SunShot Incubator Program

CSP Program Review 2013

Deploying Low-Cost Suspension Heliostats™

U.S. Department of Energy
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Phoenix, AZ

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Presentation Outline

- SunShot
  - Solaflect Successes of Tier One
  - Solaflect Goals for Tier Two
- Overview of Suspension Heliostat™
- SunShot Cost Goals and Suspension Heliostats
- Current Progress

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Tier 1 Project Goals Met

December 2011 to December 2012

1: Reduce heliostat cost by $25/m², when manufactured in volume.

2: Rigorously test and validate heliostat performance.

3: Create additional data to further reduce cost and improve performance of future iterations of the Suspension Heliostat™.

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Tier 2 Project Goals

Started February 1, 2013

- Optimize Heliostat for High Volume Production
- Reduce Shop Assembly Labor
- Reduce Field Installation Labor and Assembly Time
- Develop Hot Water Receiver
- Engage Customers

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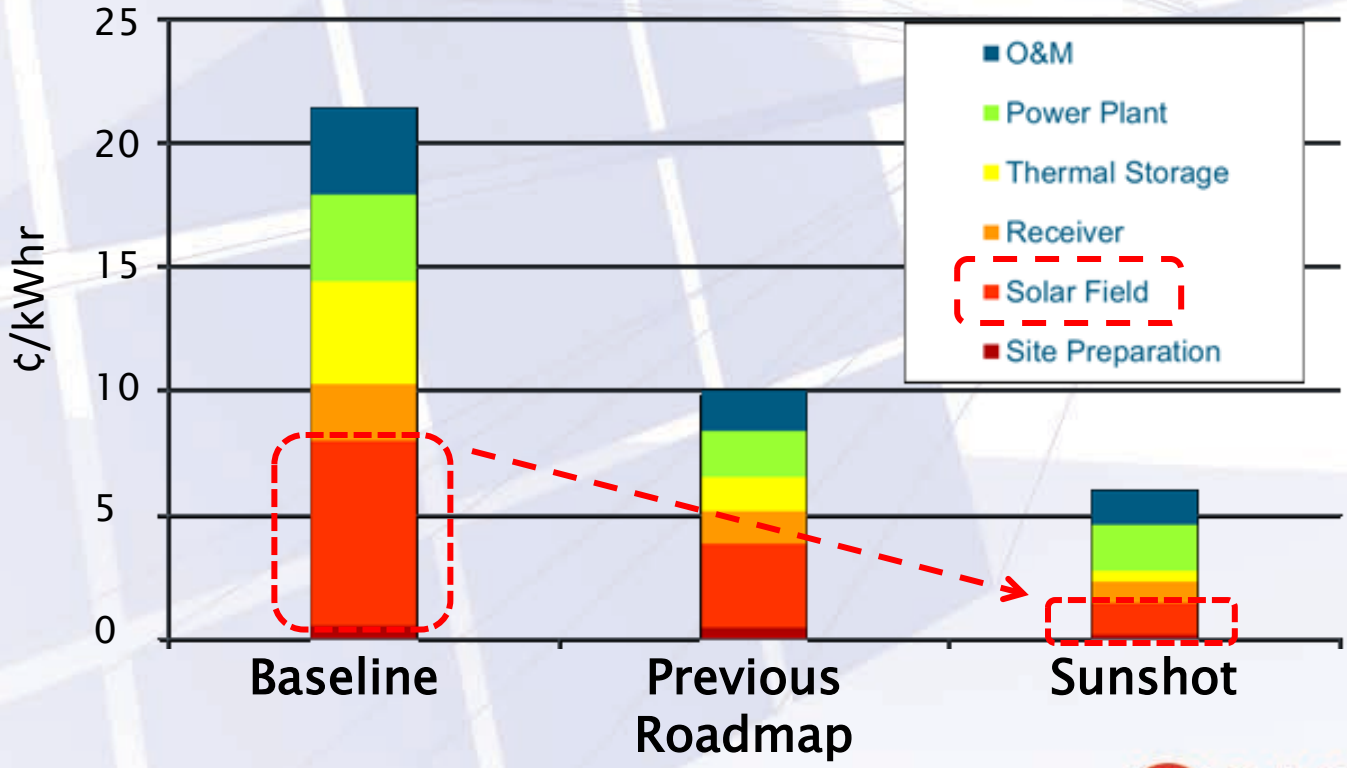
Problem: *Heliostats Too Expensive*

- Heliostats 30% to 50% of CSP plant cost
- SunShot goal: $75/m²



http://www1.eere.energy.gov/solar/sunshot/

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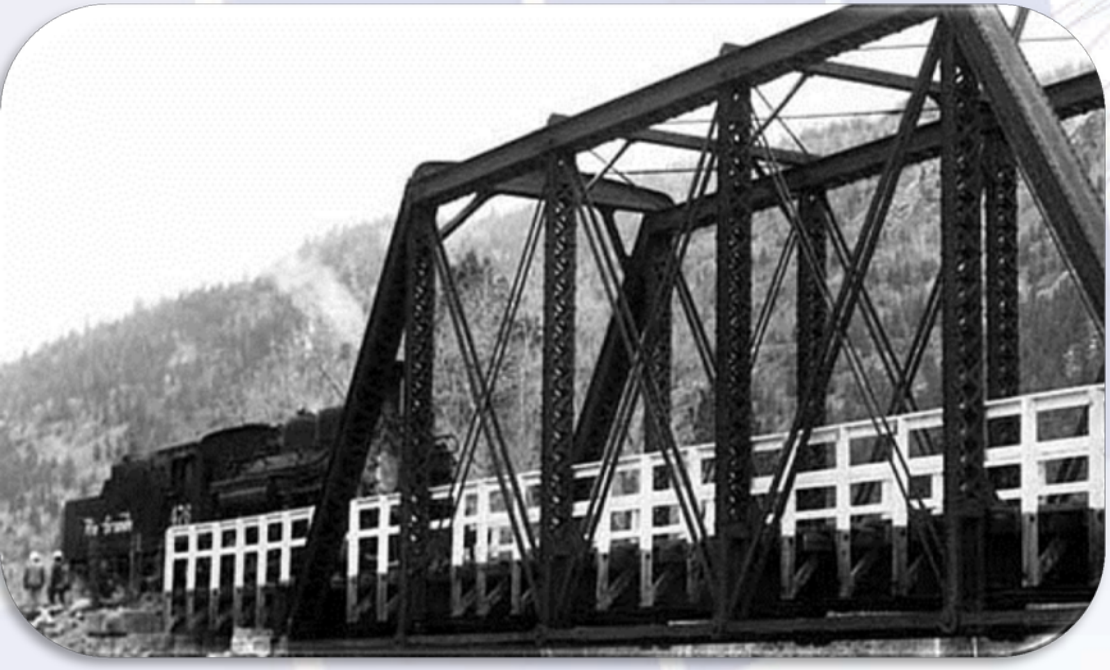
Background: Conventional Heliostats

- Typical “truss” design
  - Heavy structural support
  - Material inefficient
  - Significant fabrication cost



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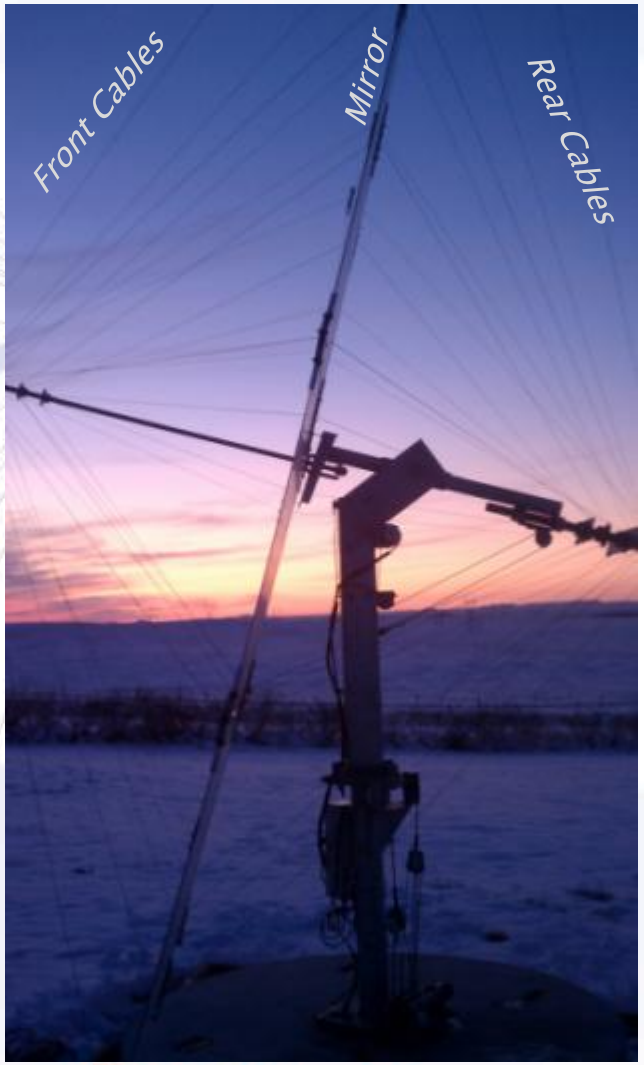
Solaflect Suspension Heliostat

- Patented heliostat design
  - Mirrors *suspended* with cables
  - Material *efficient*
  - Greatly reduced cost



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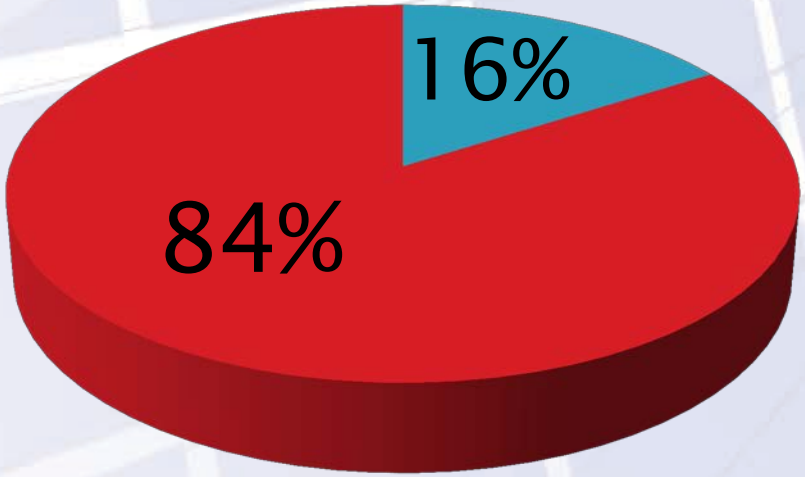
SunShot Goal: Achieving $75per m²

Structural steel cost in volume

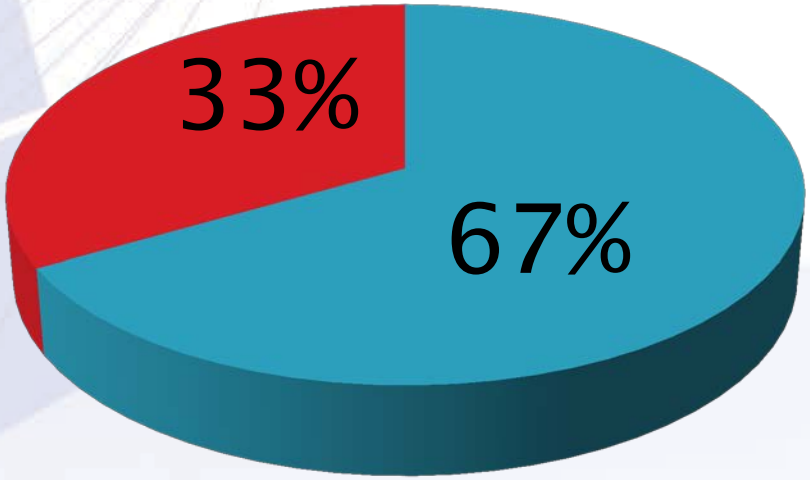
Resulting allowable balance of heliostat cost

Assuming total of $75/m²

Sandia Base Case



Solaflect Incubator Baseline



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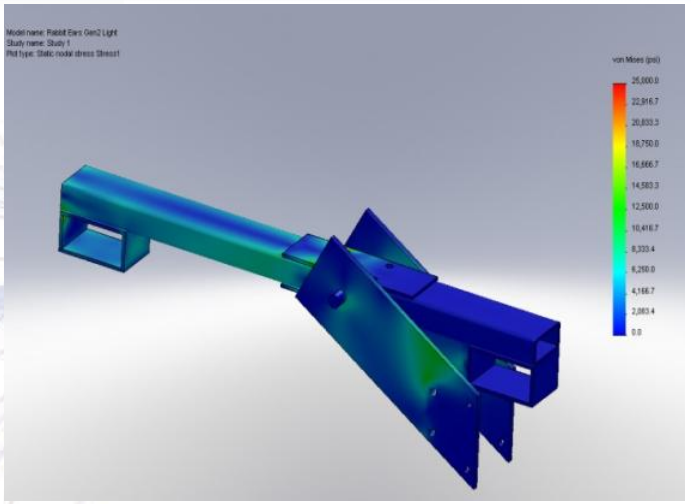
Cost Reduction Example: Redesigned Elevation Assembly

- Improved Performance:
  - Simplified construction
  - Reduced peak stresses
- Reduced Cost:
  - Cut total material usage by nearly half
  - Eliminated unnecessary hardware.
  - Simplified assembly, reducing handling



Description	Initial Prototype	Final Prototype
Carbon steel in elevation assembly	-39%	**-37%**
Stainless steel in elevation assembly	-47%	**-47%**
Carbon steel in “rabbit ears”	0%	**-54%**
Fabricated part reduction	-5	**-8**

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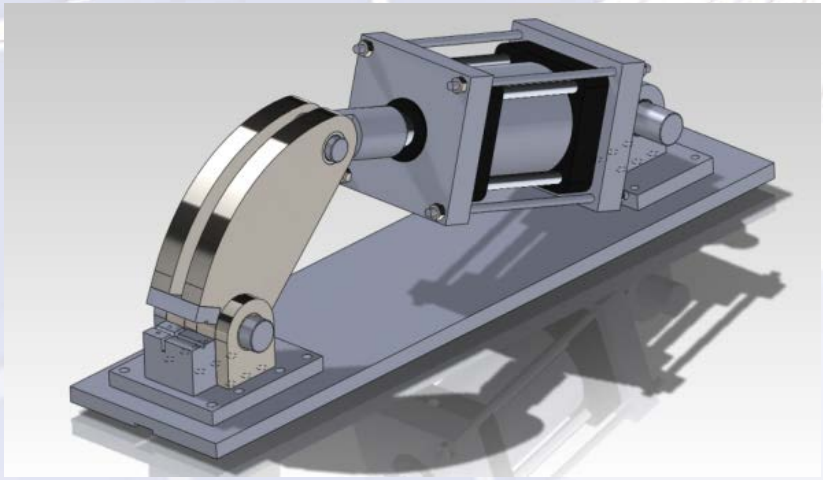
Improving Canting Accuracy

- Wire length critical to suspension structure.
- Team at Thayer School of Engineering
  - Created custom swaging machine for Solaflect cables
  - Achieved 10x greater consistency than industry standard



THAYER SCHOOL OF ENGINEERING AT DARTMOUTH

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Tier 1 Reliability Testing

- Testing at high-wind site in Cheyenne, WY
- Extreme wind event testing with jet engine

Long-term testing in Cheyenne

Survival wind testing by Jet Engine

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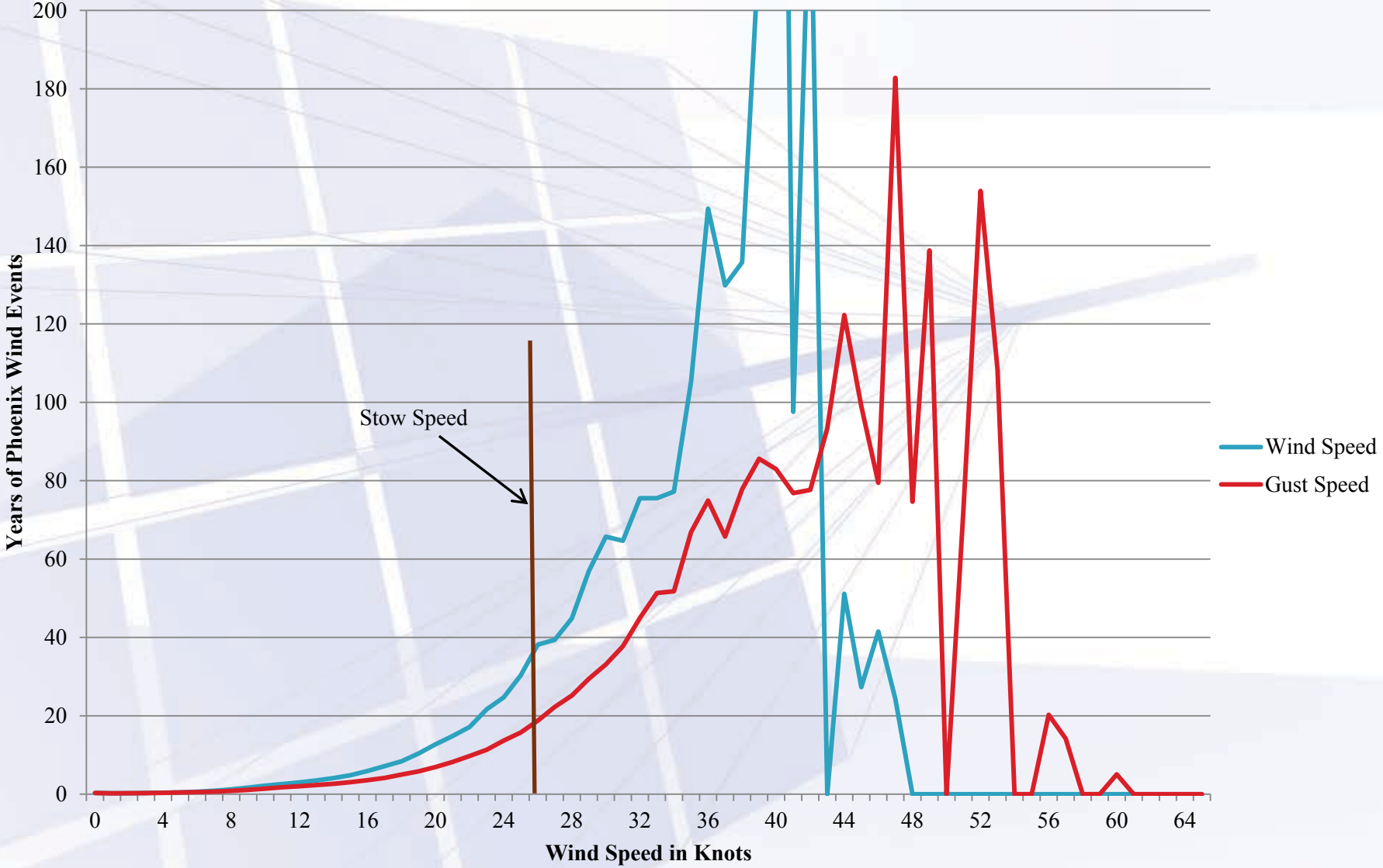
Cheyenne Winds as Number of Years of Phoenix Winds



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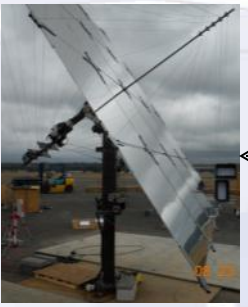
Confidential

Jet-Engine Set-Up

Heliostat

Cooling mist

Jet engine



Anemometers

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Tier 1 Surpassed all deliverables

- Cost reduced by over $25/m²
  - ~$10/m² from redesigned elevation drive
    - ~60% from steel reduction
  - ~$17/m² from redesigned controller
  - Many improvements in manufacturability, performance and reliability not captured in reduction.
- Met canting accuracy, vibration and wind specifications
- Many more opportunities for further development and cost reduction.

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Gen 4 vs. Gen 3 (Baseline Tier 2)

- Tubular posts and slotted crowns replace threaded rods, nuts, doughnuts

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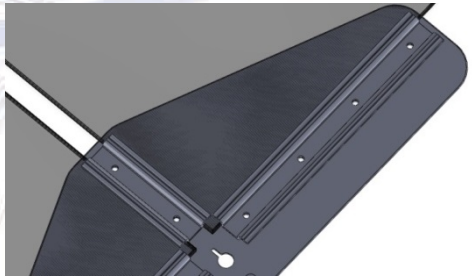
Tier 2 Progress

- Shop Assembly Labor Goals already Met
- Further Reduction in Assembly Labor Likely
- Cable Length Accuracy and Throughput Improved Further
- Components being Optimized for High Volume Manufacturing and Assembly



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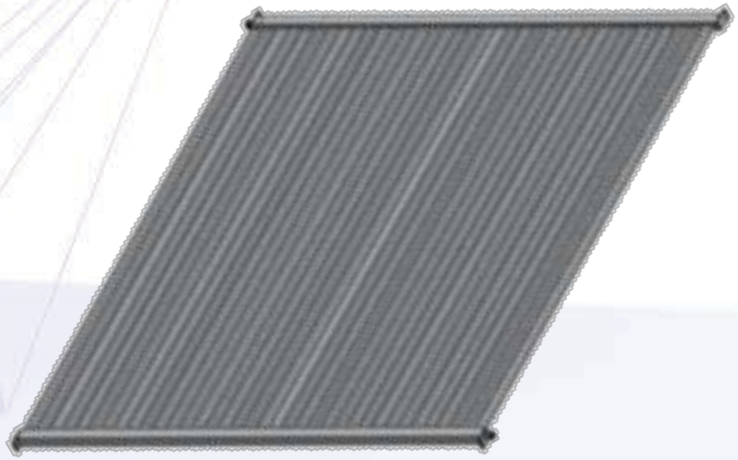
Future Work

- Optimize Design for Volume Manufacturing
- Minimize Labor in Shop and Field Assembly
- Design and Build Hot Water Receiver
- Complete Operational Pilot Installation
- Engage Customers



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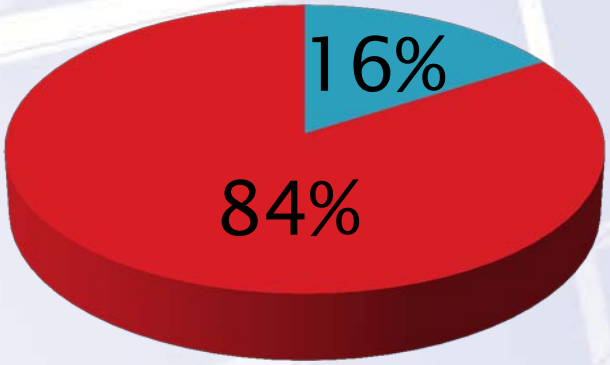
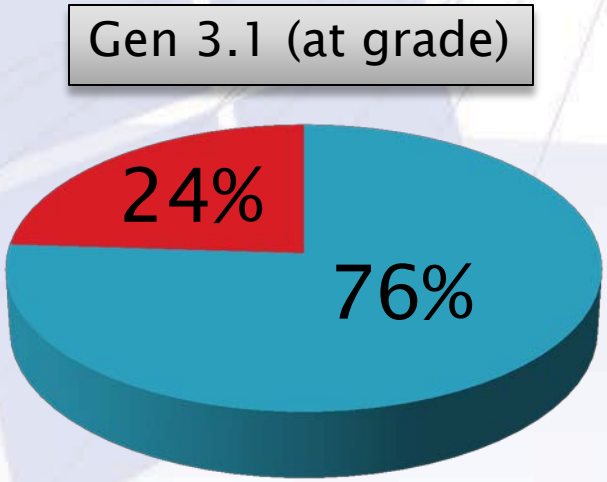
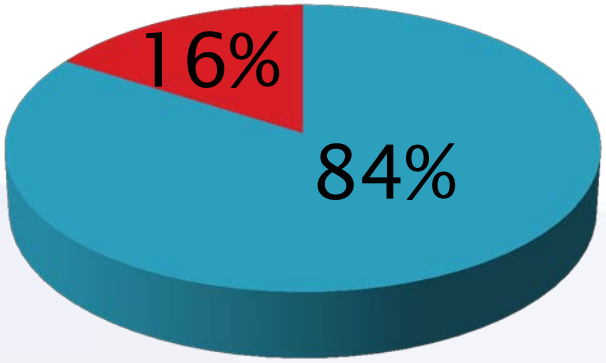


Gen 3.1 (at grade)



Gen 3.1 (driven pile)



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