



Showcase - Mildura CPV Power Facility

David Barshevski & Daniel Ruoss, Solar Systems P/L

Date: 09/12/2011

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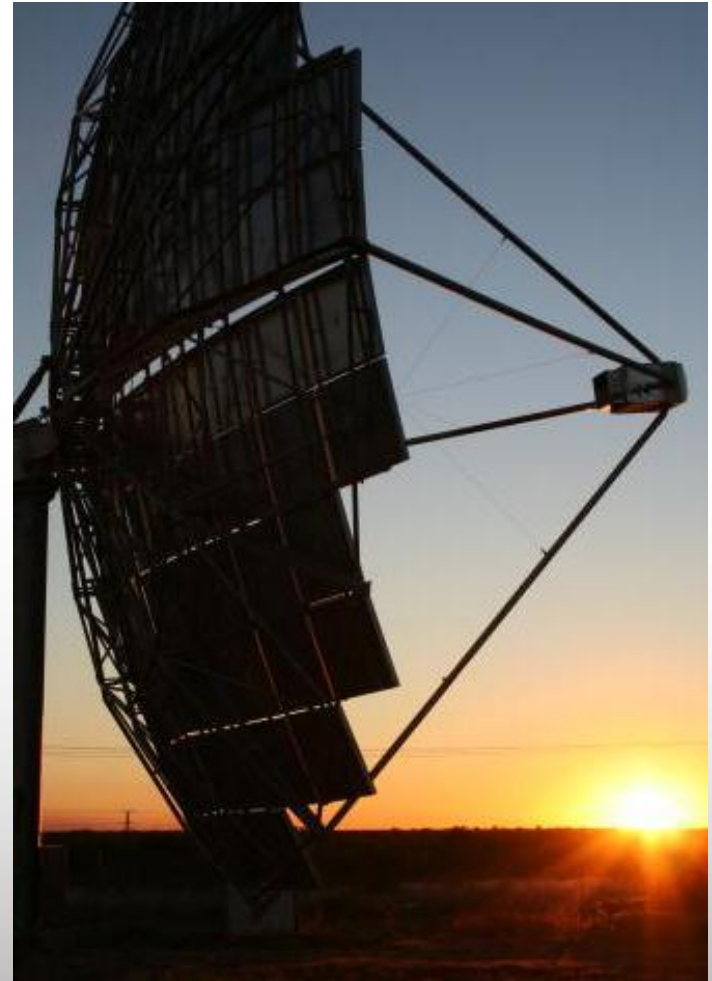
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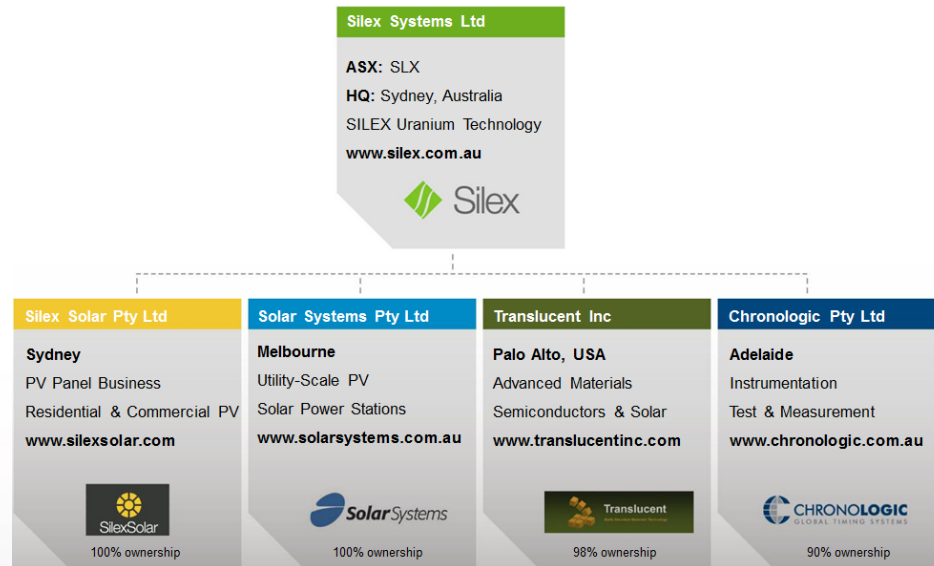
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- Solar Systems – Company Profile
- Introduction to Mildura Project
- Existing Electrical Grid Infrastructure
- CPV Performance Profile
- Resulting Issues
- Conclusions
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Solar Systems – Company Profile

- Solar Systems Pty Ltd is a wholly owned subsidiary of Silex Systems.

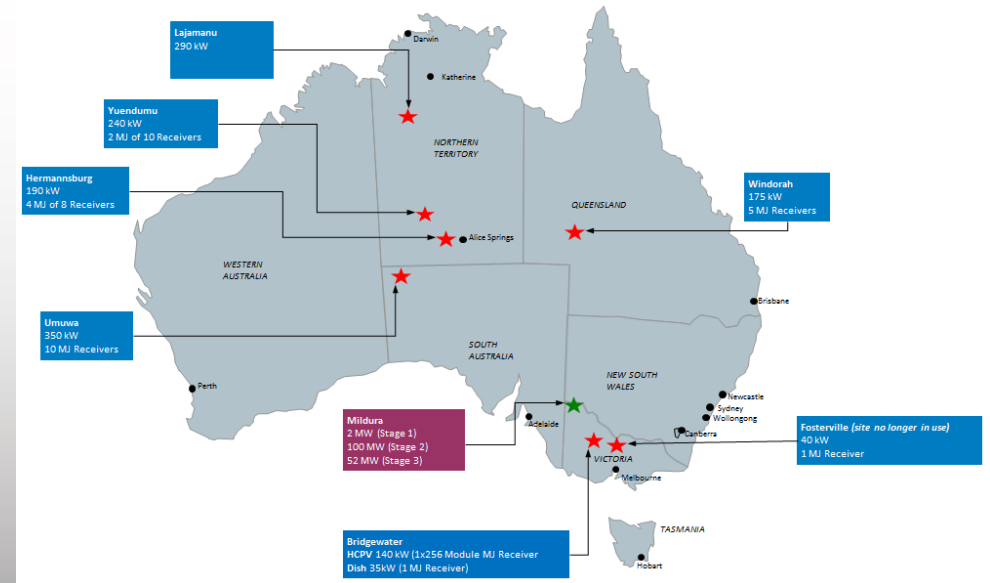


- Solar Systems has been developing world-leading Concentrating Photovoltaic (CPV) technology for 20 years in Melbourne, Australia.
- Solar Systems CPV technology based on the unique '**Dense Array Converter**' concept using the most efficient solar cells in the world (currently ~40%).

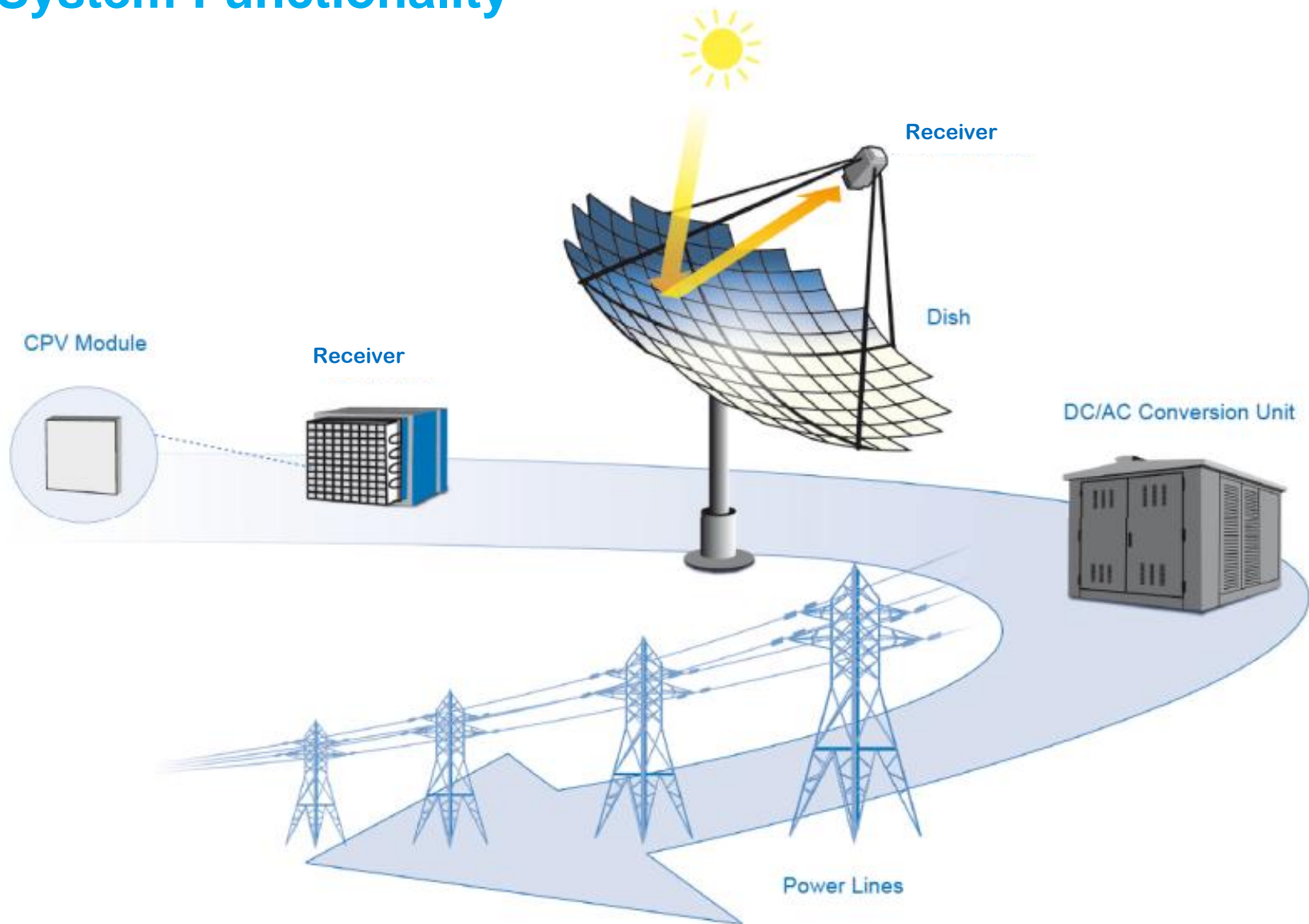
Solar Systems CPV Solar Plant Operating Experience

10+ Years Operations with 5 CPV Installations

- 5 power plants installed in central Australia.
- Triple Junction Cell introduced 2005 – 2 * efficiency of silicon cells.
- 1.2MW reliable, integrated, manageable power stations commissioned.
- Over 100 dish years of experience.

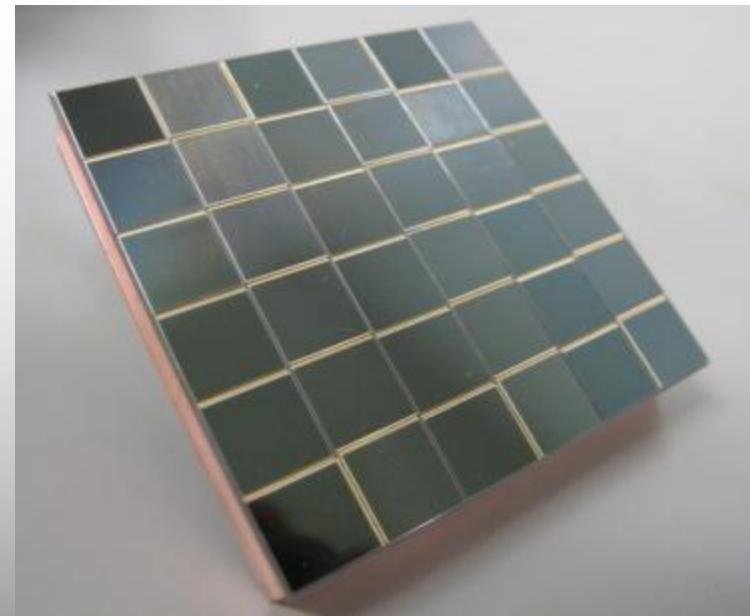


System Functionality



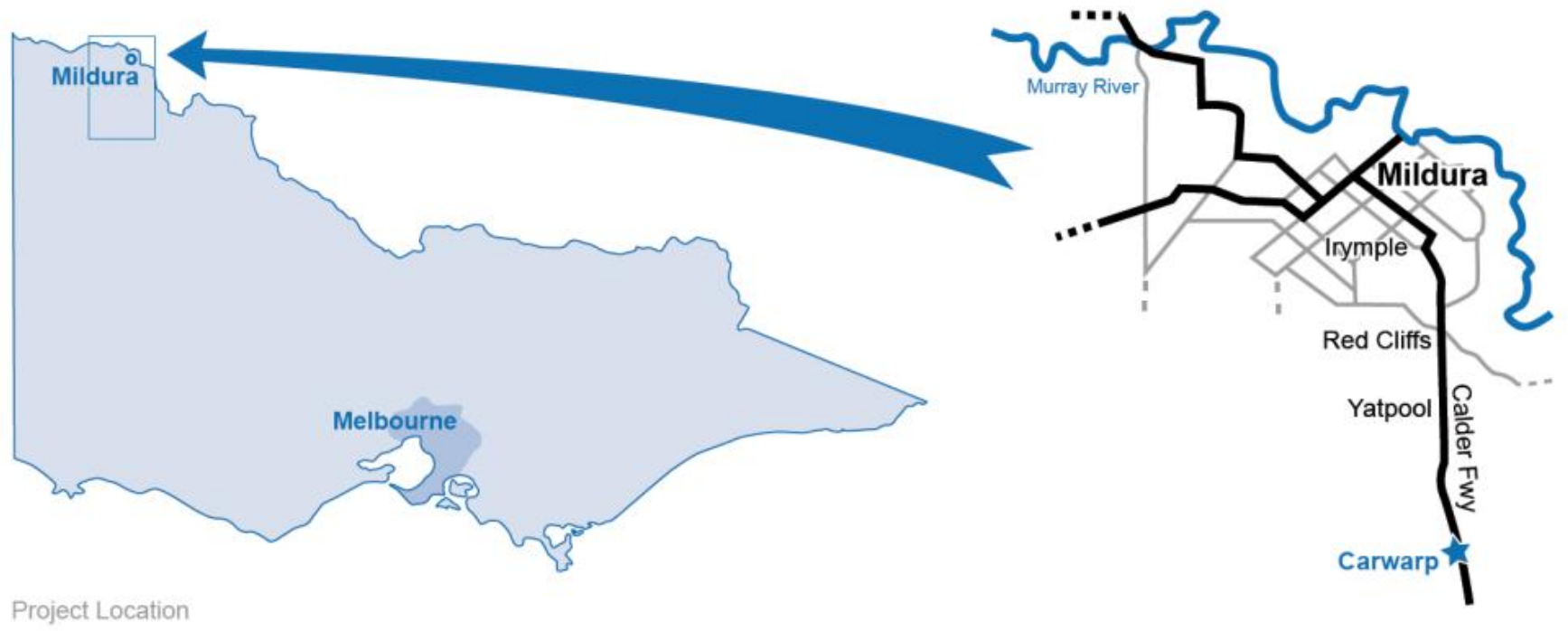
Key Advantages of 'Dense Array' CPV Technology

- Based on ultra-high efficiency triple junction cells (now ~40% cells, future ~50+%).
- Very low land requirements (5 acres per MW).
- Lower PV Cell Operating Temperature by active closed-loop fluidic cooling provides:
 - ⇒ Higher conversion efficiency
 - ⇒ Higher reliability of module
 - ⇒ Very low water consumption
- Highly modular, easily replaceable parts, high system redundancy, double-axis tracking.



Introduction to Mildura Project

- Permitting requirements completed (Environmental Management Plan, etc.).
- Construction planning work commenced, located in Carwarp, south of Mildura.



Introduction to Mildura Project

- Permitting requirements completed (Environmental Management Plan).
- Construction planning work commenced, located in Carwarp, south of Mildura.
- Stage 1 sized to approx. 2MWp and connected to the local 22kV distribution grid (PowerCor).
- Community engagement ongoing (WIN TV, Mildura Weekly, ABC Radio, etc.).



Artist Impression



Timeframe

1. Technology Commercialisation Program

- Target completion date  Q1 2012

Funding contributions of \$5 million (VIC Government) and \$1.88 million under APP Funding (Asia-Pacific Partnership on Clean Development and Climate)

2. Mildura Stage 1: approx. 2MW Pilot Demonstration Facility

- Target Date - Construction commencement  Dec 2011
- Target Date - Commissioning  Q4 2012

3. Mildura Stage 2: 100MW Solar Power Station

- Target Date - Construction commencement  2015

Up to \$120 million government funding support for Stages 1 and 2:

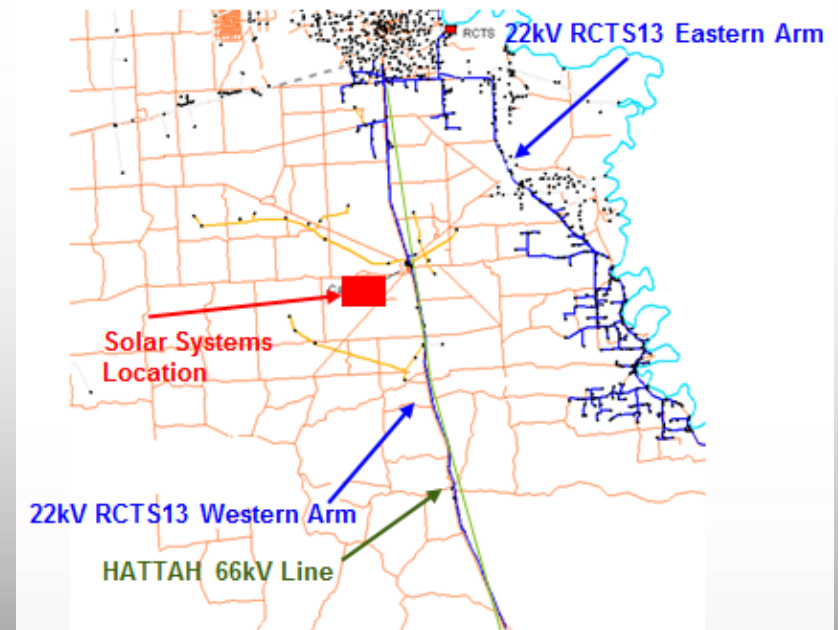
Up to \$75 million funding from Federal Government (Low Emissions Technology Demonstration Fund) and up to \$45 million funding from Victorian Government.

Existing Electrical Grid Infrastructure (66kV and 220kV)



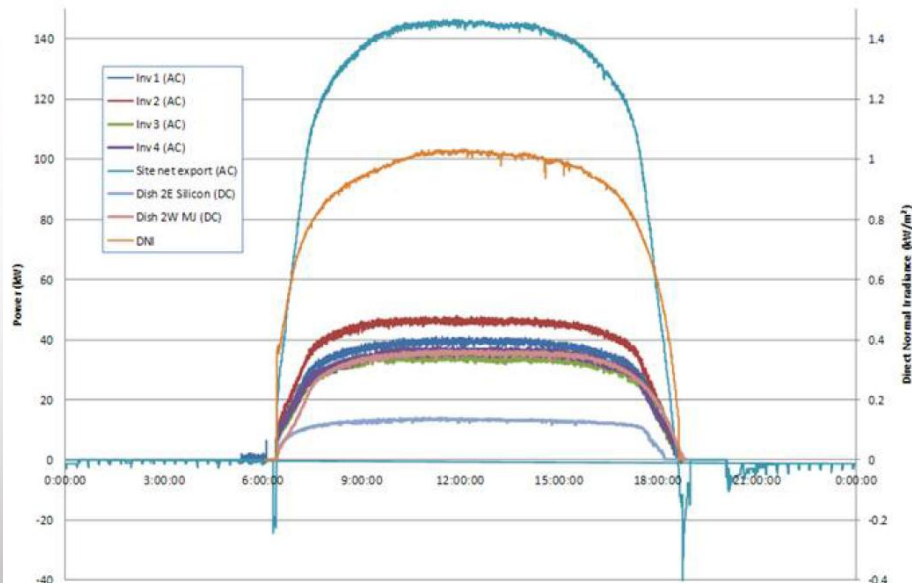
Existing Electrical Grid Infrastructure (22kV)

- RCTS13 is a 'rural long' feeder, 157km long with two distinct arms:
 - Eastern Arm: 78% of the feeder demand.
 - Western Arm: 22% of the feeder demand and Solar Systems point of connection.
- The RCTS13 (E&W) load varies from 9.9MVA in the high load case to 2.8MVA in the low load case.
- Steel conductor (ACSR/GZ) is old.

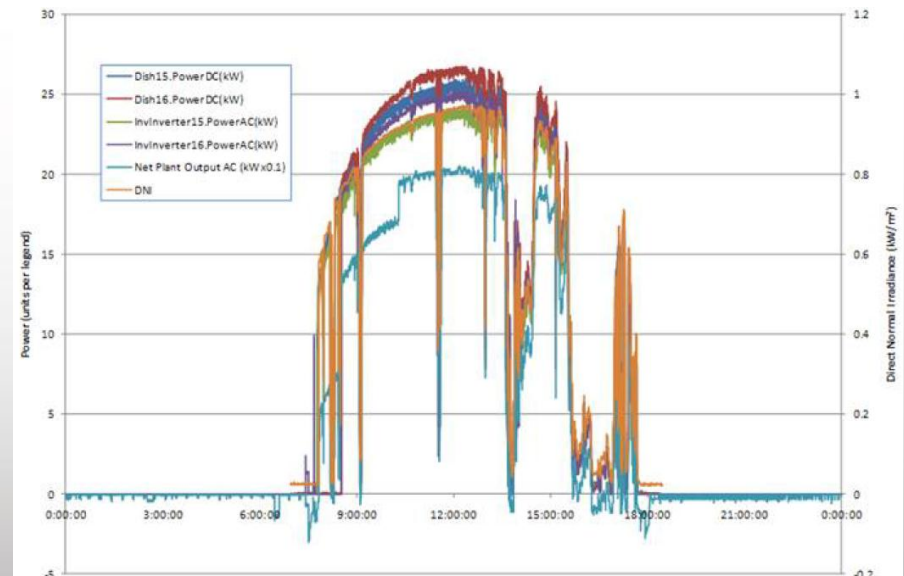


CPV Performance Profile

- CPV utilizes reflective optics or lenses to concentrate the sunlight at x times on a multi-junction high-efficiency cell.
- The CPV power dispatch fluctuates instantly as a result to irradiance interference such as clouds.



Performance profile during a clear day



Performance profile during a cloudy day

Impact Concerns

- **Steady-state:** Thermal loading and voltage during normal operations.
- **Fault levels:** To demonstrate mitigated impact on short circuit levels.
- **Stability:** Meet acceptable levels of oscillations, damping, transient stability and long-term stability when integrated with an existing grid.
- **Switching:** Should not exceed allowable delta-V at the load and transmission buses.
- **Power Quality:** Power factor, voltage flicker and harmonic distortion.

Resulting Issues

Grid-Connection – Steady State

- Detailed grid-connection modeling required in order to understand the impact of the solar generator at point of connection and along the distribution (or transmission) lines ⇒ PSS®E or DigSilent.

⇒ Very critical to be addressed during the site evaluation.

- Distribution infrastructure (11kV to 66kV) in urban areas suitable for larger-scale solar generators to be connected.

However, in rural areas it tends to be old and requires replacement or reinforcement (e.g. conductor, poles, etc.), and could potentially limit (or make it costly) the connection of an intermittent power generator (wind, solar).

Resulting Issues

Grid-Connection

- 66kV for up to 5MW too costly (at least \$4 to \$6 million), more power capacity makes it viable again.
 - ⇒ Find 'sweet spot' for grid-connection (cost, thermal capacity, benefits, etc.)
- Cost-sharing of grid-connection assets (e.g. substation, hub) on 66kV or 220kV would enable increased viability of several projects. Not pioneer scheme (first-come first-pay) but cost-share as per thermal capacity used.

Resulting Issues

Quality of Supply (as per Electricity Distribution Code)


- Voltage Variations @ Steady State ($\pm 10\%$ rural areas / ($\pm 6\%$ urban areas)).
 - ⇒ Feeder voltages change in 7.9% in 'High Load' and 7.8% in 'Low Load' as a result of our CPV power generation injected (old conductor and weak grid).
- Power Factor (0.80 minimum leading & lagging).
 - ⇒ Power Factor can be easily corrected with inverters and additional compensators.
- Harmonics (2% Odd / 1% Even \Rightarrow 3% Total).
 - ⇒ Harmonics are strongly depending on the selected inverters. Select quality products only!

Resulting Issues

Quality of Supply (as per Electricity Distribution Code)

- Voltage Fluctuation (as per AS/NZS 61000.3.7:2001)

Voltage fluctuations at MSPS allowed
with upgrade conductor



Voltage fluctuation limits as per AS/NZS 61000.3.7:2001	
r (hour ⁻¹)	$\Delta V_{\text{dyn}}/V_N$ (%, at 22kV)
$r \leq 1$	4
$1 < r \leq 10$	3
$10 < r \leq 100$	2
$100 < r \leq 1000$	1.25

- ⇒ A potential challenge if injecting in weak and old feeder, and under cloudy conditions.
- ⇒ Voltage regulators are not suitable solution for Solar (PV & CPV) since the frequent changes in the power dispatch of the plant will deteriorate the regulator.

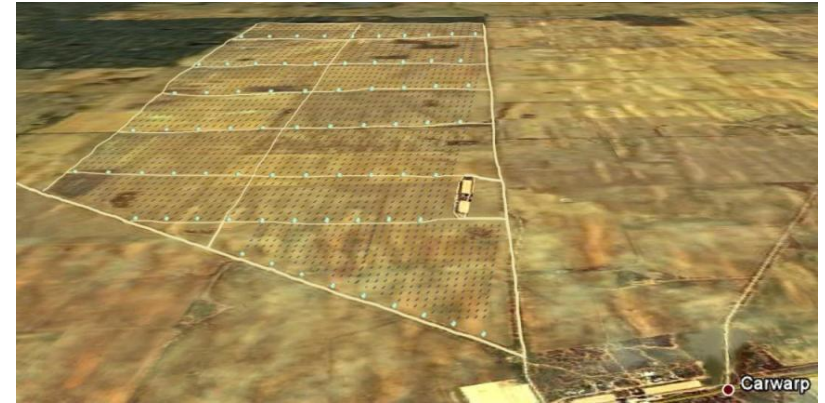
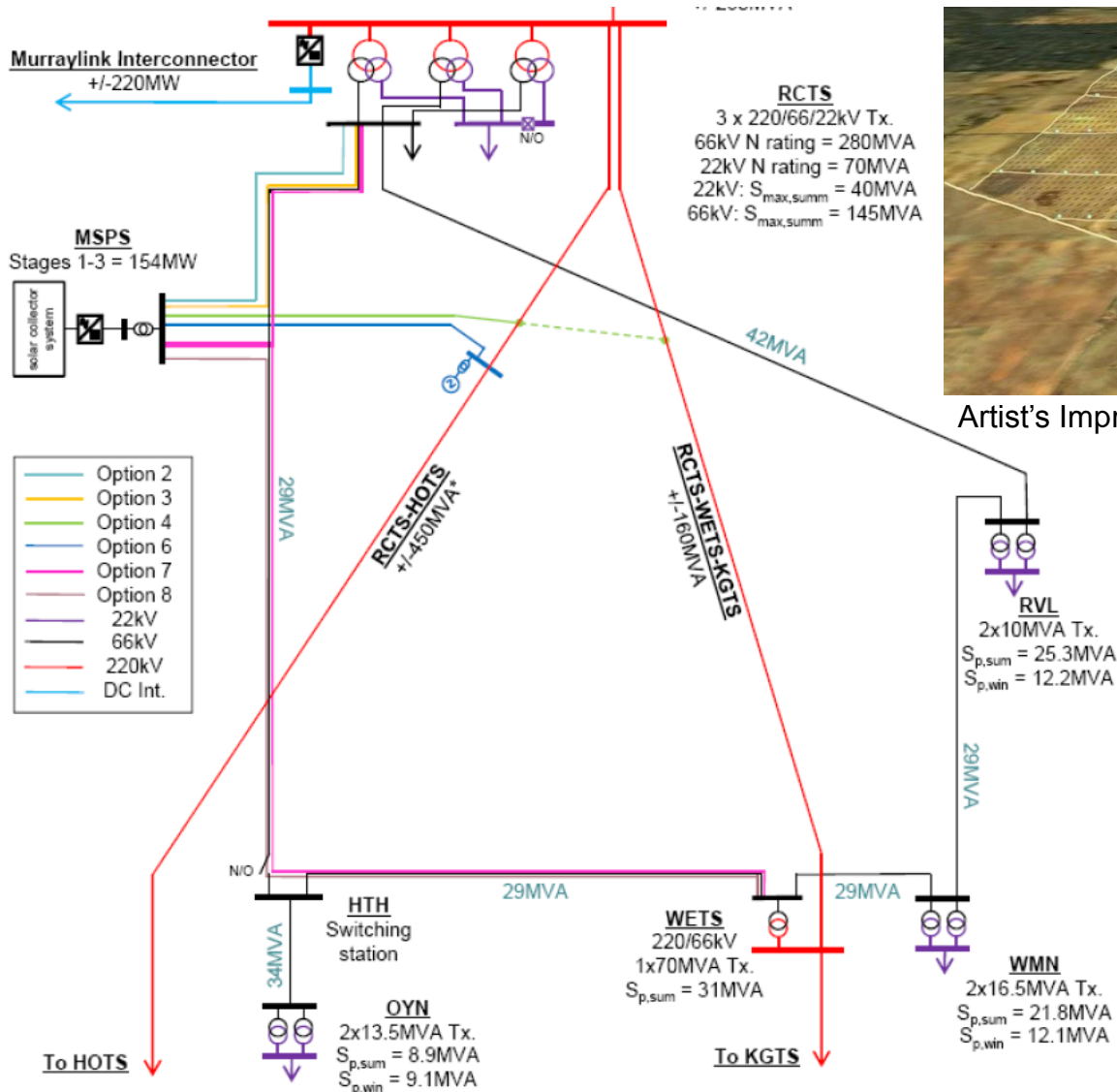
Resulting Issues

Alternative Voltage Control Solution

- Smart grid-connected inverters and Static VAR Compensator (SVC) can assist the local distribution grids to regulate the voltages with the supply of reactive power (leading or lagging) for effective power management.
- ⇒ Reactive Power Control is an ideal solution to make optimum use of grid distribution capacities for larger-scale Solar power plants.



Future Plans – Mildura Stage 2



Artist's Impression: 100MW Mildura Solar Power Station



Conclusions

- Site assessment requires a strong focus on grid infrastructure modeling.
 - ⇒ A good spot for grid integration can potentially save few million Dollars for a x MW Solar power plant.
- Use high quality and field-tested inverters only. Smart centralized inverter solutions offer additional capabilities, such as low-voltage-rid-through (LVVRT), VAR (power factor) control, dynamic control, etc.
 - ⇒ Helps to improve the grid system stability and allows Solar to be part of the utility system.

Conclusions

Utilities and independent power providers (IPPs) show tremendous interest in the three phase inverter's capability to absorb and provide reactive power Q (kVAR) from and to the grid.

Over 95% of the time a PV inverter is running below its rated output power. The unused capacity of the inverter can then be put to use to produce reactive power.

⇒ Reactive Power Control is an ideal solution to make optimum use of grid distribution capacities for larger-scale Solar power plants.

Conclusions

- Revision of grid codes/standards to have Frequency RT and LVRT, and other measures implemented.
 - ⇒ Way forward for high penetration PV markets (grid), as it increases the ability for better planning and control of the dispatch.
- Control the intermittency with smart forecasting and potentially with energy storage solutions, e.g. sodium-sulfur (NaS) battery.

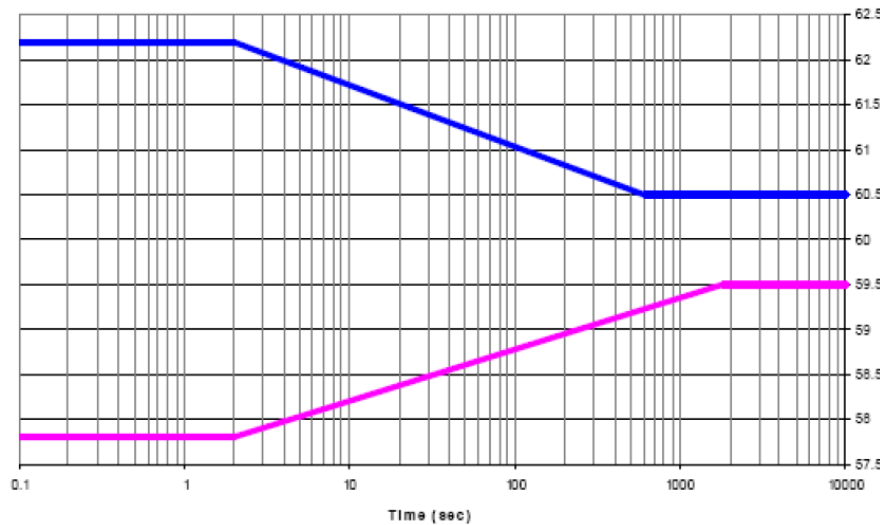
(subject to viability assessment)



Issues for Discussion

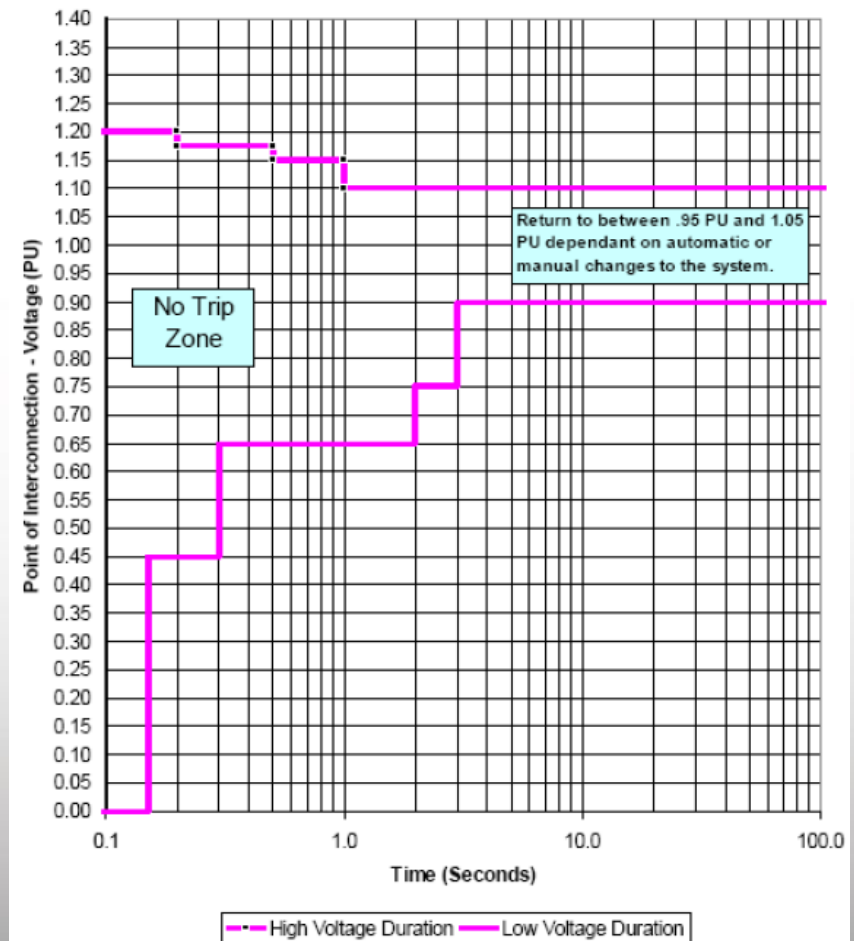
Frequency RT and LVRT (Example NERC - USA)

OFF NOMINAL FREQUENCY CAPABILITY CURVE



⇒ Need to operate as a traditional power generator, with utility-friendly features for solar in high penetration grids.

Voltage Ride-Through Time Duration Curves



Issues for Discussion

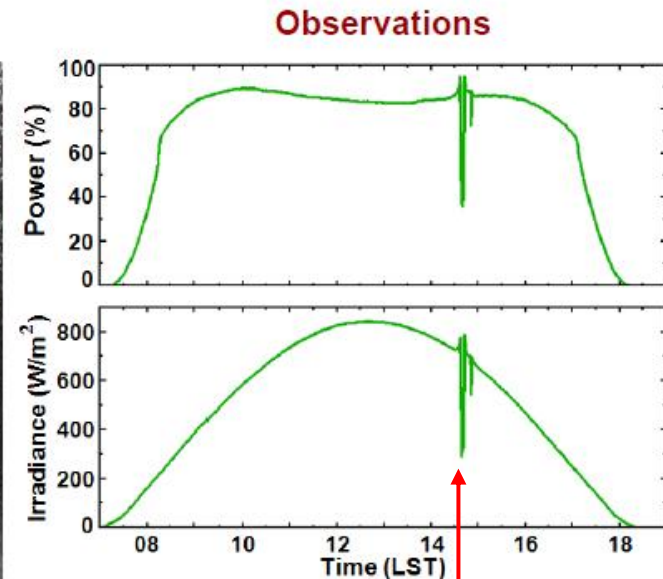
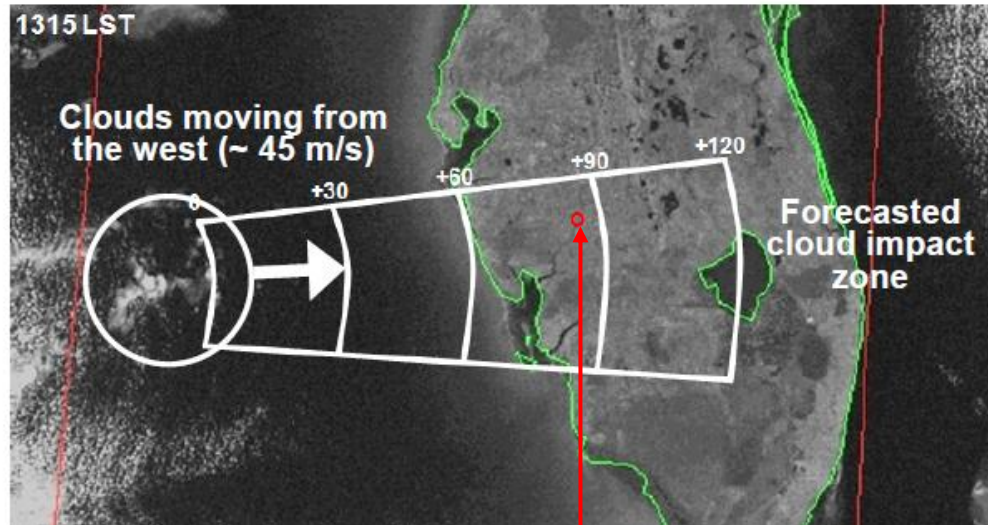
Reactive Power Control

- VAR control greatly enhances grid stability and reduces line transmission losses.
- The reactive power capacity of a smart PV inverter can be used as a fast-acting static VAR compensator, controlled either through a supervisory control and data acquisition (SCADA) system or as a stand-alone voltage regulator and acting as either a shunted inductor or capacitor decreasing or increasing the AC voltage along the line.
- The great benefit of this implementation is that it comes at very little additional component cost.

Issues for Discussion

Forecasting Capabilities

⇒ Dealing with Cloud Intermittency and Despatchability:



- Satellite and land-based (short-term) solar forecasting.
- Optimal blending of the methods ⇒ bridging the gaps smoothly between time.



Thank You