

2008 Solar Annual Review Meeting

Session: Grid Integration & Inverters



Development of an AC Module System

Miles C. Russell

GreenRay, Inc.

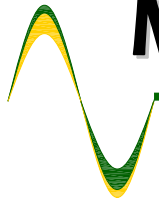
Project Objective

Create a Simpler PV System

- Easier system design
- Faster system installation
- Safer to work with
- Size flexibility
- Performance advantages
- Improved reliability
- Easier performance monitoring



Lower cost
energy to
the
customer



Meeting DOE Goals

| TIOs | | Metrics | | | |
|---|----------------------------------|------------------------|------|-----|-------------|
| Tier 1 TIOs | Tier 2 TIOs | Performance Efficiency | Cost | O&M | Reliability |
| Modules | Module | | | | |
| | Cells and Contacts | | | | |
| | Interconnects | | | | |
| | Packaging | | | | |
| Inverter & BOS | Inverter | x | x | x | x |
| | Inverter Software | | | | |
| | Inverter Components/Design | | | | |
| | Inverter Packaging/Manufacturing | | | | |
| | Inverter Integration | x | x | | |
| | Other BOS | | | | |
| System Engineering & Integration | System Engr. & Integration | | x | | |
| | System Manufacturing/Assembly | | | | |
| | Installation Maintenance | | x | | |
| Deployment Facilitation | | | x | | |



The GreenRay Team

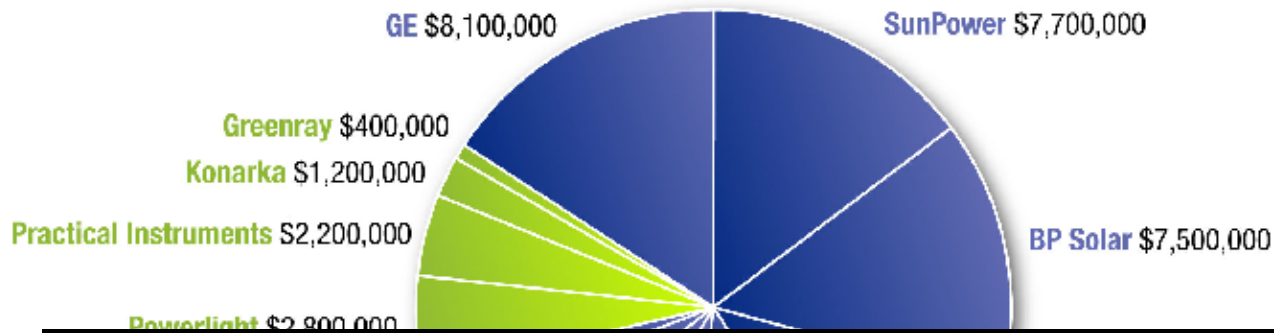
GreenRay is leading the team

Our key partners:

- World class PV module manufacturer
- PV installers
- Electric utilities
- Sandia, NREL, SWRES, SERES

Budget Summary

TPP Project DOE Funding Breakdown: Year One



| GreenRay, Inc. | | | | |
|----------------|---------|---------|---------|---------|
| Award Date | Phase 1 | Phase 2 | Phase 3 | Total |
| July 2007 | \$1.04M | \$1.15M | \$2.85M | \$5.04M |

Subsystems Total:
\$6,600,000

Total Funding:
\$51,600,000

Systems Total:
\$45,000,000



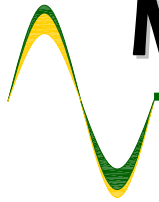


Development Activity

Innovative Micro-Inverter

Frame and Mounting System

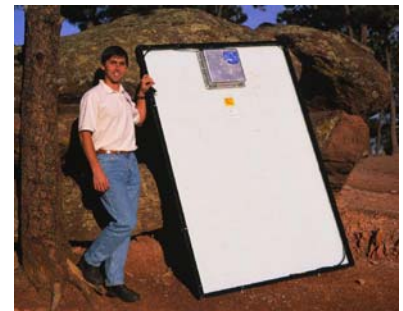
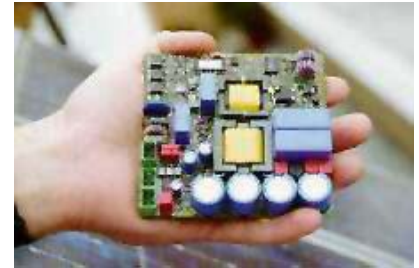
Data Communication Elements

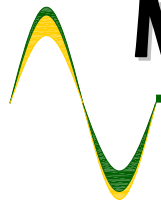


Micro-Inverter

Accomplishments

- Reviewed AC module history →
- Thermal issues analyzed; outdoor experiments conducted; thermal environment of a PV module characterized
- Design study completed; approach selected;
- Alpha prototype fabricated in desired form factor for optimum integration and heat rejection
- Design reviews completed – reliability, emissions, construction, etc.
- Bench testing underway





Micro-Inverter

Next Steps

- Tweak the design; fabricate Beta version
- Sequence of thermal and electrical stress tests
- Operational testing to standards
- Accelerated lifetime testing



Frame and Mounting System

Accomplishments

- Stakeholder input and concept review
- Innovative frame and mounting system design developed; IP generated
- SLA prototypes fabricated for form and fit evaluation

Next Steps

- Fabricate Alpha prototypes
- Full-scale tests
- Stakeholder review

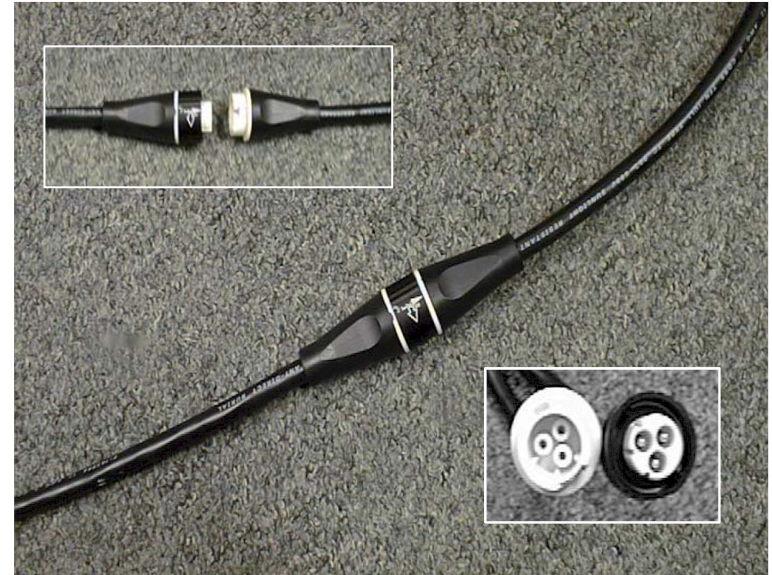
Plug and Play Wiring

Accomplishments

- Design and engineering of components underway

Next Steps

- Fabricate prototypes
- Evaluation and review with stakeholders
- Finalize, obtain certification



Quick Connectors from an early AC Module circa 1998



Data and Communications

Accomplishments

- Specifications created for data communications in the AC Module System
- Technology options researched; design approach developed; IP secured
- Communications circuitry incorporated in Alpha micro-inverter

Next Steps

- Communications demonstrated in lab



Looking Ahead...FY 08/09

Key Challenge

- Develop a reliable micro-inverter that can withstand the harsh thermal environment under a PV module

Main Activities

- Finalize all elements of the AC Module System
- Testing, testing and more testing
- Behind-the-fence demos
- Plan for manufacture and market launch