

A tops down approach to heliostat cost

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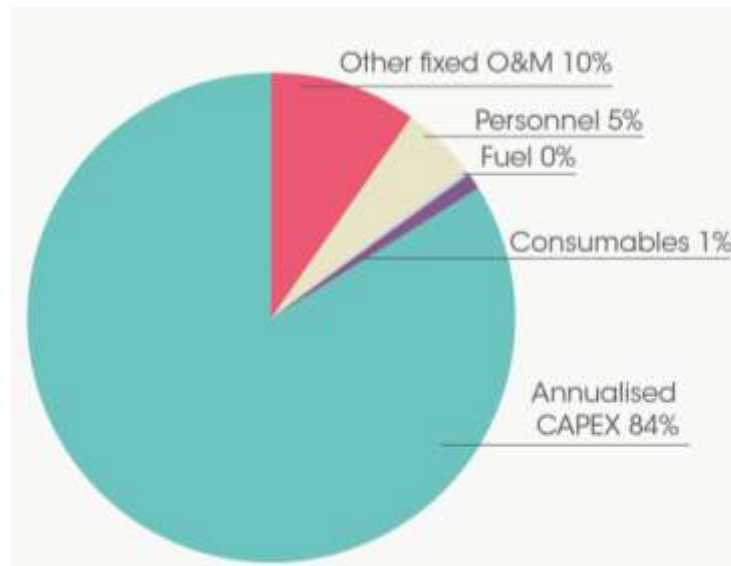
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- Heliostat cost reduction
- Tops down approach
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- Landing zone
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- Results

LCOE Breakdown

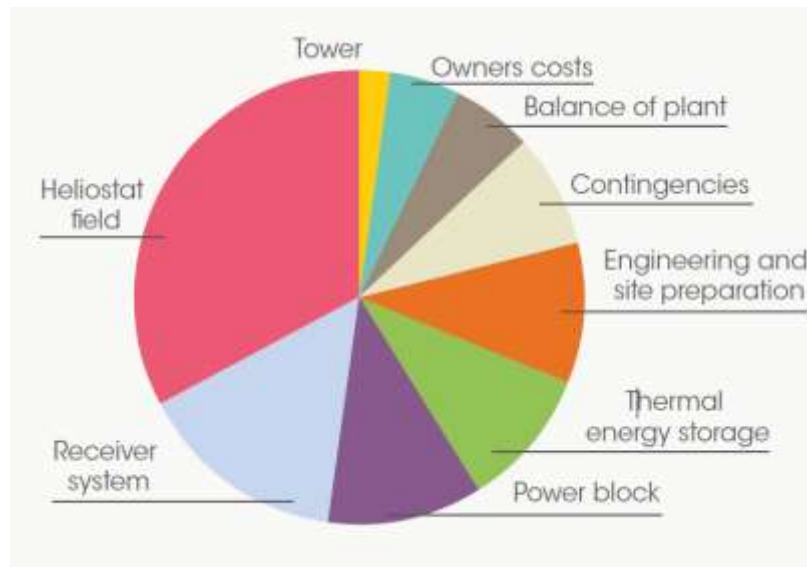
100MW Tower
15hr Storage



LCOE breakdown for a central receiver CSP plant in South Africa
(IRENA 2012)

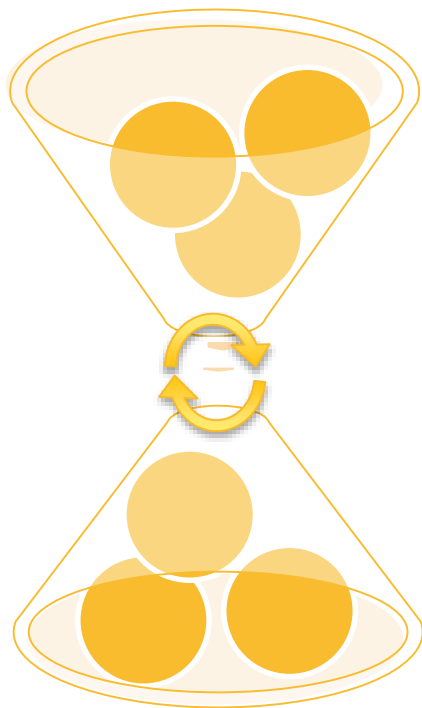
Total Installed Costs

100MW Tower
15hr Storage



Total installed cost for a central receiver CSP plant in South Africa
(IRENA 2012)

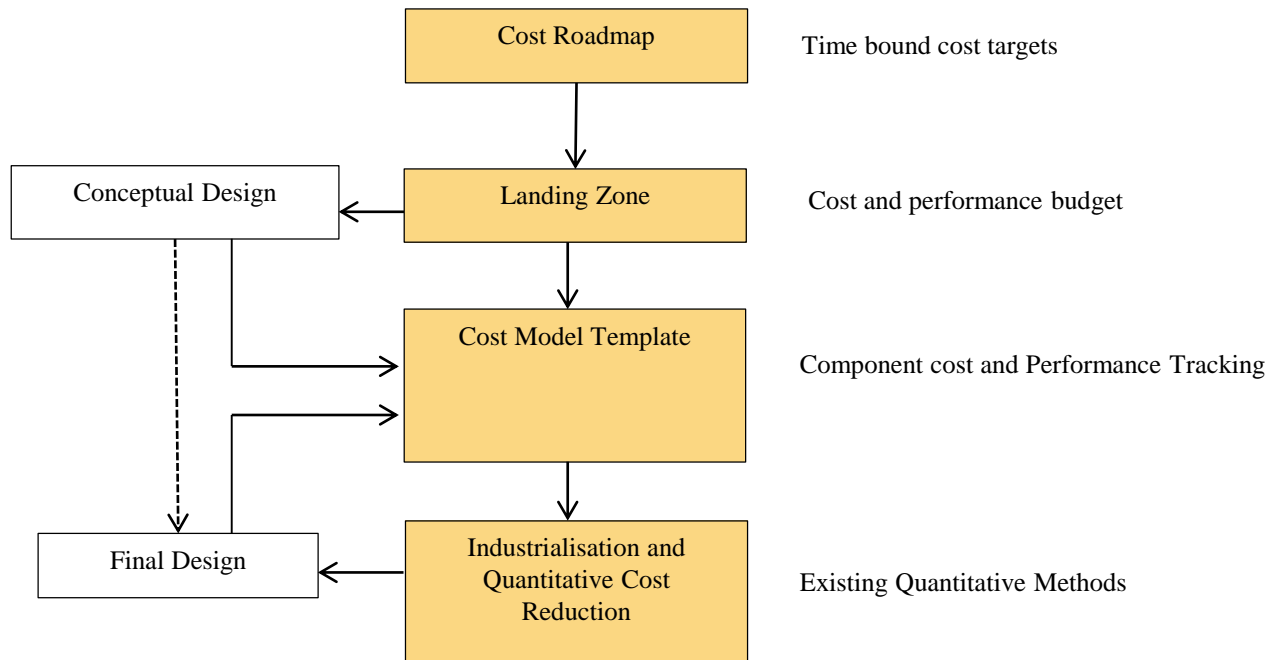
Finding the Right Solution



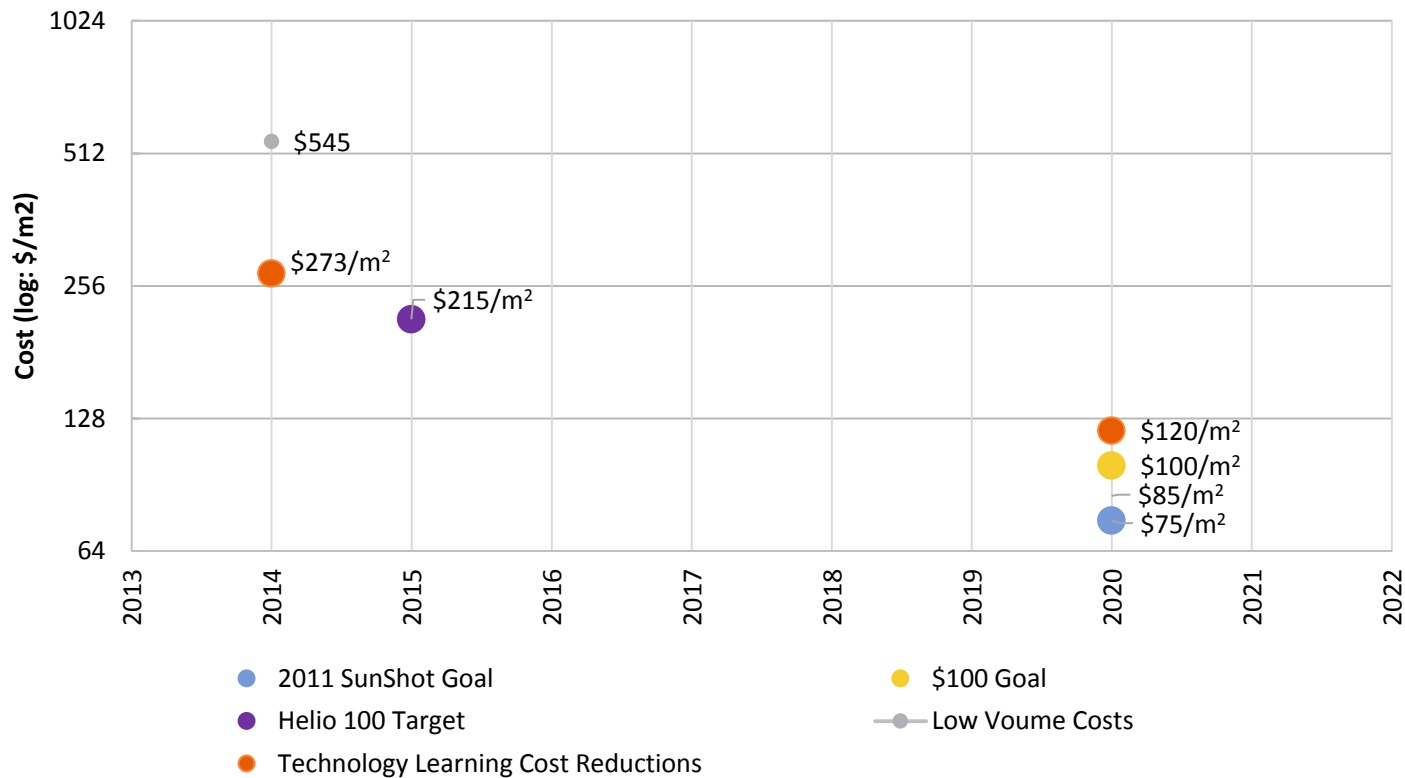
- Tops Down

- Bottoms Up

Methodology

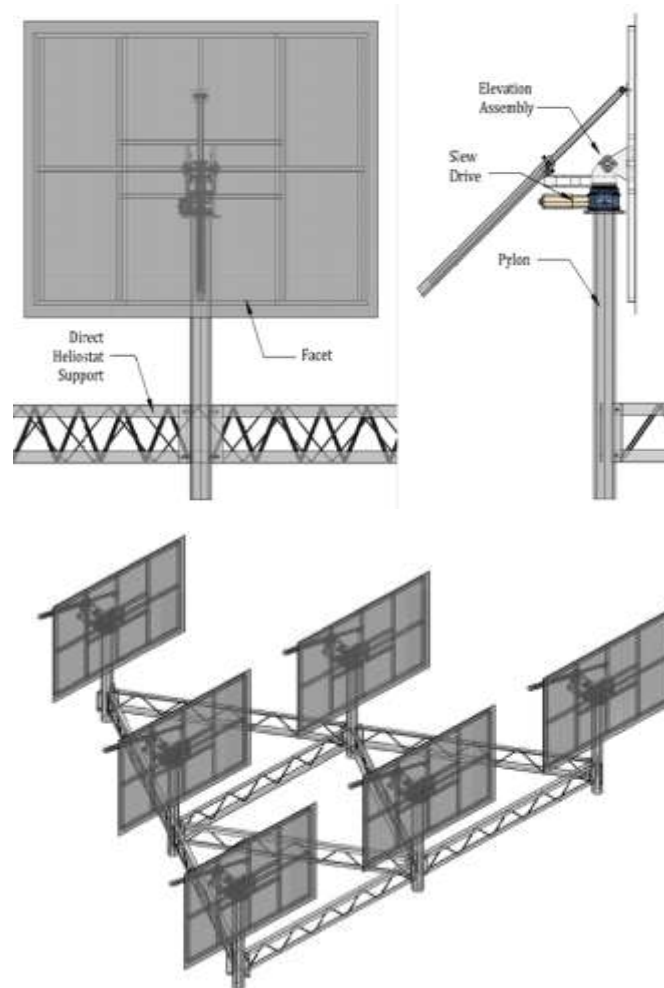


Cost Roadmap

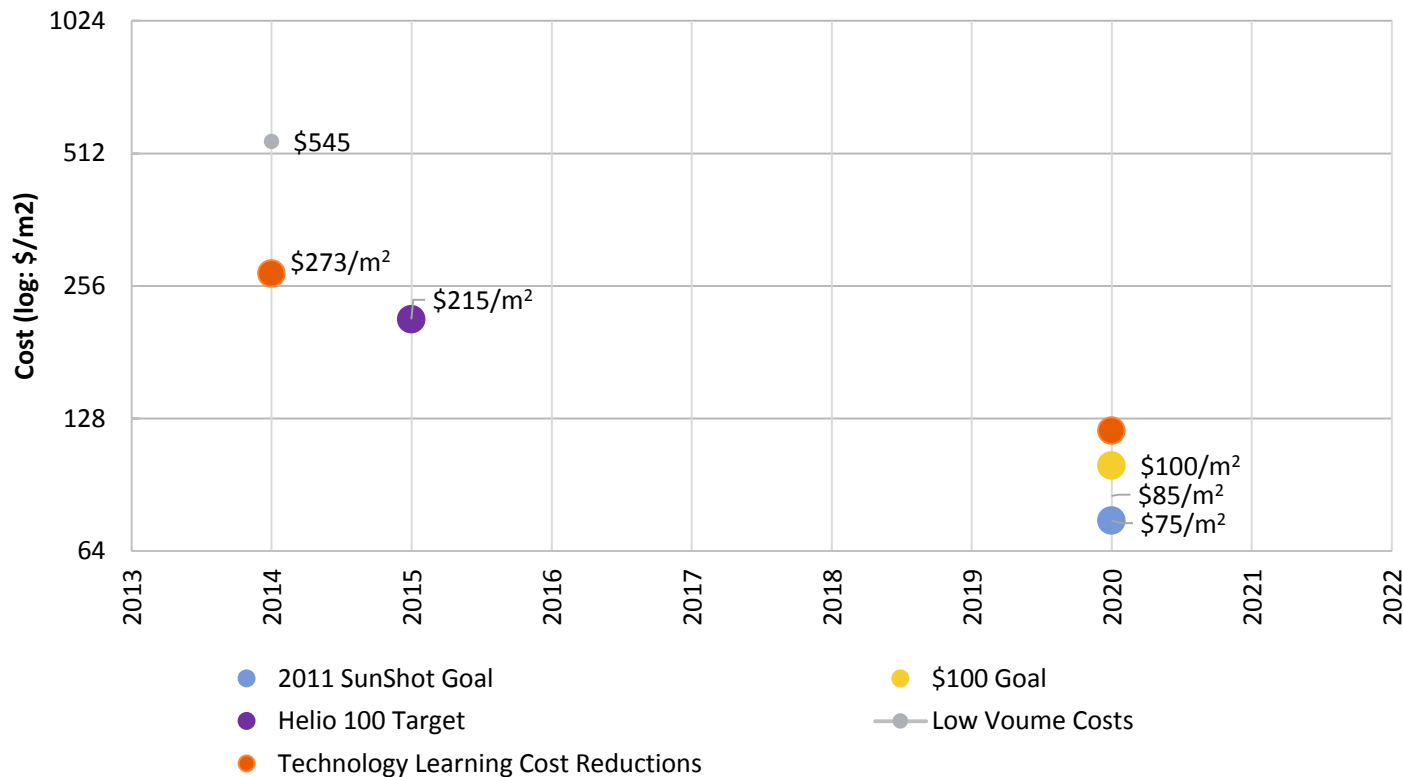


Departure Point

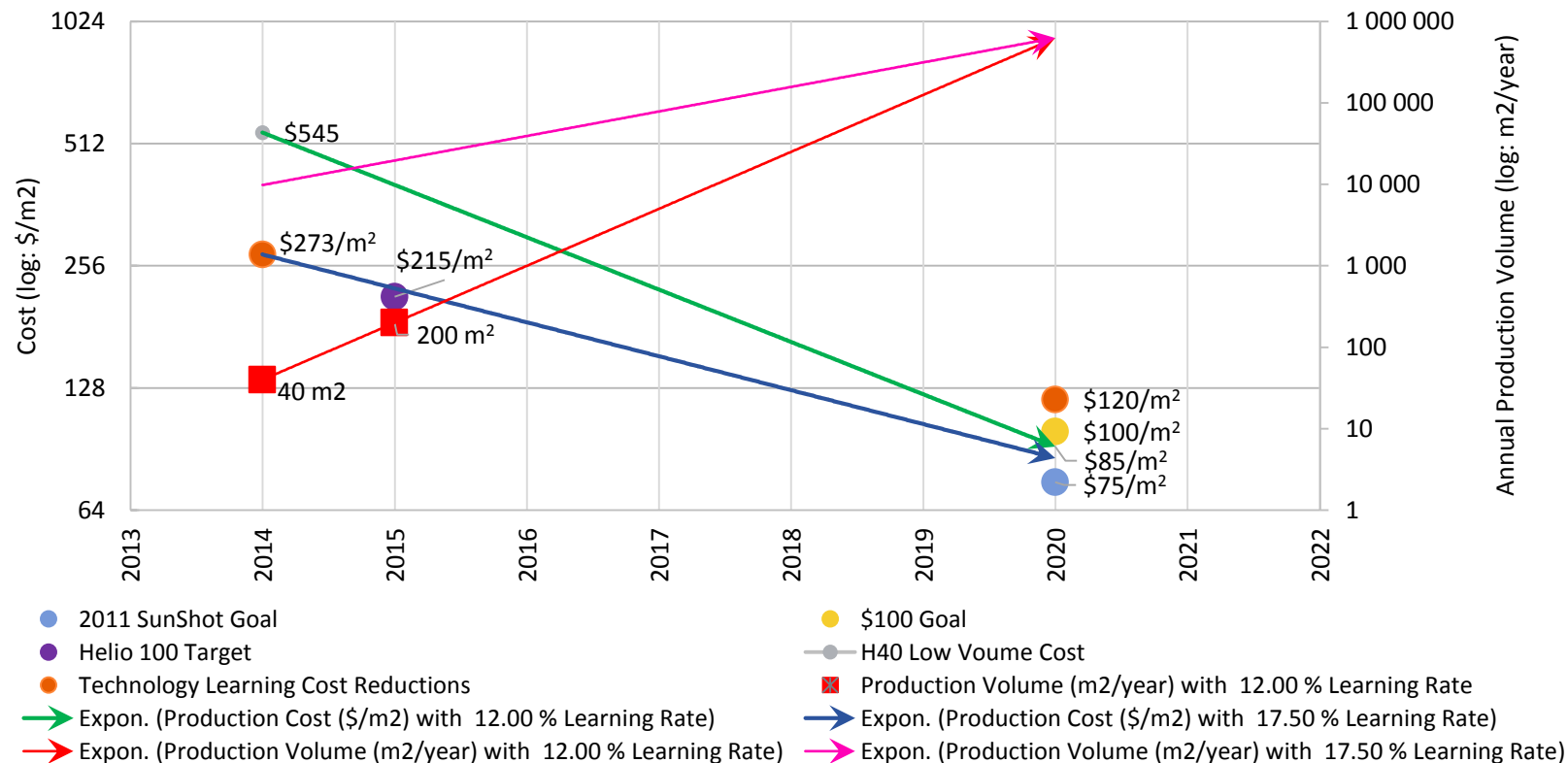
- The Helio40 Heliopod
- Research heliostat located on campus
- Physical data set with full invoiced Costs



Departing and Setting Targets

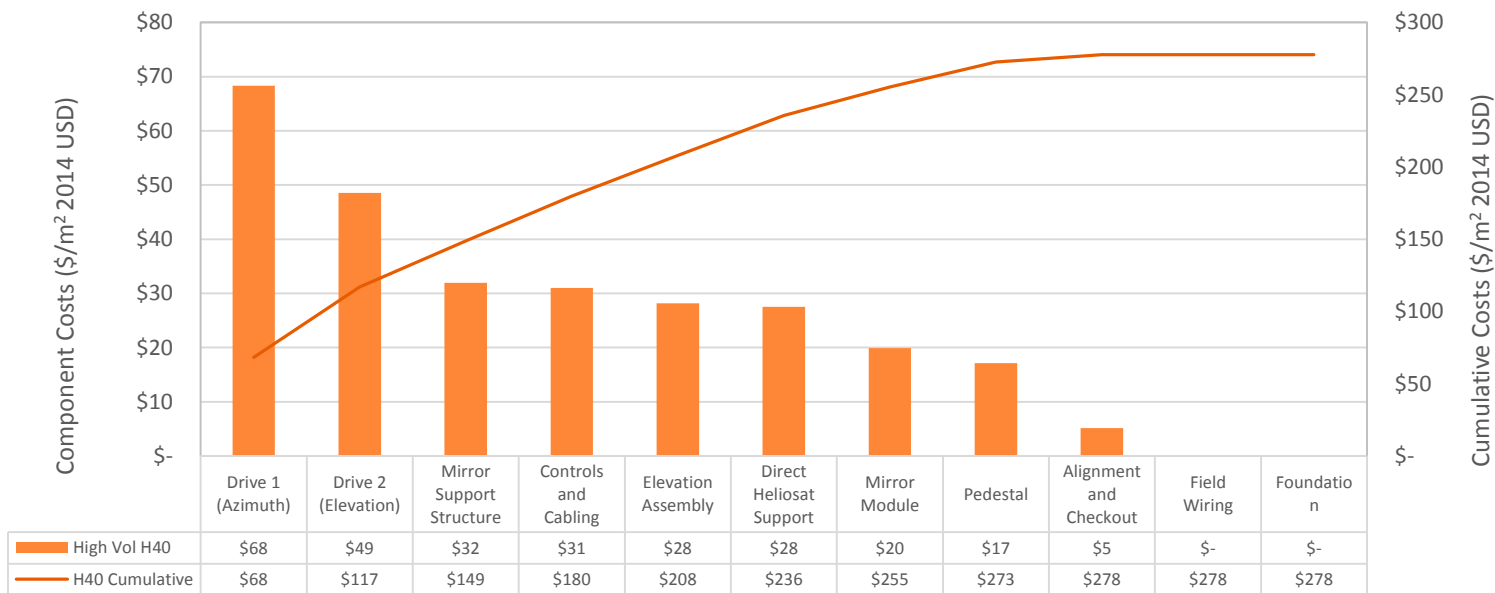


Departing and Setting Targets



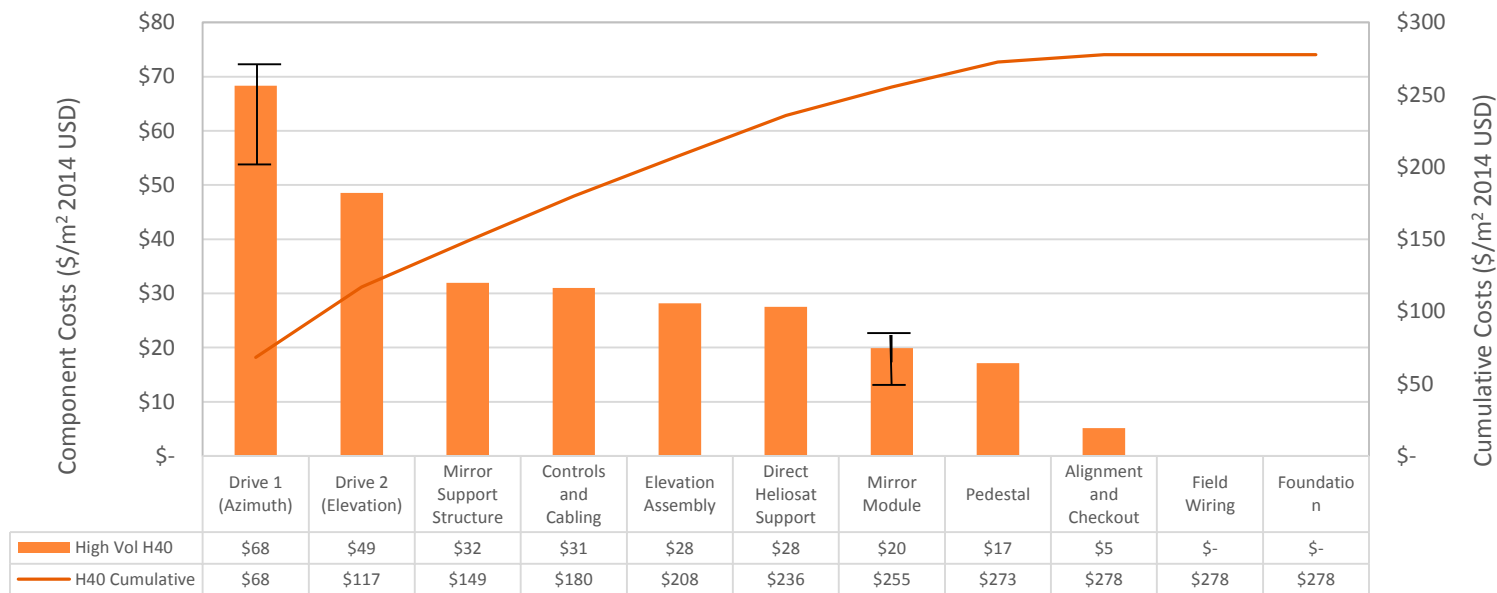
Landing Zone

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Landing Zone

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Benchmarking

| | ATS Heliostat | HI Heliostat | SAIC SM Heliostat | BSE Heliostat | DLR Novel Heliostat |
|-----------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|
| | Published Data (Unproven) | Published Data (Unproven) | Published Data (Unproven) | Unproven (DLR Estimate) | Aspirational DLR Estimate |
| Confidence | | | | | |
| Production Rate | 5 000/yr. | 1000 units | 2000/yr. | - | - |
| Direct Cost/Area | \$130.22 | \$129.72 | \$181.83 | \$124.37 | \$90.12 |
| Mirror Module | \$28.31 | \$33.01 | \$46.92 | \$16.44 | \$16.44 |
| Mirror Support Structure | \$24.91 | \$7.16 | \$83.36 | \$39.73 | \$28.77 |
| Elevation Assembly | \$0.00 | \$0.00 | \$0.00 | \$6.85 | \$13.70 |
| Drive 1 (Azimuth) | \$27.41 | \$30.02 | \$18.43 | \$28.77 | \$2.74 |
| Drive 2 (Elevation) | \$27.41 | \$30.02 | \$18.43 | \$8.22 | \$2.74 |
| Controls and Cabling † | \$2.23 | \$24.68 | \$2.62 | \$8.84 | \$10.21 |
| Pedestal | \$19.94 | \$4.83 | \$12.06 | \$15.53 | \$15.53 |
| Direct Heliostat Support | \$0.00 | \$0.00 | \$0.00 | \$0.00 | \$0.00 |
| Field Costs | \$18.88 | \$26.96 | \$32.02 | \$57.84 | \$57.84 |
| Foundation | \$2.74 | \$2.41 | \$18.92 | \$7.76 | \$7.76 |
| Field Wiring | \$8.70 | \$15.31 | \$7.26 | \$14.73 | \$14.73 |
| Alignment and Checkout | \$7.45 | \$9.23 | \$5.85 | \$35.35 | \$35.35 |
| Total Installed Cost | \$149.10 | \$156.68 | \$213.85 | \$182.21 | \$147.96 |

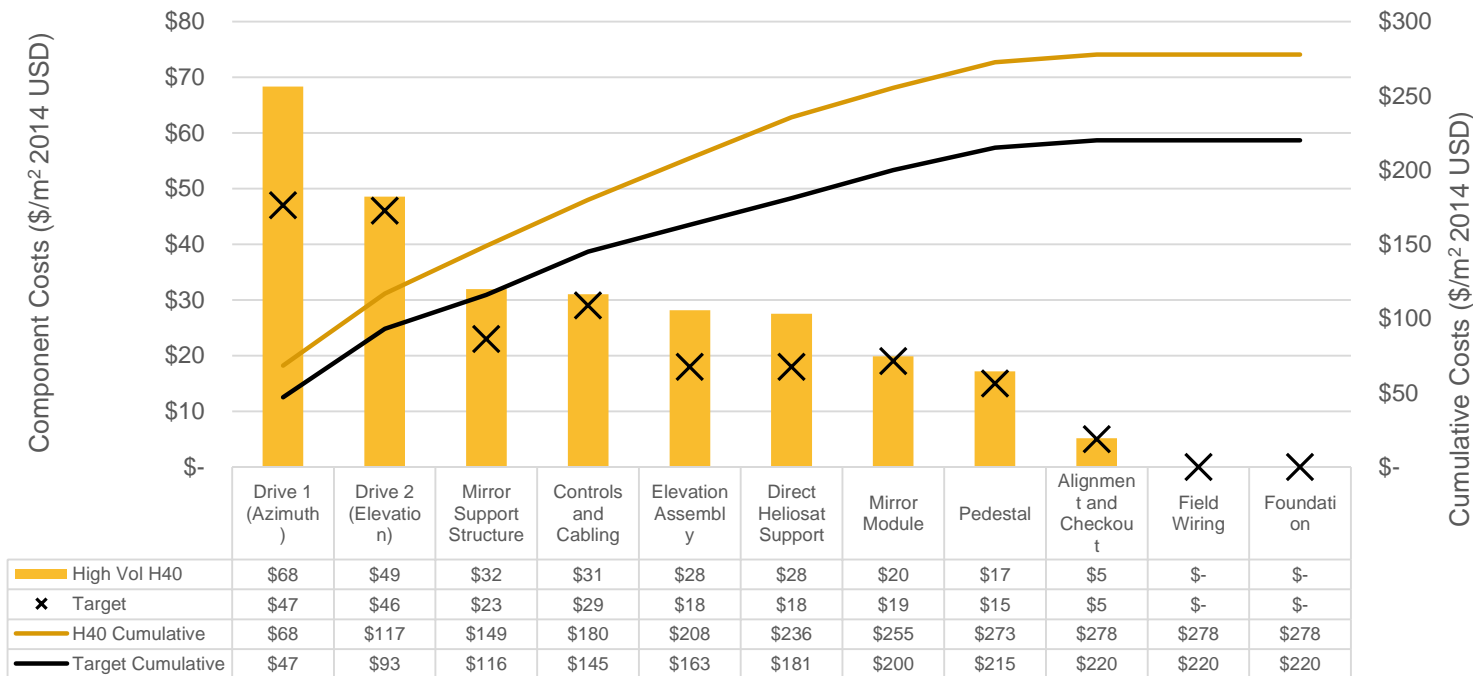
Landing Zone

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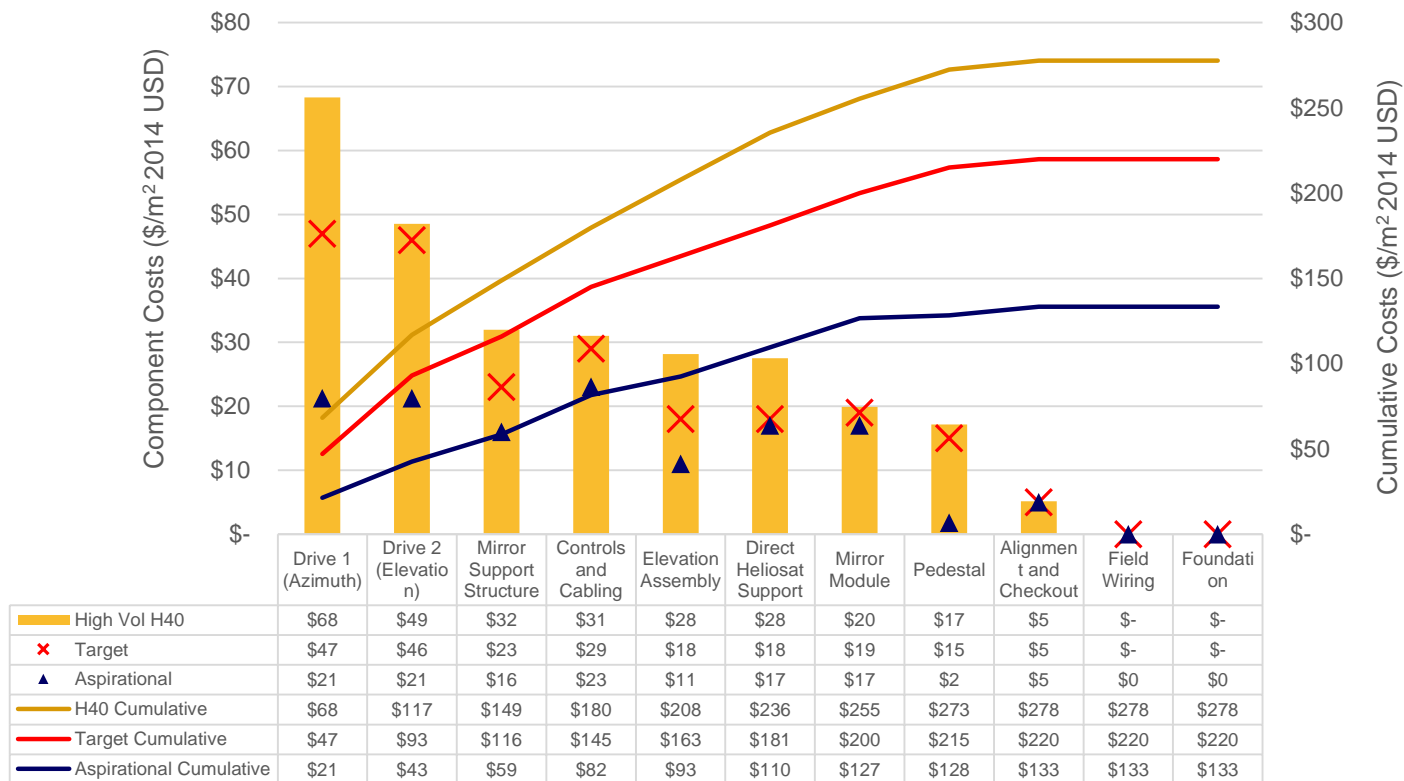
Landing Zone

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Landing Zone

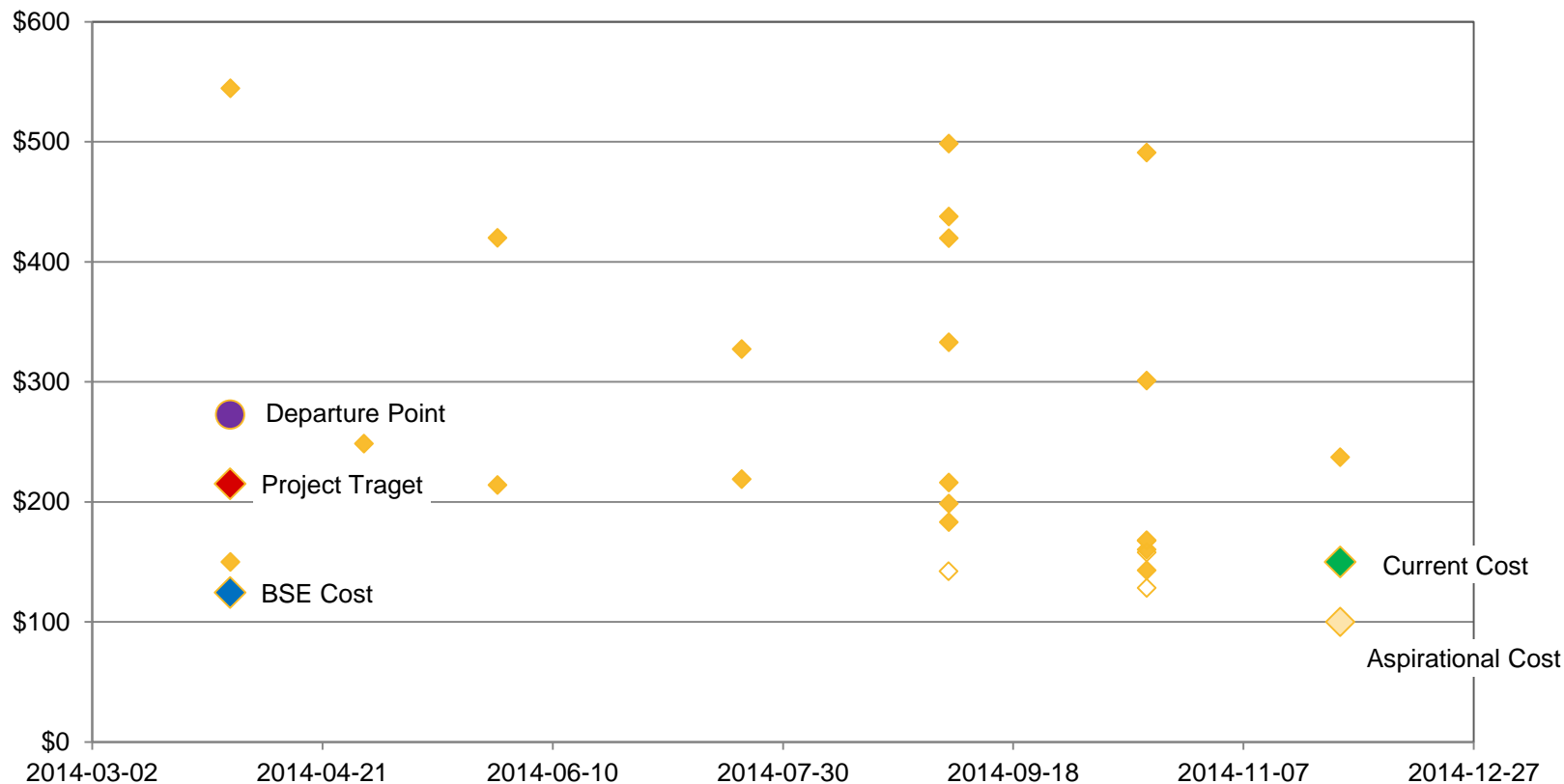
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Tracking Progress

| | Current Cost | | Target Cost | Concept 1 | Concept 2 | Concept 3 |
|-----------------------------|--------------|--------------|--------------|-----------|-----------|-----------|
| Production Rate | 20/yr. | 20 000/yr. | 20 000/yr. | | | |
| Direct Cost/Area | \$545 | \$273 | \$215 | | | |
| Mirror Module | \$33 | \$20 | \$20 | | | |
| Mirror Support Structure | \$110 | \$32 | \$22 | | | |
| Elevation Assembly | \$55 | \$28 | \$18 | | | |
| Drive 1 (Azimuth) | \$114 | \$68 | \$47 | | | |
| Drive 2 (Elevation) | \$69 | \$49 | \$46 | | | |
| Controls and Cabling | \$54 | \$31 | \$29 | | | |
| Pedestal | \$54 | \$17 | \$15 | | | |
| Direct Heliostat Support | \$56 | \$28 | \$18 | | | |
| Field Costs | \$6 | \$5 | \$5 | | | |
| Foundation | \$0 | \$0 | \$0 | | | |
| Field Wiring | \$0 | \$0 | \$0 | | | |
| Alignment and Checkout | \$6 | \$5 | \$5 | | | |
| Total Installed Cost | \$551 | \$278 | \$220 | | | |

Progress



Heliostats Differ...



(Google, 2011)



(Brightsource, 2013)



(Japan Solar Techno 2012)



(eSolar, 2013)

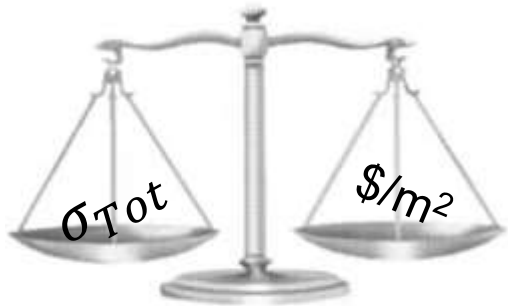


(Kolb, 2007)

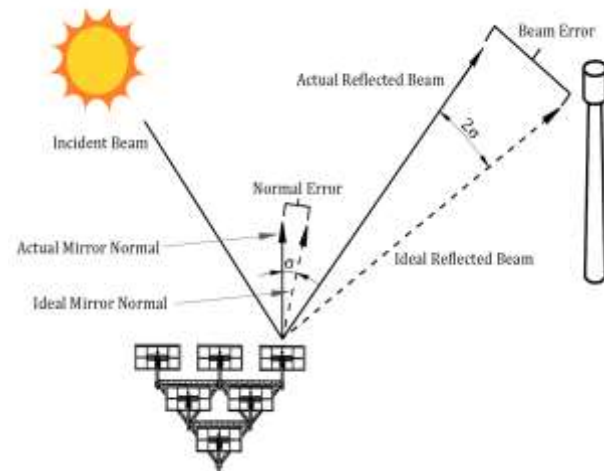
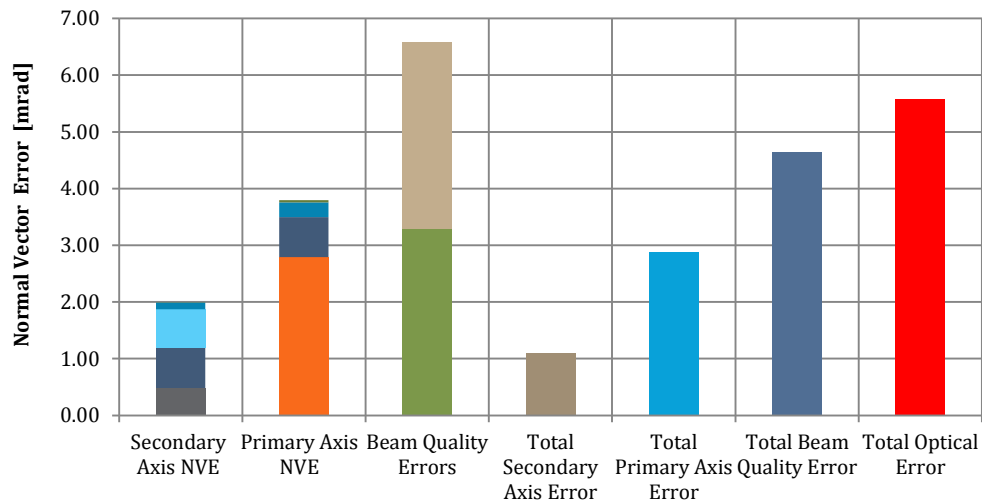


(Pfahl, 2013)

Net Plant Effect ?

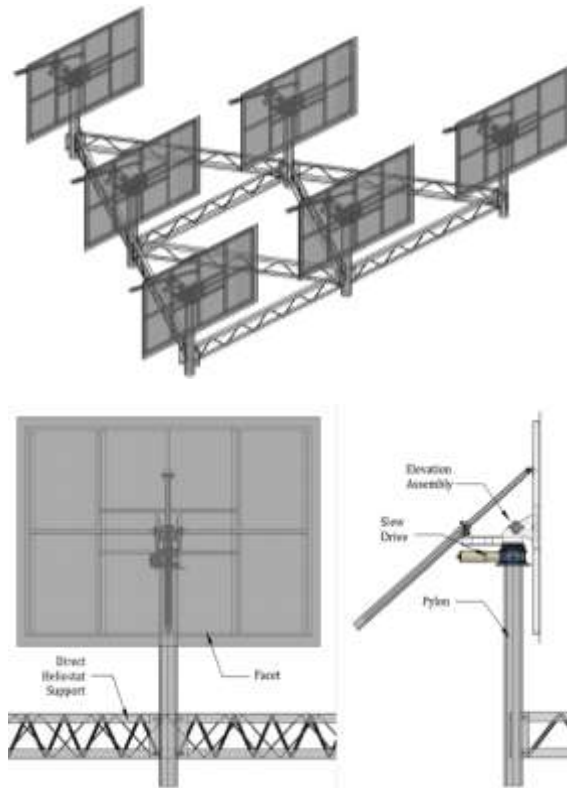
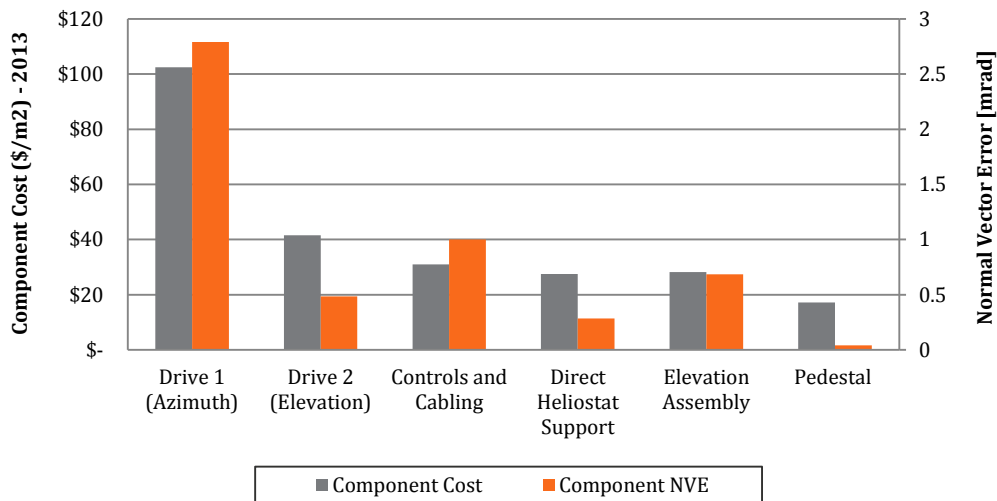


Component Performance

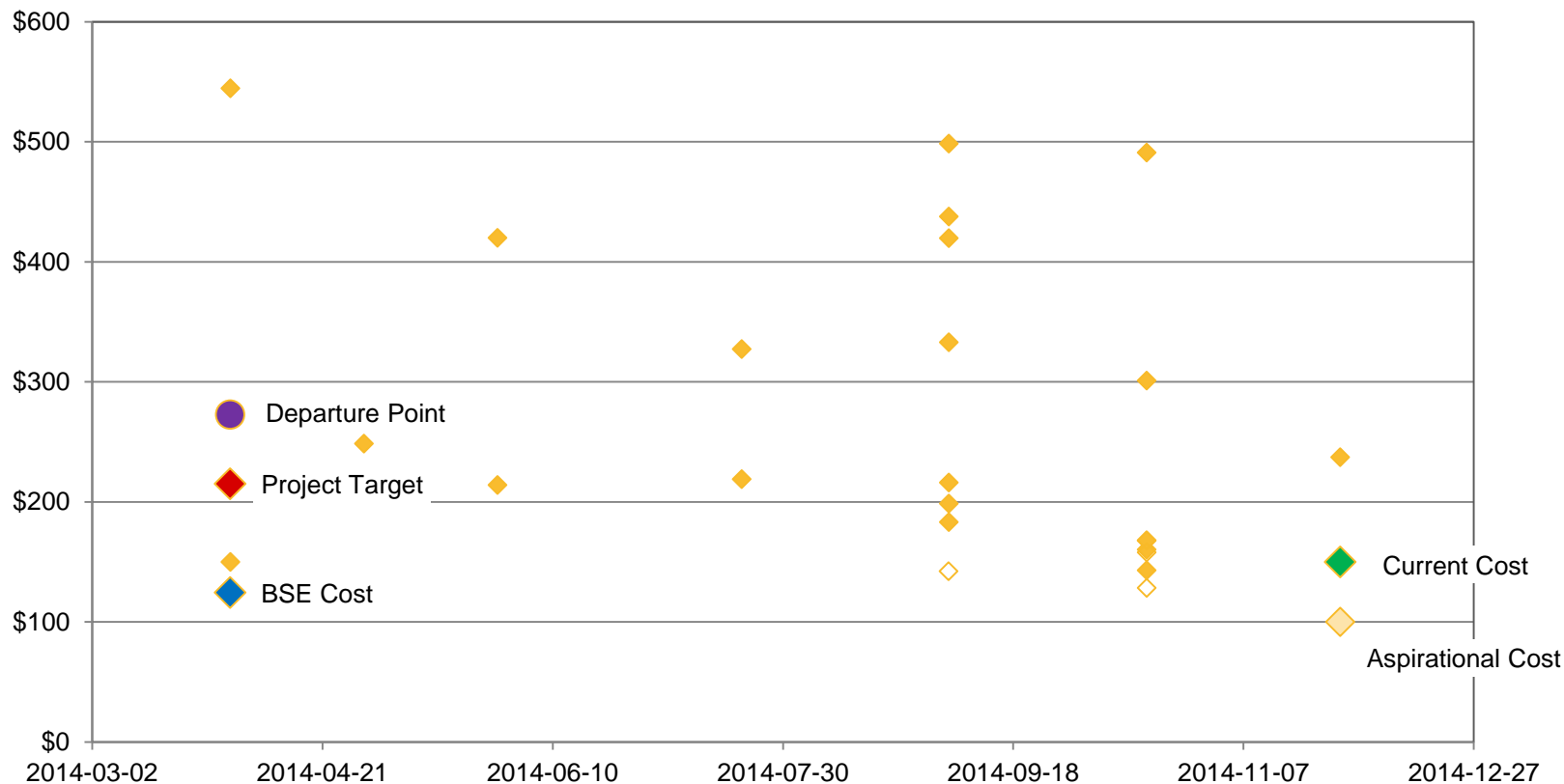


$$\sigma_{Tot}^2 = \sigma_{Aberr}^2 + \sigma_{Sun}^2 + \sigma_{BQ}^2 + (2\sigma_{Track})^2$$

Component Performance



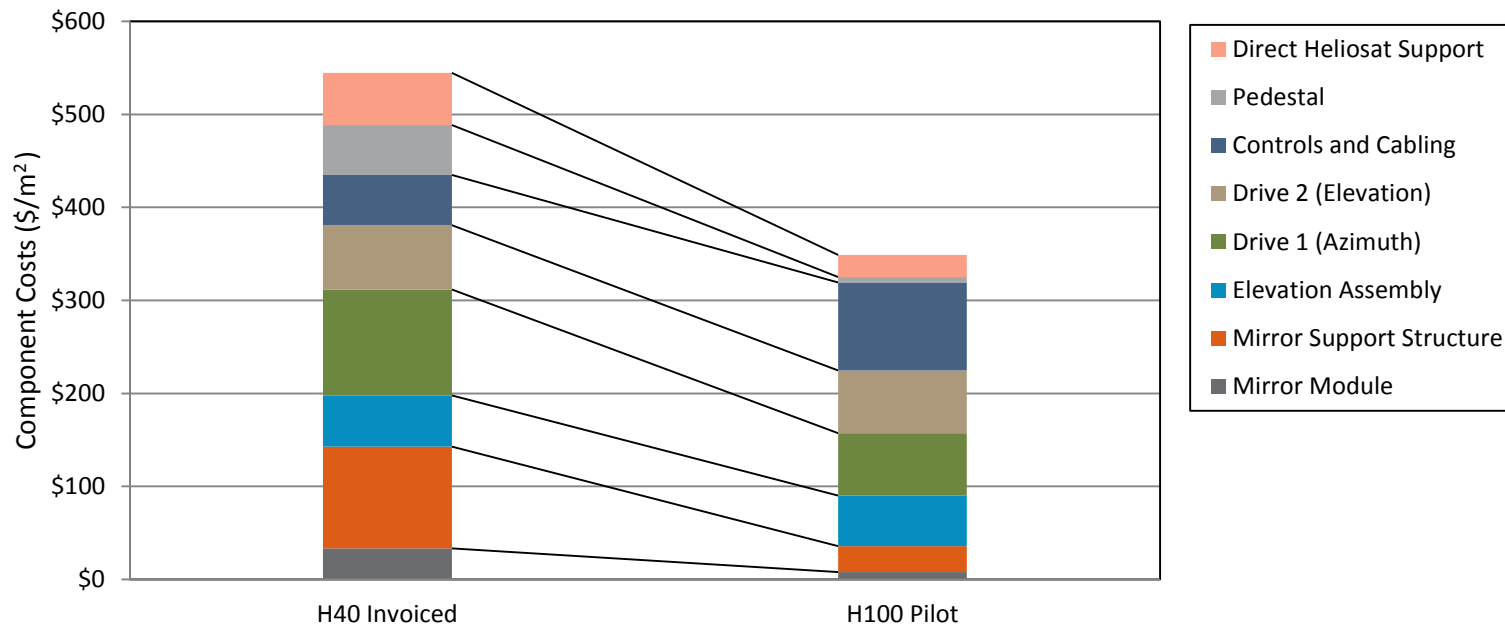
Progress



Indicative Costs

Low Volume Costs

< 100 units p.a

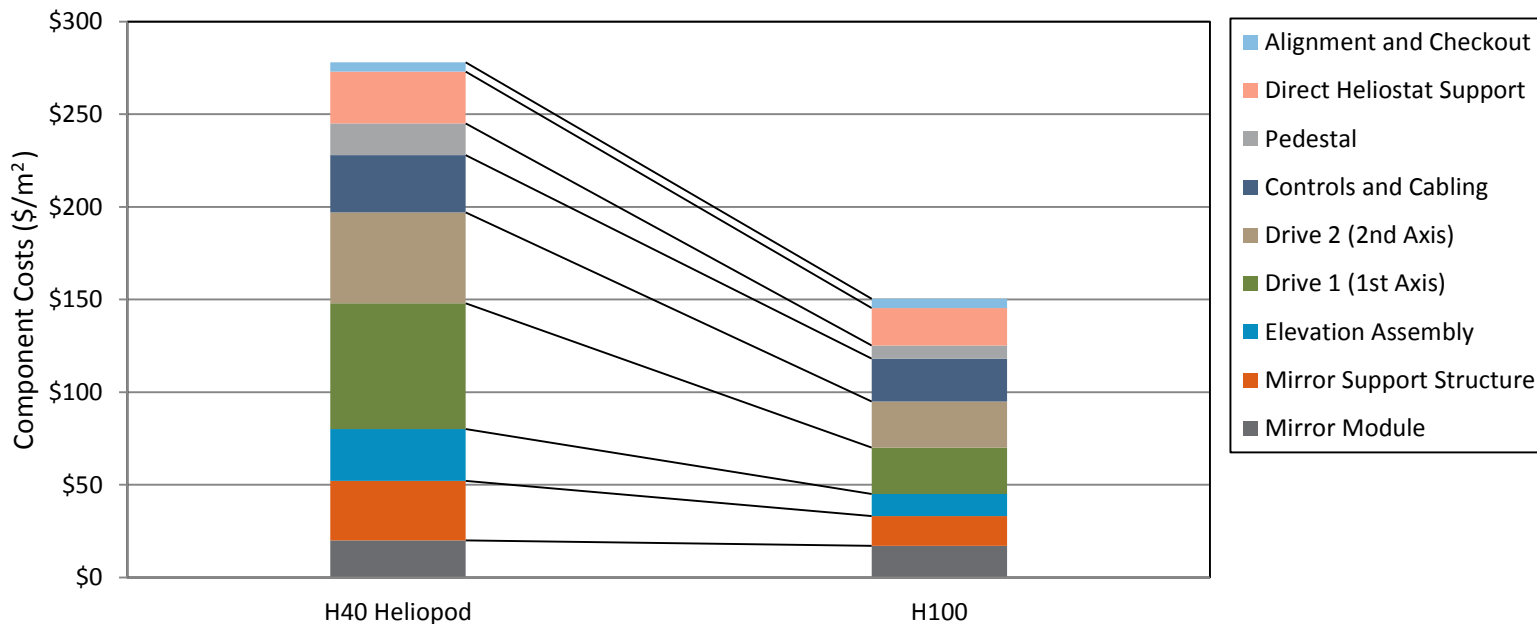


Indicative Costs



Volume Costs

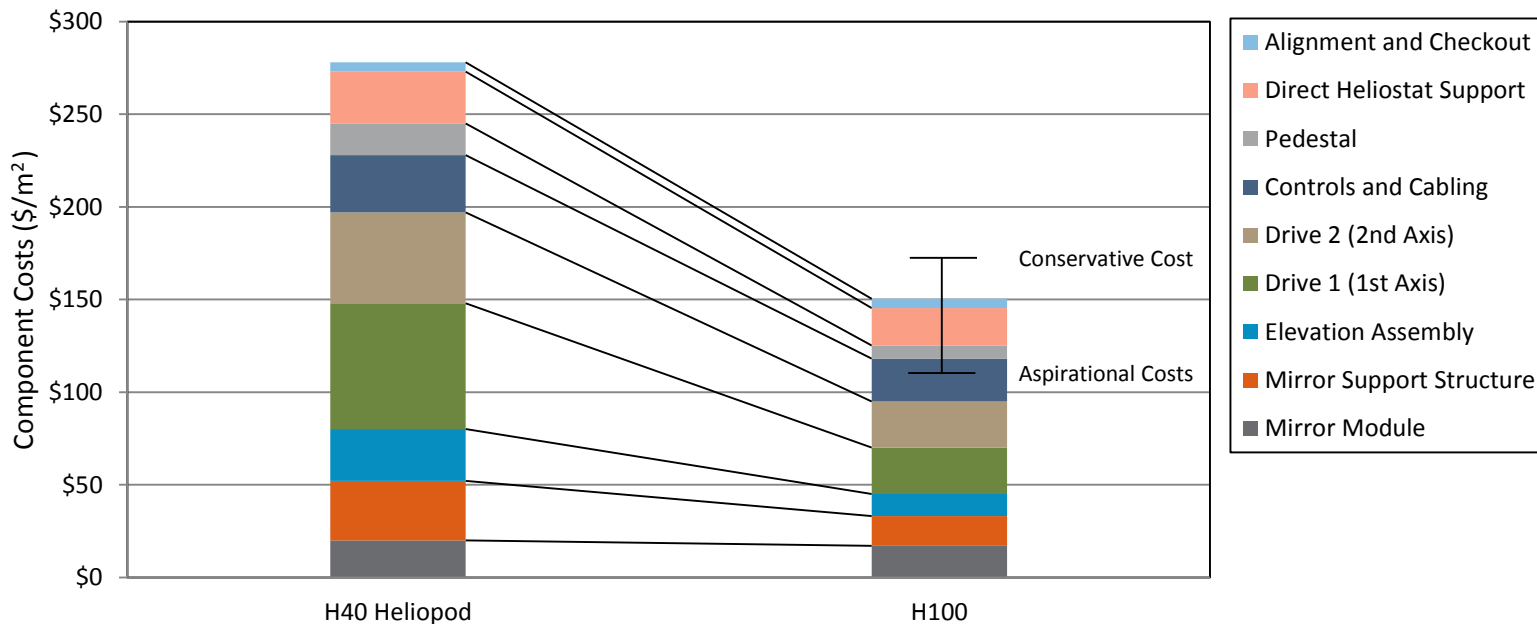
20 000 units p.a.



Indicative Costs

Volume Costs

20 000 units p.a.



Conclusion



- Heliostat cost is complex and inexact science
- This method provides a convenient approach during early design phase
- Allows for continuous cost learning through the design process
- Realises \$150/m² heliostat cost



ACKNOWLEDGEMENTS:

STERG

TIA - Technology Innovation Agency

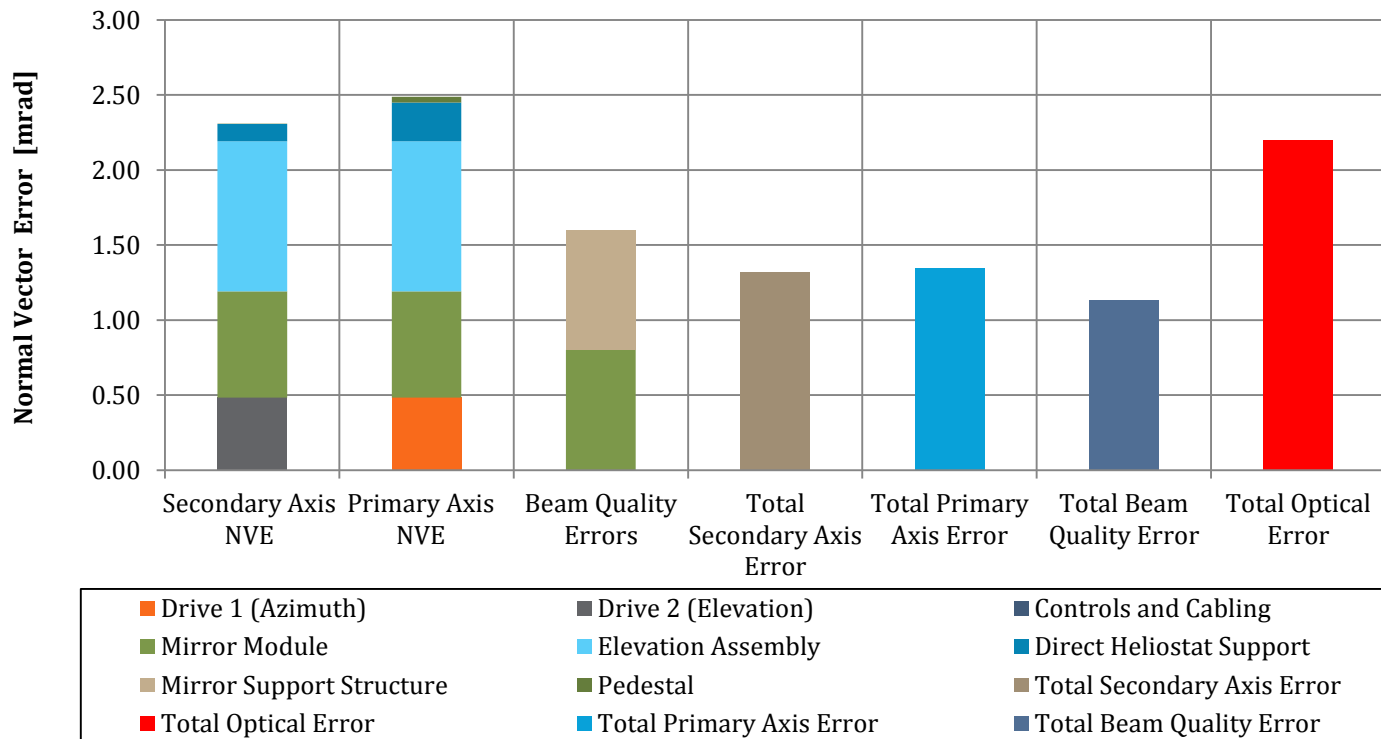
Helio100 Staff

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Learning Rates



$$p = \frac{1}{\ln 2} \left(\ln \frac{QCUM}{QL} \right)$$