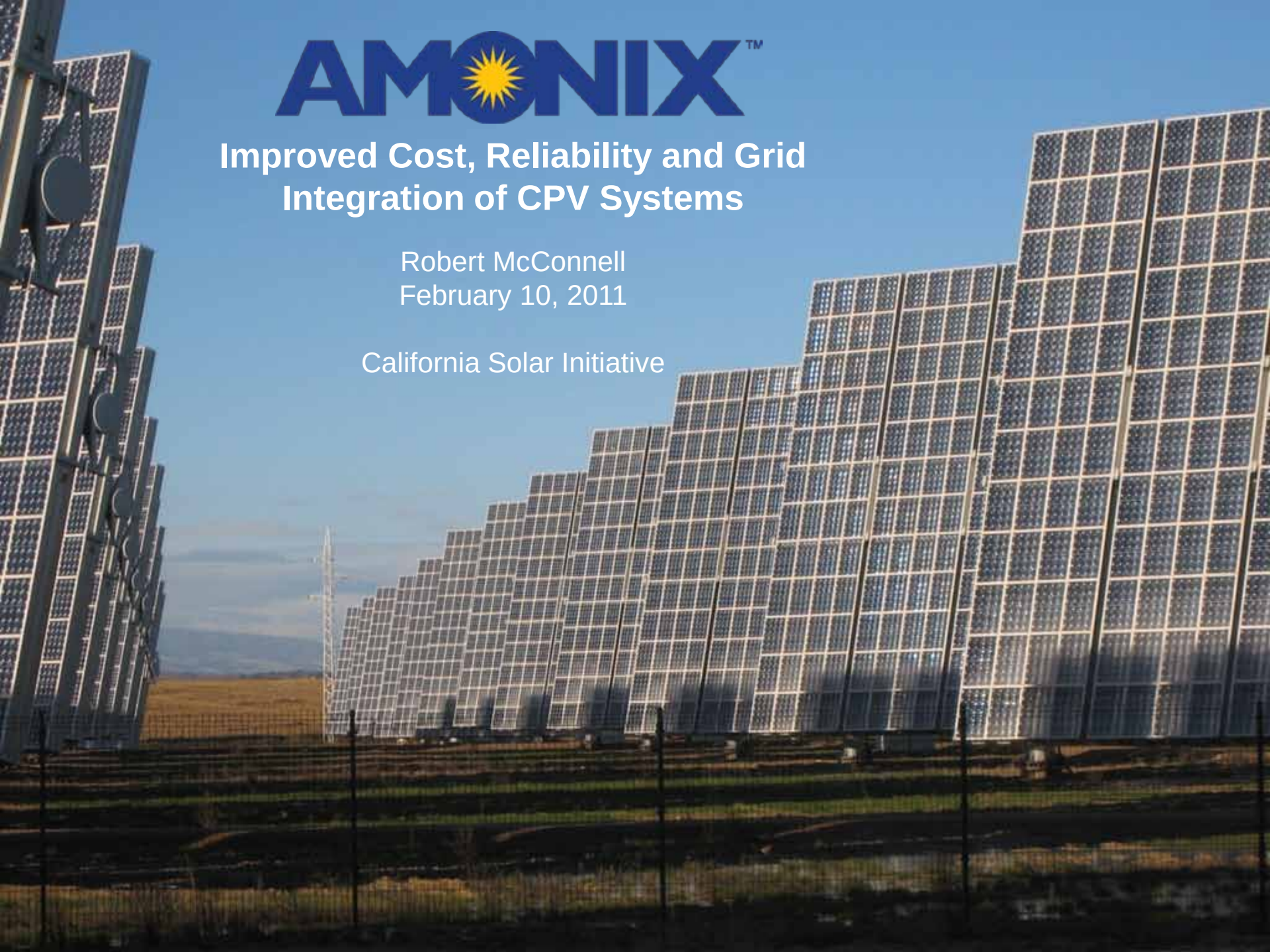


Improved Cost, Reliability and Grid Integration of CPV Systems

Robert McConnell
February 10, 2011

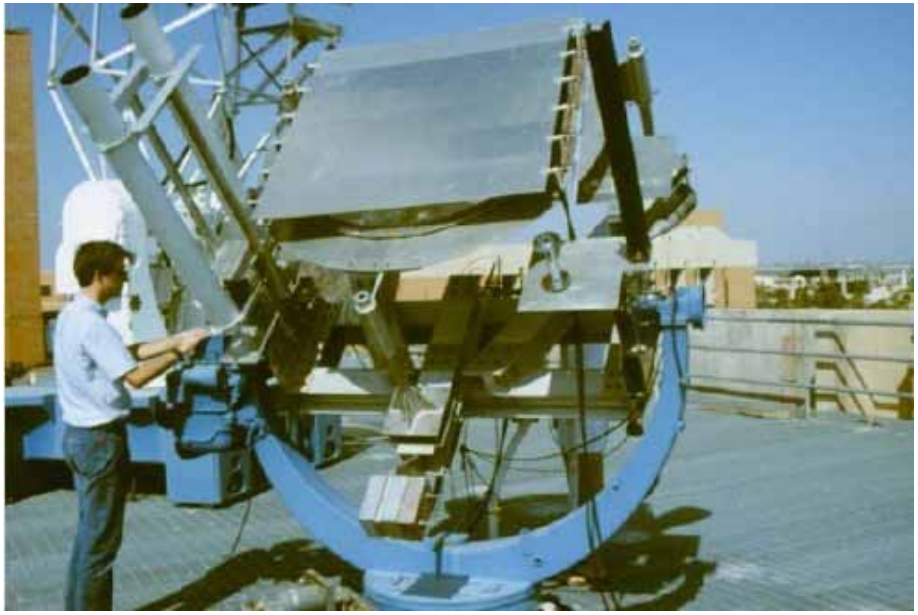
California Solar Initiative

Where We Have Come From

CPV Has a Long History

Concentrator PV Testing in Arizona in the 1970s

- Early testing was done with 1.5 meter diameter reflectors that could supply over one hundred suns of intensity.



One Meter Fresnel Lens for Testing up to 2000 Suns

Where We Have Come From

1980s

Martin Marietta
CPV 1980s

Saudi Arabia
Soleras

Sky Harbor,
Phoenix

Where We Have Come From

1990s

Linear-Focus Reflector

Linear Fresnel Lens

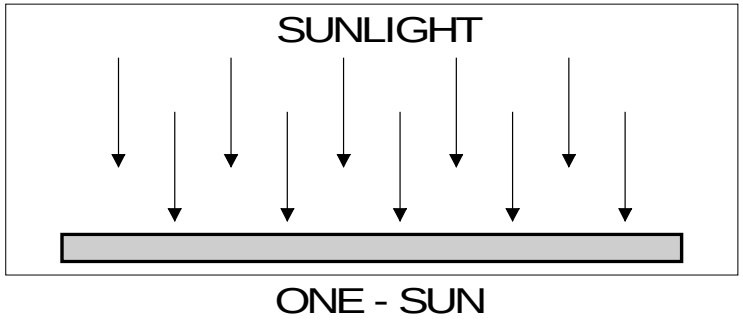
Point-Focus Reflector and its 20-kW Receiver

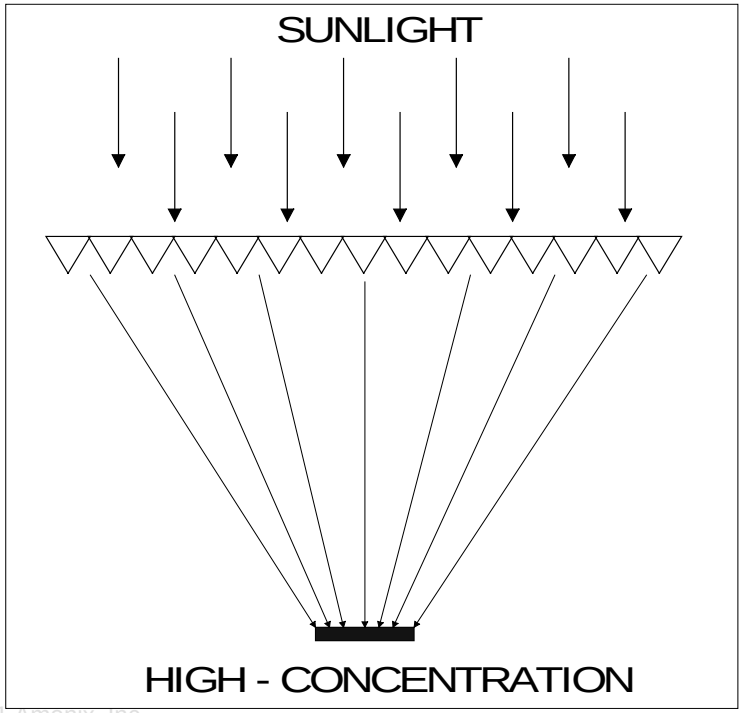
AMONIX

Where We Have Come From

How Amonix Concentration Works

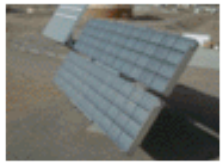
- Sunlight is concentrated using low cost Fresnel lens
- Cell area (cost) reduced by concentrating sunlight by factor of 500 or more
- High system conversion efficiency using high efficiency solar cells: > 27% module efficiency today!
- Solar tracking => high capacity factor





Amonix CPV is Evolving

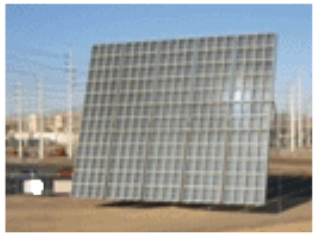
An Evolution that Parallels the Wind Industry



Amonix “Stumpy”
1997 – 8kW

1998 – 16kW

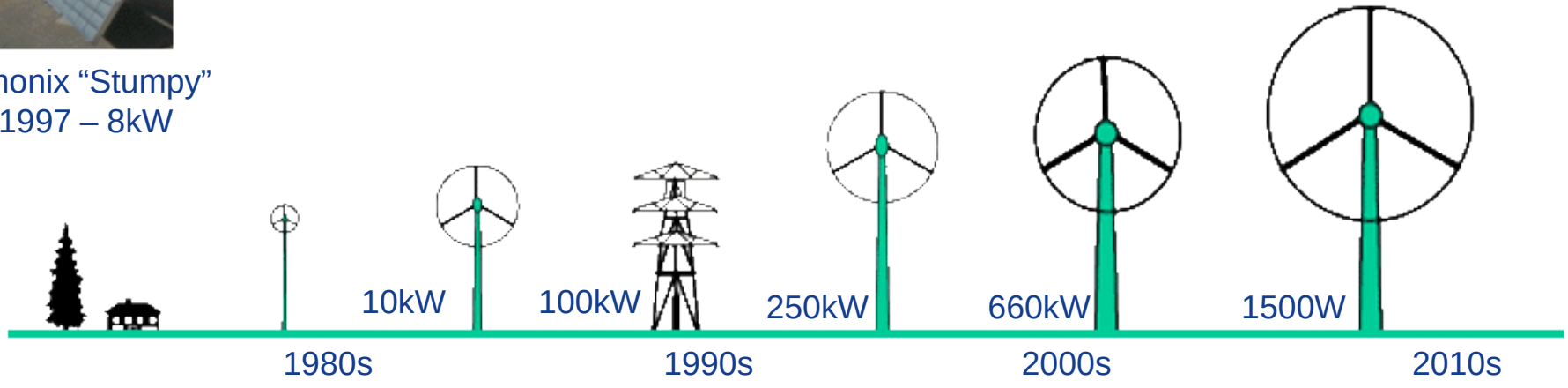
1999 – 20kW



2000 – 25kW

2002 – 35kW

2010 – 60kW



Amonix Today

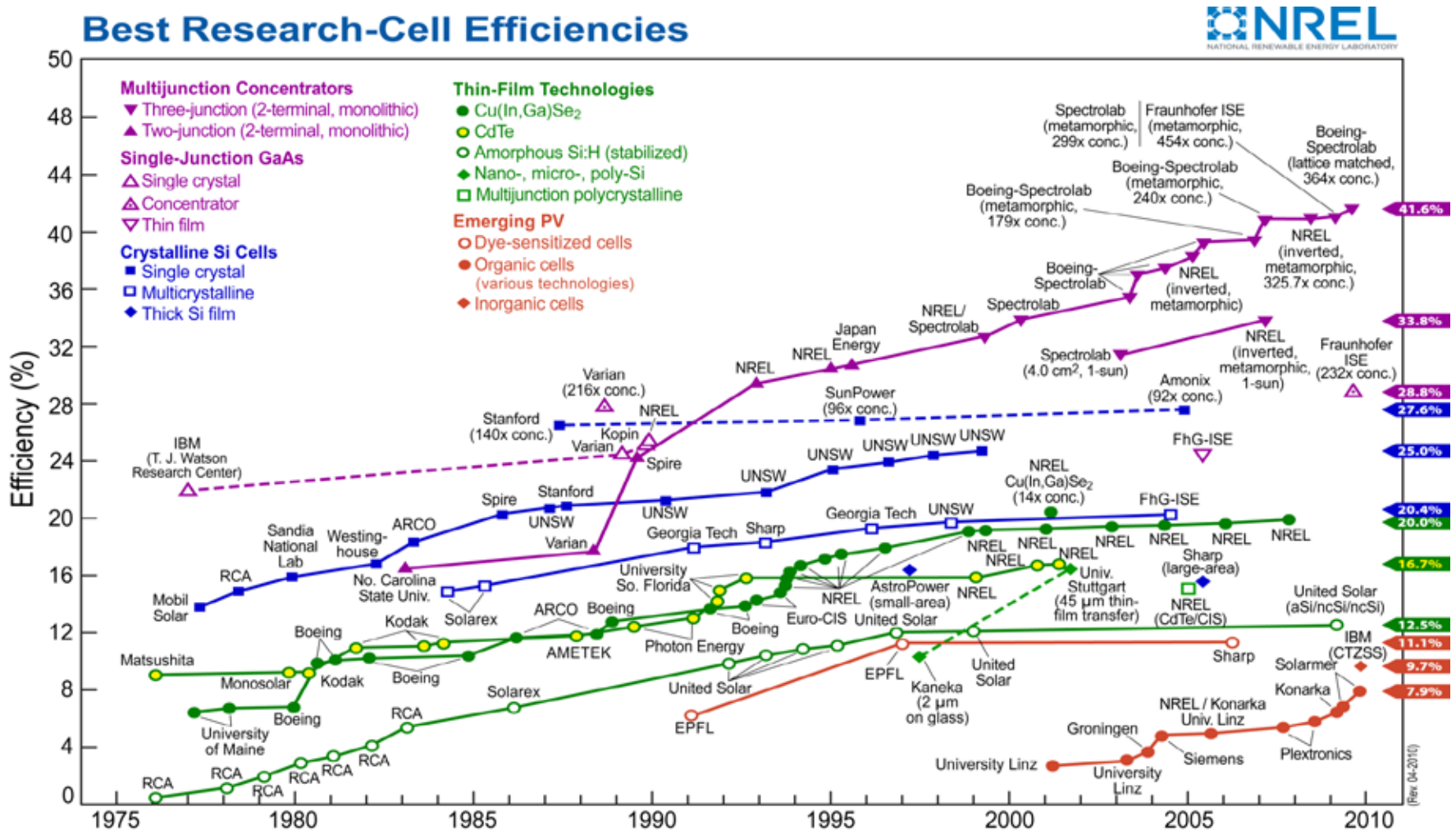
Low LCOE	Exceptional Performance	Low Carbon Footprint	Rapid Deployment	Low Capital Costs




Fastest Way to Terawatt Production of Solar Electricity

The Past as Prologue

Higher Efficiencies are on the Way



Amonix Installation in Spain

Largest CPV Installation Worldwide

Flexible Deployment Leads To Largest CPV Solar Power Plant Under The Sun

With more available sunshine than any other European nation, Spain is committed to developing solar energy as a way to power its economy cleanly and cost-efficiently. To capitalize on this opportunity, Amonix and Guascor Foton, a division of Spanish solar power industry leader Guascor Solar Corporation, formed a joint venture to install a 7.6 MW CPV solar power plant in Navarra, Spain.

The world's largest CPV installation was deployed in three incremental phases, between 2006 – 2008.

"The Amonix CPV technology at Parques Solares de Navarra has been instrumental to our efforts to install proven solar technology that can generate energy quickly and cost-efficiently for Navarra's citizens and businesses. We believe that utility-scale solar power will play a significant role in the region's future."

Jordy Creixell, Industrial VP of Guascor Futon

Parques Solares de Navarra (Villafranca - Navarra):
7.6MW Amonix CPV Technology

2011 Amonix Installation—30 MW at One Site

Wall Street Journal: August 9, 2010

Cogentrix Energy LLC, a leading electric power generation project development company, announced today that it has entered into a contract with Public Service Company of Colorado (PSCo), an Xcel Energy company, for a solar generating project to be located near Alamosa, in southern Colorado. The solar power generating facility will use 30 MW of concentrating photovoltaic (CPV) systems supplied by Amonix, Inc., a leader in the design and manufacture of CPV systems.

California Solar Initiative Award

Grid Integration of CPV Systems

- The purpose is to install and monitor the performance of nine 53 kW CPV units in an urban location, monitor their performance and monitor the associated circuits in the University of California, Irvine (UCI) electric infrastructure to evaluate and compare grid interconnection and energy management strategies.
  - Manufacture CPV systems
  - Install CPV Systems
  - Interconnect Systems in Distributed Grid
  - Assess Preferred CPV Integration
  - Coordinate with RESCO and SCE

Project Funding

Co-sponsored through California Public Utility Commission (CPUC) grant funding from California Solar Initiative (CSI) Research, Development, Demonstration, and Deployment (RD&D) Program with Itron, Inc. as the program manager.

GO solar CALIFORNIA

Itron

CSI RD&D
Program Manager

California Solar Initiative Award

Manufacture CPV Systems

Capital Efficient Assembly Enables Distributed Manufacturing

MegaModule fabrication

Truck bed to field

California Solar Initiative Award

Choosing a Site on UCI Campus

California Solar Initiative Award

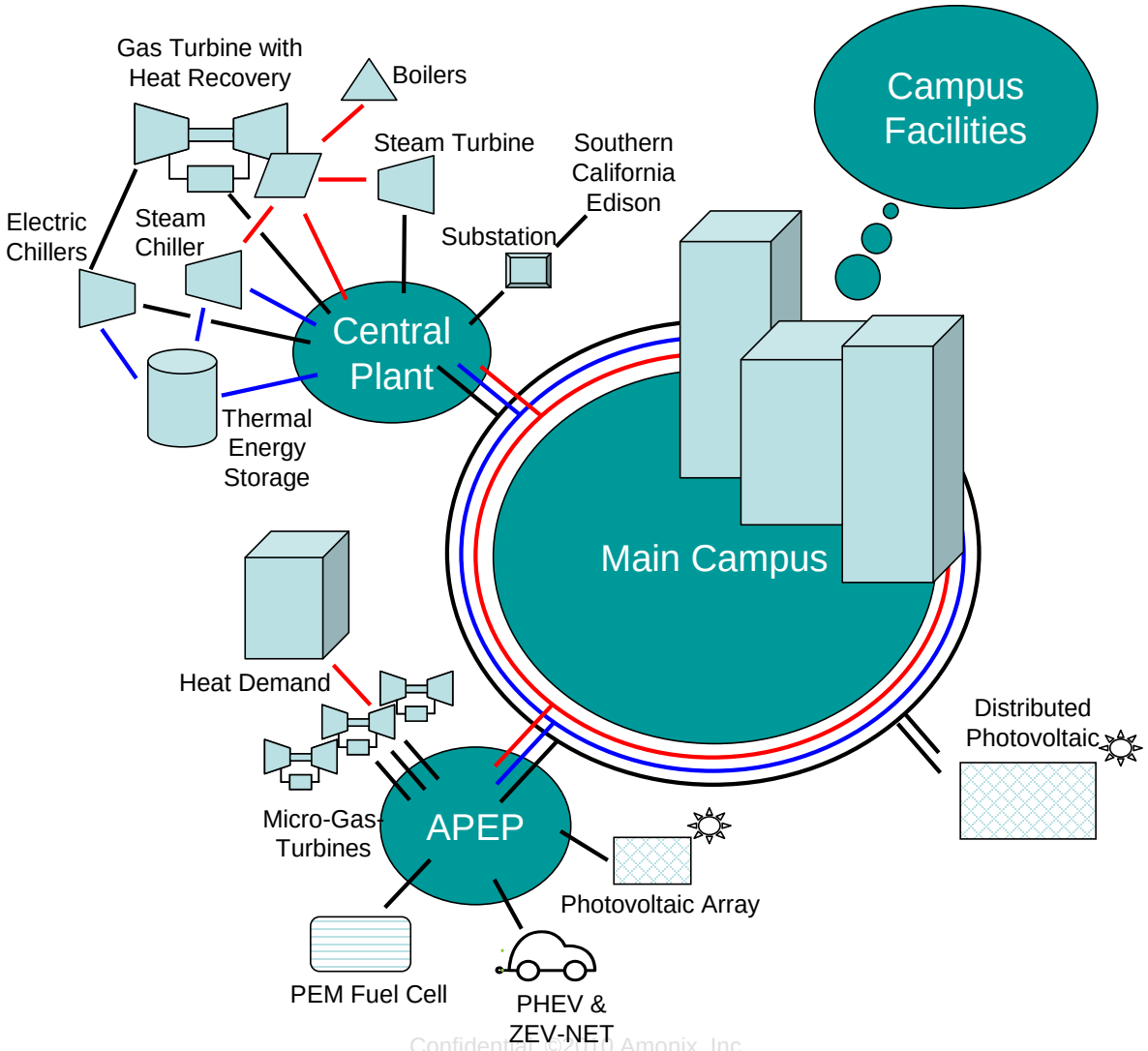
Choosing a Site on UCI Campus

California Solar Initiative Award

Installation

California Solar Initiative Award

UCI Electrical Infrastructure



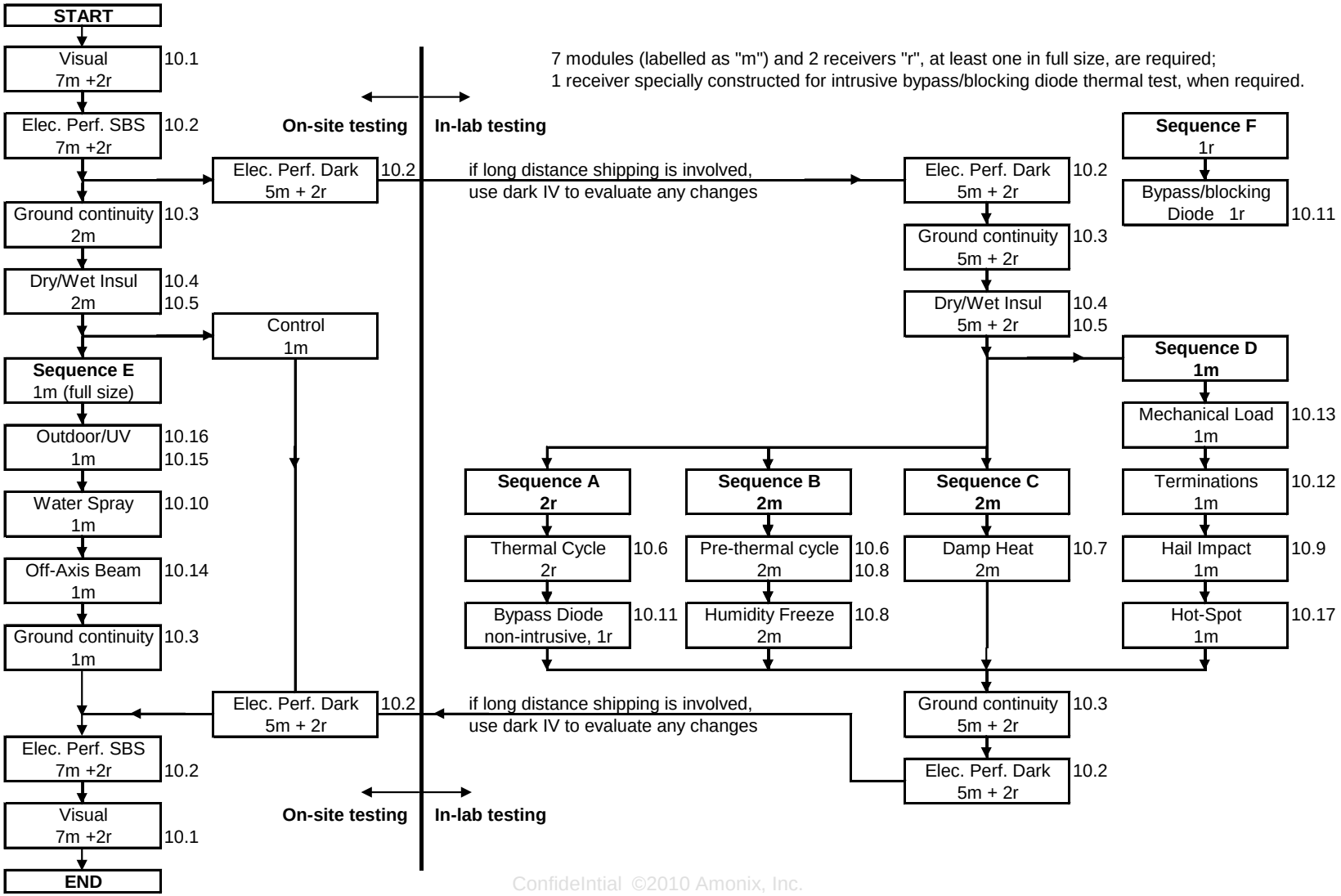
California Solar Initiative Award

CPV Lifetime and Reliability Modeling

- The purpose of this task is to conduct accelerated testing jointly with NREL and compile field data to develop a method to evaluate the reliability and lifetime of CPV technologies. Lifetime and reliability validation will be essential to secure major investment and financing of future CPV system deployment.
  - Conduct HALT
  - Correlate field data with HALT
  - Develop thermal fatigue model
  - Develop lifetime test protocol

California Solar Initiative Award

IEC 62108 CPV Module Qualification Test Sequence



California Solar Initiative Award

Conduct Highly Accelerated Life Tests

- HALT start with extended IEC62108 Qualification Tests
  - Increasing the number of cycles, temperature range or applied current in the thermal cycle test
  - Increasing the number of cycles or temperature or humidity ranges in the humidity freeze test
  - Increasing the number or exposure hours or humidity range of damp heat test
- HALT can add other tests such as weatherometer testing using combined cycles of temperature, sun and humidity

California Solar Initiative Award

Develop Lifetime Test Protocol

- Lifetime Test Protocol is established by a correlation of HALT failures with field failures
    - Design and quality assurance failures need to be separated from lifetime limiting failures
    - HALT failures should occur much sooner than field failures
    - HALT failures should be identical with field failures
- Existence Proof for Lifetime Test Protocol
    - Amonix discovered a specific field failure on a multijunction cell package in 2006 after a year of field testing
    - NREL encountered a similar failure on a similar multijunction cell package in 2009 after several weeks of HALT weatherometer testing
    - Now, Amonix doesn't use that specific multijunction cell package
        - But the result could have been the basis for a lifetime prediction

California Solar Initiative Award

Major Deliverables

- Manufacture and installation of nine 7700 CPV systems (08/2011)
- Summary of the operation of the campus energy system with regard to the installed campus CPV resource (12/2011)
- UCI's central plant and CPV dynamic models (12/2012)
- Preferred deployment and operation of CPV technologies with CHP and dispatchable loads (12/2012)
- A developed thermal fatigue model to predict die-attachment lifetime from meteorological data (06/2012)
- A developed lifetime test protocol for CPV systems (12/2012)


AMONIX™
Thank You