government Notice R543 of 2 August 2010 in terms of Section 24 of the National Environmental Management Act (Act No. 107 of 1998), a feasible and reasonable alternative has to be considered within the Environmental

Scoping Study, including the 'No Go' option. All identified, feasible and reasonable alternatives are required to be identified in terms of social, biophysical, economic and technical factors.

The consideration of project alternatives, site as well as technical, is a key requirement of an EIA as it provides information on environmental impacts on various alternatives so that the best case scenario is based on valid environmental and economic considerations. The NEMA EIA Regulations of 2010 define alternatives in relation to a proposed activity as "*different means of meeting the general purpose and requirements of the activity which may include alternatives to the:*

(a) Property on which or location where it is proposed to undertake the activity;
(b) Type of activity to be undertaken;
(c) Design or layout of the activity;
(d) Technology to be used in the activity;
(e) Operational aspects of the activity; and
(f) Option of not implementing the activity."

Alternatives are considered as a means of reaching the same need and purpose as the originally proposed project in a way that minimises its negative and maximises its positive impacts.

A key challenge of the EIA process is the consideration of alternatives. Most guidelines use terms such as 'reasonable', 'practicable', 'feasible' or 'viable' to define the range of alternatives that should be considered. Essentially there are two types of alternatives:

- Incrementally different (modifications) alternatives to the Project; and
- Fundamentally (totally) different alternatives to the Project.

Fundamentally different alternatives are usually assessed at a strategic level, and EIA practitioners recognise the limitations of project-specific EIAs to address fundamentally different alternatives.

2.1 Site Alternatives

No site alternatives are proposed for this project as the placement strongly depends on the consistent solar radiation, flat and sparsely populated land, grid connection, water supply, good transport infrastructure and the availability of a large portion of municipal land.

The desirability of the proposed site for the development of the proposed Solar Park is due to the following key characteristics:

- **Solar Radiation**: The feasibility of a solar facility especially a Solar Park of this magnitude is dependent on the direct solar irradiation levels. The Clinton Climate Initiative (CCI) study identified the Northern Cape Province as the most suitable location due to its consistent solar radiation. The conclusions of the Department of Trade and Industry (DTI's) Special Economic Zones (SEZs) program also support selection of the Northern Cape as the best location for solar power development, based on solar irradiation levels, socio economic impact and potential for civil and electrical infrastructure development (DEA/CSIR, 2013).

Figure 2.1: Upington in the context of Solar Irradiation Map of South Africa (CSIR)

- **Topography**: The suitability of the surface area is an important characteristic for the construction and operation of solar facilities. It was found that the majority of the site has a slope of less than 2% and can therefore be considered as suitable for most technologies. **Table 2.1** indicates the solar technology slope requirements.

Table 2.1: Solar Technology Slope Requirements.

Technology	Slope requirement (%)
CSP PT	< 1-2 %
CSP CR	< 2-4 %
PV Fixed	< 10% for north facing slope <5% in all other directions
PV tracking	<8%
CPV	<5%

- **Grid connection**: The Eskom Transmission Development Plan (TDP) 2013-2022 has identified the Upington Solar Park area as part of the Namaqualand customer load network. The Eskom TDP has also identified the Upington Solar Park as an integration point renewable energy input. Accordingly, Eskom intend to construct a new 400kV line and Eskom Main Solar Substation (MSS) in order to facilitate evacuation of up to 1.5GW from the Upington area – of which 1GW would be generated from the SP and the remaining 0.5GW generated from the Eskom CSP plant and multiple REIPPPP projects being developed in the area. It is proposed that the Upington Solar Park will be connected to the grid through a new 132kV line to the new proposed MSS on the upgraded 400kV network (**Figure 2.2**) as part of the Eskom Solar Park Integration Project.

- **Water supply**: Solar technologies such as Concentrated Solar Power (CSP) may require water as a heat transfer medium. The feasibility study indicates an operational water supply requirement of 3030kl/day if CSP is employed across the Klipkraal site. The municipality which is a water services provider indicated that they have sufficient capacity to supply the necessary quantity of water. The most feasible option investigated is via a pipeline to the Upington Water Treatment Plant (WTP) along the N10 or the N14. Although this is a water scarce area; there is a need to consider minimal water usage and possibility of dry cooling methods.

- **Site access and road infrastructure**: The site is bordered and can be accessed by both the N10 and the N14. For future development of the site, it is proposed that access roads will enter the site via the N14 on the south as the main entrance and an alternative, from the N10 on the northern side as a secondary access road.

- **Availability of land**: Concentrated Solar Power (CSP) technologies such as Parabolic Trough (PT) and Central Receiver (CR) require large portions of land. A 100 MW CR for example will require about 400 – 500ha. The DoE Solar Park concept focuses on a municipal owned site with a nominal generation capacity of 1 GW (1000 MW) at Upington, Northern Cape Province. The proposed municipal owned klipkraal site is 5011ha in extent and satisfies this planning requirement.

2.1.1 Layout Design Alternatives

The proposed Solar Park can be appropriately placed within the 5011ha Klipkraal 451 site. The klipkraal site is sufficient to accommodate the required servitude requirements for the proposed overhead lines, the access roads, the water infrastructure, the buildings, internal roads, telecommunication infrastructure and waste management requirements.

Taking spatial considerations of the site, as well as the various objectives of the Solar Park into consideration, three preliminary layouts have been derived from the feasibility study (Arup, 2014):

- The first option (**Figure 2.3**) considered a blend of the two strategies, where CSP with storage makes up over half of the park, but a significant proportion of the Solar Park is allocated to PV to allow for some cost competitiveness as PV technologies are generally lower cost than CSP technologies.

- The second option (**Figure 2.4**) maximizes the amount of CSP projects with storage in order to allow for the most generation during peak demand hours

- Since one of the stated objectives of the Solar Park is to identify the lowest cost option, the third technology mix (**Figure 2.5**) is weighted more heavily towards PV and CSP projects without storage options.

Table 2.2 below lists the mix of solar technologies which have been considered for the three layout options (Arup, 2014).

Technology	**Option 1 Capacity (MW)**	**Option 2 Capacity (MW)**	**Option 3 Capacity (MW)**
CSP Total	**625**	**825**	**300**
Parabolic Trough with Storage	325	725	100
Central Receiver with Storage	300	100	100
Central Receiver without Storage	-	-	100
PV Total	**375**	**175**	**700**
Tracking	225	70	240
Fixed tilt	125	100	400
CPV	25	25	60

The proposed Solar Park grid connection as part of the separate Eskom Solar Park Integration Project 5 (**DEA Ref No: 12/12/20/2610**) is on the western end of the site which is considered to be optimal for access to the Eskom power corridor servitude. This is also considered to be optimal given the location of the Main Solar Substation (MSS) to the south west of the Solar Park. **Figure 2.2** illustrates this proposed grid connection power corridor and MSS.

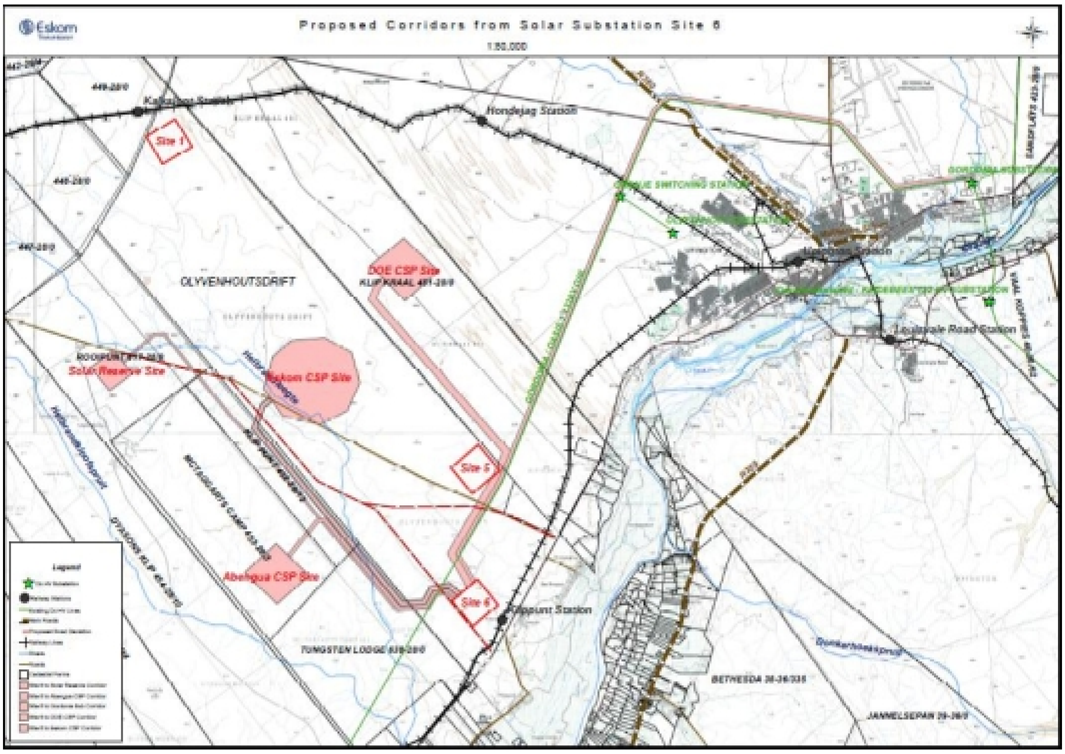


Figure 2.2: The proposed grid connection power corridor from the Solar Park (DoE CSP site) to the Main Solar Substation (site 6)

There are a number of possible strategies for the interconnection between the IPPs in the proposed Solar Park and the Main Solar Substation (MSS). One option is to connect each IPP individually to the MSS. Another option is to have collector substations on the Solar Park site that link between the individual IPPs and the MSS. The number of collector substations could vary from one to multiple collector substations. The alternative option of using collector substations would reduce the width of 132kV line servitudes required and would reduce the connection costs for the IPPs. The typical IPP substation configuration, one direct connection option and two collector substations options and their proposed locations in relation to the site are illustrated in **Appendix L**.

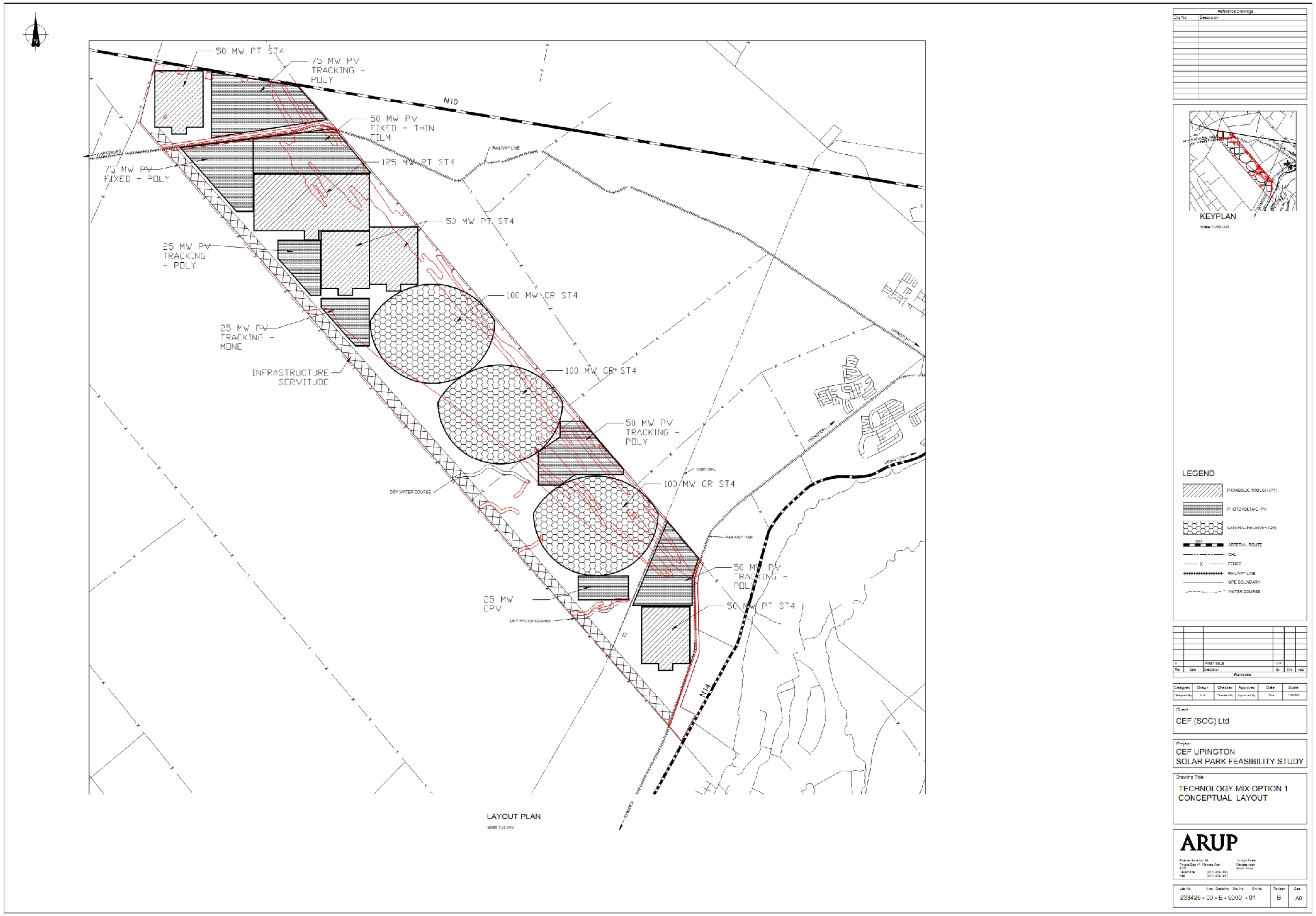


Figure 2.3 IPP option 1 layout.

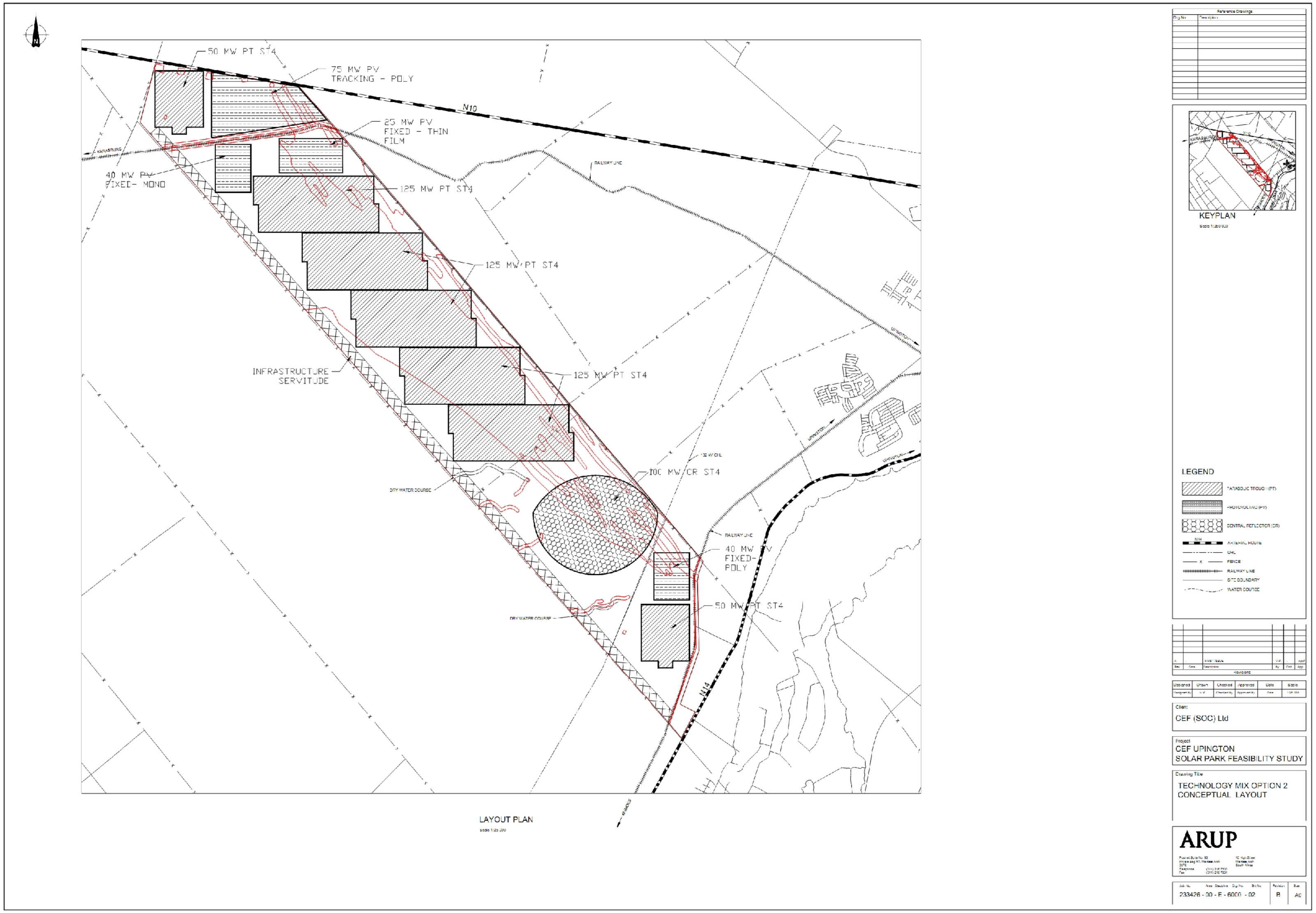


Figure 2.4 IPP option 2 layout.

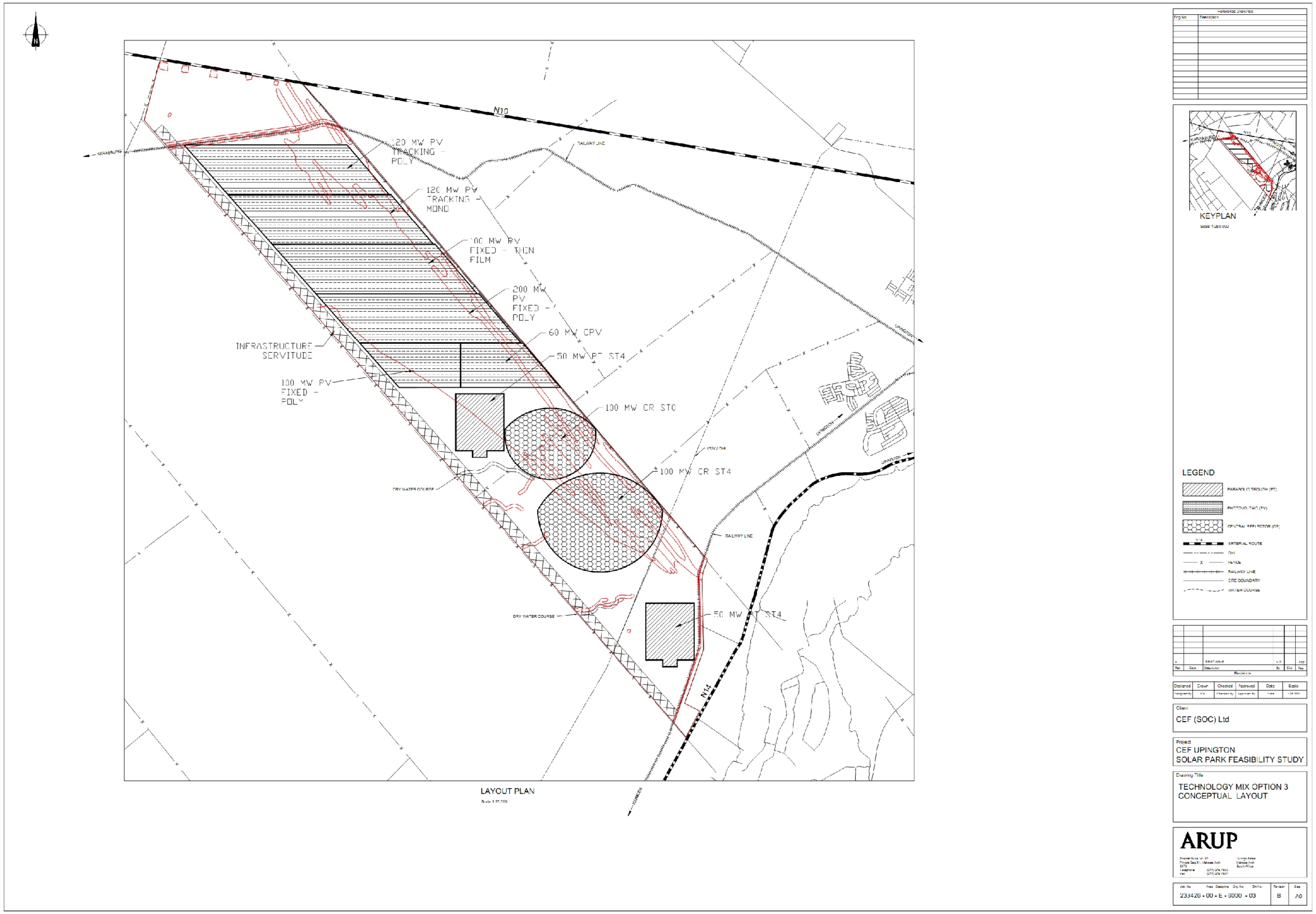


Figure 2.5 IPP option 3 layout

2.1.2 The 'no go' alternative

In the context of this project, the no-go alternative implies that the proposed 1GW Upington Solar Park will not be constructed.

The no-go alternative can be regarded as the baseline scenario against which the impacts of the Solar Park are evaluated. This implies that the current biophysical and social/tourism conditions associated with the proposed sites will be used as the benchmark against which to assess the possible changes (impacts) to these conditions as a result of the Solar Park.

In most cases, the no-go alternative will imply that the identified negative impacts of proceeding with the project will not be incurred. Conversely, selection of the no-go alternative will also result in the benefits (including the potential economic development and related job creation, and increased security of electricity supply) of this renewable energy project not being realised. Some of the most important aspects that will not be realised as also described in the South Africa REFIT Regulatory Guideline published by NERSA (March 2009) include: the increased security of electricity supply; exploitation of South Africa's renewable energy resources; pollution reduction and climate friendly development to name a few.

The 'no go' alternative will, however, be investigated further in the EIA phase as an alternative as required by the EIA Regulations.

2.1.3 Technology Alternatives

The technologies evaluated in this project fall into two main general categories:

- Photovoltaic (PV) and;
- Concentrating solar power (CSP).

In PV technologies the sunlight photons are converted directly to electricity. Fixed and tracking crystalline PV, fixed thin film PV and Concentrated PV (CPV) fall into the PV category. CSP technologies are those that concentrate the sun's energy to produce heat; the heat then drives either a steam turbine or an external heat engine to produce electricity. Parabolic trough and power tower fall into the CSP category.

Photovoltaic (PV) technologies for peak load application:

PV solar power generation

Photovoltaic power systems are power systems energised by photovoltaic panels. Photovoltaic panels convert solar radiation into direct current electricity using semi-conductors; this is known as the photovoltaic effect. Photovoltaic solar panels are composed of a number of solar cells containing a photovoltaic material. Individual ground mounted PV panels will be connected to a string of panels forming an array. The array of panels will be attached to a steel support structure at an angle in order to receive the maximum amount of solar radiation. **Figure 2.6** below indicates an example of a Photovoltaic facility.

Figure 2.6: Examples of a Photovoltaic facility

CPV solar power generation

Concentrated photovoltaic (CPV) systems the sunlight concentrates directly onto photovoltaic surfaces for the purpose of electrical power generation. Solar concentrators of all varieties may be used, and these are often mounted on a solar tracker in order to keep the focal point upon the cell as the Sun moves across the sky. Concentrated photovoltaic (CPV) is generally installed in "solar farms" and uses reflective or transmissive optics-either mirrors or Fresnel lenses-that concentrate light rays (photons) from the sun onto a photovoltaic (PV) module to increase its conversion efficiency. The photons, which are individual quantum units of light energy, are directly converted into electricity by the PV module.

Concentrating Solar Power (CSP) technologies:

Parabolic trough (PT) solar thermal power generation for mid-merit application

A parabolic trough power plant consists basically of a solar field and a conventional power block. Parabolic trough-shaped mirrors in the solar field concentrate the incident solar radiation onto an absorber tube located in the focus line of the collector. A heat transfer fluid inside the absorber tube is heated by the absorbed solar radiation and produces steam in the power block by means of heat exchangers. From there, the steam is fed into a turbine to generate electricity in the same way it is done in conventional power plants. With an integrated thermal energy storage system, the supply of electricity can be stored and made available in a plan able manner. **Figure 2.7** below indicates examples of PT plants in Kramer Junction California.

Figure 2.7 CSP parabolic trough plants, Kramer Junction California

Central receiver (CR) solar thermal power generation for mid-merit application

CR technology utilizes focused sunlight. CR plants also generate electric power by using mirrors to concentrate (focus) the sun's energy and convert it into high-temperature heat. That heat is then channelled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, and another that converts the heat energy to electricity. **Figure 2.8** below show examples of the Solar One and Abengoa Central Receiver plants.

Figure 2.8 Solar One and Abengoa Central Receiver plants

The preferred Solar Park technologies has been informed by the market review of current commercial PV and CSP technologies being utilised in the market global and locally.

2.2 Solar Technology Descriptions and Electricity Generation

Solar energy facilities operate by converting solar energy into a useful form (i.e. Electricity). The use of solar energy for electricity generation is a non-consumptive use of a natural resource and consumes no fuel for continuing operation. Solar power produces an insignificant quantity of greenhouse gases over its lifecycle as compared to conventional coal-fired power stations. The operational phase of a solar facility does not produce carbon dioxide, sulphur dioxide, mercury, particulates, or any other type of air pollution, as do fossil fuel power generation technologies.

Solar facilities are likely to have an operational 26 lifetime of 30 years or more. Utility-scale facilities are those generating electricity that will be delivered into the electricity transmission grid.

2.2.1 Photovoltaic

Photovoltaic (PV) arrays use semiconductor materials to generate electricity directly from solar irradiance through the photo-electric effect. PV technology produces direct current (DC) which is then converted to alternating current (AC) via power electronic inverters. The main technology categories are crystalline modules (mono or poly), thin film, and concentrated photovoltaics (CPV). **Figure 2.9** below indicates a typical PV field layout.

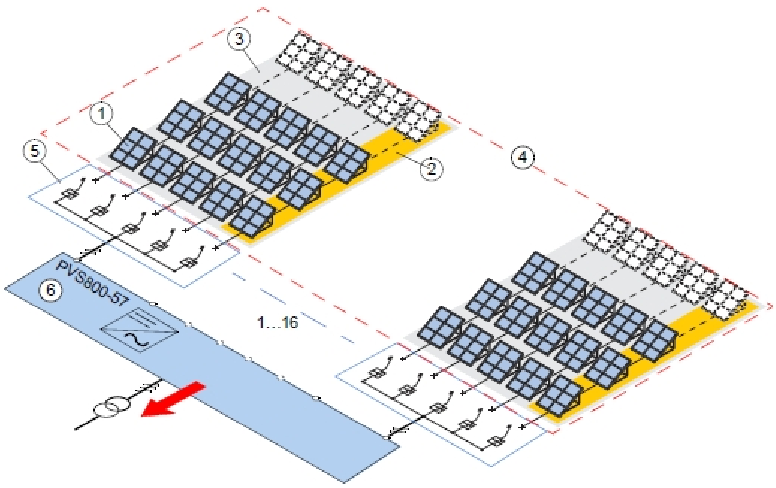
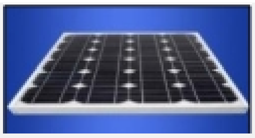
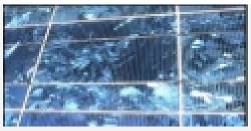
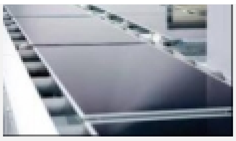


Figure 2.9 Description of a typical PV field layout.

The components and the functioning of a PV Facility can be discussed in more detail below:

Photovoltaic panels/modules: A photovoltaic (PV) cell is made of silicone which acts as a semiconductor used to produce the photovoltaic effect. Individual PV cells are linked and placed behind a protective glass sheet to form a photovoltaic panel. The differences in cell technology are mainly attributed to the way they are manufactured and the different semi-conductive materials used. A single PV cell is sufficient to power a small device such as an emergency telephone, however to produce 1GW of power, the proposed plant will require numerous cells arranged in multiples/arrays which will be fixed to support structures or mounts. **Table 2.3** includes the different PV module technologies that are considered.

Table 2.3: The different PV module technologies that are considered.

PV module types			
MONO-CRYSTALLINE	POLY-CRYSTALLINE	THIN FILM	CONCENTRATED PV
			
Silicon single Crystalline cell structure	Silicon multi-crystalline cell structure string	Semi-conductive Materials with amorphous structure combined in thin layers	Optical concentration of irradiation onto PV cells

The Support Structure (mounting structure options): There are options to have fixed tilt or tracking systems, with either one or two axes. **Table 2.4** indicates the mounting structure options to be used in conjunction with the different PV Module. In order to maximise the electricity generated these mounts need to be angled in such a fashion so to receive the maximum amount of solar radiation throughout the year. The preferred angle of the panels (which is dependent on the latitude of the proposed facility) may be adjusted to optimise for summer or winter solar radiation characteristics. This is further optimised through the utilisation of tracking technology, whereby the PV panels are able to 'track' the sun during the day.

Table 2.4: The mounting structure options.

Mounting structure options	
FIXED TILT	SINGLE/DUAL AXIS TRACKING
	
Fixed tilt is the simplest of the designs, and as a result is the most common. The panel is usually fixed at a permanent angle on a rigid frame. The fixed tilt results in no moving parts, therefore low levels of required maintenance.	Tracking systems maximises exposure to irradiation and may produce a greater yield through maintaining optimum alignment with the sun. One could either use single or dual axis trackers, depending on the cost and land requirements.

Cables between the PV panels: Underground cables from the arrays of panels will feed into the invertors.

Inverters: The photovoltaic effect produces electricity in direct current. The inverter serves to convert the electricity, which is produced as direct current, into alternating current. The generated power can then be stored or evacuated into a local electricity grid to meet the load requirements. In the case of the latter, the electricity is evacuated to either a substation or a switching station which houses an inverter.

PV Land Occupation:

PV plants, including monocrystalline, polycrystalline, and thin film, can be of any size as the systems are modular and in recent years there have been a few projects of a capacity as great as 250MW, although many are in the 10-75MW range. It is also flexible in the layout, as the PV modules can be arranged to fit within most footprints even if the land shape is not rectangular. This is of benefit compared to CSP where particular footprints and aspect ratios are usually required.

The overall footprints required for each technology are summarized below and these have been used for the Solar Park layout options assessed.

Table 2.5: PV technology footprints.

Module	Mounting configuration	Footprint (MW/ Ha)
Mono-crystalline	Fixed tilt	0.5
Mono-crystalline	Single-axis tracking	0.3
Poly-crystalline	Fixed tilt	0.5
Poly-crystalline	Single-axis tracking	0.3
Thin film	Fixed Tilt	0.25
CPV	Tracking	0.4

2.2.2 Concentrated Solar Thermal Power (CSP)

PT and CR technologies are selected for the Solar Park based on the maturity of each technology and the technological risks. PT and CR are also the only technology with viable storage capabilities. PT technology is the most mature technologies; however, the commercial market-share of CR is expected to grow substantially in the near future and currently there is a larger cost reduction potential. PT plants sized approximately at 125MW and 50MW and CR plants sized approximately at 100MW are being considered for the proposed Solar Park (**Figure 2.3** to **2.5**). In principle, 4 hours of storage for the CSP technologies is being considered based on Eskom's peak and mid-merit needs.

Unlike PV, solar thermal technologies use incident solar radiation as a heat source; concentrating and collecting it in order to heat a thermal fluid. This heat is then used to produce steam to run a turbine and produce electricity. This process can be carried out directly or indirectly, through an intermediate heat transfer fluid and the use of heat exchangers.

2.2.2.1 Parabolic Trough (PT)

PT technology is the most mature CSP technology. Commercial PT plants have been operating successfully for more than 20 years, which has resulted in optimisation of this design as well as well-established operation and maintenance procedures.

The basic components of a PT power plant are shown in **Figure 2.10**. The system can be divided into the following parts:

- Solar field (yellow);
- Thermal conversion system, HTF forward system and steam generator (red);
- Storage system (green); and
- Electric conversion system: power block (blue).

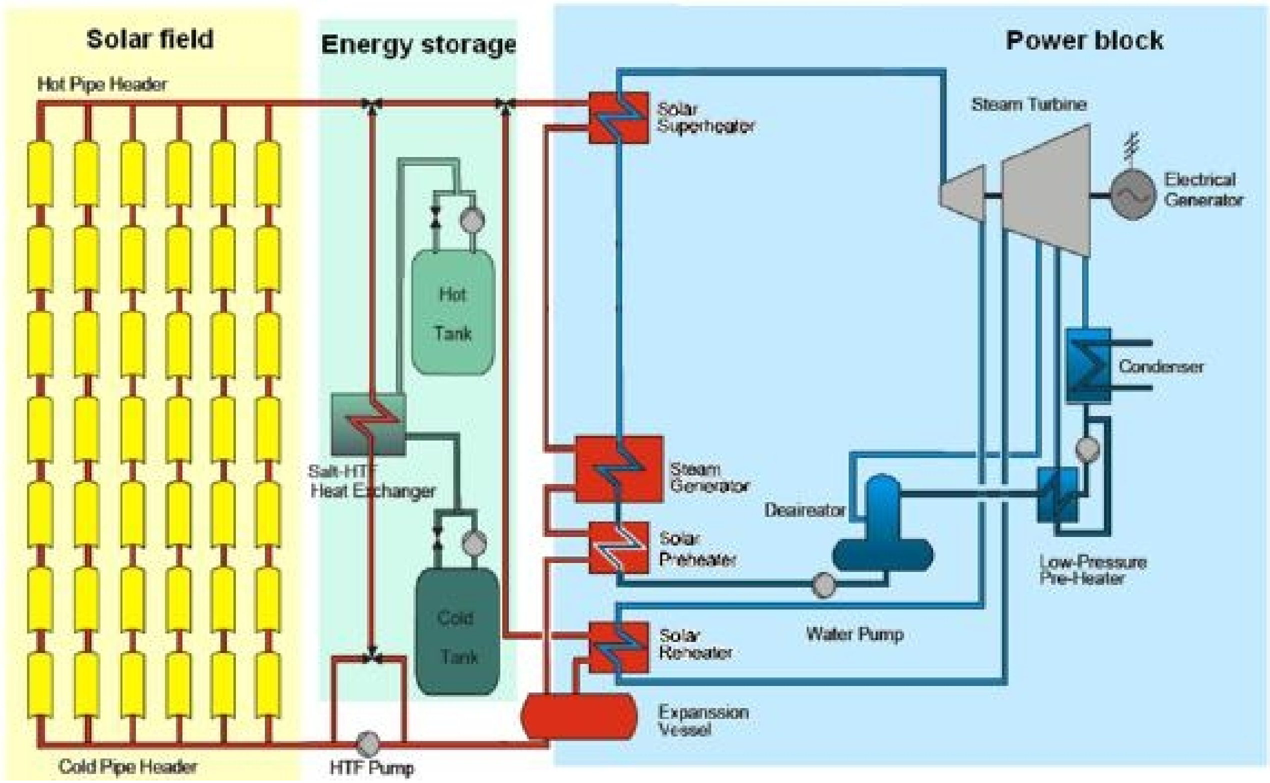


Figure 2.10: Components of a Parabolic Trough plant

<u>Solar field (yellow)</u>
Solar field is comprised of two subsystems, the collectors and the receiver.

Collectors – All collectors are oriented by a single axis solar tracking system, which concentrates the solar irradiation onto a linear receiver located at its focal line.

The orientation of this field can be either North-South (with East-West sun tracking) or East-West (with North-South tracking). The Solar Park project will only consider the

North-South orientation, because it is the most common, providing the highest annual energy generation. It’s noted that the E-W orientation can provide more generation during winter for future considerations.

The Receiver – The receiver converts solar irradiation to thermal energy in the form of sensible and latent heat of the fluid which circulates through it. Currently, only one type of receiver is available for parabolic trough power plants, the vacuum tube receiver.

Heat Transfer Fluid (HTF) system (red)

The HTF is a synthetic oil which is heated in the receiver up to temperatures of up to 400 ºC. This passes through a heat exchanger to create pressurized steam to be used by the turbine.

The solar collector system involves an extensive piping network which circulates HTF in a closed loop to and from the power block and solar field. This system is designed to maintain an equally distributed flow through all the solar collector assemblies (SCAs) so as to avoid low and high temperature areas.

Auxiliary components and systems in the HTF system include: Variable speed drives, expansion tanks, the HTF freeze protection system and the Ullage system.

Thermal Energy Storage (TES) (green)

The storage system is an optional addition which allows the plant to produce electrical energy in low or zero irradiation periods. It also increases the capacity factor of the plant. Thus introducing storage allows the plant to generate reliable, dispatchable, and stable electrical energy to the grid.

In PT technology the most mature TES scheme is two-tank molten salts storage. The system consists of an indirect thermal storage system with two molten salt tanks (one hot and one cold). Auxiliary systems includes: vents, pressure relief devices/systems in TES Storage Pumps.

Power Block

A PT plant operates with a reheat Rankine power cycle with five extractions in order to increase the efficiency of the cycle and offset the losses in the solar field. The steam generation system supplies the required quantity and quality of superheated steam to the steam turbine via the HTF. This pressurized steam expands, driving the turbine, which in turn powers the generator to deliver electrical power.

The system described above includes the following components, amongst others: feed water pump and heater, turbine, air-cooled condenser, pumps, compressors, tanks, auxiliary heat exchangers, steam turbine generator.

2.2.2.2 Central Receiver (CR)

Requirements to install CR plants are very similar to those necessary for a Parabolic Trough plant. However, in this case, the field slope angles up to around 3-4º are allowable and thus it is not necessary to level the site in cases with low inclination terrains such as for the proposed Solar Park.

The components of a CR plant include (**Figure 2.11**):

- Solar field;
- Thermal conversion system;
- Storage system; and
- Power block.

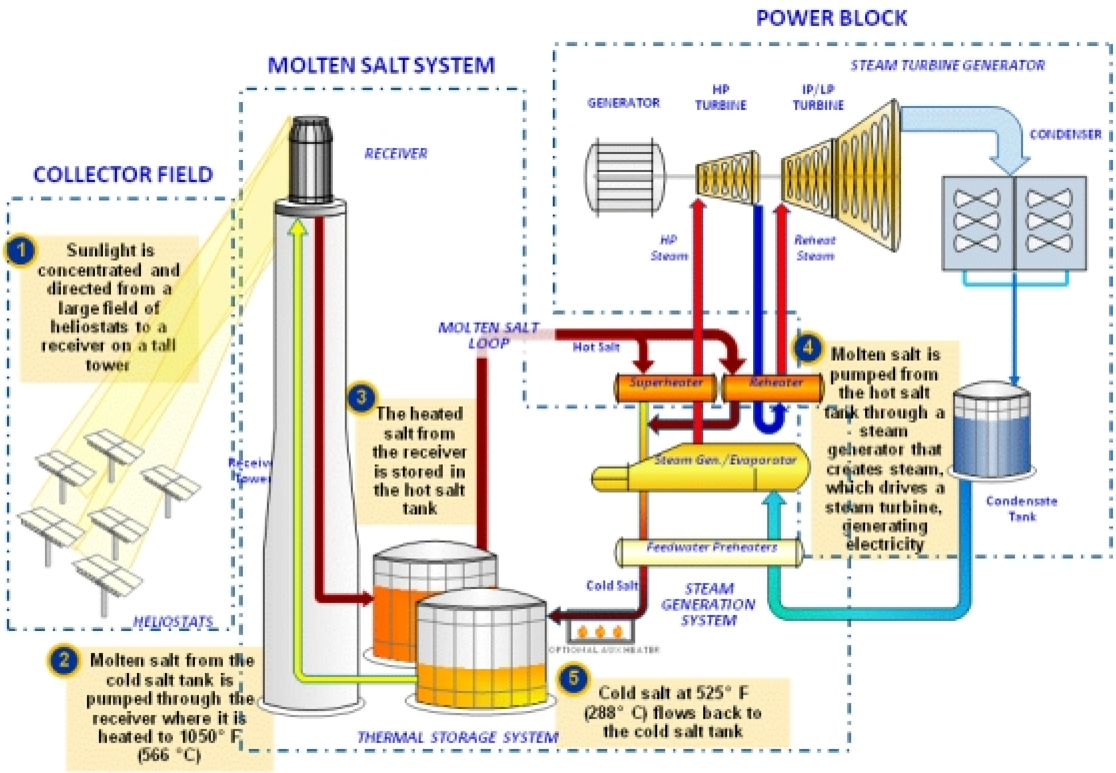


Figure 2.11: Components of a Central Receiver plant (Molten Salt Tower)

<u>Solar Field</u>

CR uses mirrors called heliostats with two-axis sun-tracking to focus concentrated solar radiation onto a receiver (Irradiate) at the top of a tower. The receiver absorbs the concentrated irradiation and converts it into thermal energy, which is carried by the working fluid (water and molten salt). The actual receiver is mounted on a 200m to 300m high power tower that provides elevation and structurally supports the receiver.

An advantage of central receiver towers over most other CSP technologies is that the solar collection occurs at one receiver atop a central tower and thus piping is not required throughout the solar field.

Thermal conversion system

There are three main technical designs which can be distinguished depending on the working fluid used: water/steam, molten salts, or air (currently only under research). In cases where the working fluid is water, the maximum storage currently under operation has approximately 5 hours equivalent. Using molten salts as heat transfer fluid this can be extended. Thus, molten salts are being considered as one of the most suitable heat transfer fluids for this project, given the possibility to install large storage systems

Storage system

For this technology, the storage tank description is very similar to the PT technology. However, CR plants do not require exchangers between the HTF and the storage system as the heat transfer fluid acts as the storage medium as well. The CR storage system consists of a direct system with two tanks (one hot and one cold). In this type of storage, the total fraction of the heat transfer fluid that leaves the solar receiver is pumped directly into a highly insulated storage tank (hot tank at 565ºC) and remains until its thermal energy is required by the thermodynamic power cycle. Thus, the heat transfer fluid itself also acts as the storage medium. During the discharging mode, the hot storage medium is pumped from the hot storage tank, delivers its thermal energy via heat exchange with the steam generation system, and is returned to the cold storage tank (305ºC).

Power block

CR plant works with a reheat Rankine power cycle as has been described for PT plant. In this case, the HTF used to produce steam in the steam generation system is molten salts. The power block equipment in this plant is the same as that described for the PT plant.

Balance of plant equipment/infrastructure associated with CR and PT technology is similar and includes the following:

- Water treatment plant;
- Auxiliary transformers;
- Auxiliary Cooling
- Compressed Air System;
- Emergency Power Supply System;
- Security system;

- Fire fighting system;
- Meteorological and monitoring systems;
- Foundations;
- Internal road network;
- Drainage system; and
- Buildings (steam turbine hall and electrical building workshop).

Components such as the water treatment plant and the associated waste management activities which is part of the operational phase of the proposed Solar Park including some of the other solar park infrastructure will be discussed in the steps and the operation of a Solar Park below.

2.3 The steps in construction and operation of a Solar Park

The typical possible steps in the construction and operation of a Solar Park is explained below and summarised in **Table 2.6**. The construction and the operational phases are being focused on.

Table 2.6: The typical steps in construction and operation of a Solar Park and associated infrastructure.

Step	Activity
1	Planning (Determination of feasibility and technology mix)
2	EIA of alternatives (technology, site) and WULA
3	Authority authorisation of site
4	Negotiation of final site alignment and grid and water connections including roads upgrade
5	Selection of best-suited foundations and structures
6	Final design of solar park
7	Establish Solar Parks Authority (SPA)
8	IPP and Construction tenders advertised and awarded
9	Construction phase (establish access roads, site preparation, transport of equipment to site, establishment of laydown areas, construct the main solar technology infrastructure and substation(s), establishment of ancillary/external infrastructure and connection to the electricity grid).
10	Rehabilitation of working areas and protection of erosion susceptible area
11	Operational Phase (testing and commissioning, water and waste management including Solar Park operation and maintenance)
12	Decommissioning

2.3.1 *Planning (Determination of feasibility) (Step 1)*

Arup was appointed by the CEF (SOC) and the Department of Energy (DoE), to undertake a Feasibility Study for the 1GW Upington Solar Park (Solar Park).

The Feasibility Study scope of work comprised an assessment of the technical (technology mix and preliminary Solar Park layout), socio-economic and financial feasibility of establishing a 1GW Solar Park on the Upington site, including consideration of appropriate procurement and governance models and completion of a risk assessment to inform the next development stage. CEF (SOC) also appointed Lidwala to undertake the process of the environmental impact assessment (EIA).

2.3.2 *EIA, WULA and authority authorisation of site (Step 2&3)*

The EIA process forms part of the scope definition stage of a project. The aim of this process is to identify the possible alignment of the site with the minimal impact on the environment and the technology mix with the least impacts.

The actual layout (technology mix) of the solar park will be determined by a number of factors, including CEF negotiation with the local municipality and other landowners, negotiations with regards to external infrastructure (for example water supply, roads, grid connection), environmental features and technical requirements. As a result of these factors, it is impossible to predict the exact technology mix within the EIA process at this stage. The inherent variation that is likely in the final role out of the Solar Park is factored into the EIA through the assessment of all possible alternatives (for example technology and layout design).

A final EIR is produced and provided to the DEA with all the alternatives assessed during the EIA process. Recommendations for the least impacted alternative are provided for consideration during authorisation. DEA will issue an environmental authorisation based on the information provided.

A project-specific Environmental Management Plan (EMP) is drafted for the project and this document details the specific controls which must be in place for the duration of the construction phase. An Environmental Control Officer (ECO) who acts as an intermediary between individual landowners, CEF and the contractors, implements the EMP.

<u>Water Use Licence Application (WULA)</u>

In terms of the National Water Act (NWA), Act 36 of 1998, the National Government, acting through the Minister of Water Affairs, is the public trustee of South Africa's water resources, and must ensure that water is protected, used, development, conserved, managed and controlled in a sustainable and equitable manner for the benefit of all persons. The Minister is responsible to ensure that water is allocated equitably and used beneficially in the public interest, while promoting environmental values. Government. Acting through the Minister, hast the power to regulate the use, flow and control of all water in South Africa.

The proposed Upington Solar Park and associated infrastructure may require the application of a Integrated Water Use Licence (IWUL) in terms of Section 21 (b), (c), (e), (f), (g) and (i) of the National Water Act, 1998 (Act No. 36 of 1998) (NWA). The IWUL application process will be integrated as far as possible with the EIA process (depending on the availability of documentation for example the final layout and design drawings in the EIA phase). The following possible water uses may be undertaken as part of the construction and/or operation of the Solar Park and associated infrastructure:

Section 21(b): Storing of Water.
Section 21(c): Impeding or Diverting the Flow of Water in a Watercourse.
Section 21(e): Controlled activity (irrigation with waster or water containing waste generated through any industrial activity or by a waterworks).
Section 21(f): Discharging waste or water containing waste into a water resource.
Section 21(g): Disposing of waste in a manner which may detrimentally impact on a water resource.
Section 21(i): Altering the Bed, Banks, Course or characteristics of a watercourse.

2.3.3 Negotiation of final site layout (other external infrastructure) (Step 4)

This step depends on the final site layout (design and technology mix) and alignment of other external infrastructure (for example water supply, roads, grid connection: Eskom Solar Park Integration Project) as per the outcomes of the EIA process(s).

Negotiations of the external infrastructure such as the water supply/connection, grid connection, upgrading of roads and other servitude arrangements can be a lengthy process.

2.3.4 Selection of best-suited foundations and structures (Step 5&6)

The topographical profile and plans are used by the design engineers to design the foundations, structures, buildings, storm water etc. All the above information would be required by the contractor before commencing construction.

2.3.5 Establish Solar Parks Authority (SPA) (Step 7)

In order to procure the Solar Park Concessionaire (SPC) for all Solar Parks within the Solar Corridor, a public sector Solar Parks Authority (SPA) is proposed to be established. Under the current South African legislation, the options for which public sector department or entity could fulfil the role of SPA are: 1) A national or provincial government department, such as the Department of Energy; 2) A local or district municipality; or 3) A Schedule 2 or Schedule 3 State Owned Enterprise, such as CEF (SOC). The final selection of the appropriate SPA entity will require Government assessment and determination.

The establishment of the SPC may be a few steps earlier or a few step later depending on the exact Solar Park role out plan determined by government.

2.3.6 IPP and Construction tenders advertised and awarded (Step 8)

With respect to IPPs who want to procure pieces of land to construct and operate generation facilities within the Solar Park will be influenced by Government policy, acts and regulations; existing IPP procurement programmes, market forces, capacity of the implementation authority and available funding.

The actual IPP procurement may be few steps later depending also on the exact Solar Park role out plan determined by government. The construction of the Solar Park phase 1 and 2 main infrastructure on the Klipkraal will most likely be procured before the IPP procurement.

2.4 Construction phase (Step 9&10)

2.4.1 Establishment of Access Roads

The site can be accessed from the N14 south of the site. A second access is proposed off the N10, in the north western corner of the site. These two access points will be linked by a proposed asphalt collector road which will traverse the western boundary of the site. This main collector road has been positioned on the boundary because of the large area typically required for the central receiver CSP technology. The proposed roads layout is common for all technology options.

Access to the IPP sites will be off the collector road. The location and configuration of these secondary roads will depend on the technology mix and how the land is allocated to individual developments. The main collector road is recommended to be a tarred or paved road due to the amount of traffic expected, including delivery trucks carrying heavy loads that will be experienced in the Solar Park. The secondary and auxiliary access roads may not need to be paved. The secondary and auxiliary roads are estimated to be 6m wide.

The main access road may need to be wider, depending on the outcome of a traffic impact study which will be conducted in the Environmental Impact Assessment phase.

2.4.2 Site Preparation

The actual site preparation will include the clearance of vegetation at the footprint of each component of the Solar Park, the possible levelling of the dunes at the klipkraal site and the establishment of internal access roads depending on the planning and the recommendations of environmental authorisation. This activity will entail the stripping of the topsoil which will need to be stockpiled, backfilled and/or spread on site.

2.4.3 Transport of equipment to site

The transportation of the different components of the Solar Park will be undertaken by road using the appropriate national, provincial or national roads. Individual components may be defined as abnormal loads in terms of the Road Traffic Act (Act No 29 of 1989) by virtue of the dimensional limitations. Some of the abnormal loads may also include specialised construction and lifting equipment/cranes for the erection of the power tower for example. Other normal construction equipment that will be brought to the site may include graders, excavators, trucks, compactors, batch plants for example.

The dimensional requirements of the load (length/height) may require alterations to the existing road infrastructure (widening on corners, removal of traffic islands), accommodation of street furniture (for example electricity, street lighting, traffic signals, telephone lines), and protection of road-related structures (for example bridges, culverts).

2.4.4 Establishment of Laydown Areas

This includes the establishment of laydown and storage areas needed for typical construction equipment which will be required on site. Specific levelled and compacted areas may also be required for operation of cranes and similar equipment.

2.4.5 Construction of the Power Block and substation(s)

The power block and associated infrastructure for a CSP facility are essentially the same as for a conventional thermal power station. A power block includes a steam turbine and generator which is normally housed in a specifically constructed building (steam turbine hall). The associated generator transformer and a small substation will be established outside of the building. The exact positioning of the power block and associated substation depends on the final positioning of the solar field (solar generating components).

2.4.6 Establishment of Ancillary and External Infrastructure

Other activities which form part of the scope of establishment of ancillary and external infrastructure include may include:

- Water supply connection (discussed in step 11 operational phase);
- Waste water treatment works and dams (discussed in step 11 operational phase);
- Installation of foundations for infrastructure such as transformers, control buildings;
- Creation of formal drainage and stormwater control measurers(discussed in step 11 operational phase);
- Delivery and installation of solar modules and associated infrastructure;
- Topsoil stockpile and Subsoil stockpile area;
- Construction of Electrical Components;
- Construction of perimeter fencing and other fencing (A 2.1m high diamond mesh fence is proposed as a boundary fence plus the internal portioning of the individual IPP plots); and
- Buildings infrastructure.

The list of building infrastructure required (as identified by the feasibility study) to support the solar park to meet its operational requirements is as follows:

- Workshop Buildings;
- Ablution Facilities;
- Offices;
- Parking;
- Solar Technology Demonstration area;
- Central solar data measurement/research facility;
- Security booths for access control;
- Water treatment control building;
- Security Centre;
- Visitors Centre;
- Staff Accommodation;
- Cafeteria; and
- Warehouse facilities.

2.4.7 Connection to the Electricity Grid

In addition to the existing 132kV line, the anticipated grid upgrade that would be required for the Solar Park will bring a new 400kV line to the area that is ultimately expected to connect the Main Solar Substation (MSS) to Upington and the rest of the transmission network. This grid connection is part of the Eskom Solar Park Integration Project 5 (**DEA Ref No: 12/12/20/2610**) scope of work undertaken by Eskom.

The proposed Solar Park point of connection is on the western end of the site which is considered to be optimal for access to the power corridor servitude. This is also considered to be optimal given the proposed location of the Main Solar Substation to the south west of the Solar Park. The Eskom CSP proposed power corridor is not expected to have an impact on the Solar Park as the servitude orientation will help to avoid the OHLs having a shading impact on the Solar Park. The Main Transmission Substation that the Solar Park will ultimately connect into falls under the scope of work being undertaken by Eskom as part of their Upington Solar Park Integration project. Refer to **Figure 2.2** for the proposed location of the MSS.

2.4.8 Undertake Site Remediation

After the project has been completed, all affected areas are rehabilitated to as close to their original status as possible. Landowners sign off release forms to confirm the rehabilitated status. When the Solar Park is commissioned any access points which are not required in the operational phase must also be closed and rehabilitated.

2.5 Operational Phase

The Operational Phase includes the testing and commissioning of solar park components, water and waste management including the actual solar park operation and maintenance.

2.5.1 Water supply, use and treatment

The CSP technologies especially require sufficient and suitable water for operation as it functions through steam generation to drive a conventional steam turbine.

The option to source water from the //Khara Hais municipality via a pipeline along the N14 or N10 is considered to be the most viable option, which would entail pumping water to the site from the existing municipal water treatment works in Upington. An existing water pipeline which will require upgrading is located along the N14 although the suggested route for the supply of potable water to the site is via the N10 national road as it is a more direct route to the highest elevation on the site. The feasibility study has discussed the municipal water capacity and initial discussions indicate that the water required for the Solar Park which is approximately 3030m^3/day can be met by the municipality as they are also a water services provider.

Two 2,000m^3 capacity potable water reservoirs are planned for the most northern part of the site. These reservoirs will be supplied with bulk water from a pumped system from the //Khara Hais Municipality water treatment works situated in the town. These reservoirs will provide 48 hour storage for the potable water demands for the entire site, should the supply from the municipal fail to be consistent. A gravitational below-ground piped water reticulation system will follow the main collector road supplying metered off-takes to each of the IPP sites as well as the administration area on the southern boundary. The potable water system is to supply water to the buildings as well as boiler water for the generation of steam for the CSP facilities. During emergencies, water can be trucked to the site.

The final solar park water requirements are presented in **Table 2.7** below. These water requirements are considered to be conservative, and the inclusion of PV technologies in the facility should result in a lower water usage requirement.

Table 2.7: The Solar Park water requirements (*Arup, 2014*)

Activity	Volume of water required (kl/day)
Fresh water for human consumption	**30**
Clean CSP panels which comprises:	**2,000**
• **Recycled water (50% of total)**	**-1,000**
• **Fresh water required for daily cleaning**	**=1,000**
Non-recycled water for steam cycle	**2,000**
Total fresh/non-recycled water required	**3,030**

The figures in the above table are based on the following (Arup, 2014):

- Fresh water for humans; 600 people at 50 litres/person/day = 30m^3
- To clean CSP panels; 100 000 m^3 per 100MW per year; assume CSP will be 1 GW; 100 000 m^3 x 7,5 = 750 000m^3/year Total of 2 005m^3/day when expressed per day
- This 2 005m3/day (fresh water) required for daily cleaning (CSP/PV) therefore ~2 000m^3 is required per day and 50% is assumed to be recycled therefore top up of 1 000m^3/day is required.
- Non-recycled water for water steam cycle= 2,000 m^3/day
- An additional 25% has been added to steam cycle total to account for IPP design and water calculation variations.
- ***The estimated quantities are worst case and this is a water scarce area; therefore there is a need to consider minimal water usage and possibility of dry cooling methods for CSP.***

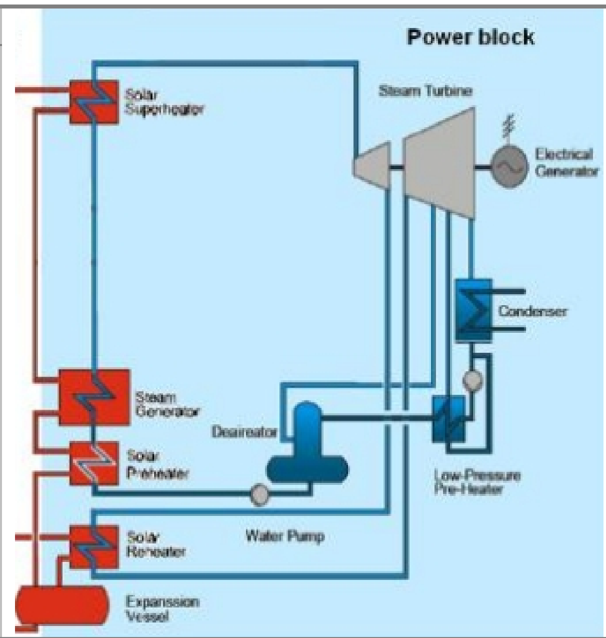
Stormwater

The stormwater run-off along the main access road will be controlled by side swales and dispersed in a controlled manner at regular intervals. Stormwater runoff from the panels and solar collectors will be collected into the wash water reclamation system. Stormwater run-off from the buildings will be disposed of through soakways. A formal piped stormwater system is not envisaged for the wider site. Water will be managed on the surface and dispersed into natural drainage routes.

2.5.2 Waste Management Activities (waste water treatment and sewage)

A basic flow chart (**Table 2.11**) for the general operation of a Solar Thermal Plant (PT or CR) shows the inputs and the outputs of these technologies.

Table 2.8: Basic Operational Phase Process Flow for a Solar Thermal Plant

INPUT		***OUTPUT***
Solar energy		*Positive output:* Energy / Electricity
Water		*Negative output:* Waste Water
Fossil fuel start up (small boiler)		*Negative outputs:* Exhaust fumes /Co^2
Chemicals used for waste water treatment processes		*Negative outputs:* Waste water / brine to evaporation pond

Waste Water Treatment

A waste water treatment plant (WWTP) is planned to service the entire Solar Park site which will form part of the Solar Park main infrastructure. The WWTP maximum design capacity is anticipated to be 4000m^3 /day. About 1000m^3 will be reused for washing of panels after treatment and about 3000m^3 to be discharged from the site or released into evaporation ponds which is anticipated to form part of the WWTP.

The typical water input to the WWTP from the different Solar Park components may include:

- Mirror wash-down water;
- Steam blow down from boilers;
- Reverse Osmosis Plant;
- Electrodeionization system (EDI); and

- Rain water from plant areas.

The exact details of the WWTP will be confirmed at a later design stage and will be discussed in more detail in the EIA phase.

<u>Sewage</u>

Sewage from the buildings and toilets across the site will be discharged into various septic tank systems. The soakway systems will be designed with sufficient spare capacity to accommodate the possibility of excessive usage above the anticipated average. This option is by far the most cost effective system for this project. It is to be considered that a well-constructed and maintained septic tank should be odourless and problem free. Other sewerage treatment options are either individual sewer treatment package plants at each of the IPP sites or a single plant at the southern end of the site.

The negative aspects of these other options when compared to the septic tank option are the following:

- The capital cost of 15 individual package plants or the large one on the southern boundary is significantly high.
- The long sewer pipe would have to run across the site with relatively low flows which could result in blockages and sediment build-up.
- Package plants require daily maintenance, including the purchasing of chemicals; and therefore require high maintenance costs.

2.5.3 Solar Park Operation and Maintenance

The Solar Park Concessionaire (SPC) to be established and discussed above will be responsible for the operation and maintenance of the Solar Park infrastructure. A centralised maintenance, security and fire protection services will form part of the SPC model. The IPPs will be responsible for operation and maintenance of their individual IPP facilities.

2.6 Decommissioning phase

Solar facilities are likely to have an operational lifetime of 26 to 30 years or more. The most likely scenario would be extension of the lifespan of the solar facilities by means of replacing individual components with newer more appropriate technology available at that time. The activities which will form part of the Solar Park EIA will thus focus on the replacement instead of full decommissioning.

The EMP will outline all activities that have to be undertaken, where they will take place, the responsible person/s, all possible environmental or social impacts, the mitigating measures, the rehabilitation plans, the monitoring methods, the frequency of monitoring and the performance indicators in terms of proposed decommissioning.

2.7 Conclusion

This chapter provides a description of the proposed development and describes the alternatives and the various components of the Solar Park. It further discusses the infrastructure and the need for certain services and resources during construction. Finally, the various steps in planning, constructing and operating a Solar Park is discussed and illustrated.