Breakout session: CPV1

Discussion leaders: Peter Hebert & Greg Flynn

8:00 – Daryl Myers (NREL) – Solar Resource Data for CPV

8:30 – Matthew Muller (NREL) – Spectral Effects in CPV Performance

9:00 – Discussion of Solar Resource Issues for CPV

9:30 – Break

10:00 – Ian Aeby (Emcore) – Failure Modes of CPV Modules and How to Test for Them

10:30 – Nick Bosco (NREL) – Thermal and Current Cycling for CPV Qualification

11:00 – Discussion of Failure Modes in CPV

MYERS SUMMARY

- Measured data SPARSE and EPISODIC
- Specialized Measured Data available
- Measured-Model broadband difference patterns ~ 10% - 15% Typical
- Uncertainty Function of Site, INPUT data and REFERENCE DATA uncertainties
- Data Sources PROLIFERATING; benchmarking is a RESEARCH project !!
- International Energy Agency Task 36 on Solar Radiation Knowledge Management http://www.iea-shc.org/task36/index.html
  - U.S. Satellite (SUNY) Uncertainty comparable European Estimates (state of the art)

NOTE: MODELS CONTINUOUSLY EVOLVING !

Measurements AND models: Similar Uncertainty Limits:

5% - 10% Global Month Mean Daily Total

10%- 15% Direct Month Mean Daily Total

Statistics help, but this is essentially WEATHER data!

Rating Conditions: DNI ~ 900 W/m^2 appropriate compromise with GNI, Flat Plate ~ 1000, and DNI Reference spectrum

Muller Summary

- CPV module performance data clearly shows spectral sensitivity
  - Clearly defined AM response peak
  - Relative sensitivity to changing AM can be determined
- PVUSA ratings taken on a monthly basis vary from 5-10%, most likely a result of spectral sensitivity
- Spectral sensitivity, as measured through an AM correction factor for 2009 data, results in significant deviations in energy production.
  - 2.2% deviation between modules
  - 7% deviation between spectrally sensitive module and a module with a fixed efficiency
- Future work will examine specific impact of AM, PWV, and Turbidity on Normalized Isc

Discussion summary – CPV Spectral Issues

- Module sensitivity very dependent on optics and optical transfer function
  - varies between manufacturers
- Open question as to the source of AM-sensitivity variation
  - aerosols
  - thermal expansion can change the focus
  - water absorption changes the optics
  - temperature

continued...

- Need to revisit standards for measurement conditions
  - eg. actual cell temp or heat-sink temp
  - isotype cells instead of multijunction cells
- Proposal to package MJ reference cells with appropriate optics and deploy around the country
  - develop a more applicable data set
  - Is the data transferable if the cell design changes?

Aeby - In Conclusion

- Rel Prediction is a tough business.
- CPV modules and systems are complex and opportunities for failure abound.
  - Examples:
    - EL can help discriminate shunting problems in the various subcells
    - Observations of “thermal runaway” following ESD damage
    - Electrolytic corrosion at contacts almost always seen in damp-heat tests

- The IEC 62108 suite of CPV module/system qualification tests provide an excellent baseline for beginning-of-life performance but little insight into long-term reliability.
  - Accelerated Life Tests at high concentration levels are difficult to implement.
- Hermeticity at the receiver subassembly level is critical.

summary: I and T cycling for CPV qualification

Nick Bosco, Cassi Sweet, Adam Stokes and Sarah Kurtz

- IEC 62108 Section 10.6: Thermal Cycling cannot be executed as written.
- Additional temperature excursions due to current cycling does not accelerate damage.
- Current application up to 4A/cm^2 is benign to the cell though will cause failure if large cracks/voids exist under bus-bar.
  - Are these representative of on-sun failures?
  - Unacceptable amounts of and sized voids/cracks not detected through failure.

- Proposed amendments to IEC 62108 Section 10.6: Thermal Cycling
  - Current application should be reduced to when T>25 C (similar to IEC 61215).
  - Cell current density level should be reduced to 4 A/cm^2 or J_{sc}.
  - Additional requirement should limit the percentage of voids/cracks as detected via an appropriate imaging technique. Alternatively, modules should be subject to an on-sun exposure for a designated time and irradiance.

Discussion summary – CPV failure modes/mechanisms

- Thermal stresses between cell and substrate/dye vs stresses within cell
- 62108 under revision
- “Hermiticity” - how is it defined for the module vs the receiver
  - do we need a better test than wet-insulation qual test?
  - biased damp-heat test would be more informative

continued...

- General observations that real cell/receiver damage may not be reflected in the IV curves
  - eg. EL or IR images show voids despite good performance of the cell
  - Future work to estimate on-sun lifetime of these damaged cells