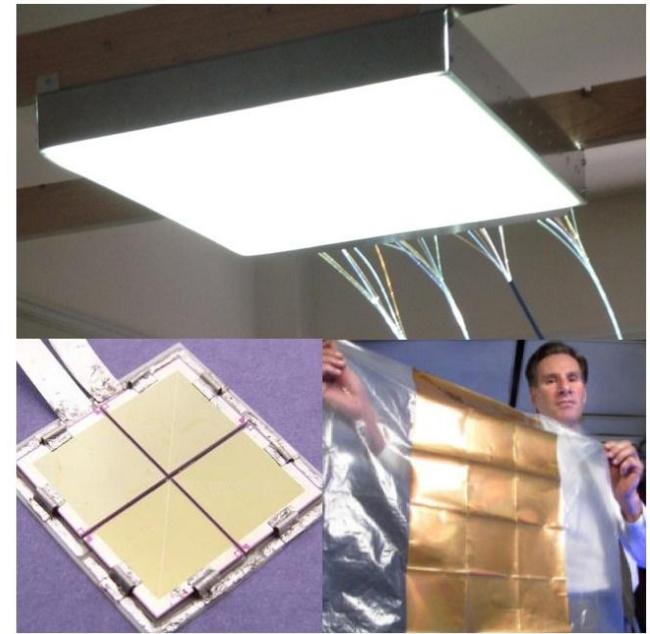
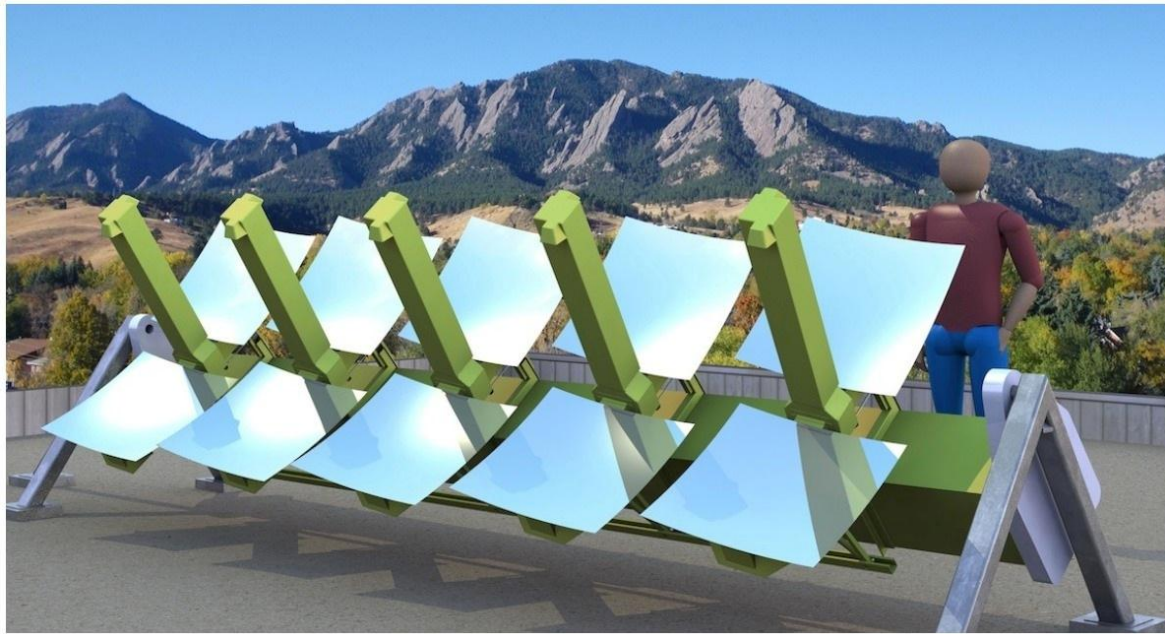


# High-Efficiency Solar Cogeneration with T-PV and Fiber Optic Daylighting

2015 Building Technologies Office Peer Review



U.S. DEPARTMENT OF  
**ENERGY**

Energy Efficiency &  
Renewable Energy

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**Creative Light Source, inc.**

# Project Summary

## Timeline:

Start date: *August, 2014*

Planned end date: *July, 2016*

## Key Milestones:

1. Y1 prototype test-bed functional; 7/15
2. Full IR-PV cogeneration system; 3/16
3. Building Trials at customer facility; 6/16

## Budget:

Total DOE \$ to date: \$975,000 (*P1 + P2, Y1*)

Total future DOE \$: \$750,000 (*P2, Y2*)

## Target Market/Audience:

Commercial and Industrial Buildings.

Early Adopters targets:

- NetZero and LEED installations
- Demanding lighting requirements (e.g. Retail)
- High solar insolation, small building footprint

## Key Partners:

JX Crystals

Pyron Solar

Redwave Energy

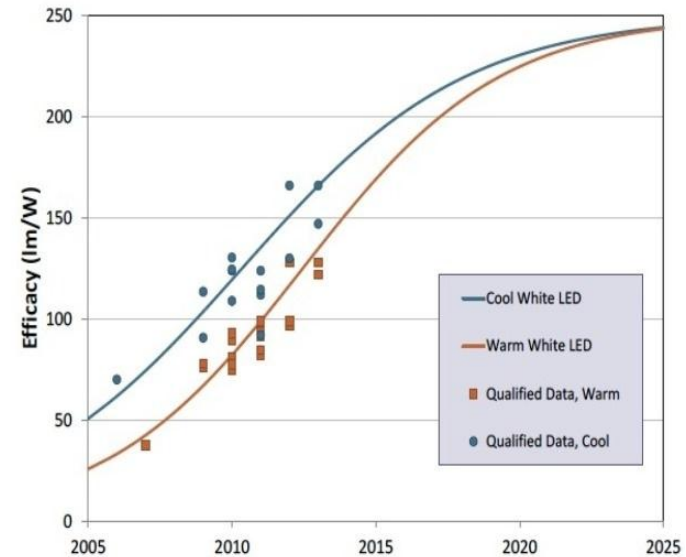
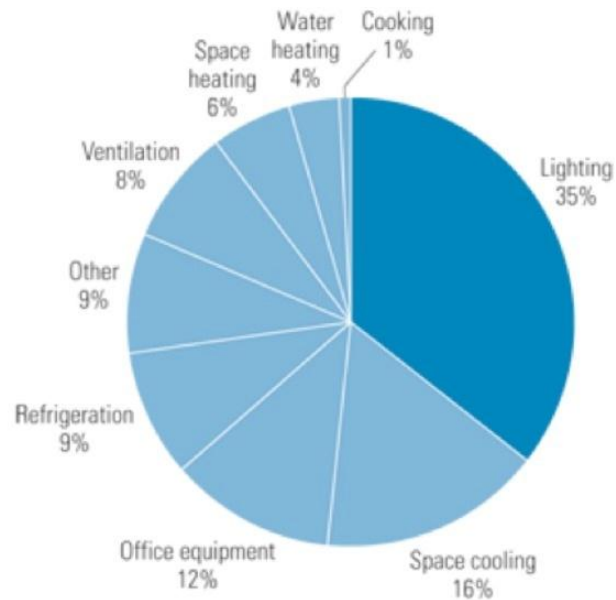
NREL

RMI

## Project Goals:

- (1) Highest-efficiency use of building envelope solar insolation resource.
- (2) Lowest lifetime cost lighting solution, with highest efficiency and lowest heat-gain.
- (3) Inexpensive onsite electricity generation.

# Purpose and Objectives - *Problem Statement*



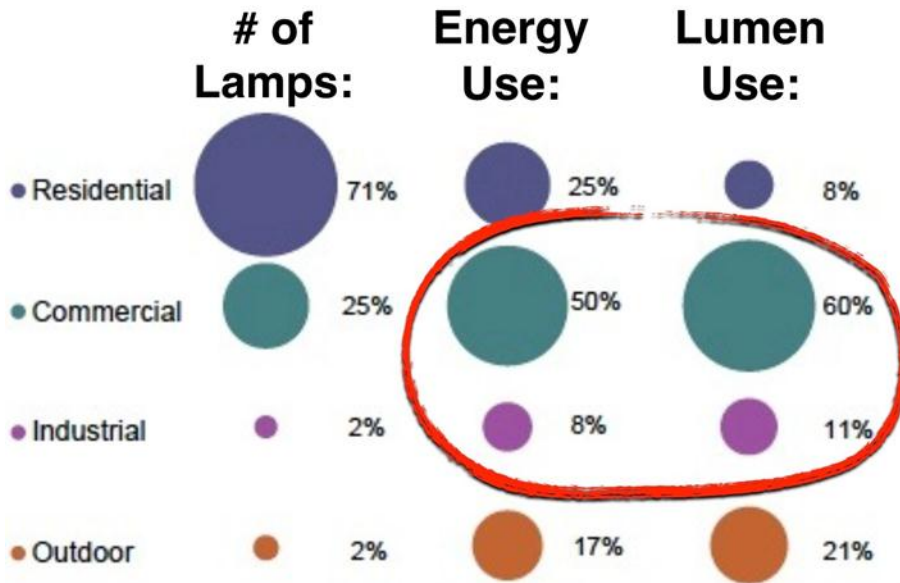
## - **NetZero buildings challenge:**

- High energy density per footprint; especially multi-story
- How optimize energy resource for footprint? -> ***“Solar Cogeneration”***

## - **Lighting is large and universal need**

- Daylighting offers enormous benefit - but is not universally possible
- LEDs can only offer limited savings

# Purpose and Objectives - Target Market & Audience

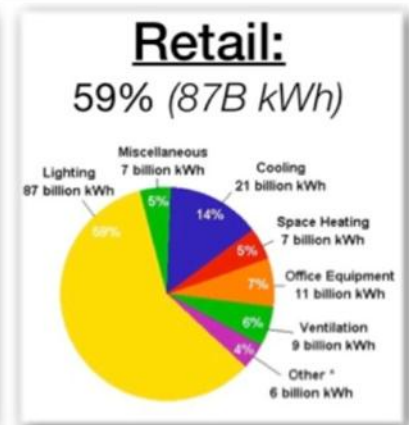
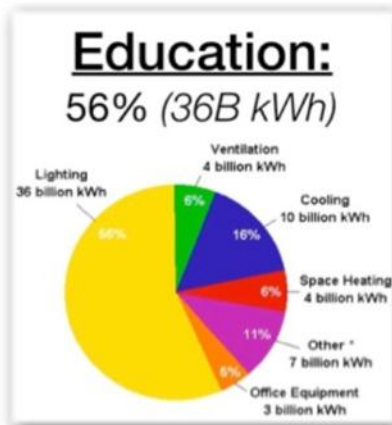


## - Commercial + Industrial:

- majority of lumens & energy use
- lighting during daytime hours

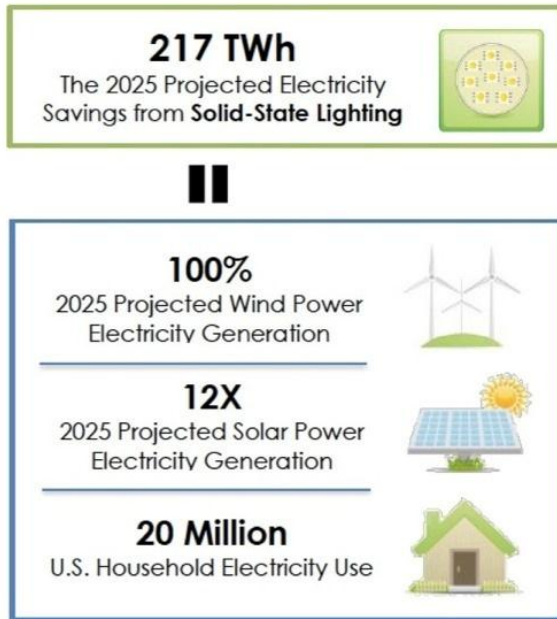
## - Target Sectors:

- NetZero and LEED Buildings
- Office/Education/Retail
- *daylight-specific benefits*

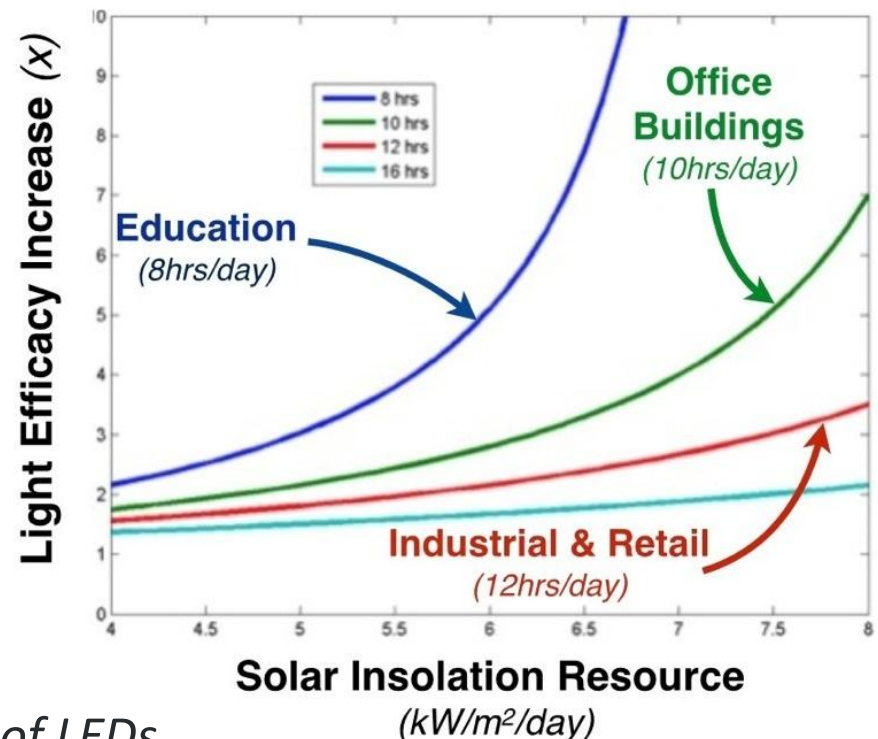


# Purpose and Objectives - *Impact of Project*

## Potential Benefit of LEDs:

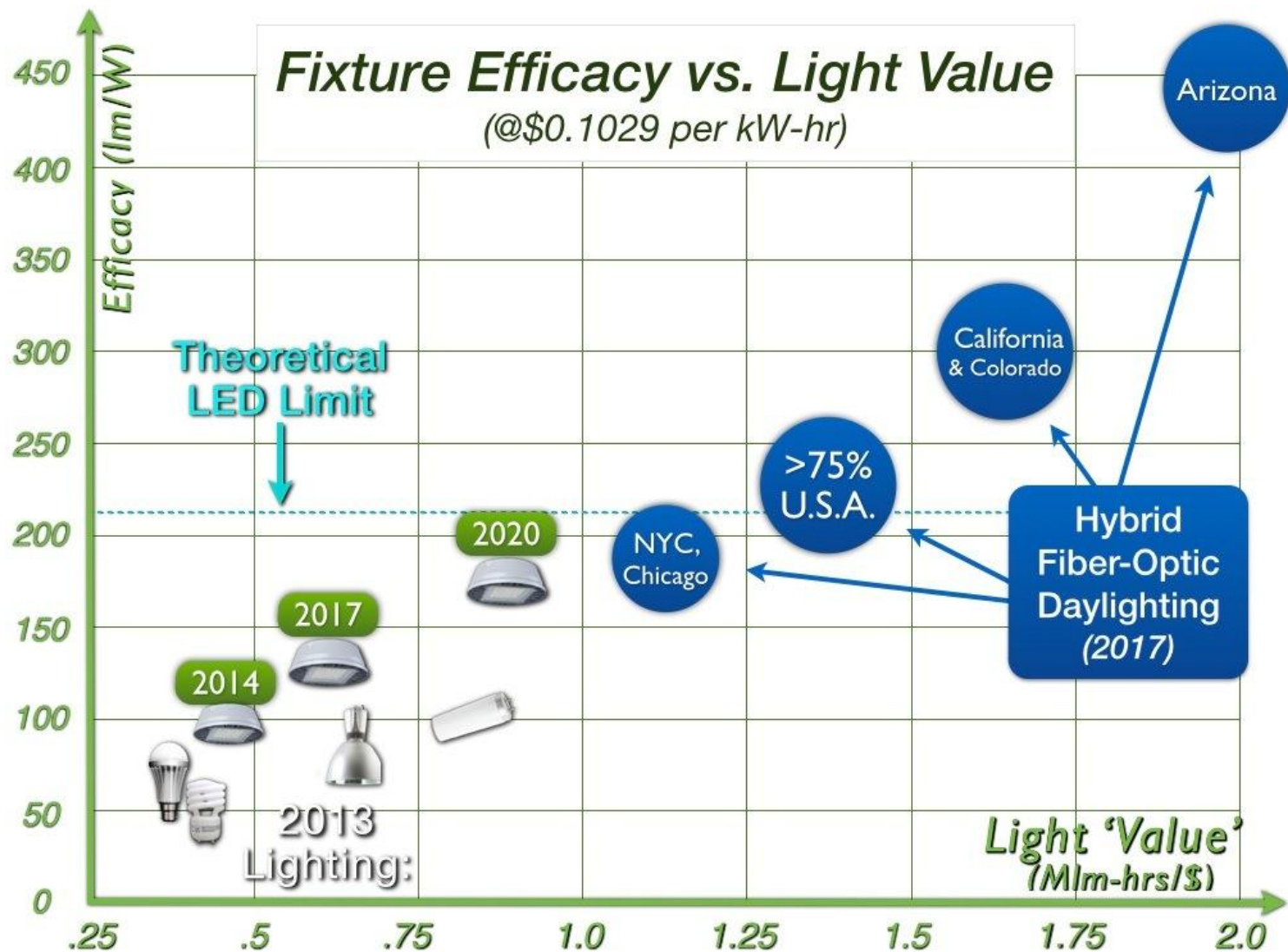


## Daylighting *Multiplies* the Savings of LEDs by 2x~10x

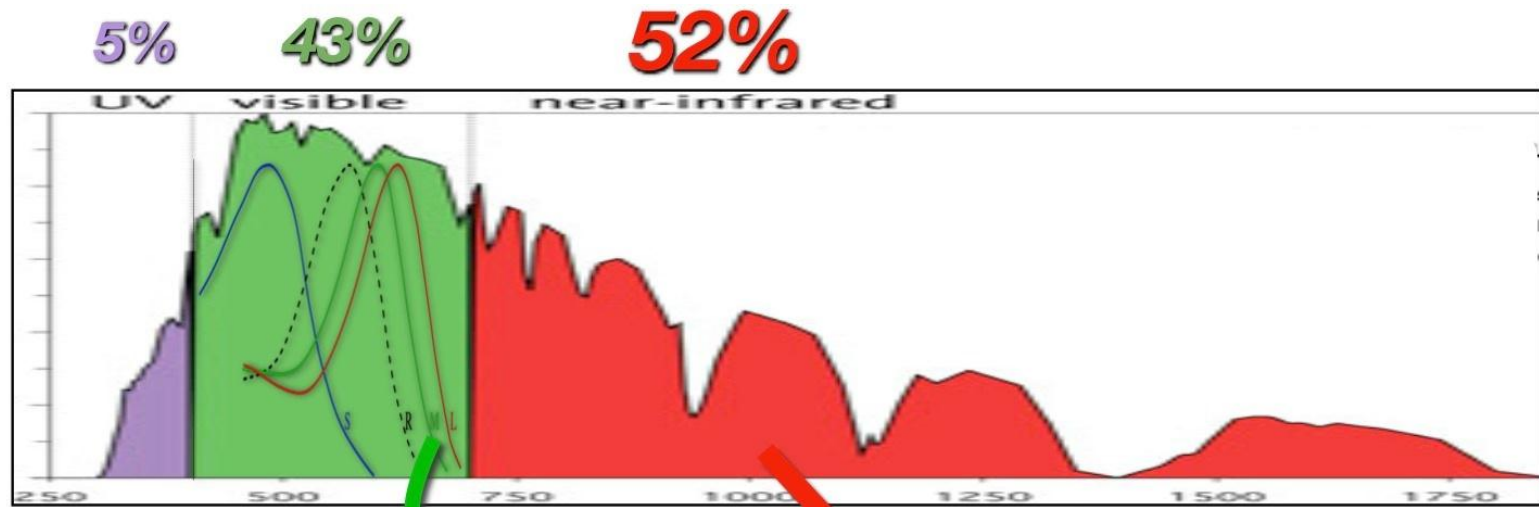


- **Potential Benefit:** *Multiply efficacy of LEDs*
- **Phase II output:** *Ready for building trials, investment, manufacturing*
- **1-3 Years Out:** *Key installation success & niche market ramp, traction*
- **3+ Years After:** *Tech proliferation, distribution chains, mfg. ramp*

# Purpose and Objectives - *Impact of Project*



# Approach - General Approach



Visible:

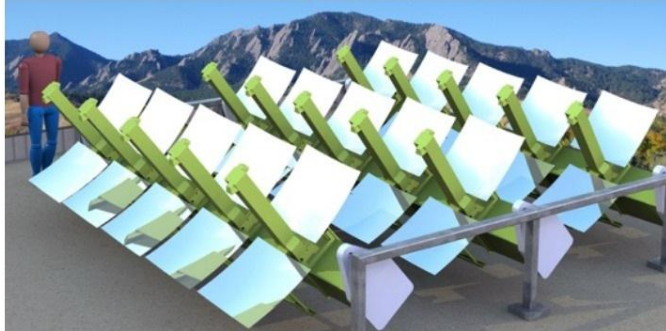
**Fiber-Optic  
Daylighting**

Infra-Red:

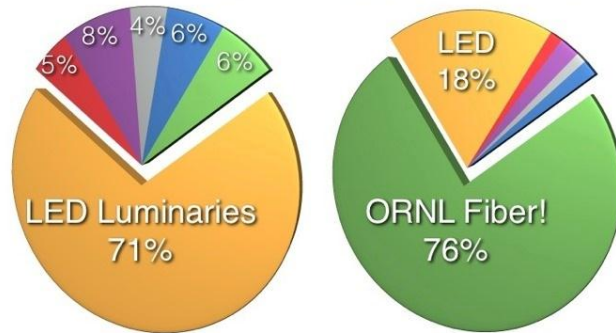
**Electricity  
Generation**

# Approach - *Distinctive Characteristics & Key Issues*

## Tracker: Scalable, Low-Cost



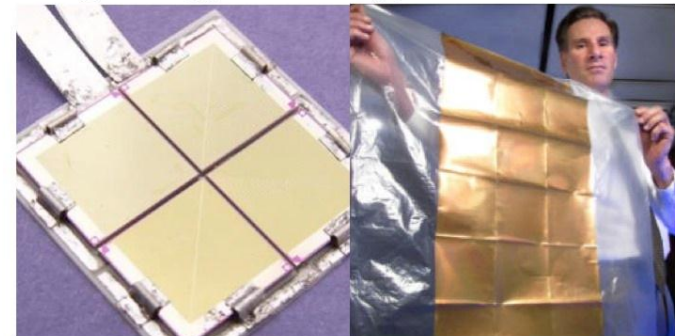
## High-Concentration: *Fiber Cost Reduction*



## Luminary: Efficient, Retrofit



## IR-PV Conversion: *High Efficiency, Low-Cost*



## Key Issues:

- Custom Optics, Thermal Management
- Tracker: Mass-Manufacture & Alignment
- Realizable path to Cost-Reduction



# Progress - Accomplishments

## Accomplishments:

- **Phase 1:** Prototype - world record! Cost/Performance Analysis tool.
- **Phase 2:**
  - **Optical:** *custom design, components & vendor selection*
  - **Tracker:** *design-for-manufacturing & system trade-offs*
  - **IR-PV:** *thermal management & IR optical design*

### Rooftop Tracker



### 30' Fiber Cable



### 2'x2' Daylight Fixture



# Progress - *Lessons, Market, Awards*

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## Lessons Learned:

- **Follow the Economics:** consider cost-reduction early in design approach!
- **Vendors:** work with early to determine custom part considerations
- **Unforeseen Design:** allot time for unseen system complications / issues

## Market Impact:

- **Impact To-Date:** Tech not complete yet (*~60% way through 1st year*)
- **Impact Acceleration:** Design for manufacturing, high-volume vendors

## Awards/Recognition:

- 'CleanTech Open' Semifinalist - national clean technology competition

# Project Integration, Collaboration & Future Steps

## Project Integration:

- *3rd Party Vendors, Manufacturers, Key Technology Partners*
- *Market Channel Partners, PACE-financing, High-Visibility Demo*

## Partners, Subcontractors, and Collaborators:

- *IR-PV and T-PV technologies*: *JX Crystals, Redwave Energy (CU)*
- *Market Adoption*: *NREL, RMI, Colorado OEDIT, Innosphere*

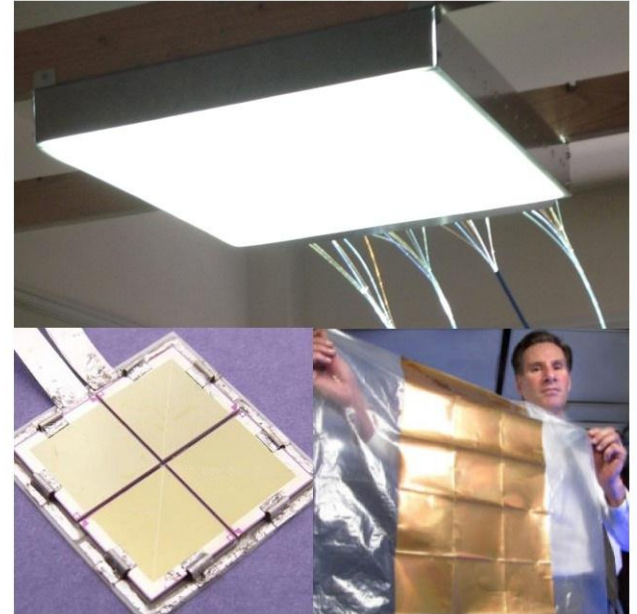
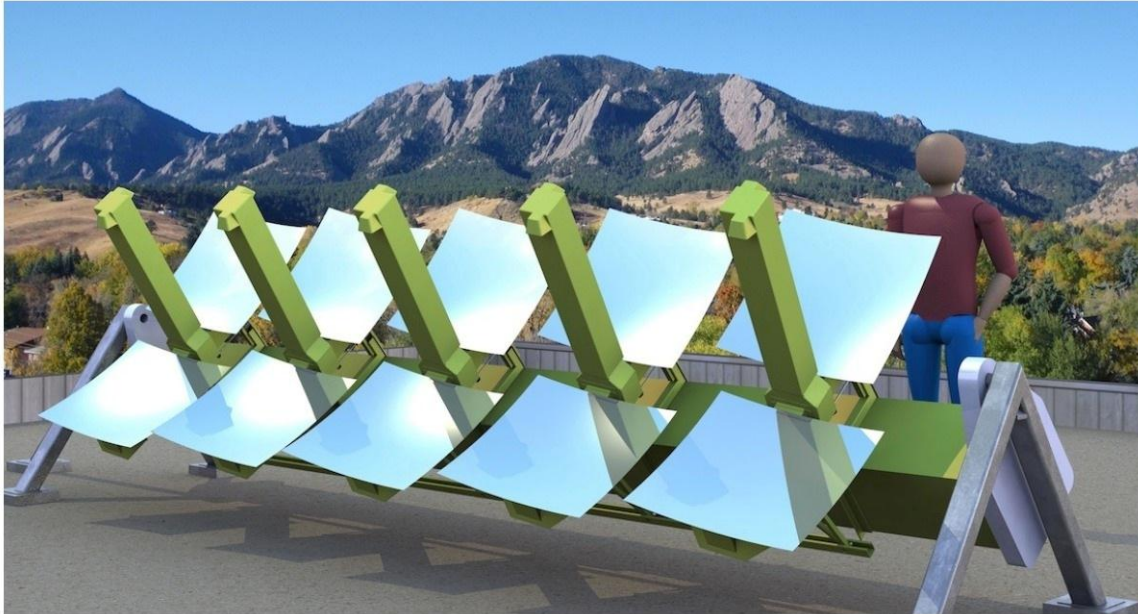
## Communications:

- *“Stealth Mode” (i.e. - No announcements until 2nd-year Proto)*

## Next Steps and Future Plans:

- *Summer Prototype - first light*
- *High-Visibility Demonstration Installations*
- *Private Investment*

# Thank You!



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# REFERENCE SLIDES

# Project Budget

**Project Budget:** Phase 1: \$225k, Phase 2: \$1.5M

## Variations:

- Extra Costs: tracker engineering/design, & custom Molds/Tooling
- Unseen Issues: building integration, outdoor survivability, mfg/alignment
- Materials Use: some cheaper, some more expensive. extra engineering hrs req'd
- Schedule: reworked aggressive milestones to match custom part lead-times

**Cost to Date:** ~\$390k spent

- Approximately 52% of Y1 budget, over 70% of Y1 schedule.
- Prototype Hardware on order now, will now burn cash faster.

**Additional Funding:** Not yet! (in talks with investors)

## Budget History

**July, 2013 – March, 2014**  
(Phase I program)

**Aug, '14 – July, 15**  
(Phase II, Year One)

**Aug, '15 – July, 16**  
(Phase II, Year Two)

**DOE**      **Cost-share**  
\$225k      N/A

**DOE**      **Cost-share**  
\$750k      N/A

**DOE**      **Cost-share**  
\$750k      N/A

# Project Plan and Schedule

## Slipped Milestones:

- Optics: mirrors MUCH harder/more expensive than expected
- Mechanical: tolerances, assembly, and manufacture issues
- IR-PV: had to wait for optics, vendor parts req'd system design changes
- Vendors: took time to find appropriate component vendors @ low cost

Project Schedule														
Project Start: August 2014	Completed Work													
Projected End: July 2016	Active Task (in progress work)													
	◆ Milestone/Deliverable (Originally Planned)													
	◆ Milestone/Deliverable (Actual)													
	FY2014				FY2015				FY2016					
Task	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)	Q1 (Oct-Dec)	Q2 (Jan-Mar)	Q3 (Apr-Jun)	Q4 (Jul-Sep)		
<b>Past Work</b>														
Phase I Milestone: <i>Proof of Concept HW Complete</i>			◆											
Phase I Milestone: <i>Final Technical Reporting</i>				◆										
PII, Y1 Milestone: <i>Optical Architecture Complete</i>								◆						
PII, Y1 Milestone: <i>Optical Vendors Chosen, Parts on order</i>								◆	◆					
PII, Y1 Milestone: <i>Mechanical Architecture Complete</i>								◆	◆	◆				
<b>Current/Future Work</b>														
PII, Y1 Milestone: <i>Mechanical Detailed Design Complete</i>														
PII, Y1 Milestone: <i>GaSb run #1</i>														
PII, Y1 Milestone: <i>Tracker Electronics</i>														
PII, Y1 Milestone: <i>Part Assembly &amp; Testing</i>														
PII, Y1 Milestone: <i>GaSb run #2</i>														
PII, Y2 Milestone: <i>Optical, Electronic &amp; Tracker v.2 design</i>														
PII, Y2 Milestone: <i>IR-PV &amp; Rectenna Integration</i>														
PII, Y2 Milestone: <i>Full Demo Assembly/Integration</i>														
PII, Y2 Milestone: <i>System Pilot Test @ Customer Site!</i>														