U.S. DEPARTMENT OF
ENERGY

Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

# Stationary Concentrator Daylighting System


Glint Photonics Inc.

Dr. Chris Gladden, Director of Engineering

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# Project Summary

**Timeline**:

Start date: 10/1/2016

Planned end date: 3/31/2020

Key Milestones

1. Panels & Mechanics Survive Testing; 12/31/17
2. Panels Pass Go/No-Go Performance Metrics; 9/30/18
3. Field installation complete; 6/30/2019

## Budget:

### Total Project $ to Date:

- DOE: $781,431
- Cost Share: $304,636

### Total Project $:

- DOE: $1,080,000
- Cost Share: $304,636

**Key Partners**: N/A

**Project Outcome**:

The goal of this program is to scale the Glint Daylight Concentrator into a full-size integrated prototype and evaluate its performance in a field installation.

In this program Glint will develop a full prototype including internal actuation mechanism, light delivery system, and building interface.

Glint will install systems in a field installation in order to evaluate real-world performance, validate the expected >50% energy savings over a pre-installation baseline, meeting MYPP daylighting goals, attracting potential customers, and further investment in the technology.

# Team

- <u>Leading development of innovative optical devices</u>
  - Advanced materials and device designs
  - Unique IP in self-tracking solar concentrators, tunable IR optical devices, and advanced luminaires
- <u>Technical leadership:</u>
  Over 60 years combined experience in materials and device technologies, product development, startup companies
- <u>Expertise:</u>
  Engineering staff from a variety of technical fields. Expertise in optical device design, optoelectronics, process development, simulation, optical test
- <u>Facilities:</u>
  Large mixed lab, office, light manufacturing and warehouse space. Located in Burlingame, CA.
- <u>History:</u>
  Founded in October 2010. Over $7 million in government funding.

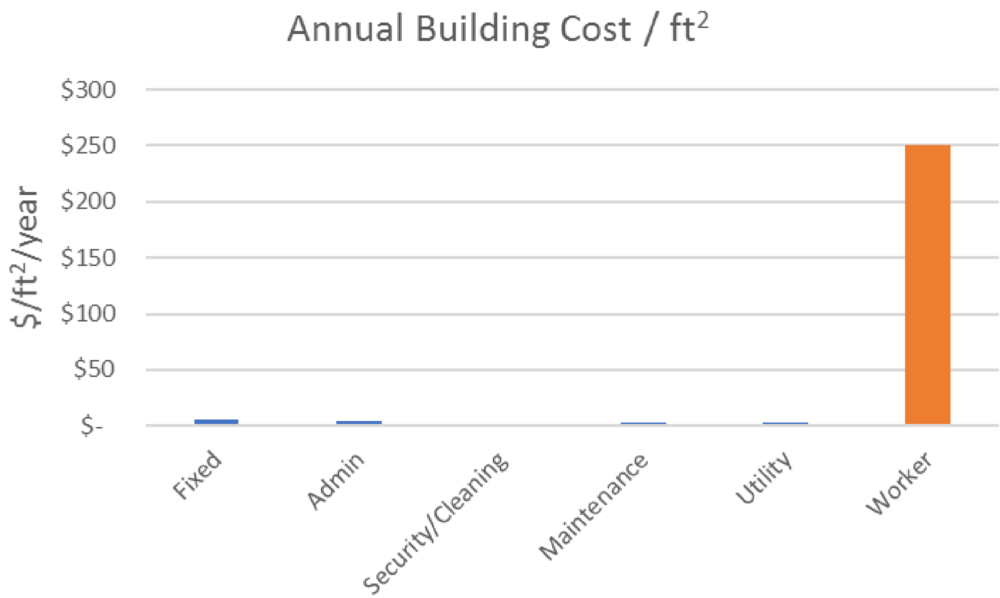
Dr. Peter Kozodoy
Founder & CEO

Dr. Chris Gladden
Director of Engineering

# Challenge

## Human Costs Dominate Building Expenses

- Human factors offer the biggest cost saving opportunity in buildings
- Total O&M + fixed costs:
  < $15/ft²
- Typical office worker:
  >$250/ft²
- Average office utility costs are ~$2.35/ft²




**Increasing worker productivity by 10% could save 10 times more that the total cumulative utility costs.**

# Challenge

## Many building interiors have insufficient daylight

Studies suggest that by adding high quality daylight to buildings:

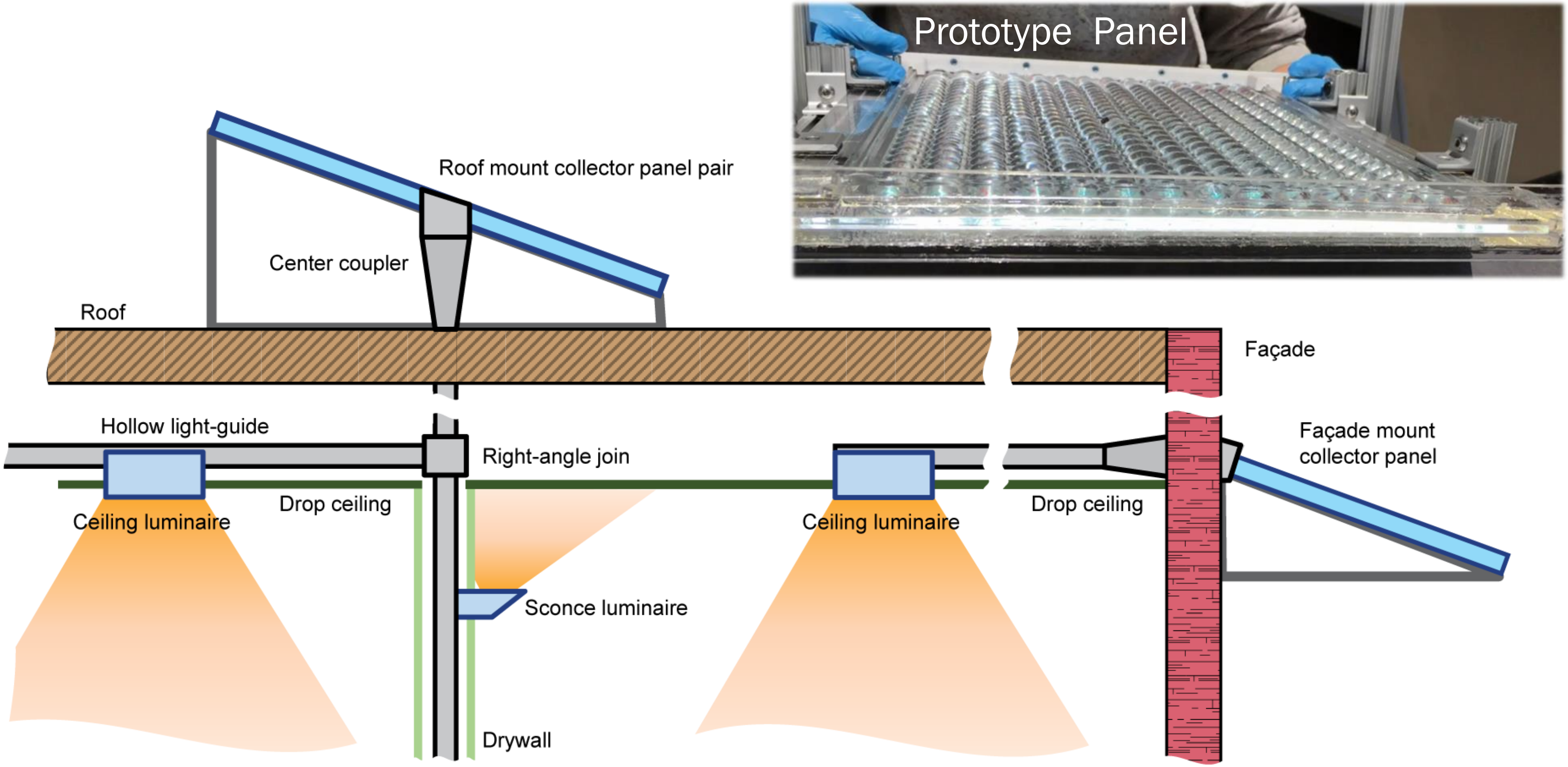
- Retail sales increase 31%-49% [1]
- Students progress 20%-26% faster in reading and math [2]
- Office worker productivity increases by 13% [3]
- Occupants can maintain healthy circadian rhythm, have increased cognitive performance, and decreased stress levels [4,5]

**The Glint Daylight Concentrator is a revolutionary new product that can bring natural daylight deep into the interior of buildings**


1. Heschong Mahone Group (1999). *Skylighting and Retail Sales: An Investigation into the Relationship Between Daylighting and Human Performance*
2. Heschong Mahone Group (1999). *Daylighting in Schools An Investigation into the Relationship Between Daylighting and Human Performance*
3. Heschong Mahone Group, I. (2003). Windows and Offices: A Study of Office Worker Performance and the Indoor Environment.
4. *Lucas, R.J., et al. (1999) Regulation of the mammalian pineal by non-rod, non-cone, ocular photoreceptors. Science Vol. 284, Issue 5413, pp. 505–507*
5. *Gabal V, et al. (2013) Effects of artificial dawn and morning blue light on daytime cognitive performance, well-being, cortisol and melatonin levels. Chronobiology International 30(8) 988-97*

# Approach

***The Glint Daylight Concentrator is a solar panel that delivers <u>concentrated daylight</u> instead of electricity.***

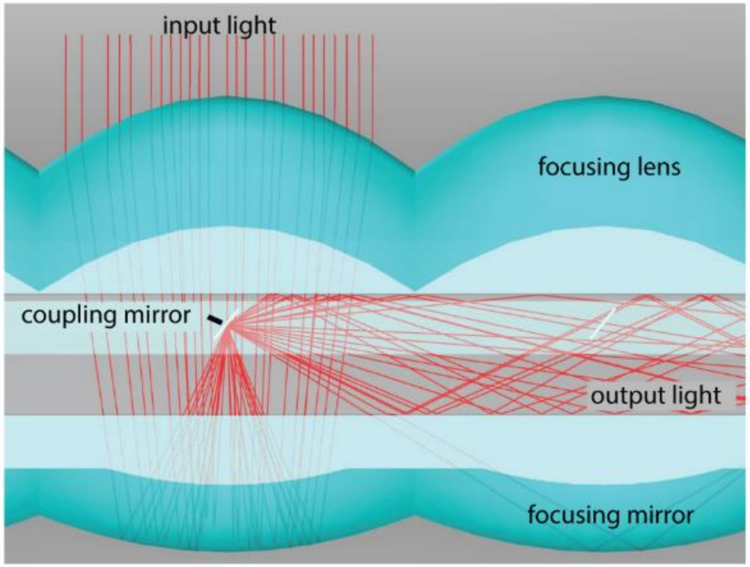


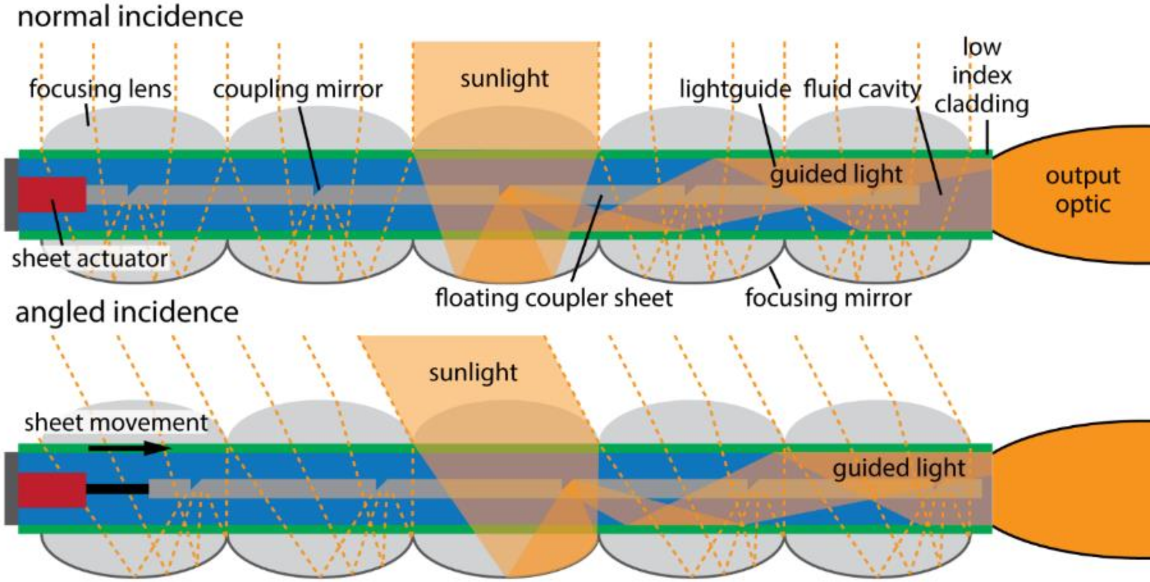

- Thin, flat, <u>stationary</u> collector panel mounted on roof or building façade
- <u>Highly concentrated</u> sunlight is delivered into hollow reflective light pipes, 2” x 12” in cross section
- Hollow light-guides can be routed through walls and plenums as desired, up to 30 meters from collector
- Gathers sunlight at angles >60°, providing >8 hours of daylight delivery per day

# Approach

***The Glint Daylight Concentrator is a solar panel that delivers <u>concentrated daylight</u> instead of electricity.***

- Panel uses injection molded acrylic catadioptric optical system
  - One refractive lens array on top
  - One reflective lens array on bottom
  - Central floating coupler sheet with 45° metalized mirrors
- Sunlight is collected and focused between the two lenses
- Mirrors on floating coupler sheet turn light 90° inside the device
- Light is trapped inside lightguide layer and concentrated as each lens adds more light to the lightguide
- Concentrated daylight exits one end of the panel into a delivery optic that distributes the light into the building

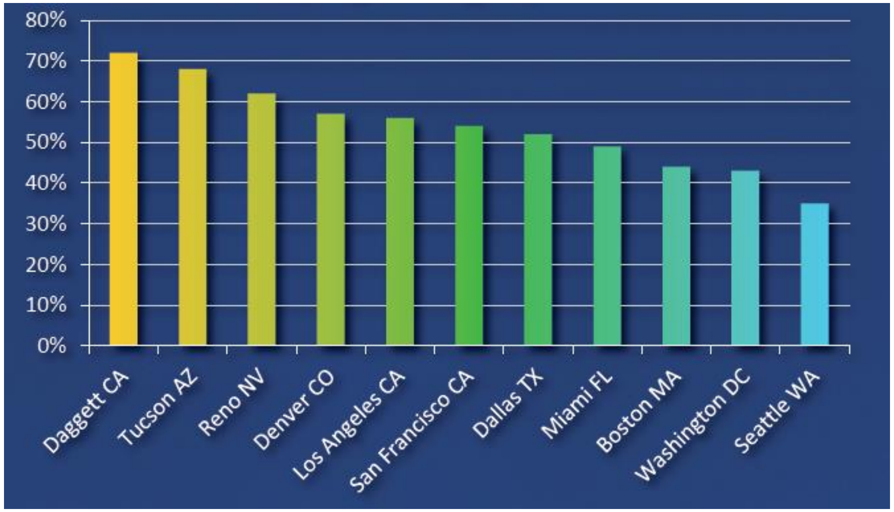


# Approach

## Market Opportunity

- 93% of the $6B daylighting market is currently skylights for commercial and institutional buildings
- California commercial buildings
  - 600,000 buildings with 6 billion square feet
  - 120,000 buildings per year perform alterations to improve energy efficiency
- Initial market: Commercial buildings in CA performing window glazing replacement or new construction (~12,000 buildings)




predicted annual lighting energy savings for US locations

# Approach

## Key Risks & Mitigation

### Risk 1 - Mechanical Actuation System Accuracy

- ✓ Develop actuation system with mechanical advantage
- ✓ Characterize performance with motion capture

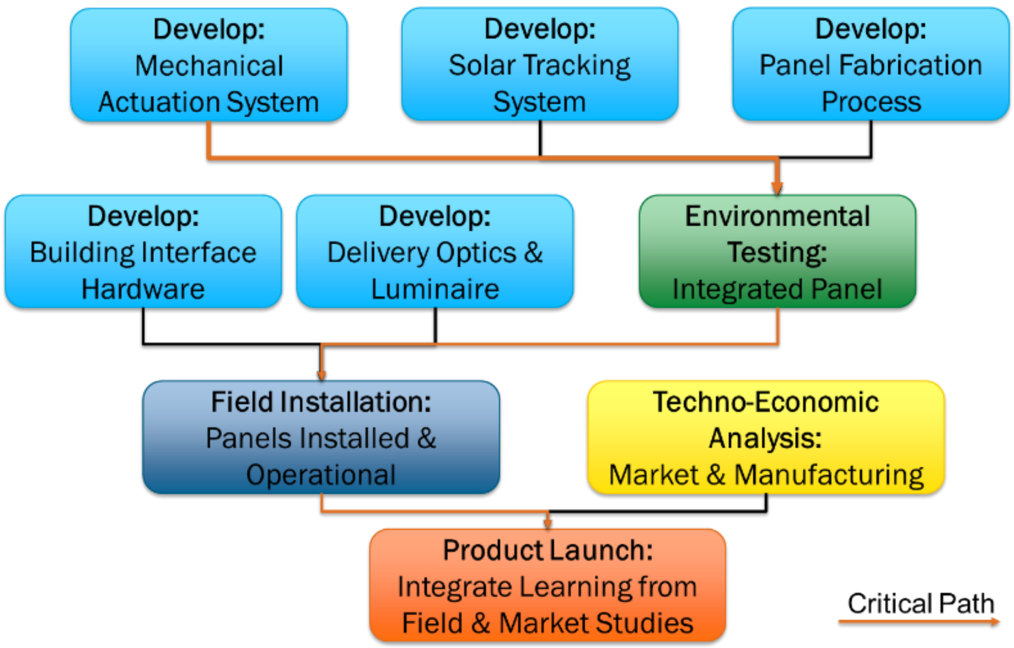
### Risk 2 - Solar Position Algorithm

- ✓ Deploy photodiode based sun tracker
- ✓ Long term algorithm testing

### Risk 3 - Panel Sealing and Environmental Durability

- ✓ Redesign panel sealing interface
- ✓ Extended environmental testing

## Project Plan Overview




### Risk 4 – Building Interface System

- ➢ Down-select to roof or façade
- ➢ Develop mounting hardware w/ input from field installation

### Risk 5 – Market Acceptance

- ➢ Stakeholder outreach
- ➢ Field Installation
- ➢ Techno-Economic Analysis

# Impact

## Multi-Year Program Plan Alignment

Project aligns with MYPP window light redirection and daylighting goals to reduce cost, improve aesthetics, reduce glare, and improve energy offset with higher efficiency and deeper redirection.

| | | | | |
|---|---|---|---|---|
| **Daylighting Technologies** | Lighting energy use (% reduction) 50 ft. floor plate; | 16% | 35% | 50% |
| | Installed cost prem. incl. sensors & controls ($/sq. ft.) | $9 | $13 | $5 |

*MYPP (pg. 83)*

*"Window light redirection technology reduces the amount of energy consumed for interior lighting, but the reach of the technological benefits is currently limited due to high cost of installations and aesthetic issues. The Sub-Program's focus is on reducing the high cost of daylighting and improving deep light redirection technologies at a low cost and without glare. Demonstrations related to appearance, the energy savings impact based on season and time of day, and appropriate integration with building controls and operation in coordination with R&D will help drive the technologies to the market." (MYPP pg. 82)*

## Field Installation

- **Field installation planned at Glint offices**
- **Panels will be retrofitted to light office area from facade**
- **System will be monitored and studied once installed**
  - Lighting circuit energy use will be monitored
  - Lighting spectral quality will be monitored
- **Energy and human impacts will be quantified**
- **System can be demonstrated to potential investors or commercial partners**

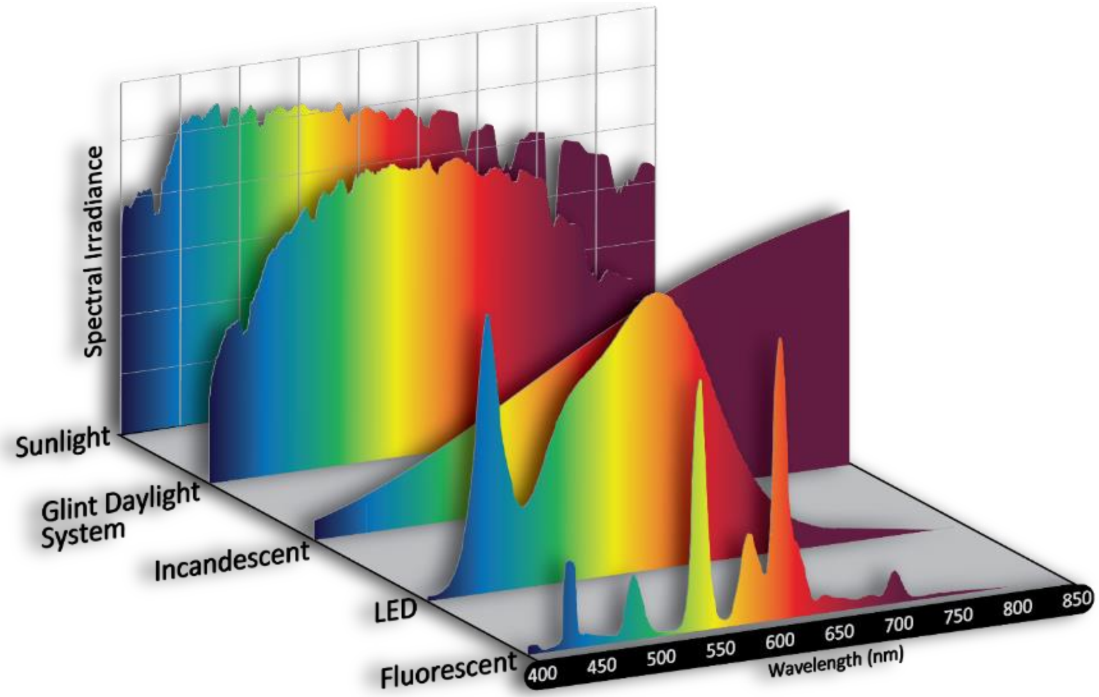
# Impact

## Cost and Performance Advantage

| Daylighting system | Routing capability | Roof penetration area (sq ft) | Peak lumens | Cost |
|---|---|---|---|---|
| Skylight in drywall shaft | None | 8.00 | 30,000 | $2,500 |
| Tubular daylighting device | Limited | 1.10 | 8,000 | $300 |
| Concentrator with fiber optics | Flexible | 0.05 | 4,000 | $10,000 |
| **Glint daylighting device** | **Flexible** | **0.17** | **13,000** | **$400** |

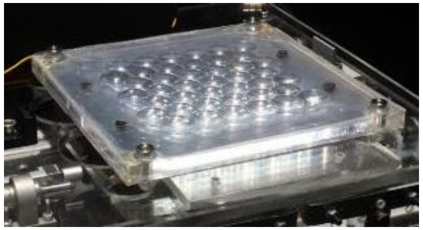
The Glint Daylight Concentrator provides significant cost and performance advantages over incumbent technology.

- More light delivered through a smaller roof penetration
- Reduced installation cost
- Increased routing flexibility
- Greater annual energy savings
- Excellent spectral quality

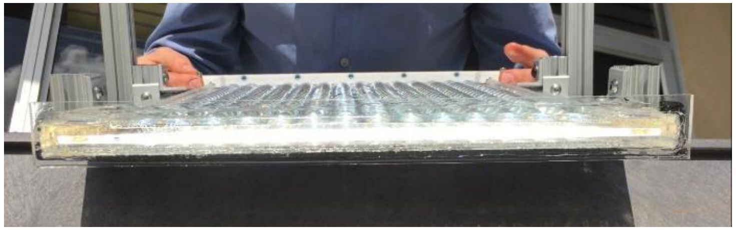


# Progress

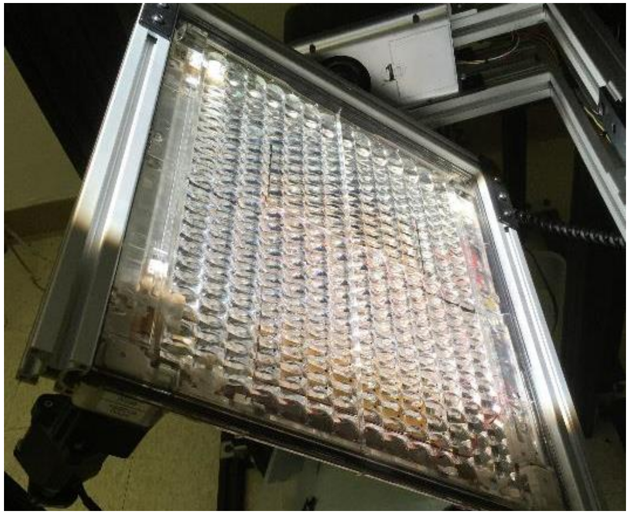
- Project is currently at start of second budget period, just past mid-point
- System successfully completed GO/NO-GO milestone, BP2 was funded
- Slight delay with BP2 funding has delayed field installation by one quarter



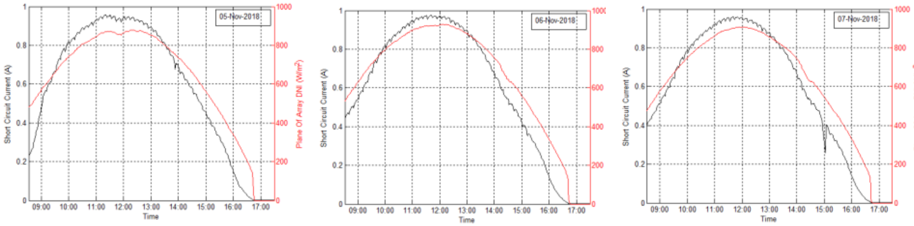
2016 – 20 in$^2$



2017 –Manually Actuated 170 in$^2$



2018 – Fully Automated 170 in$^2$




2019 – Rooftop Solar Tracking

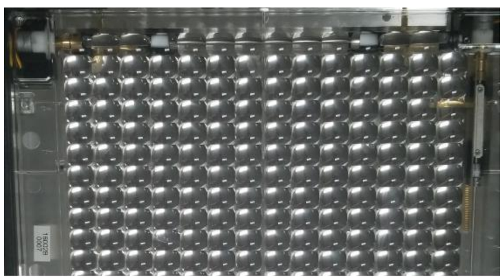
Technology featured in Scientific American, MIT Tech Review, CleanTechnica, TechSpot, Gizmodo and more.

# Progress

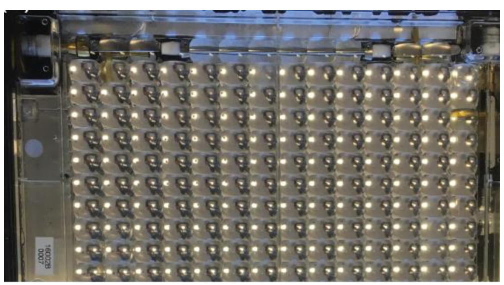
## Major Accomplishments

- Developed integrated motor platform to reduce weight and cost
- Actuation system and panel rigorously tested for environment durability
- Developed panel sealing process that survives thermal cycling (-30C to 65C)
- Solar tracking demonstrated in long term roof-top installation
- System passed GO/NO-GO Milestone testing – Performs as intended across wide temperature range

Thermal Cycle Testing

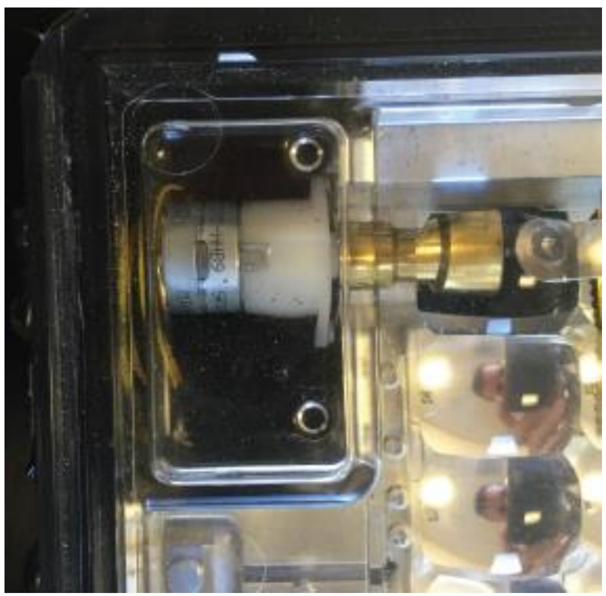


Before Testing



100 Thermal Cycles + 10 DH/HF

Integrated Motors



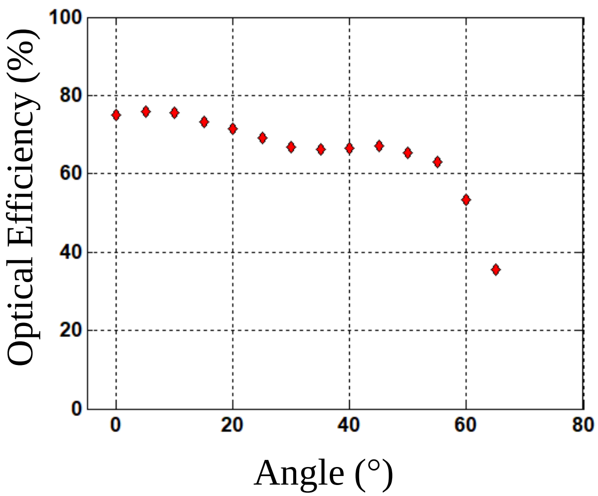
GO/NO-GO Testing

# Progress

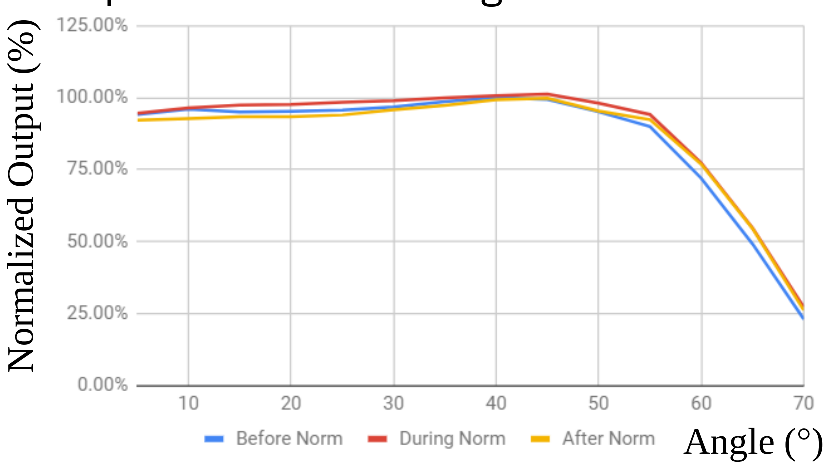
**Go/No-Go Testing**

- Panel tested at 9 different incidence angles and 5 different temperatures
- Performance benchmarked at room temperature
- Panel performed at >90% of benchmark at all but two test conditions
- Milestone was to perform at >75% of benchmark
- Optical efficiency of panel focusing optics measured at nearly 100% of modeled performance

| Long Axis | Short Axis | 50 °C | 37 °C | 19 °C | -2 °C | -10 °C |
|---|---|---|---|---|---|---|
| 60 | 0 | 79% | 89% | 100% | 101% | 105% |
| 50 | 0 | 91% | 96% | 100% | 98% | 99% |
| 40 | 0 | 98% | 99% | 100% | 93% | 91% |
| 30 | 0 | 95% | 98% | 100% | 95% | 94% |
| 20 | 0 | 98% | 100% | 100% | 92% | 90% |
| 0 | 0 | 89% | 94% | 100% | 98% | 98% |
| 0 | 10 | 92% | 94% | 100% | 95% | 96% |
| 0 | 20 | 92% | 96% | 100% | 95% | 95% |
| 0 | 30 | 92% | 96% | 100% | 95% | 95% |




Panel performance unchanged after thermal testing



# Stakeholder Engagement

- **Project is currently in last year of contract**
  - Working towards first field installation at Glint office
  - Second field installation currently under negotiation (details can't be shared publicly)
- **Extensive interaction with lighting designers and industry experts:**
  - George Loisos, Principal at Loisos + Ubbelohde, an Oakland-based architectural design firm. Potential future field installation site when new offices are constructed.
  - Eight Inc., a San Francisco-based "experience design" firm that designs high-profile retail, hospitality, and commercial spaces. Met with a group of 10 designers.
  - Jeremy Steinmeir, a leading lighting designer at the San Francisco office of the architectural design firm Gensler.
  - Dane Sanders, Principal at Clanton & Associates, a Boulder-based lighting design and engineering firm.
  - Earl Armstrong, a builder and developer in the Santa Barbara area active in the construction of schools, museums, and office space.
  - Konstantinos Papamichael, Co-director at California Lighting Technology Center, UC Davis.

# Stakeholder Engagement

- **Industry engagement has provided several inputs:**
  - Target façade mounted applications for initial field installation
  - Free space optical transmission for initial field installation
  - Target new construction or buildings with planned window replacement/retrofit
  - Emphasize aesthetic appeal of product to improve adoption by lighting designers and architects
  - Develop attractive/unique internal luminaires to distinguish product
  - Design optical system to eliminate glare as much as possible (downfall of many previous daylighting system)
  - Solar tracking / mechanical actuation system must be automated, robust, and self correcting (many previous daylighting trackers eventually stop tracking the sun)

# Remaining Project Work

## Key Risks Remaining

**Risk 1 - Mechanical Actuation System Accuracy (COMPLETE)**

**Risk 2 - Solar Position Algorithm (COMPLETE)**

**Risk 3 - Panel Sealing and Environmental Durability (COMPLETE)**

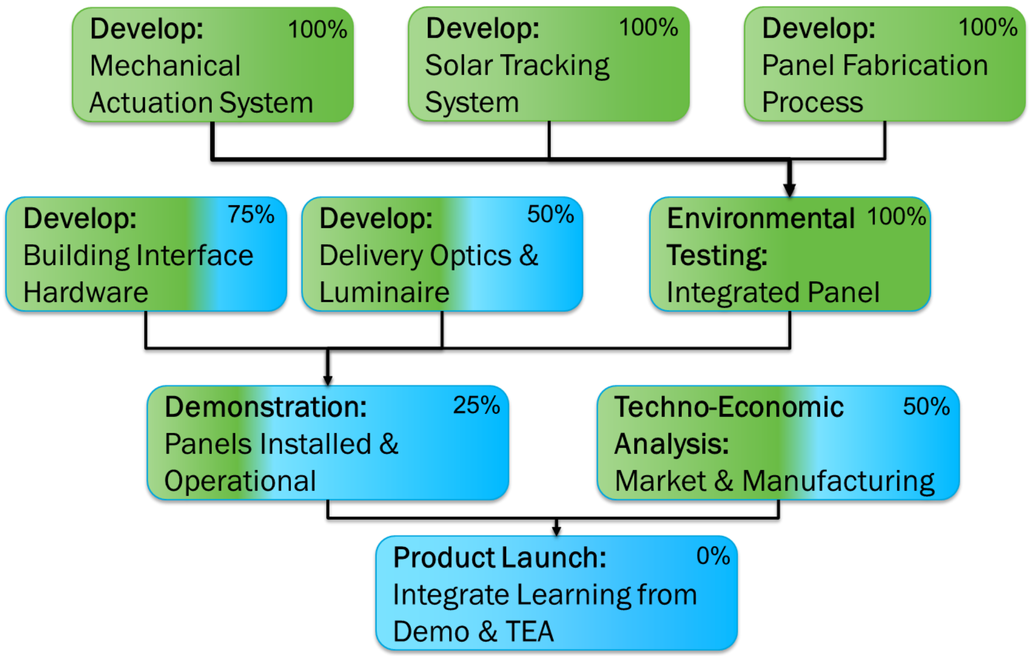
**Risk 4 – Building Interface System**

- Down-select to roof or façade (COMPLETE)
- Develop mounting hardware w/ input from field installation (IN PROGRESS)

**Risk 5 – Market Acceptance**

- Stakeholder outreach (COMPLETE)
- Field Installation (IN PROGRESS)
- Techno-Economic Analysis (IN PROGRESS)

## Project Plan Progress




**Long Term Planning**

- Secure second field installation
- Work with strategic partners to bring product to market
- Engineer second generation panel with improved performance

# Thank You

Glint Photonics Inc.
Chris Gladden, Director of Engineering
chris@glintphotonics.com

# REFERENCE SLIDES

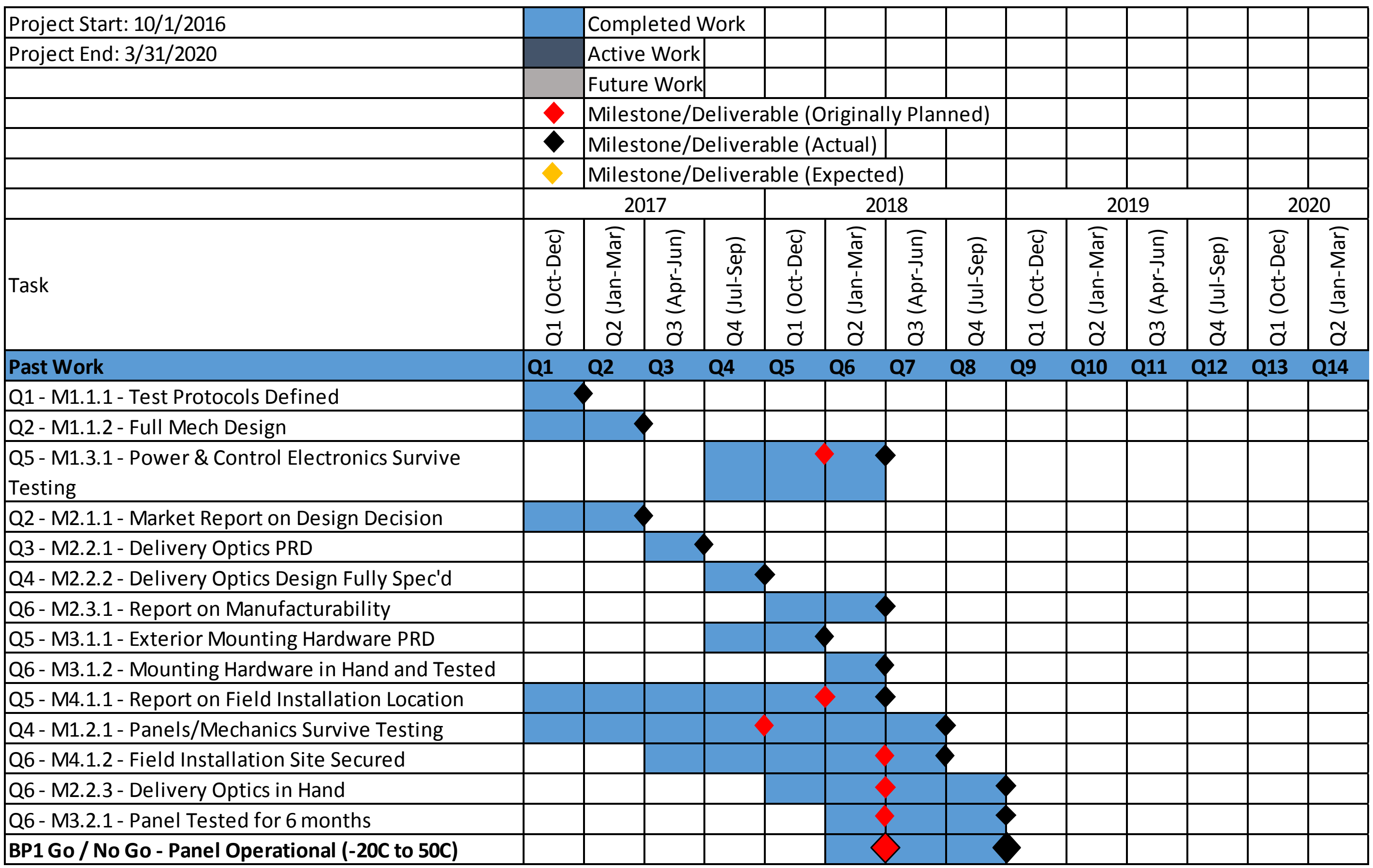
# Project Budget

**Project Budget**: $1.08M DOE, $270K cost-share (CEC)
**Variances**: No major variances aside from NCE. 2019 spend began in Feb due to contract delays with BP2.
**Cost to Date**: 72.3% of 1,080,000 DOE Spent, 100% of Cost Share
**Additional Funding**: ARPA-E MOSAIC DE-AR0000644, CEC EPC-14-040

| Budget History | | | | | |
|---|---|---|---|---|---|
| 10/1/2016– FY 2018 (past) | | FY 2019 (current) | | FY 2020 – 3/31/2020 (planned) | |
| DOE | Cost-share | DOE | Cost-share | DOE | Cost-share |
| $781,431 | $304,636 | $0 | $0 | $1,080,000 | $304,636 |

# Project Plan and Schedule

- Vendor delays for molded optical panels resulted in program wide delays
  - Mechanical system changes required mold revision
  - Vendor had 3 month delay in completing mold revisions
  - Molded part planarity issues required additional 3 months of work
- Six-month no cost extension was used to re-align project schedule
- All slipped milestones are a result of these delays



# Project Plan and Schedule

- **Budget Period 2 work began Feb 1 2019**
- **Expected end date is 3/31/2019**

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Start: 10/1/2016 | | Completed Work | | | | | | | | | | | | |
| Project End: 3/31/2020 | | Active Work | | | | | | | | | | | | |
| | | Future Work | | | | | | | | | | | | |
| | | Milestone/Deliverable (Originally Planned) | | | | | | | | | | | | |
| | | Milestone/Deliverable (Actual) | | | | | | | | | | | | |
| | | Milestone/Deliverable (Expected) | | | | | | | | | | | | |
| | 2017 | | | | 2018 | | | | 2019 | | | | 2020 | |
| 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) | Q1 (Oct-Dec) | Q2 (Jan-Mar) |
| **Current/Future Work** | **Q1** | **Q2** | **Q3** | **Q4** | **Q5** | **Q6** | **Q7** | **Q8** | **Q9** | **Q10** | **Q11** | **Q12** | **Q13** | **Q14** |
| Q10 - M5.1.1 - Interior Mounting Hardware PRD | | | | | | | | | | | | | | |
| Q10 - M5.1.2 - Interior Mounting Hardware Tested | | | | | | | | | | | | | | |
| Q11 - M5.2.1 - Full Panel Data for 6 months | | | | | | | | | | | | | | |
| Q13 - M5.3.1 - New Panel Design Finalized | | | | | | | | | | | | | | |
| Q14 - M5.3.2 - New Hardware and Delivery System Design | | | | | | | | | | | | | | |
| Q10 - M6.2.1 - Baseline Data Collection Complete | | | | | | | | | | | | | | |
| Q12 - M6.2.3 - Performance and Energy Savings Analysis | | | | | | | | | | | | | | |
| Q14 - M6.2.4 - Revised design and documentation | | | | | | | | | | | | | | |
| Q10 - M6.3.1 - Key Partner Engagement | | | | | | | | | | | | | | |
| Q12 - M6.3.3 - Business Model Canvas Complete | | | | | | | | | | | | | | |
| Q14 - M6.3.4 - Tranistion Plan Complete | | | | | | | | | | | | | | |