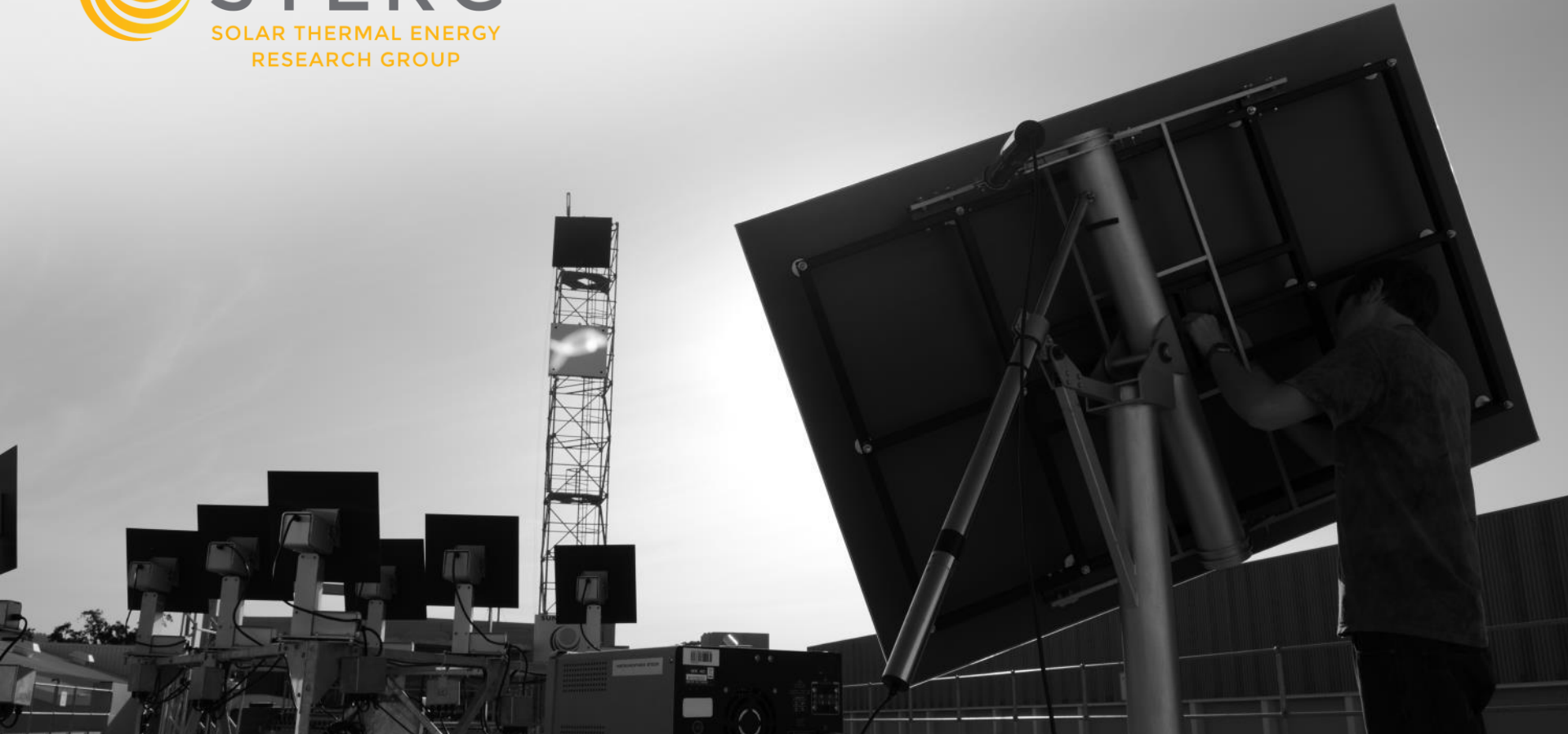




STERG

SOLAR THERMAL ENERGY
RESEARCH GROUP



A tops down approach to heliostat cost

J. Larmuth, W. Landman and P. Gauché

TIA Helio 100 Project,
University of Stellenbosch

Solar Thermal Energy Research Group (STERG),
University of Stellenbosch

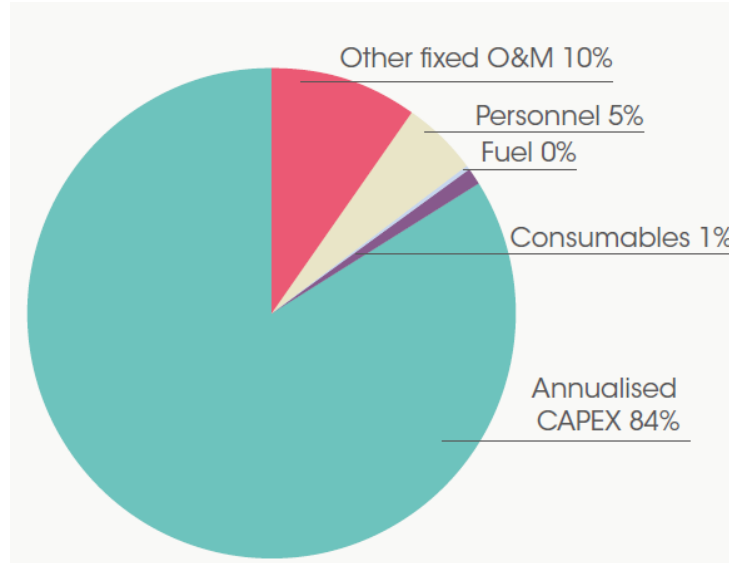
Contents



- Heliostat cost reduction
- Tops down approach
- Cost road map
- Landing zone
- Cost model template
- Results

LCOE Breakdown

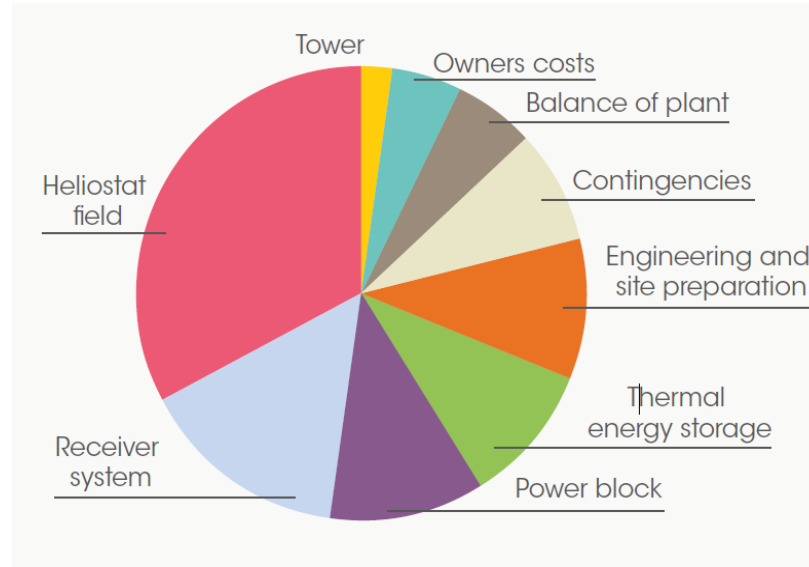
100MW Tower
15hr Storage



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

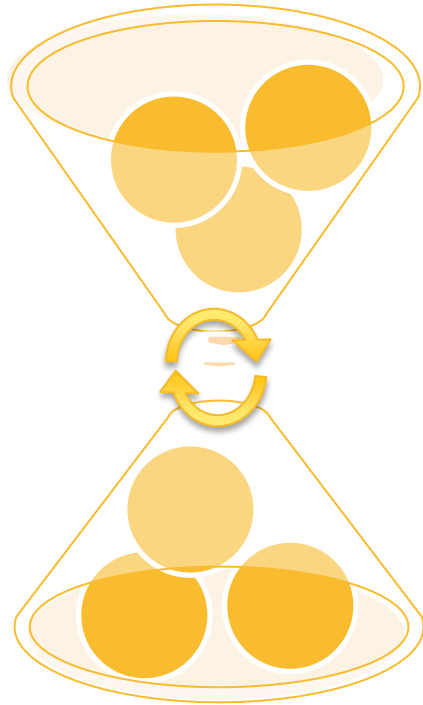
Total Installed Costs

100MW Tower
15hr Storage



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

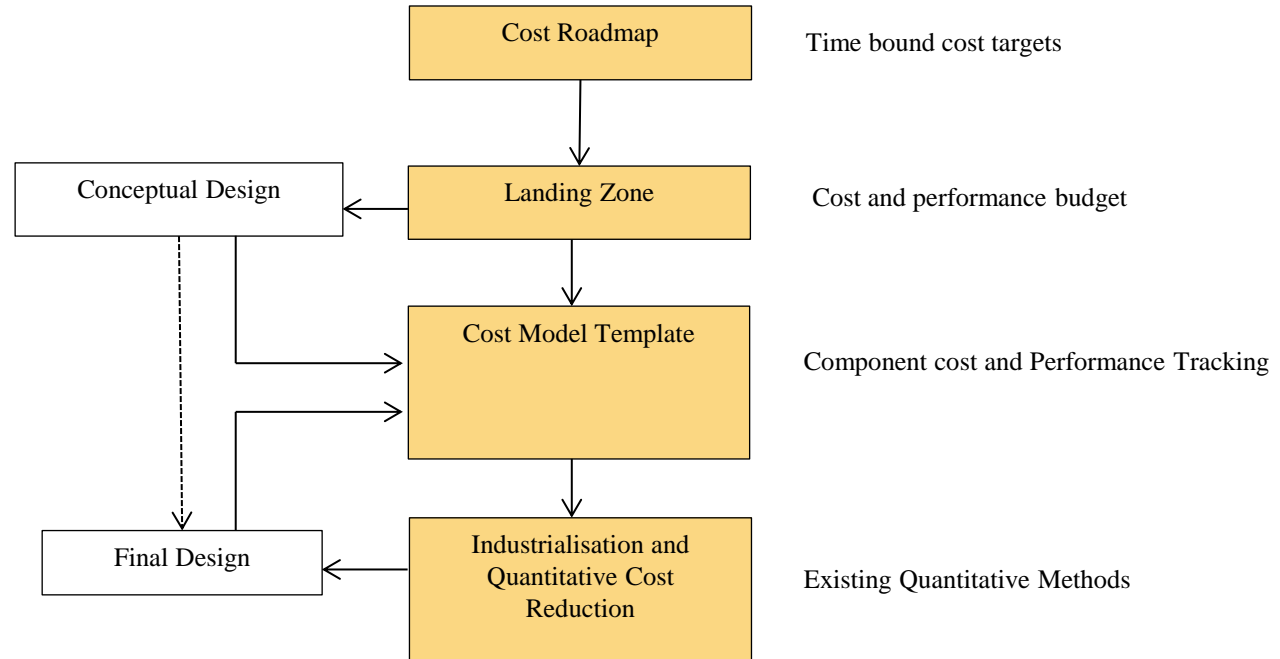
Finding the Right Solution



- Tops Down

- Bottoms Up

Methodology



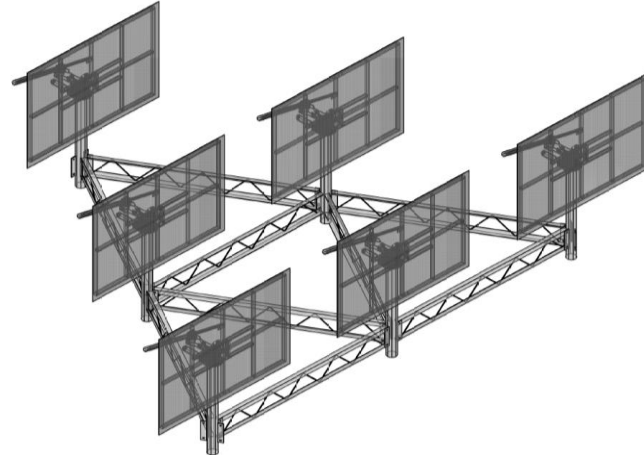
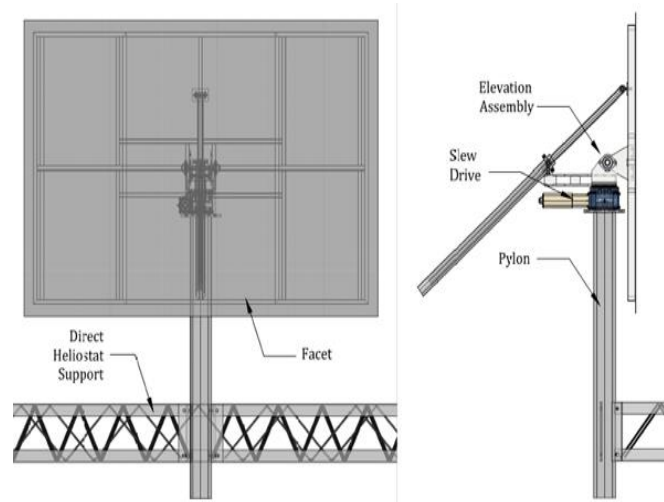
Cost Roadmap



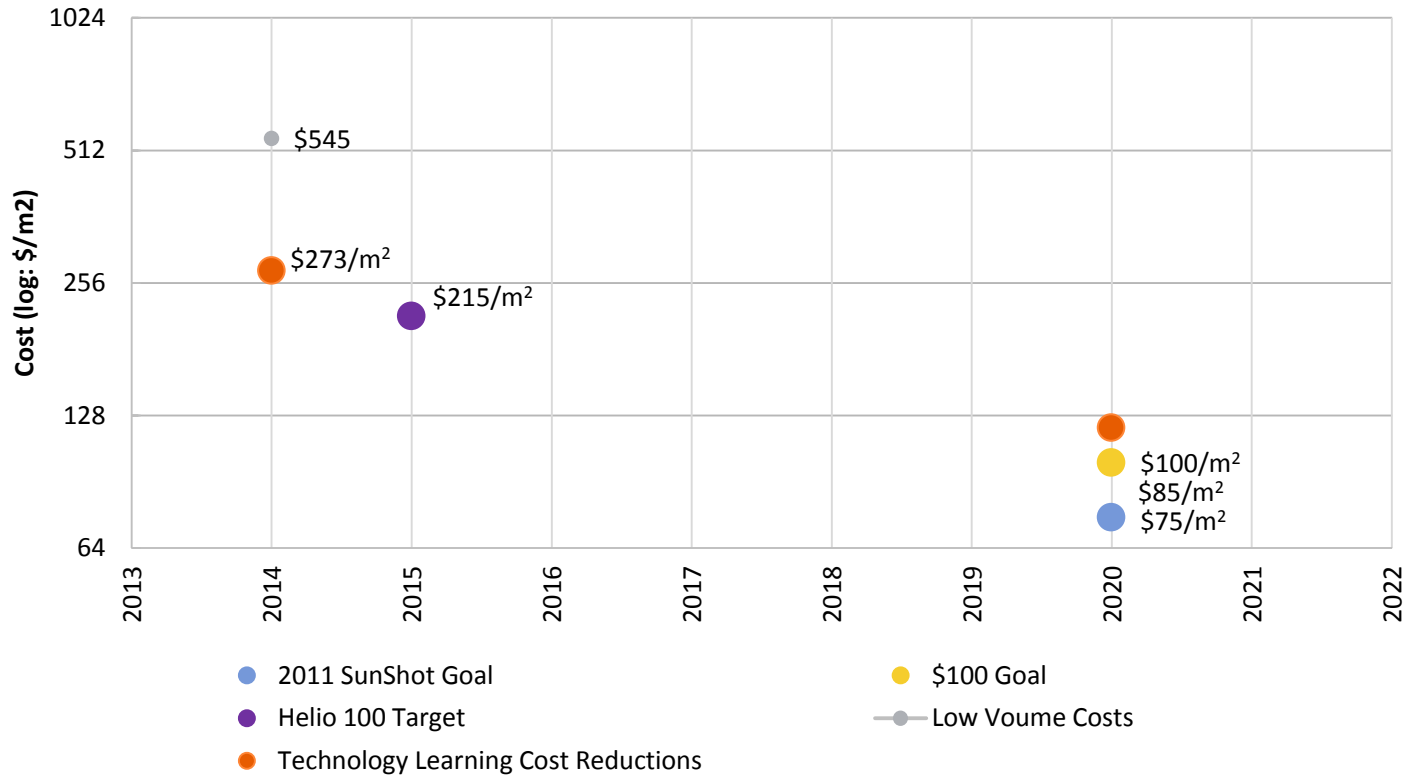
- 2011 SunShot Goal
- \$100 Goal
- Helio 100 Target
- Low Voume Costs
- Technology Learning Cost Reductions

Departure Point

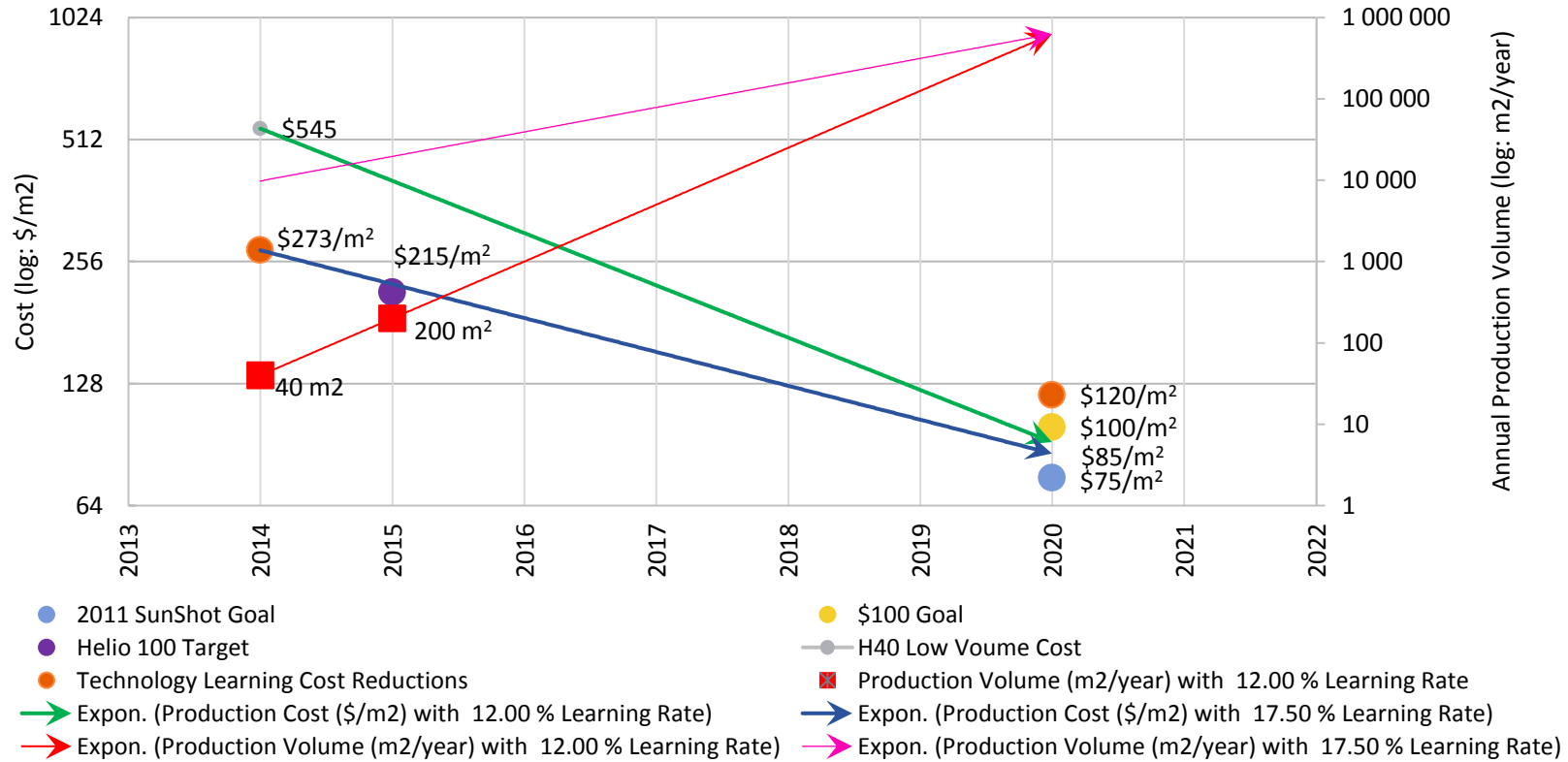
- The Helio40 Heliopod
- Research heliostat located on campus
- Physical data set with full invoiced Costs



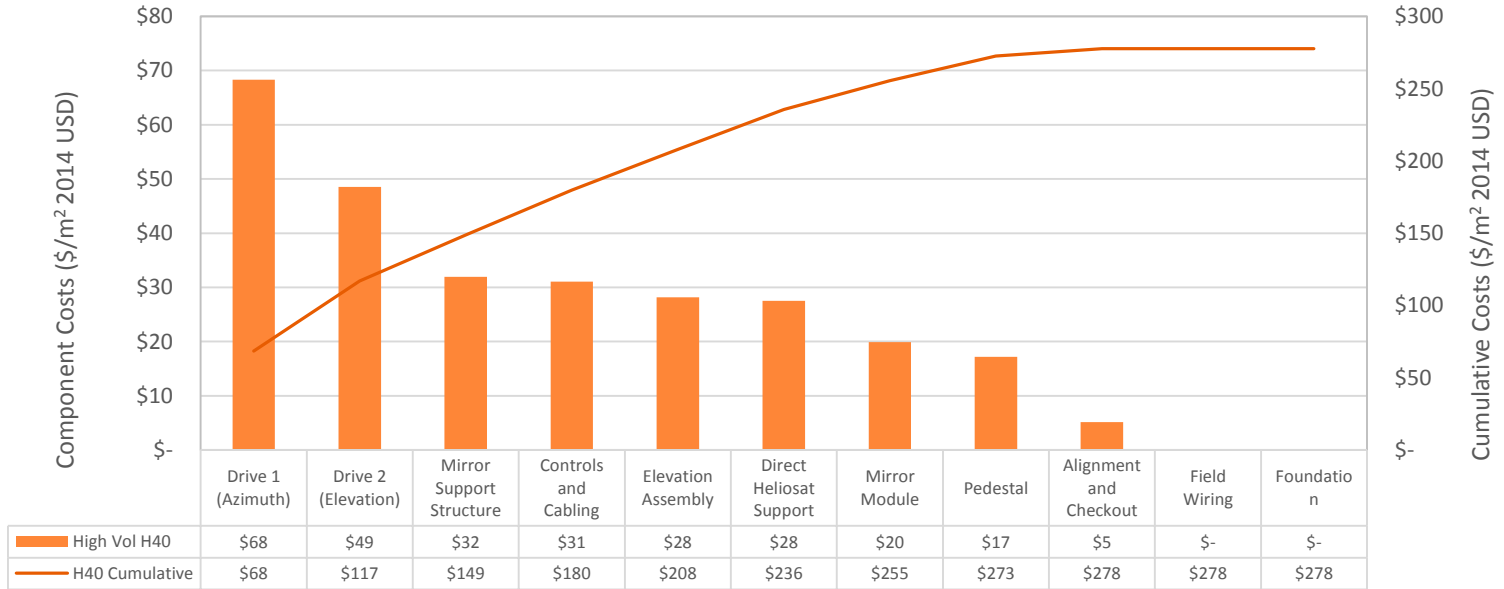
Departing and Setting Targets



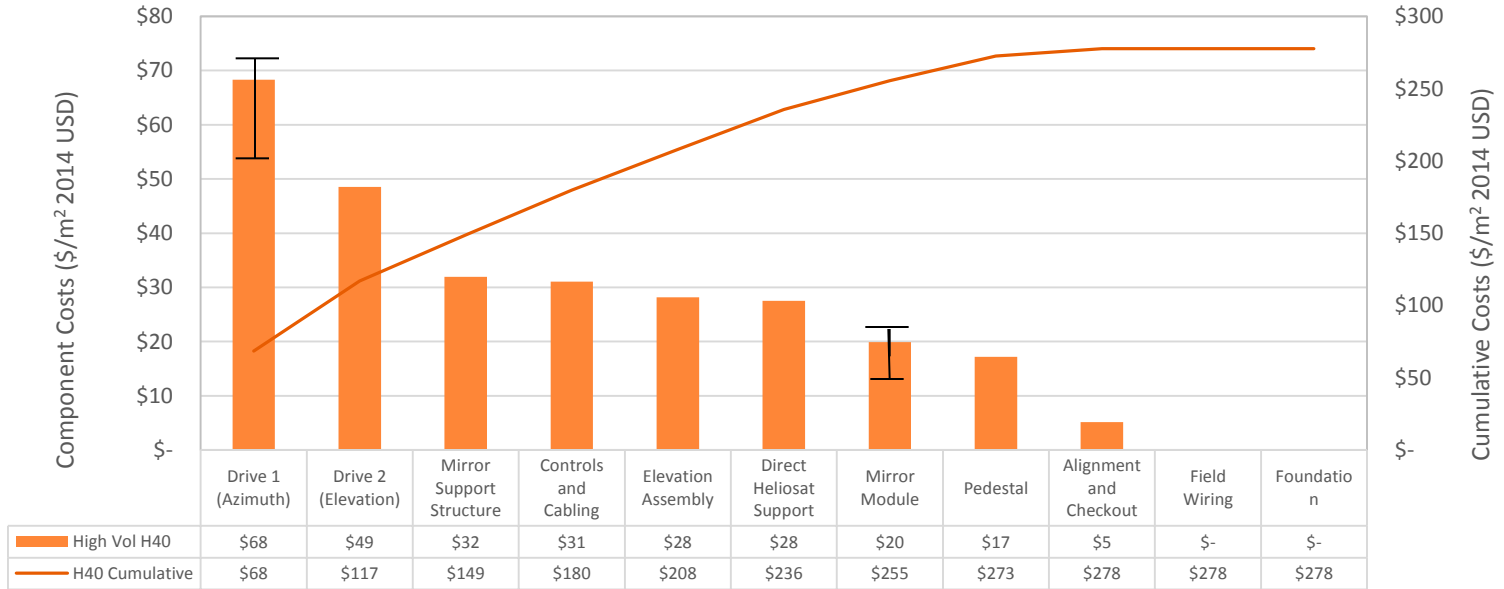
Departing and Setting Targets



Landing Zone



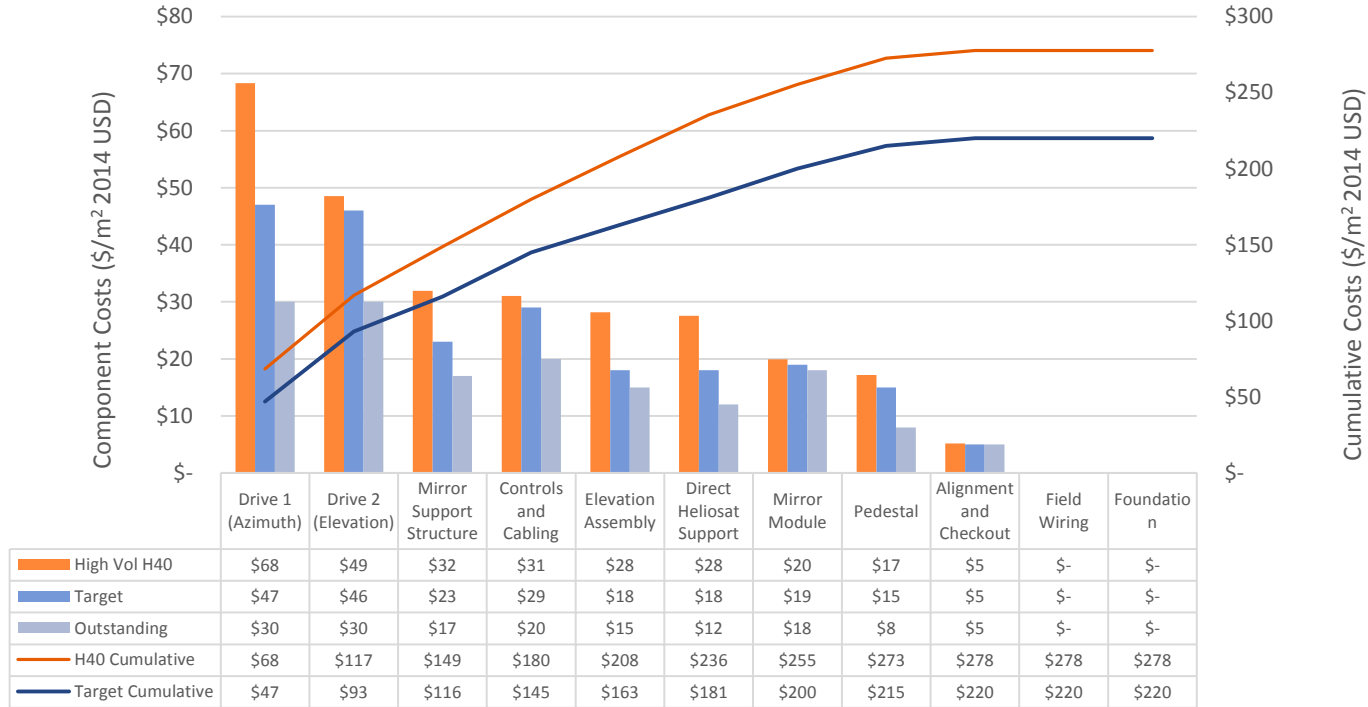
Landing Zone



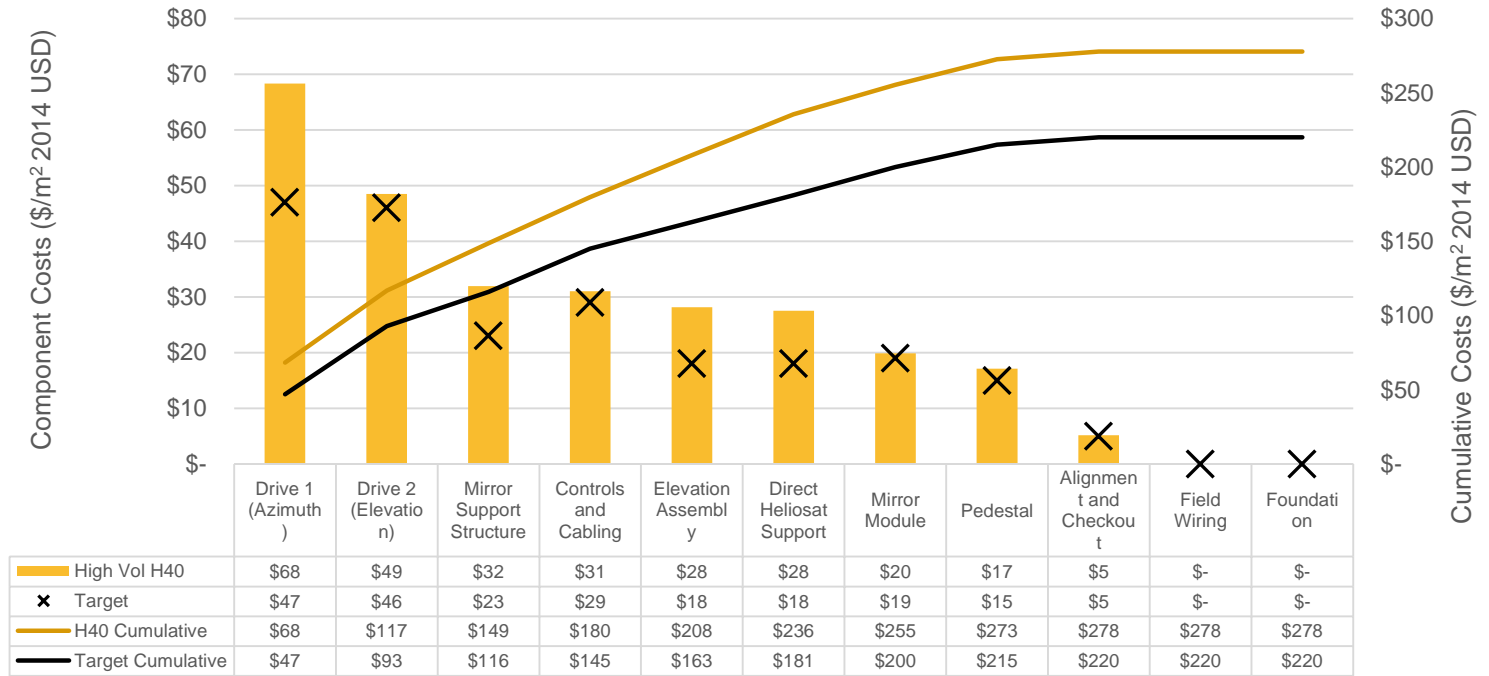
Benchmarking

	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

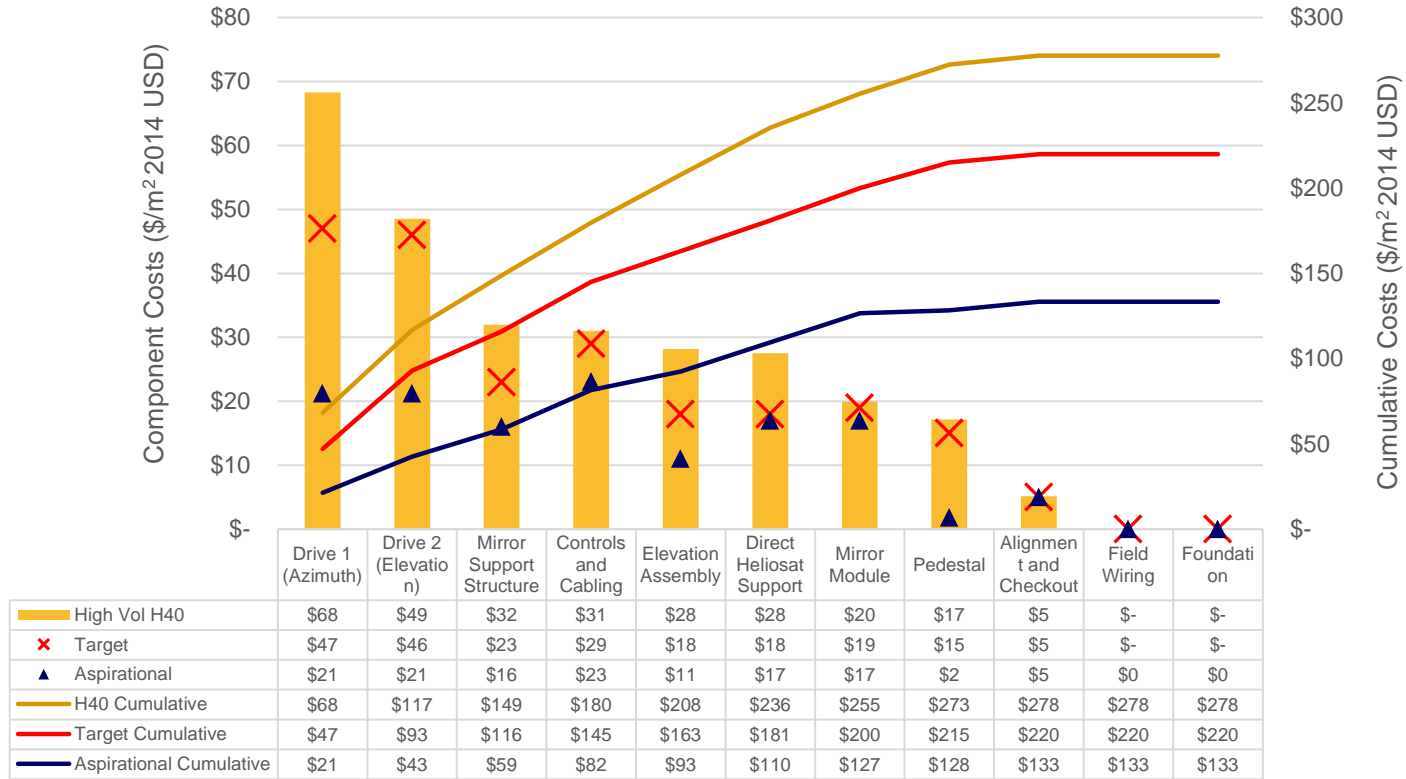
Landing Zone



Landing Zone



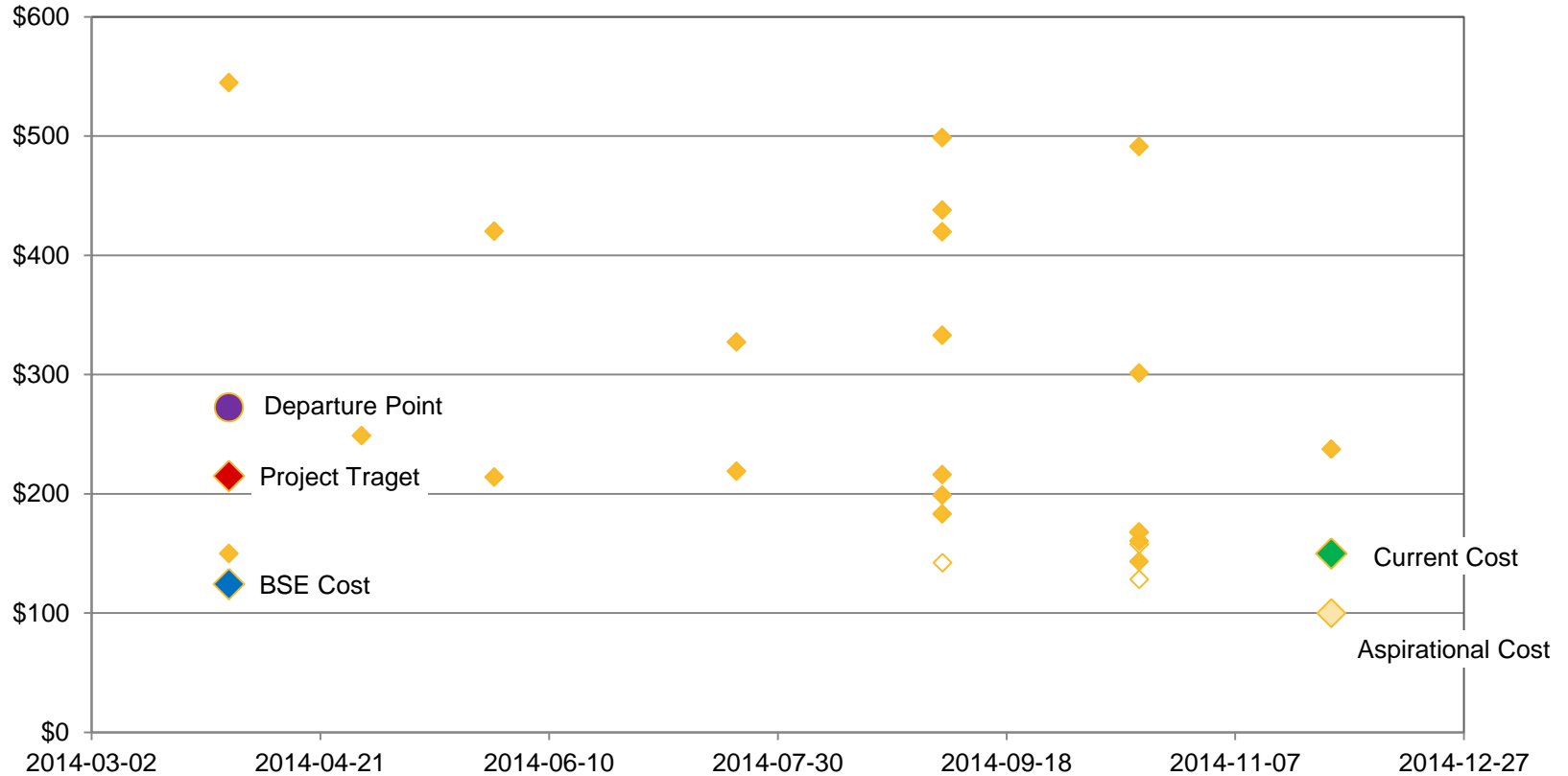
Landing Zone



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, 2010)



(Japan Solar Techno, 2012)



(eSolar, 2013)

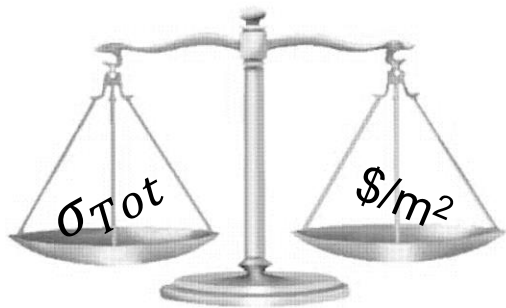


(Kolb, 2007)

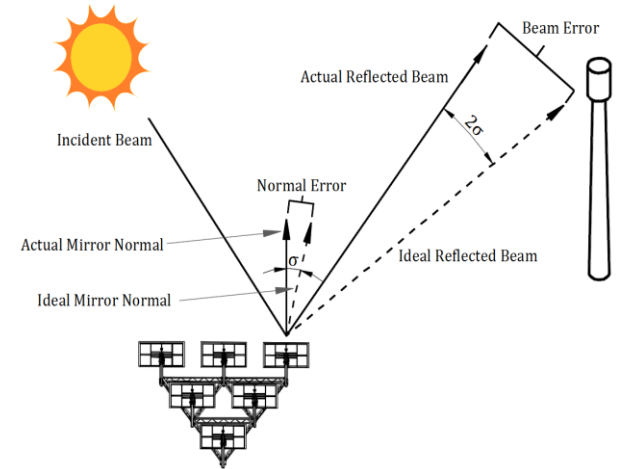
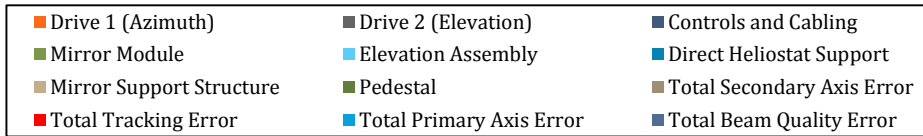
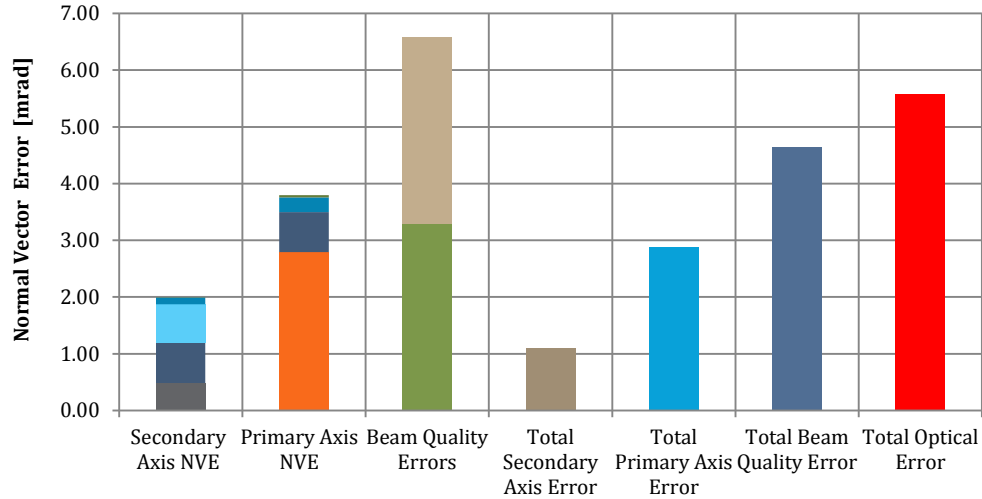


(Pfahl, 2012)

Net Plant Effect ?

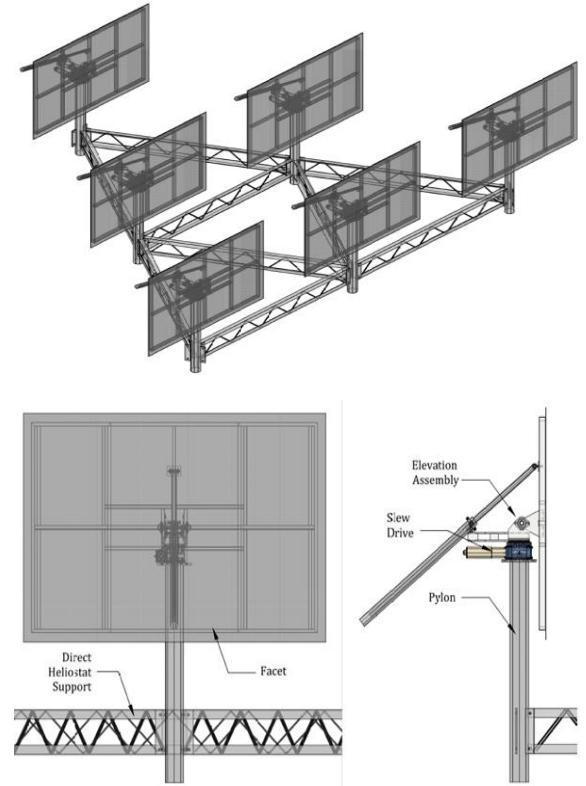
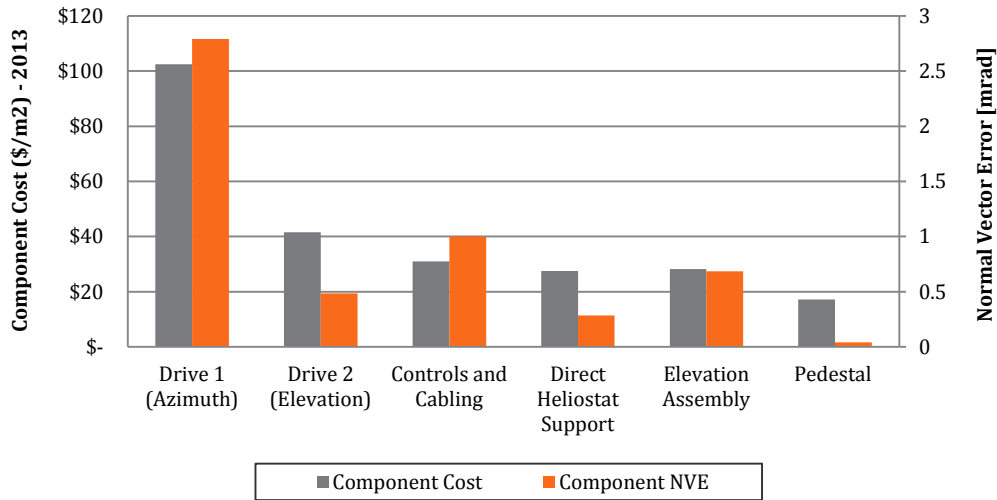


Component Performance

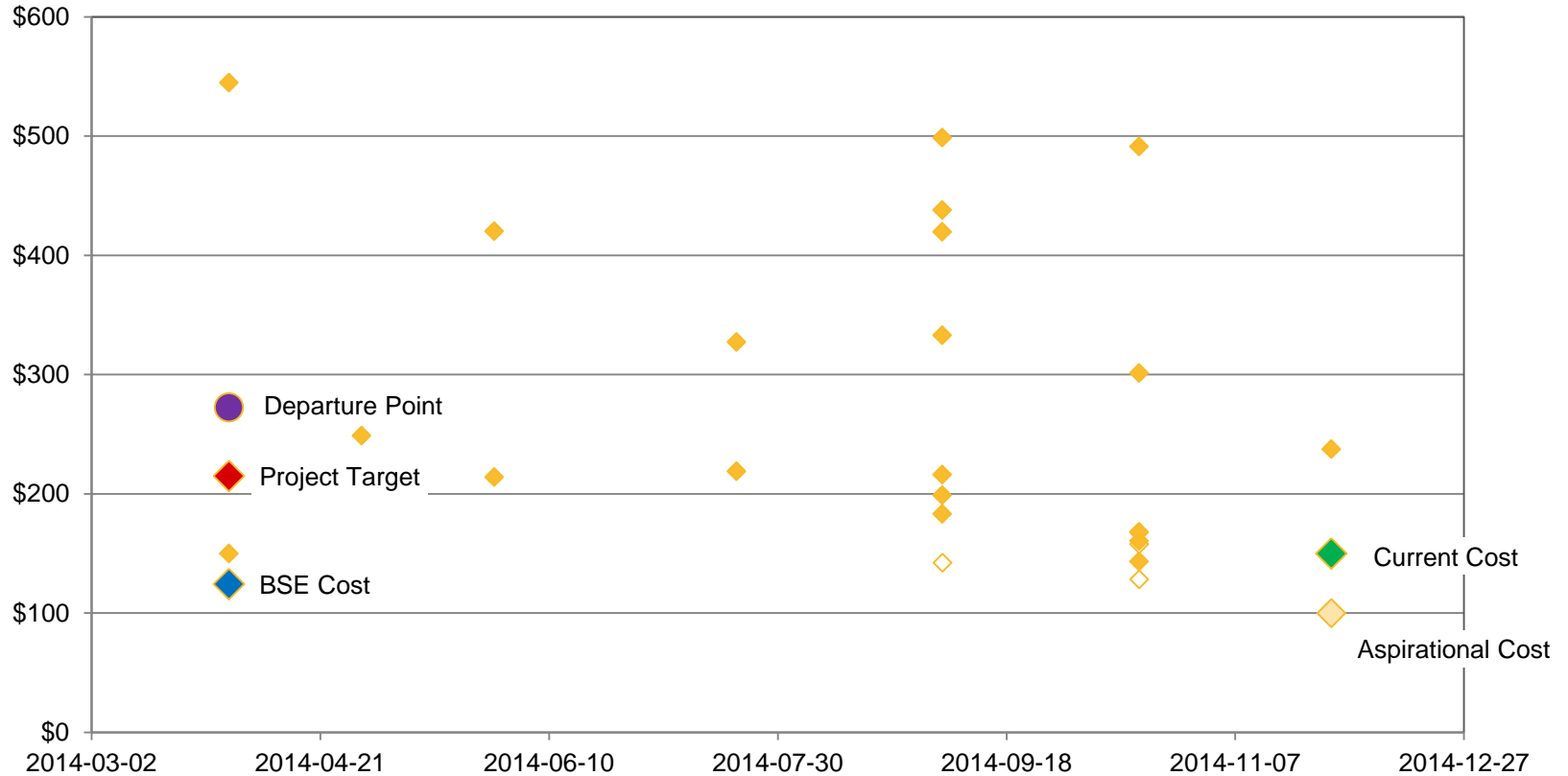


$$\sigma_{Tot}^2 = \sigma_{Aberr}^2 + \sigma_{Sun}^2 + \sigma_{BQ}^2 + (2\sigma_{Track})^2$$

Component Performance



Progress

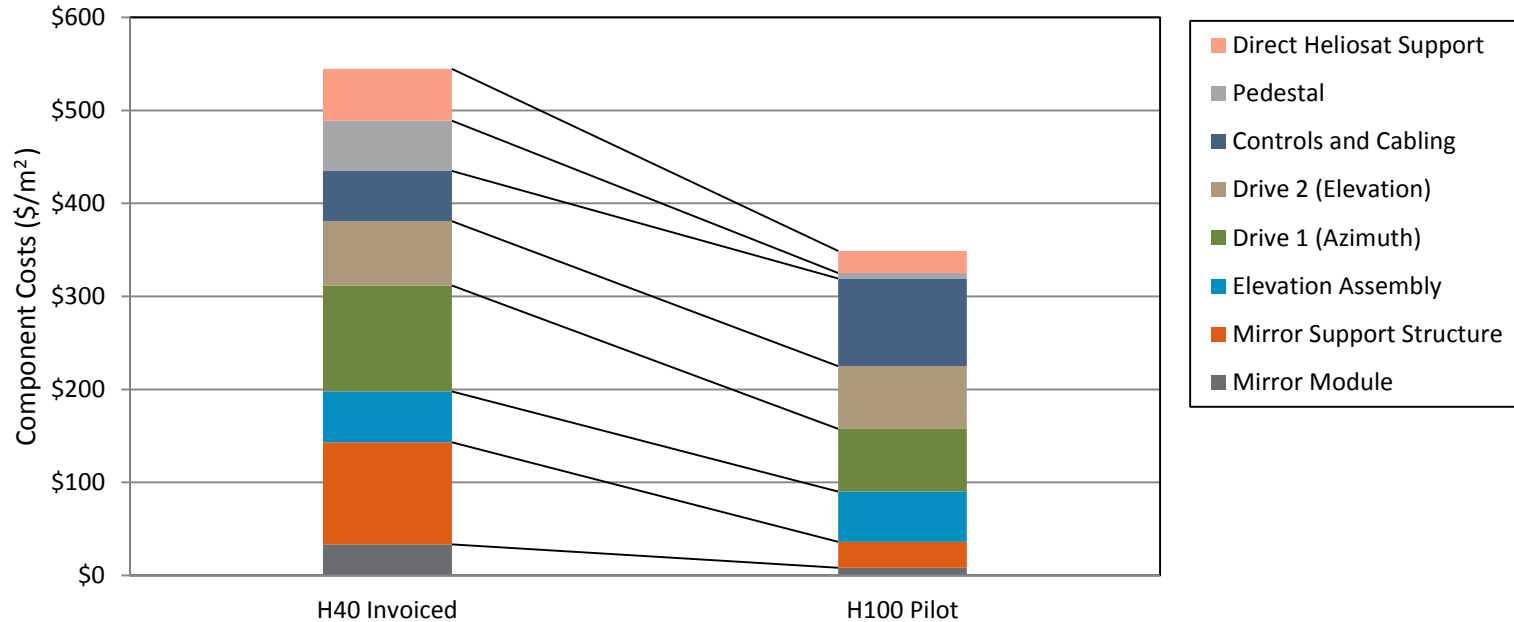


Indicative Costs



Low Volume Costs

< 100 units p.a

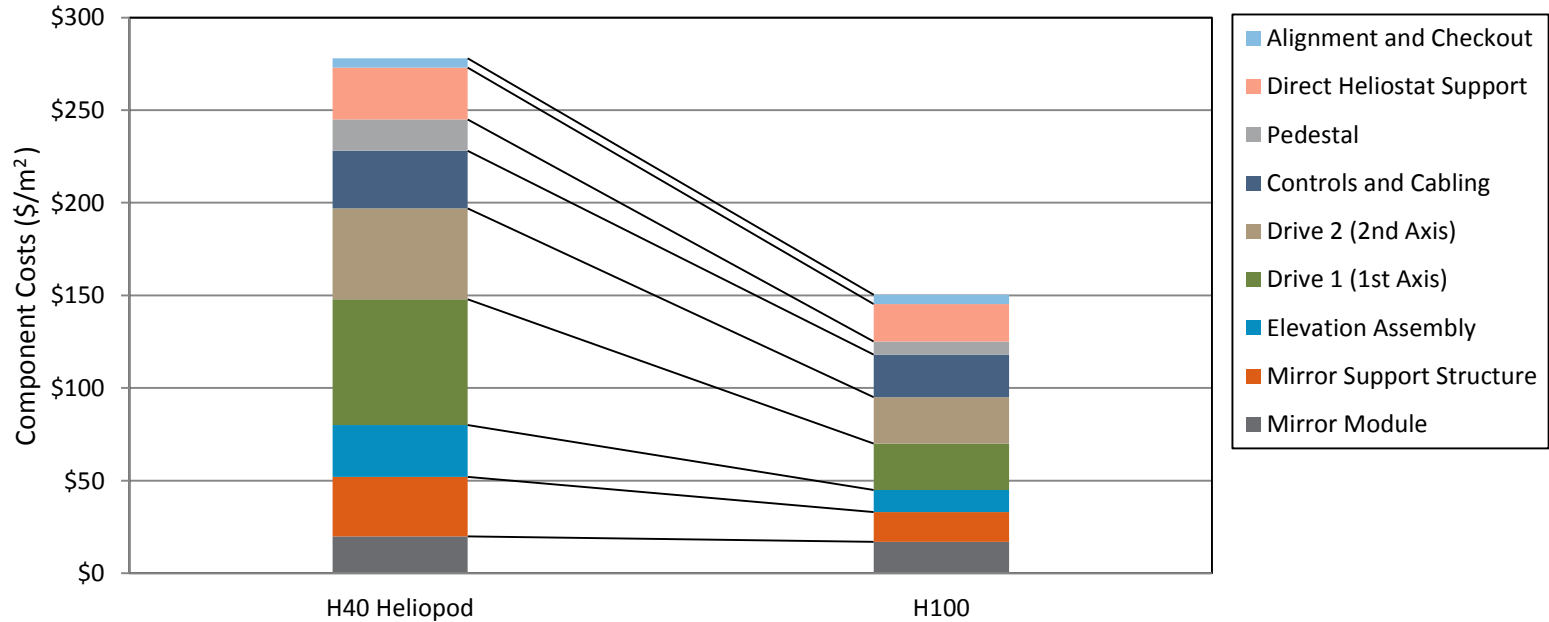


Indicative Costs



Volume Costs

20 000 units p.a.

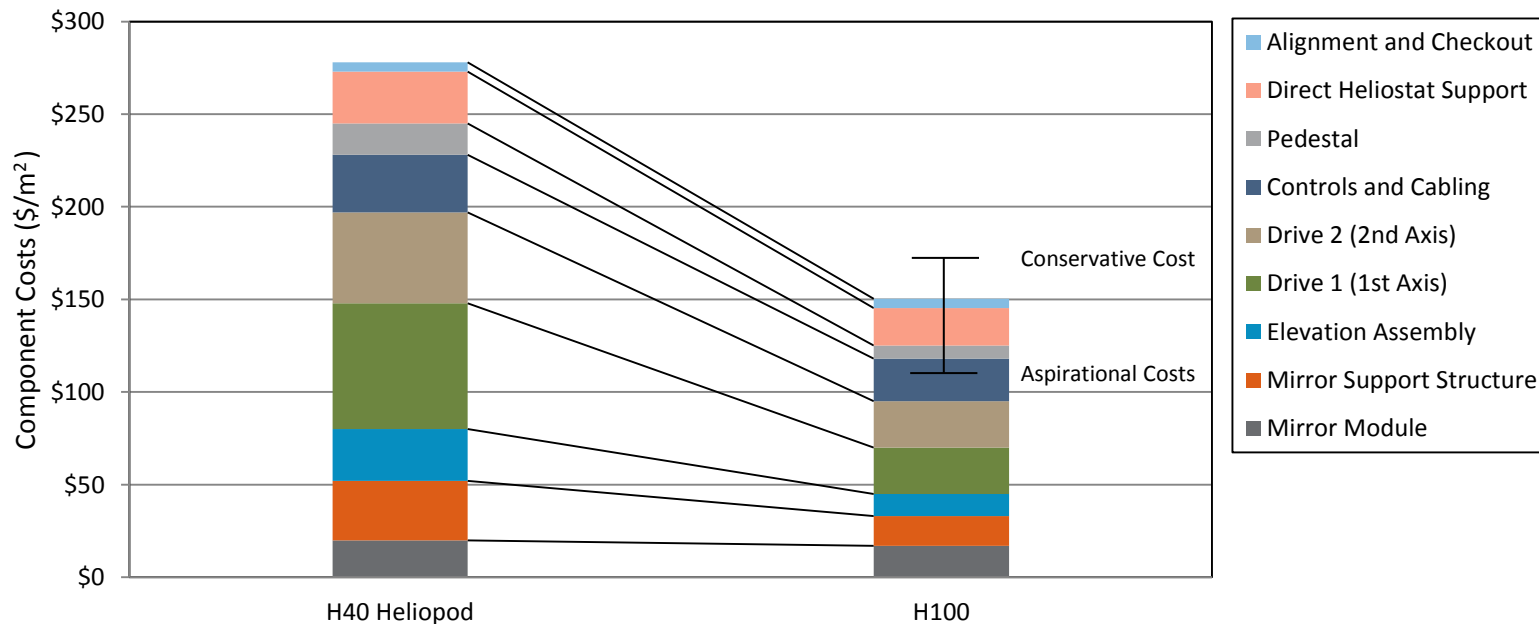


Indicative Costs



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

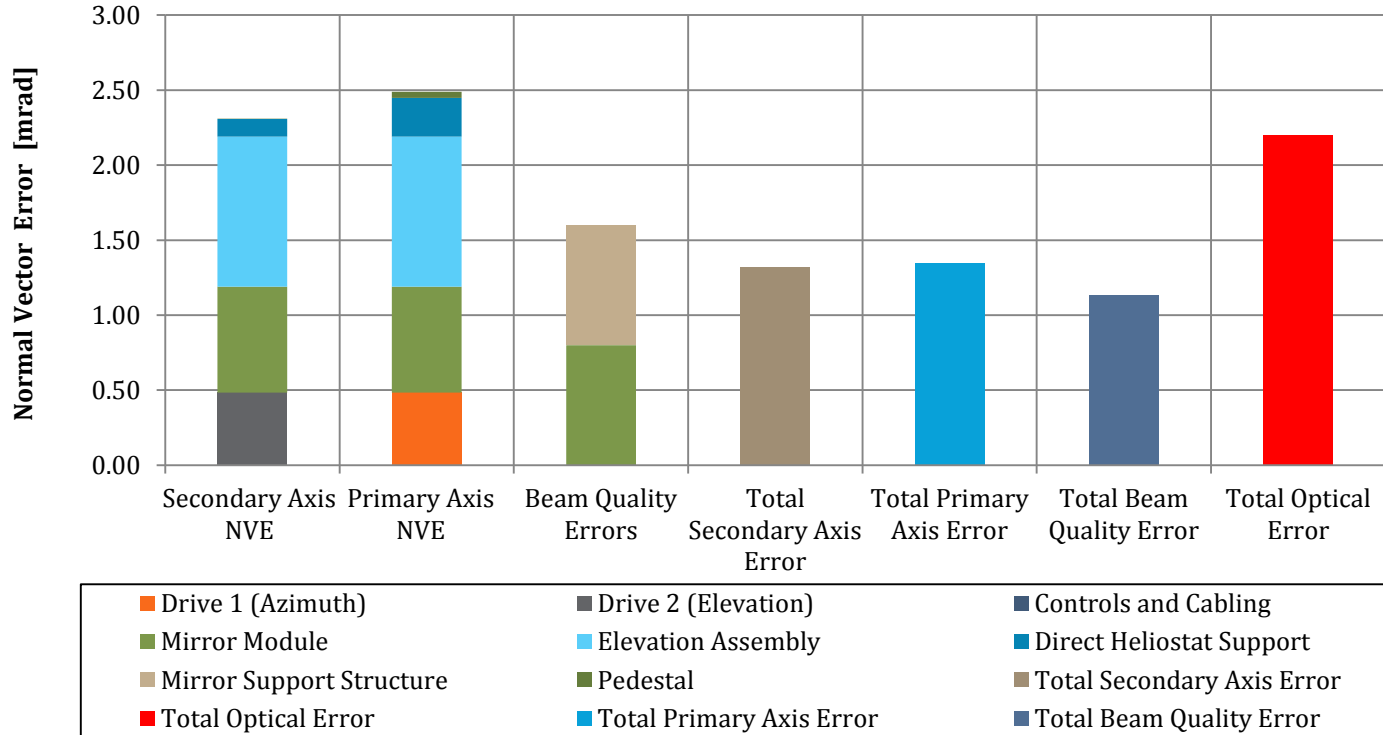
CONTACT DETAILS:

James N. Larmuth
Solar Thermal Energy Research
Group (STERG)
Stellenbosch University
South Africa

larmuth@sun.ac.za
+27 (0)21 808 4016

visit us: concentrating.sun.ac.za

H100



Learning Rates



$$p = \frac{1}{\ln 2} \left(\ln \frac{QCUM_1}{QL} \right)$$