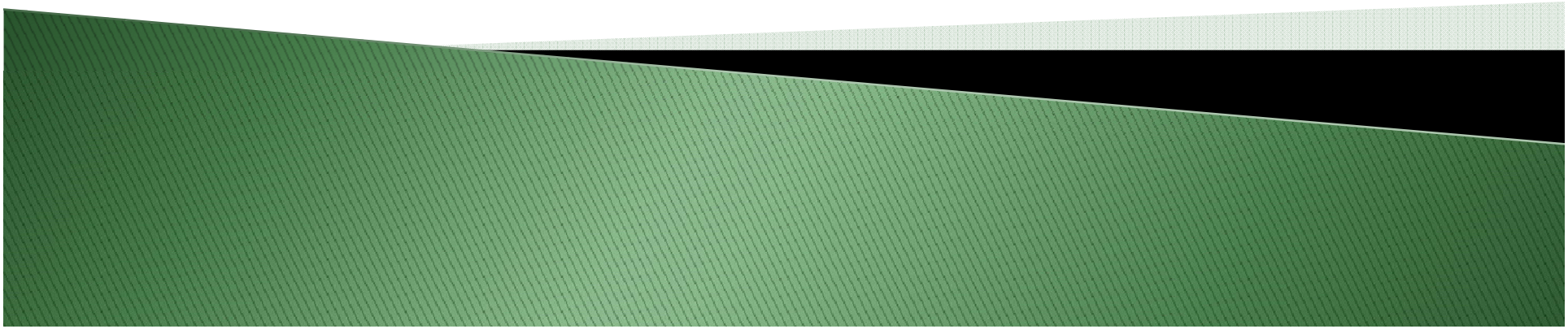
Grand Challenges for Advances in Photovoltaic Technologies

Roger Little, CEO, Spire Corporation
Robert Collins, Professor, University of Toledo

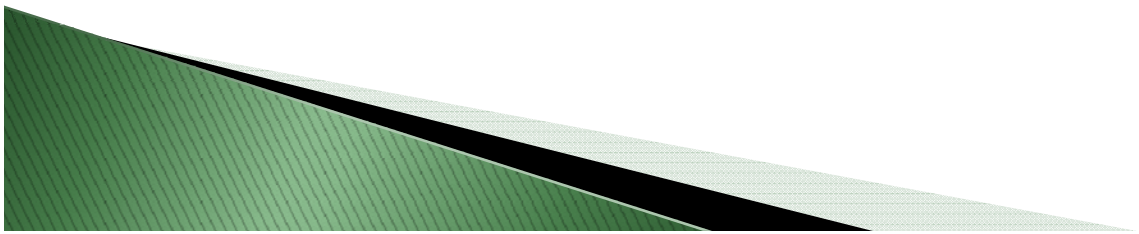


Today

Who?	• Steering Committee • Participants
What?	• Scope • Workshop and Documents
Why?	• External Drivers • Barriers
Next Steps	• Opportunities Document • Other Activities

Steering Committee

- Selection
  - Identify “PV stars”
  - More than half Industry, with remainder split between Academia and Government
  - Represent the entire gamut of interests and expertise in breakout areas
- Major tasks
  - Finalize scope and breakout areas
  - Identify key participants
  - Lead workshop and associated activities

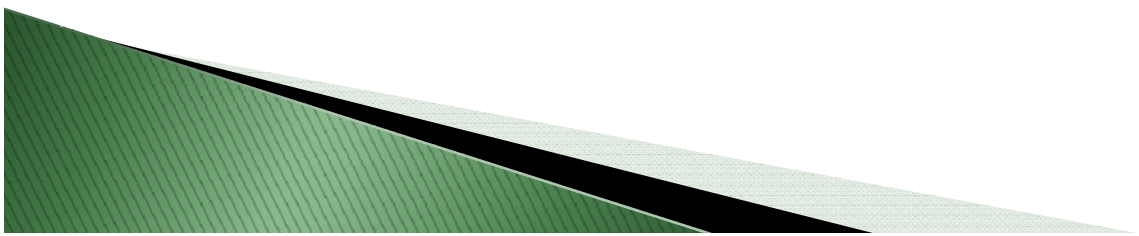


Steering Committee

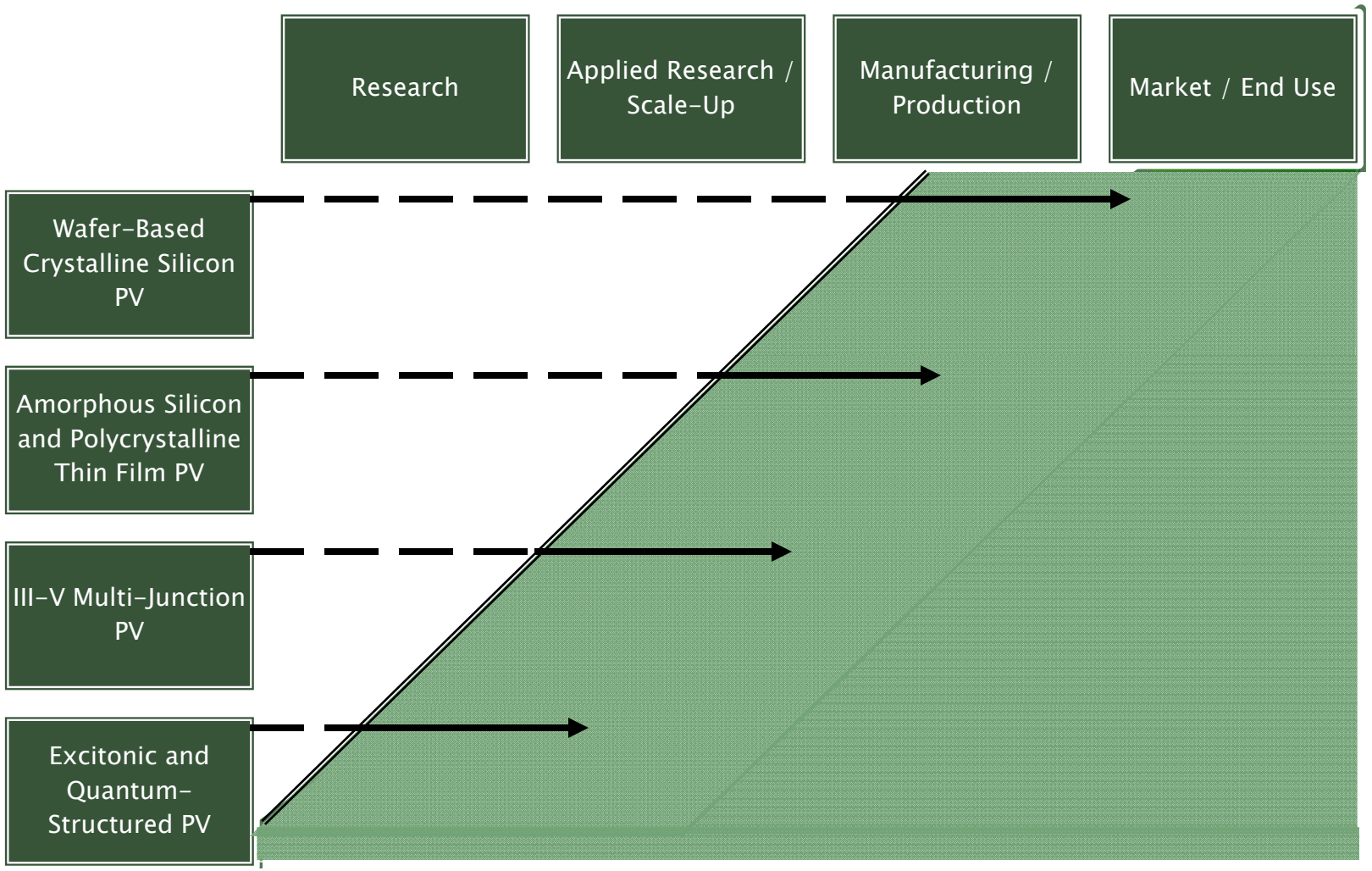
Roger Little	• Chairman and Chief Executive Officer, *Spire Corporation*
Robert Collins	• Distinguished University Professor and NEG Endowed Chair of Silicate & Materials Science, *University of Toledo*
John Wohlgemuth	• Program Manager, *BP Solar*
Tom Surek	• President, *Surek PV Consulting*
Tim Anderson	• Distinguished Professor, Director of the Florida Energy Systems Consortium, *University of Florida*
Benny Buller	• Director of Device Improvement, *First Solar*
John Iannelli	• Chief Technology Officer, *Emcore Corporation*
Nasser Karam	• Vice President, Advanced Technology Products, *Boeing Spectrolab Inc*
Sarah Kurtz	• Principal Scientist, *National Renewable Energy Laboratory*
Gilles Dennler	• Director Device Research, *Konarka Tehnologies, Inc*
Dana Olson	• Research Scientist, *National Renewable Energy Laboratory*

Workshop

- May 11–12, 2010; Denver, CO
- Participants (75 total):
  - Industry: 42
  - Academia: 16
  - Government: 17
- Breakout Topics
  - Wafer-Based Crystalline Silicon PV
  - Amorphous Silicon and Polycrystalline Thin Film PV
  - III-V Multi-Junction PV
  - Excitonic and Quantum-Structured PV

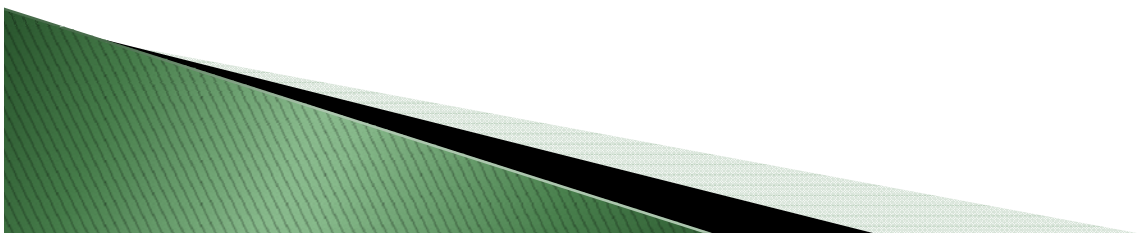


Scoping


Research
Applied Research / Scale-Up
Manufacturing / Production
Market / End Use
Wafer-Based Crystalline Silicon PV
Amorphous Silicon and Polycrystalline Thin Film PV
III-V Multi-Junction PV
Excitonic and Quantum-Structured PV

Workshop Outputs

- Vision/ Drivers
- Critical Technology Challenges
- Technology-Measurement Grand Challenges
- Recurring Themes



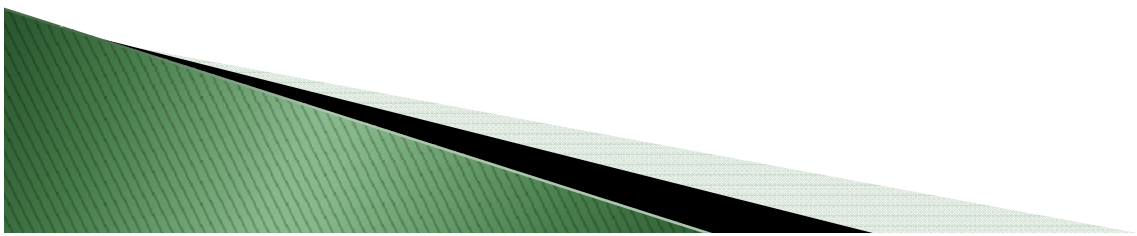
Vision / Drivers

- Atomic scale to module-level understanding
- Sustained growth rate of industry
- Predictable, reliable performance over life
- Wide acceptance for utility power plants and all new buildings

- Performance
- Cost
- Reliability and acceptance
- Lifecycle sustainability

Technology-Measurement Grand Challenges

- 22 grand challenges identified among 4 breakout areas
- Selected examples from each breakout area
  - What makes these challenges “grand?”



Technology-Measurement Grand Challenge

- Accurate Prediction of System Energy Production
  - **Targets/Goals:**
    - Prediction within +/- 3%
  - **Major Applications:**
    - All PV applications from residential to utility
  - **Technology Barrier(s) Addressed:**
    - Rating system must be accurate and become the standard
  - **Pathway Elements:**
    - Module energy rating system
    - Populated and validated module database
    - PV system prediction tool
    - Validated PV system performance

Technology-Measurement Grand Challenge

- In-line Cell Characterization
  - **Targets/Goals**:
    - Testing should be <5% of cell cost
    - 10 min/wafer ~ 35 MW/year per tool
  - **Major Applications**:
    - High volume cell manufacturing and testing
  - **Technology Barrier(s) Addressed**:
    - Cells and interconnects, yield and reliability
  - **Pathway Elements**:
    - Evaluation of EL as a screening technology for cells
    - High concentration solar simulation compatible with in-line testing
    - Measurement methods for J ratio of components in the cell
    - Alternative cell evaluation methods

Technology-Measurement Grand Challenge

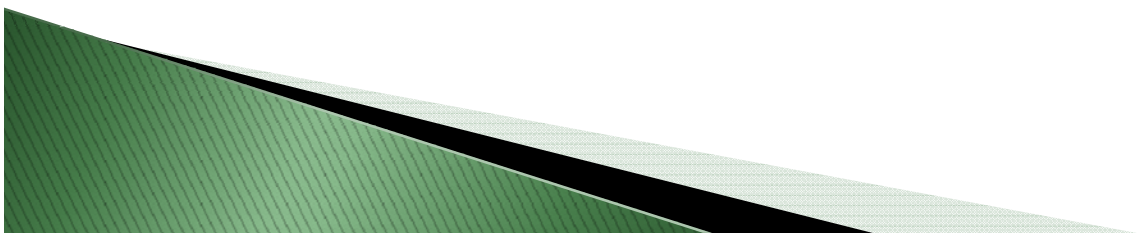
- Low Cost/High Throughput Manufacturing
  - **Targets/Goals:**
    - Market share of thin-films greater than 50%
  - **Pathway Elements:**
    - 20% module efficiency
    - Identification of process and material parameters predictive of performance
    - Continuous and automated production
    - Process modeling and validation from substrate to package
    - In-situ, real time process monitoring and control
    - Vertical integration of the entire supply chain

Technology-Measurement Grand Challenge

- Accelerated Life and Reliability Testing
  - **Targets/Goals:**
    - Strong correlation between accelerated indoor and outdoor tests;
    - Key probes and level of uncertainty over time
  - **Major Applications**:
    - Product R&D, module reliability, system level financing
  - **Technology Barrier(s) Addressed**:
    - Material and device stability and reliability
  - **Measurement Barrier(s) Addressed**:
    - Lack of robust instrumentation for key properties
  - **Pathway Elements**:
    - Outdoor testing to assess key properties & degradation factors
    - Environmental test chambers to mimic outdoor testing under accelerated time scales
    - Understand degradation mechanisms

Recurring Themes

- Efficiency > 20%
- Understanding performance from atomic level to device level
- In-line testing in manufacturing for higher throughput and reduced cost
- Energy rating methodologies
- Module characterization (power output)
- Standards for reliability



Next Steps

- Impact of workshop on participants
  - Interactive participation; honed prioritization
  - Networking across technology areas
- Documents
  - Workshop Summary
  - Opportunities Document
- Knowledge Use
  - PV community