



# **Solar Technology Test, Evaluation, and Data Collection**

## **Cooperative Research and Development Final Report**

**CRADA Number: CRD-08-279**

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## Cooperative Research and Development Final Report

In accordance with Requirements set forth in Article XI. Reports and Abstracts A.(3), of the CRADA agreement, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

**Parties to the Agreement:** Abengoa Solar PV Inc

**CRADA Number:** CRD-08-279

**CRADA Title:** Solar Technology Test, Evaluation, and Data Collection

### **Joint Work Statement Funding Table Showing DOE Commitment:**

<b>Estimated Costs</b>	<b>NREL Shared Resources</b>
Year 1	\$ 50,000.00
Year 2	\$ 200,000.00
Year 3	\$ 200,000.00
Modification #1	\$ 60,000.00
Modification #3	\$ 63,000.00
Modification #4	\$ 475,000.00
<b>TOTAL</b>	<b>\$ 1,048,000.00</b>

### **Abstract of CRADA Work:**

Under this Agreement, NREL will work with Abengoa Solar Inc. on the testing, evaluation, and collection of data related to Abengoa Solar Inc. solar technologies and systems. This work includes, but is not limited to, testing and evaluation of solar component and system technologies, data collection and monitoring, performance evaluation, reliability testing, thermal energy storage integration, solar resource measurement and forecasting, grid impact testing, and analysis.

NREL will establish collaborative research activities with Abengoa Solar Inc. on the development of deposition methods for the fabrication of Cu(In,Ga)Se<sub>2</sub> (CIGS) solar cells. Tasks under this CRADA include, but are not limited to, investigating different approaches for the deposition of CIGS films, fabrication of CIGS solar cells, and evaluation of the CIGS thin films and solar cells. Deposition methods include conventional close-spaced sublimation (CSS) and hybrid vapor transport (HVT) of metal chlorides with selenium.

NREL will work with Abengoa Solar to model, design, evaluate cost, and implement a method to prevent the accumulation and buildup of hydrogen gas in the components of the Abengoa Solana power plant currently under construction in Gila Bend, Arizona. This work includes, but is not limited to, mathematical modeling, equipment specification, capital cost evaluation, equipment design, fabrication, and installation.

NREL will establish collaborative research activities with U.S. based Abengoa Solar PV Inc. on high-concentration photovoltaics (HCPV). NREL will perform two tasks:

1. Perform technoeconomic analysis of the Abengoa HCPV system, to guide its further development and to gain a better understanding of its competitiveness against other PV technologies and energy sources.
2. Develop and execute an experimental plan that will ultimately eliminate failure mechanisms from Abengoa's Generation 3 module.

This work will be conducted at NREL, SolarTAC (Aurora), and other field test locations.

**Summary of Research Results:**

In FY 2015, NREL patented a new technique for depositing CIS and CIGS thin films using chloride transport (U.S. Patent 9,054,264 B2) and demonstrated its functionality through making a 10.2% thin-film CIS device. NREL also began incorporating Ga-chlorides for making CIGS devices and were able to boost open-circuit voltage to over 640 mV. Our partner team at the Colorado School of Mines (CSM), also funded in parallel by Abengoa Solar, developed a new chloride injector design and prototype to increase film uniformity in our atmospheric-based chloride transport system. The patented chloride process has the potential to reduce equipment and operational costs by reducing high-vacuum requirements during deposition, reducing source heating requirements, and providing higher reactant throughput rates.

**Subject Inventions Listing:**

1. U.S. Patent No. 9,054,264, "SYSTEMS AND METHODS FOR SOLAR CELLS WITH CIS AND CIGS FILMS MADE BY REACTING EVAPORATED COPPER CHLORIDES WITH SELENIUM," issued June 9, 2015
2. International Application No. PCT/US13/28078, "SYSTEMS AND METHODS FOR FORMING SOLAR CELLS WITH  $\text{CuInSe}_2$  AND  $\text{Cu(In,Ga)Se}_2$  FILMS," filed February 27, 2013.
3. U.S. Application No. 14/382,106, "SYSTEMS AND METHODS FOR FORMING SOLAR CELLS WITH  $\text{CuInSe}_2$  AND  $\text{Cu(In,Ga)Se}_2$  FILMS," filed August 29, 2014.

**Report Date:**

8 March 2016

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