

# Performance monitoring of different module technologies and design configurations of PV system in South Africa

## Presentation at the EU PVSEC 2016

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# Agenda

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**Polycrystalline and thin film Market and Technology status**

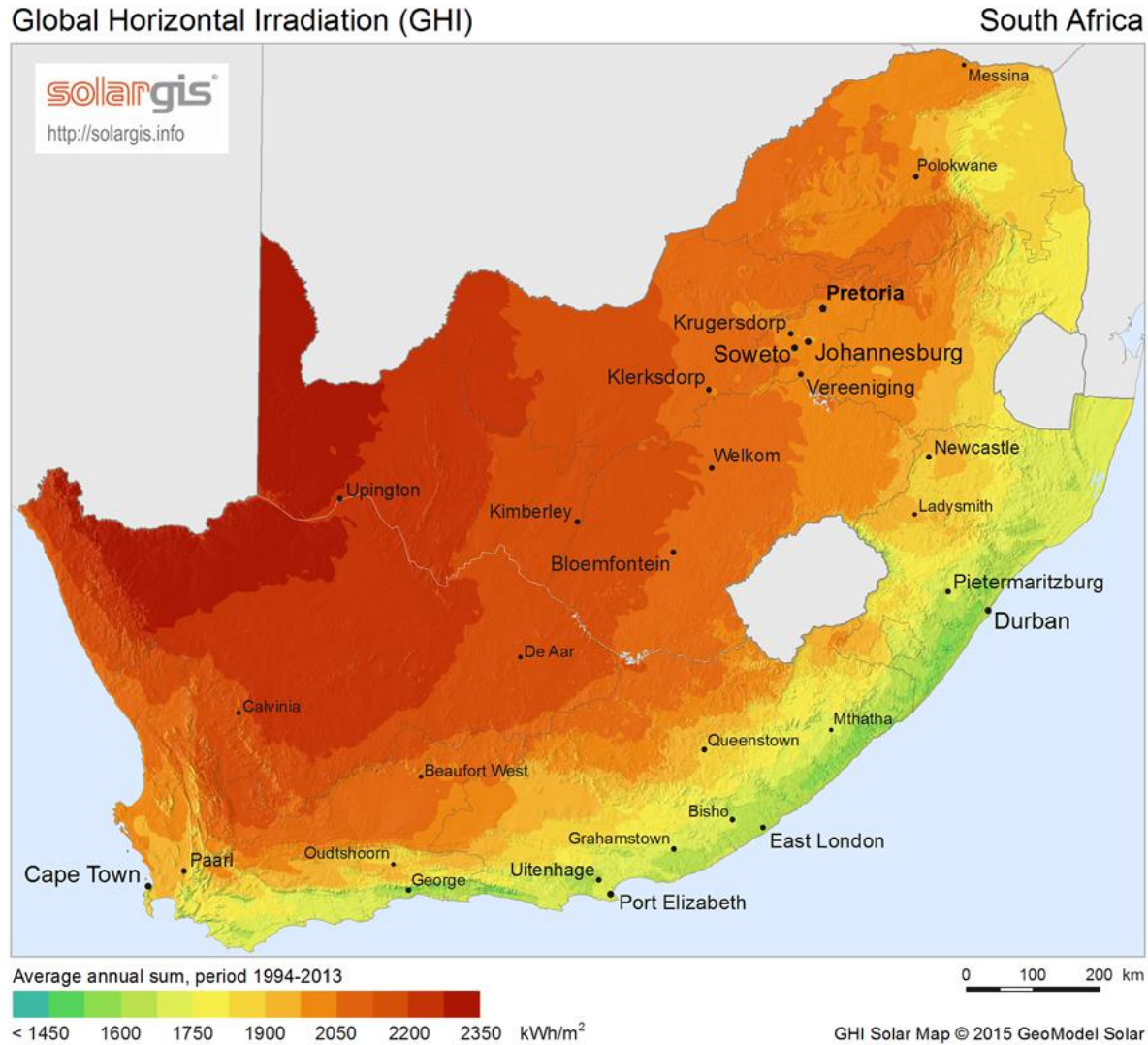
The ERIC system description

Methodology

Performance comparison

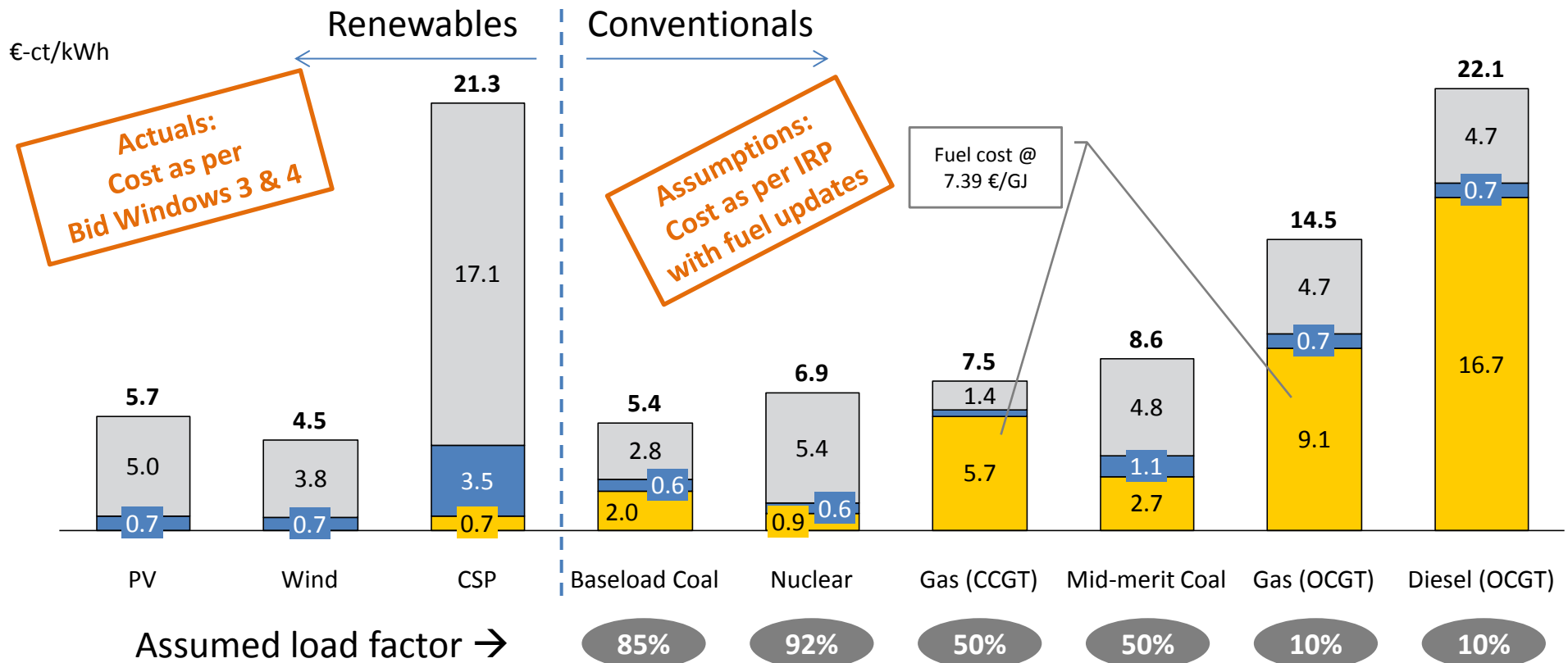


# Solar irradiance in South Africa



# Consequence of renewables' cost reduction: PV and wind are cost-efficient fuel-savers for CCGTs already today

## Lifetime cost per energy unit

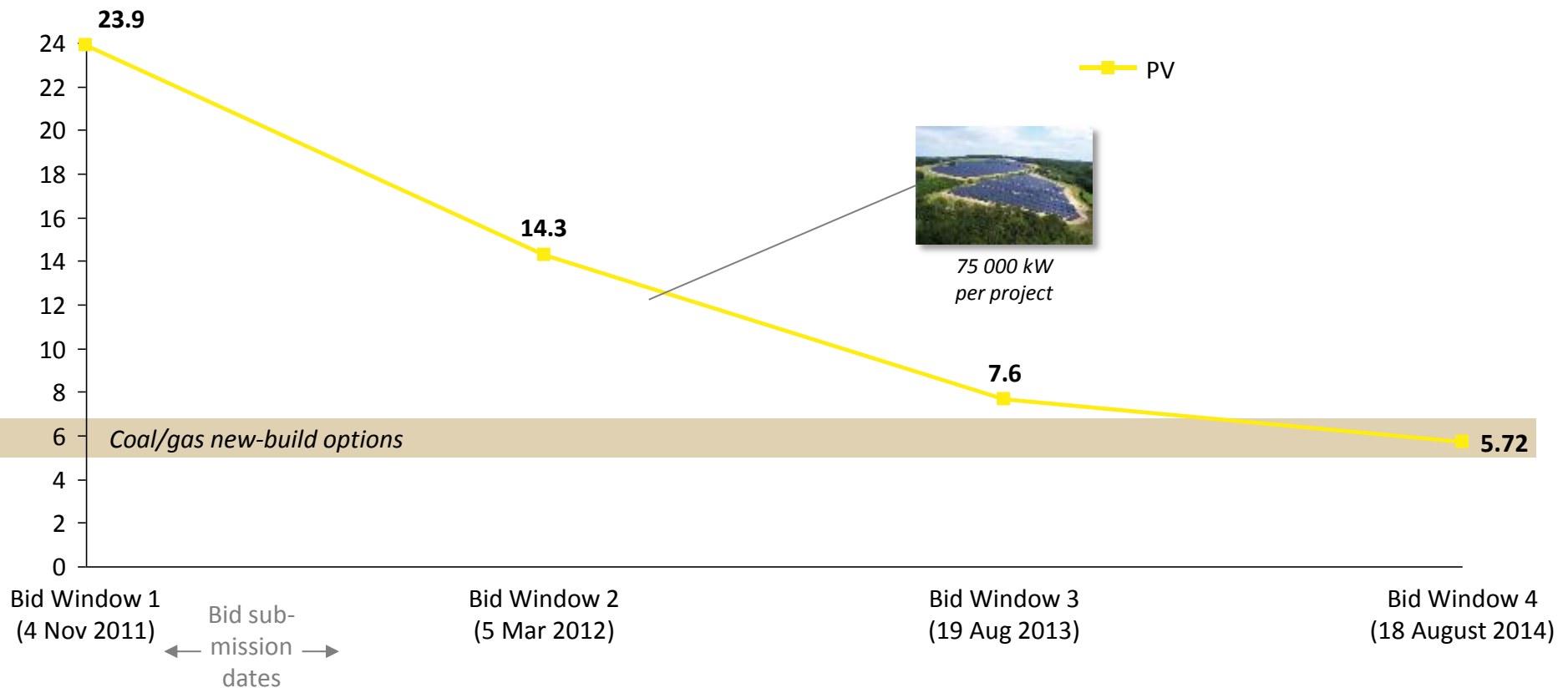


Note: Changing full-load hours for conventionals drastically changes the fixed cost components per kWh (lower full-load hours → higher capital costs and fixed O&M costs per MWh); Assumptions: average efficiency for CCGT = 50%, OCGT = 35%; coal = 37%; nuclear = 33%; IRP cost from Jan 2012 escalated with CPI to May 2015; assumed EPC CAPEX inflated by 10% to convert EPC/LCOE into tariff; CSP: 50% annual load factor and full utilisation of the five peak-tariff hours per day assumed to calculate weighted average tariff from base and peak tariff Sources: IRP Update; REIPPPP outcomes; StatsSA for CPI; Eskom financial reports on coal/diesel fuel cost; CSIR analysis

# Actual results: PV in South Africa are cost competitive today

First four bid windows' results of Department of Energy's RE IPP Procurement Programme (REIPPPP)

Average tariff  
in €-ct/kWh



Notes: For CSP Bid Window 3, the weighted average of base and peak tariff is indicated, assuming 50% annual load factor

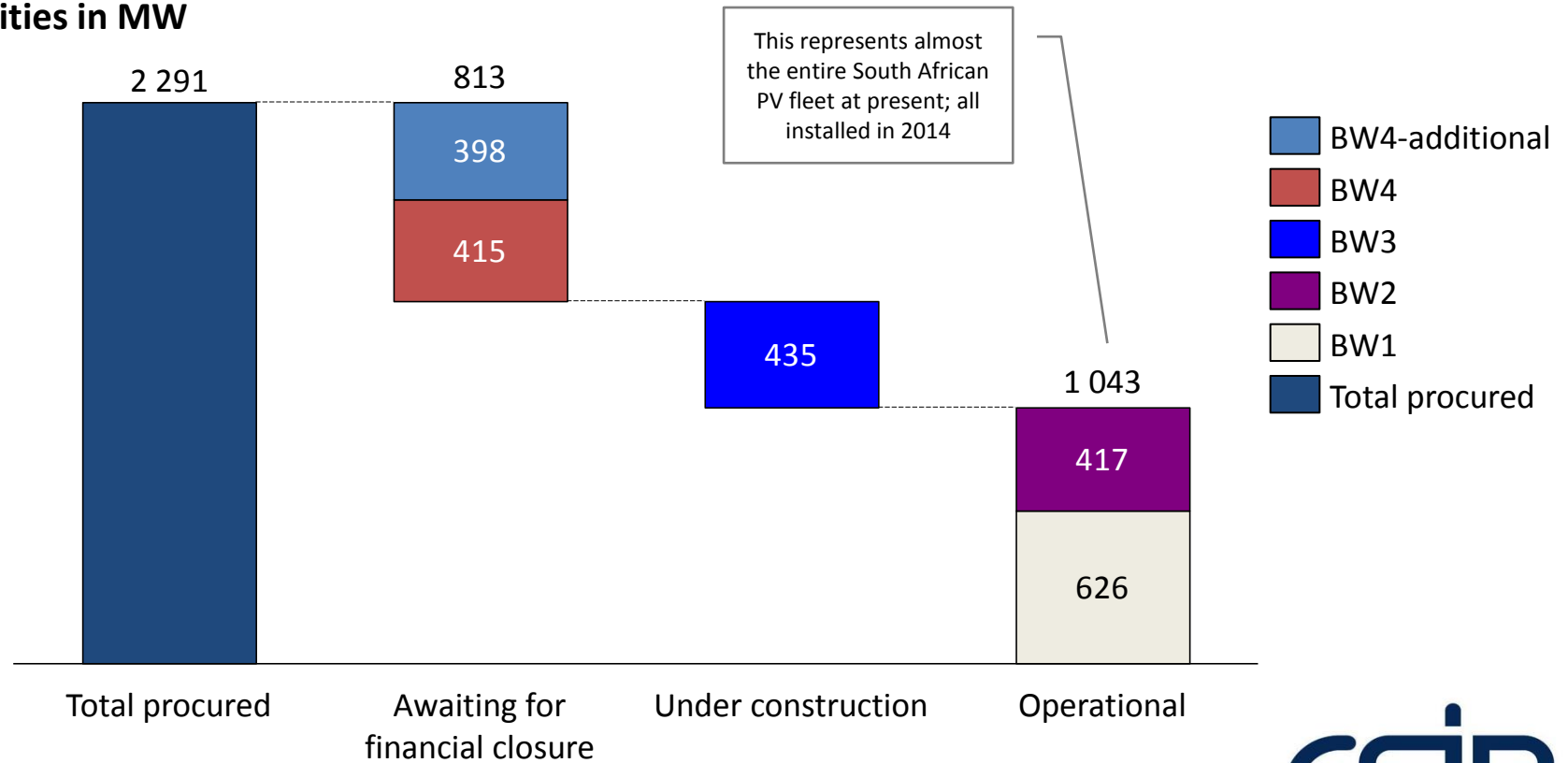
Sources: StatsSA on CPI; Department of Energy's publications on results of first four bid windows <http://www.energy.gov.za/IPP/List-of-IPP-Preferred-Bidders-Window-three-04Nov2013.pdf>;

[http://www.energy.gov.za/IPP/Renewables\\_IPP\\_ProcurementProgram\\_WindowTwoAnnouncement\\_21May2012.pptx](http://www.energy.gov.za/IPP/Renewables_IPP_ProcurementProgram_WindowTwoAnnouncement_21May2012.pptx); <http://www.ipprenewables.co.za/gong/widget/file/download/id/279>; CSIR analysis

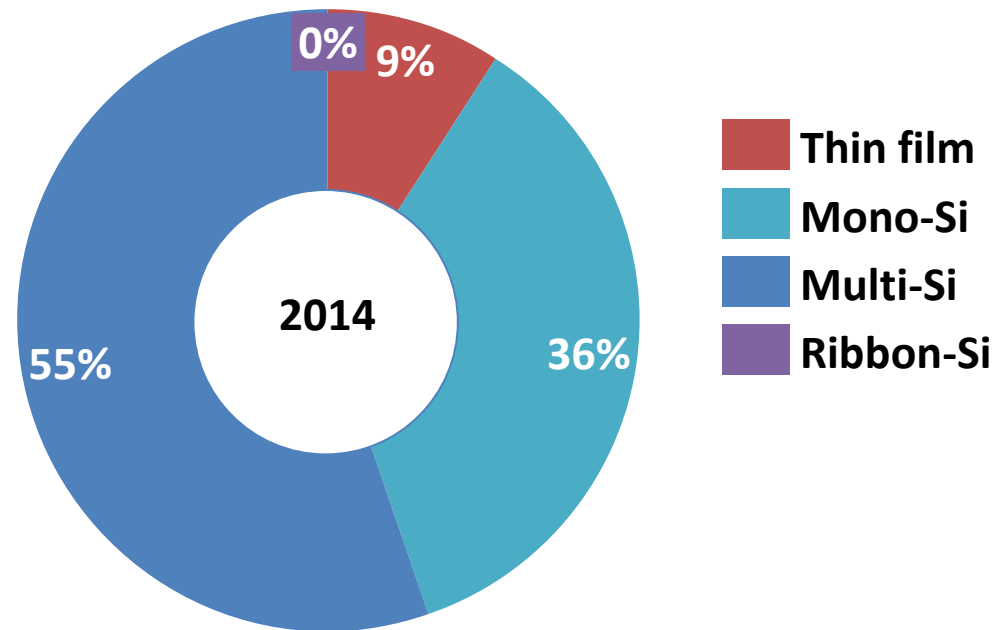
# At present, more than 1 000 MW of PV are operational in South Africa

Pipeline of PV projects in the REIPPPP for large, utility-scale PV

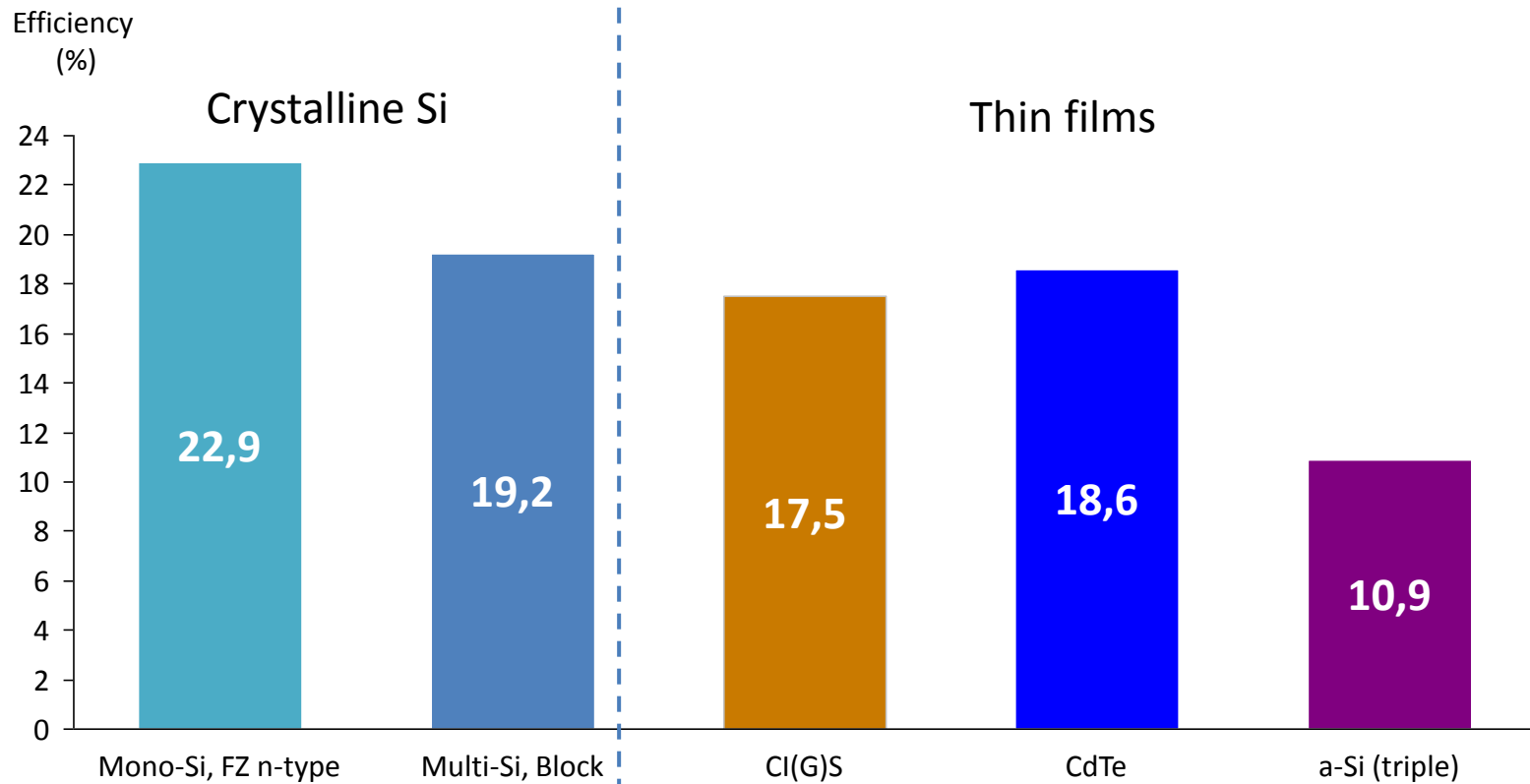
## PV capacities in MW



# Global PV production by technology in 2014



# Best module efficiencies by technology in 2014





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# PV system set up and aerial Photograph of ERIC Solar PV plant

PV system No	1	2	3	4	5	6	7
Orientation	North		East/West		E-W tracking		N-S tracking
Inclination	25°		10°		E-W tracking		N-S tracking
Technology	c-Si	CIGS	c-Si	CIGS	c-Si	CIGS	c-Si

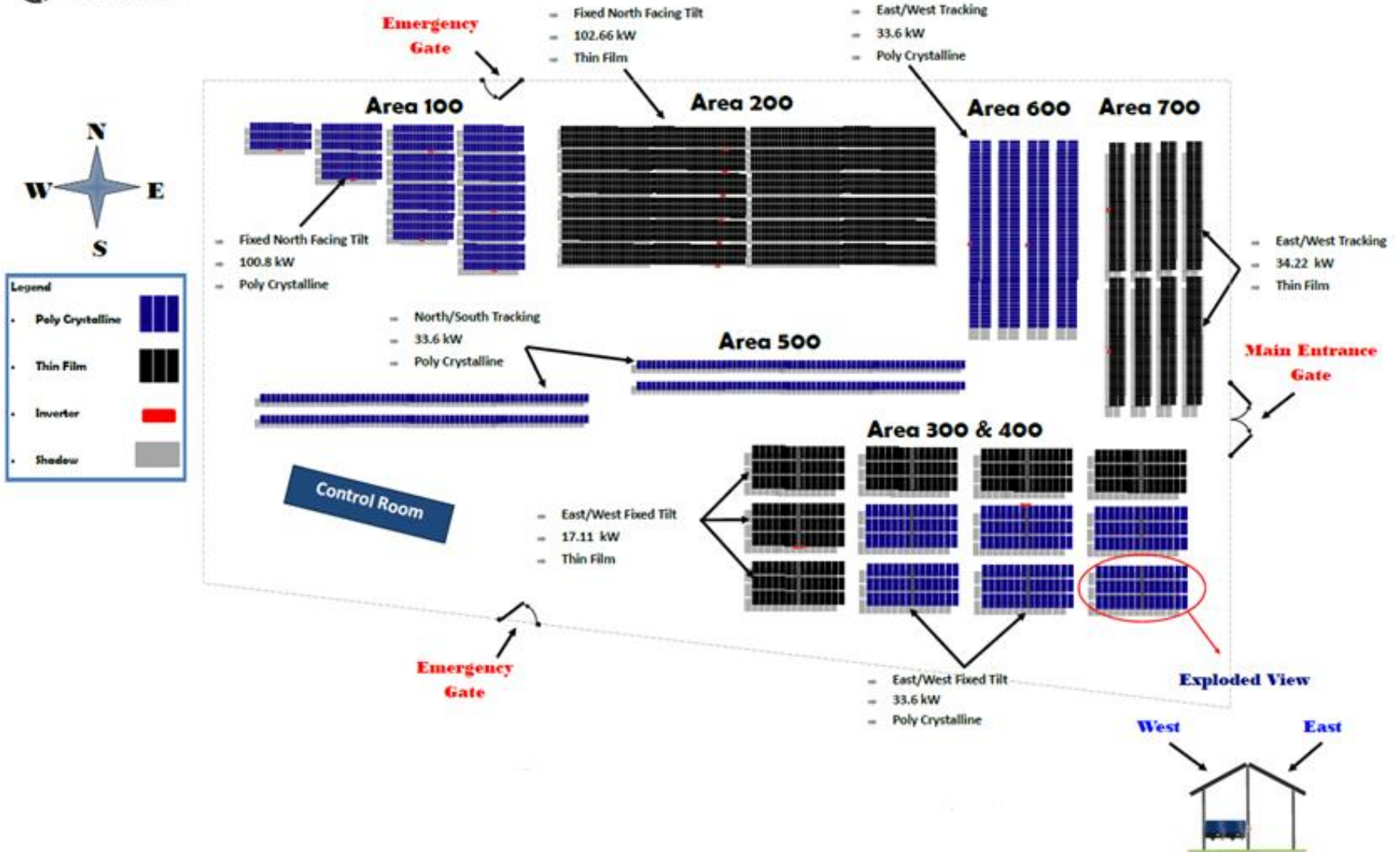
- 1 & 2 - Reference system  
(Optimum tilt for Johannesburg)
- 3 & 4 - East/West configuration  
(Half of the installed system faces east while the other half faces west)
- 5 & 6 - East West tracking  
(To maximize yield)
- 7 - North – South tracking



# Layout of the Eskom Rosherville solar PV plant in South Africa



## Rosherville 400 kW PV Power Plant



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Performance comparison: Crystalline & thin films



# Methodology



- As received from SCADA
- The duration of operation kept constant
- Outliers were removed (for fair comparison)
- Key performance indicators investigated:
  - Final yield
  - Reference yield
  - PR
- Performance comparison using:
  - Monthly yield
  - Monthly yield
  - Yield gain

# Key technical assumptions

Similar PV module installed capacity

Similar shading losses (entailing a greater land area for the thin film plant)

Some sections of DC cable length for the thin films plant is twice that of polycrystalline module due to the larger area required for thin film modules (short distance <10 m)

Similar inverter, AC cable size, DC cable size



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## 1. Module technology comparison



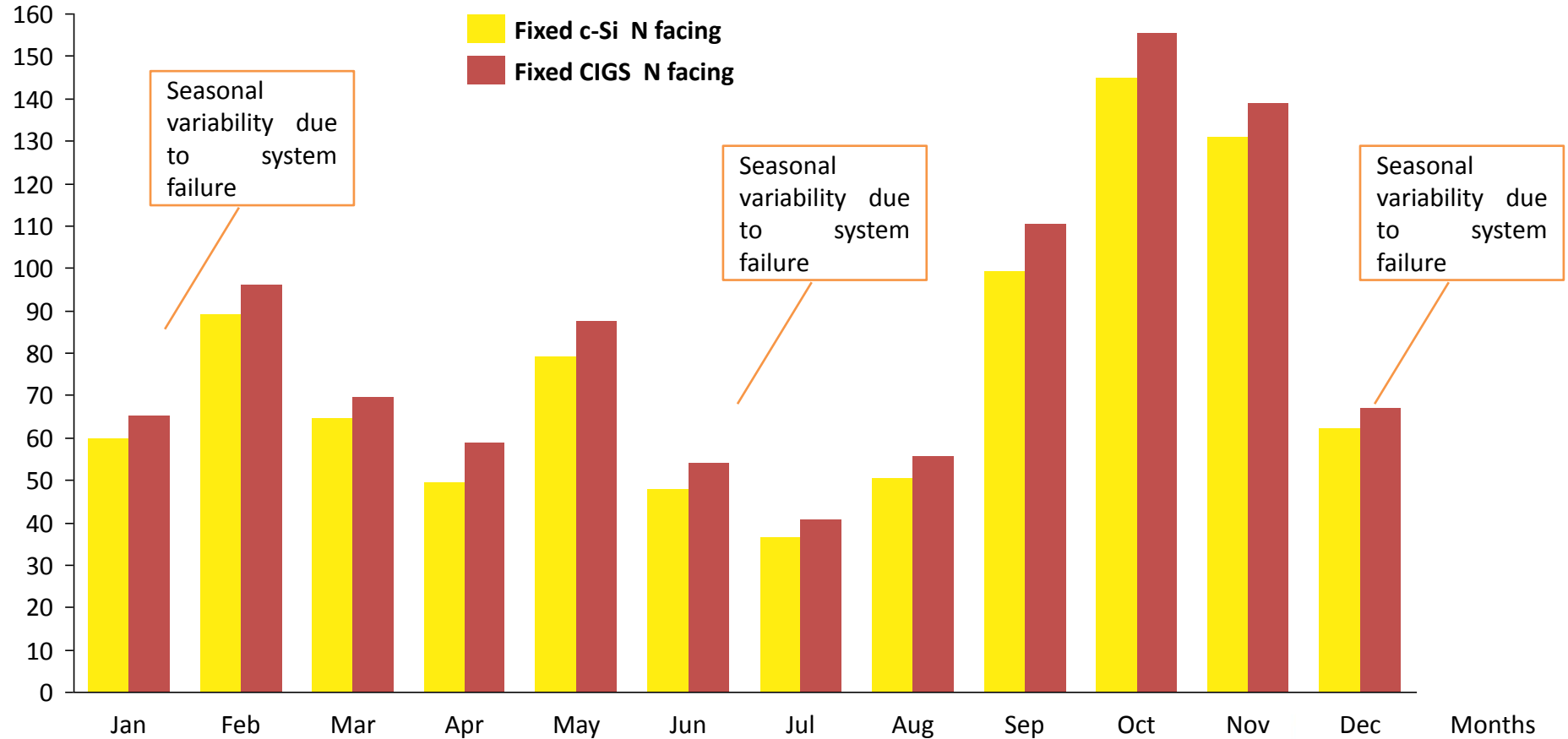


## 1.1 Configuration: Fixed tilt (optimum)

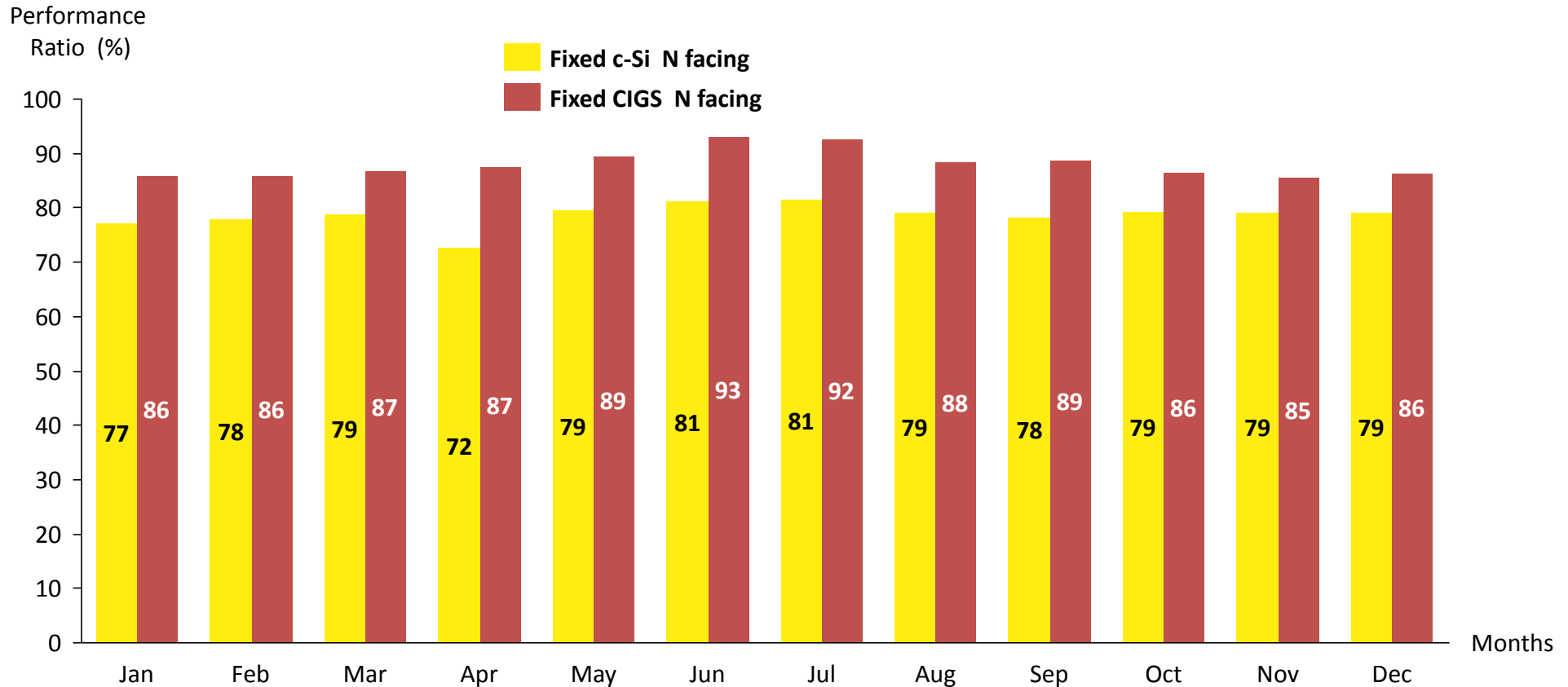


# Throughout the year the CIGS thin film section yields more energy

Specific yield  
(kWh/kW<sub>p</sub>/m)



# Performance ratio of CIGS thin film section is higher for all months



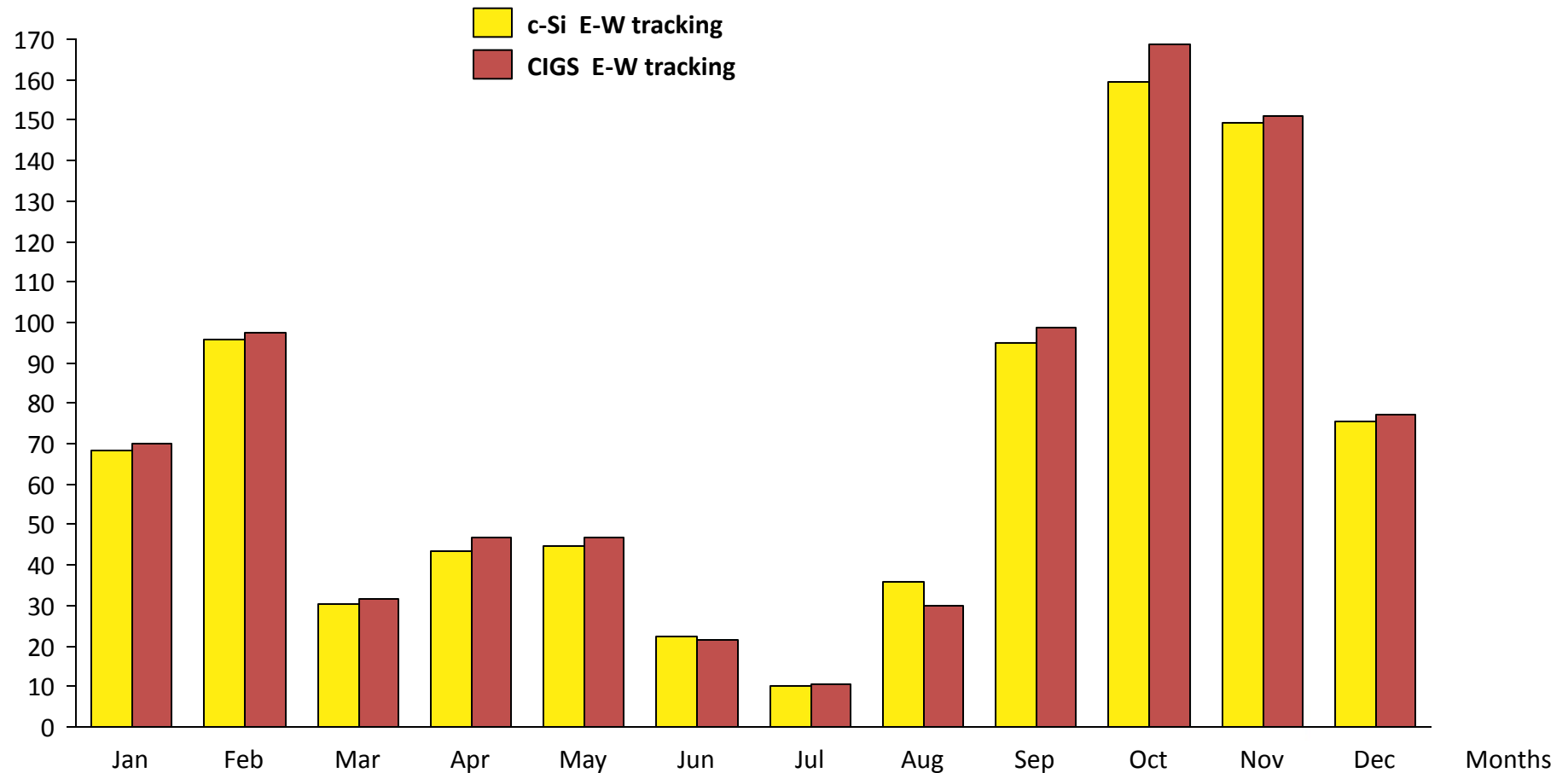
**PR ratio of > 90 has been achieved for winter months due to cooler module temperature**

## 1.2 Configuration: Tracking

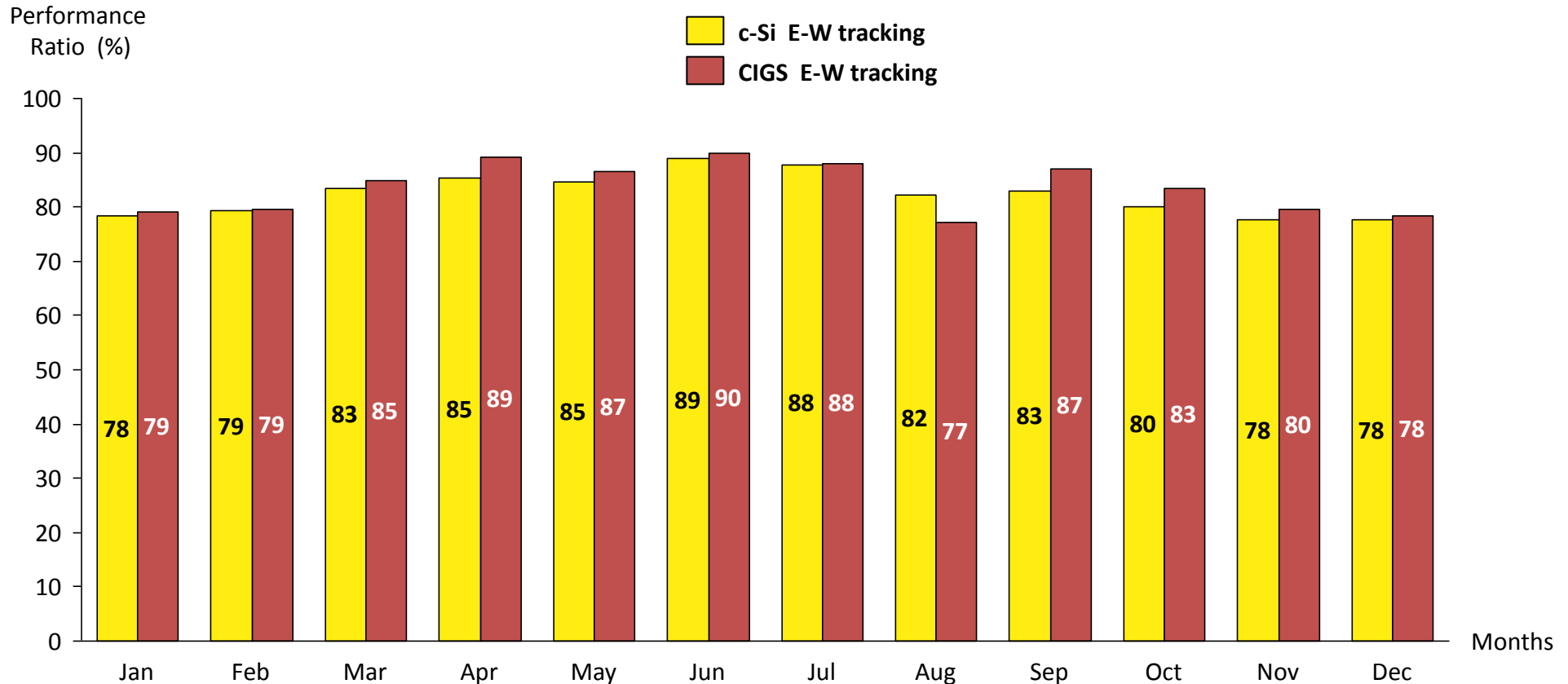


# CIGS thin film section yielded more for most of the months

Specific yield  
(kWh/kW<sub>p</sub>/m)



# Performance ratio of the CIGS thin film section is higher for all months



**CIGS performed better than c-Si technology in both fixed north facing and tracking configurations when considering specific/final yield**

## 2. Design configuration comparison



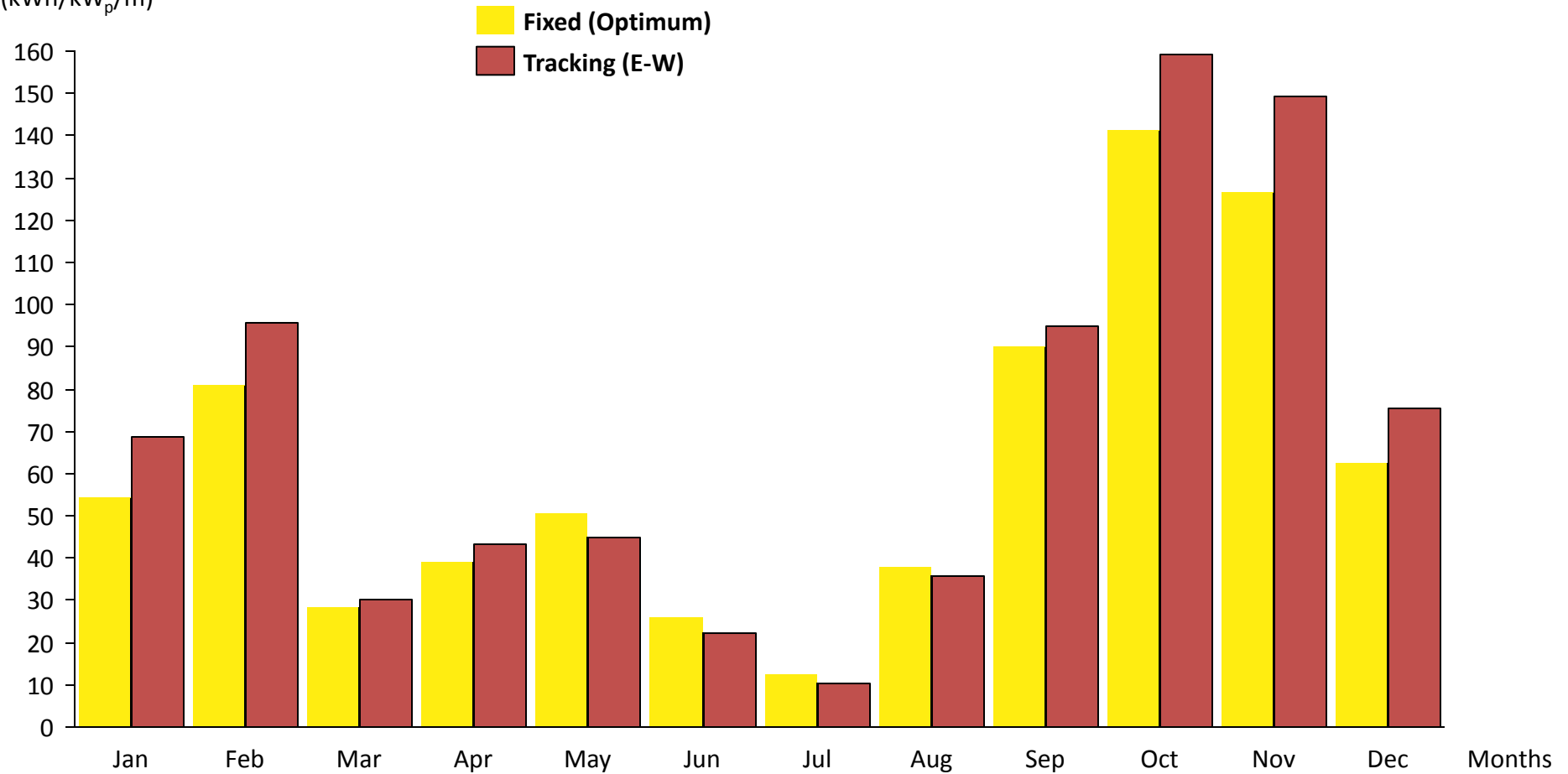
## 2.1 Fixed (optimum) vs Tracking





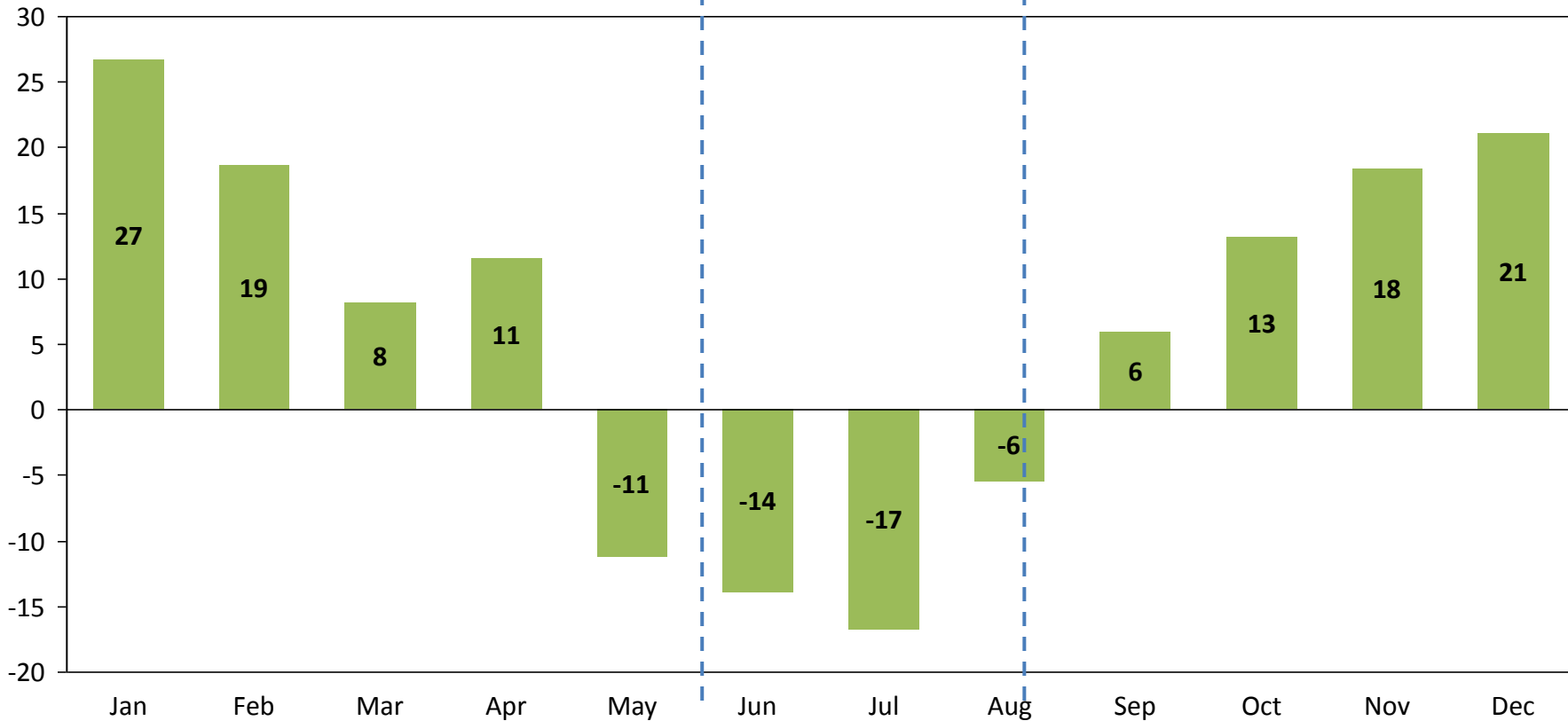
# Tracking configuration yielded more for summer months when compared to optimum tilt configuration

Specific yield  
(kWh/kW<sub>p</sub>/m)



# Tracking: Yield gain in summer month, while losing in the winter month

Yield gain (%)



**Tracking the astronomical movement of the sun does not always give more yield!**

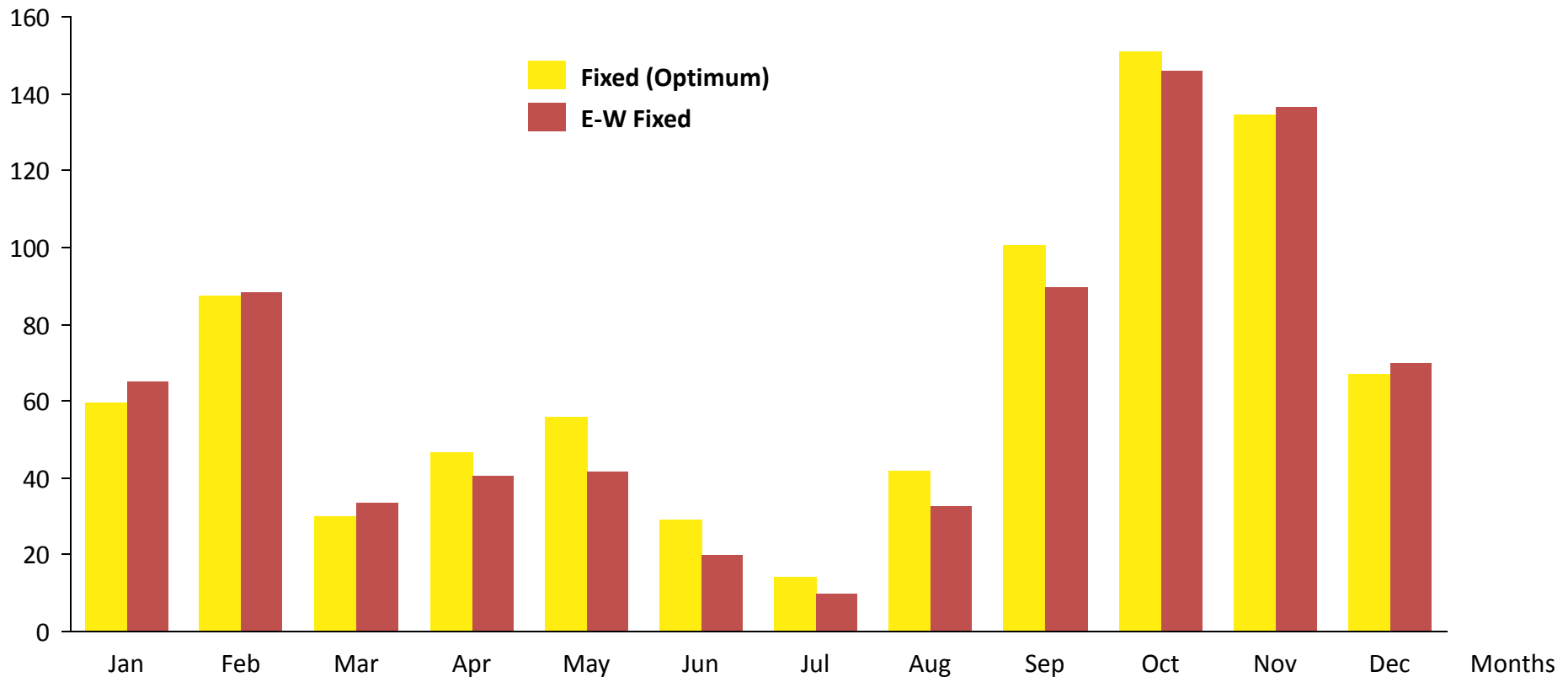
Note: Data filtered for irradiation > 400 W/m<sup>2</sup>; for a fair comparison between technologies the hours of operation were kept the same  
Sources: Eskom, CSIR EC analysis

## 2.2 Fixed (Optimum) vs E-W fixed ( $10^\circ$ tilt)



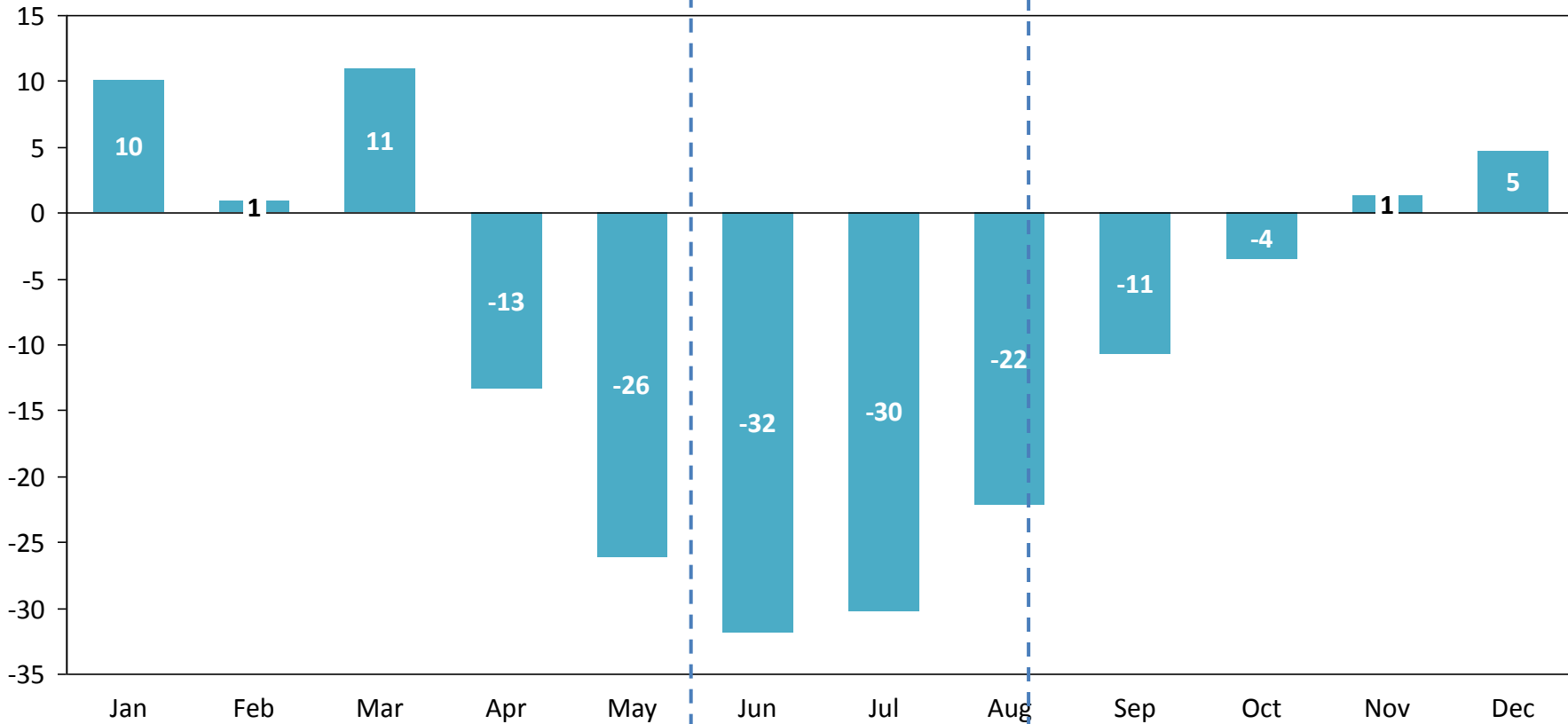
# The yield of east/west PV system is lower during winter time

Specific yield  
(kWh/kW<sub>p</sub>/m)



# North facing: Good yield in winter time, while yielding less in summer time

Yield gain (%)



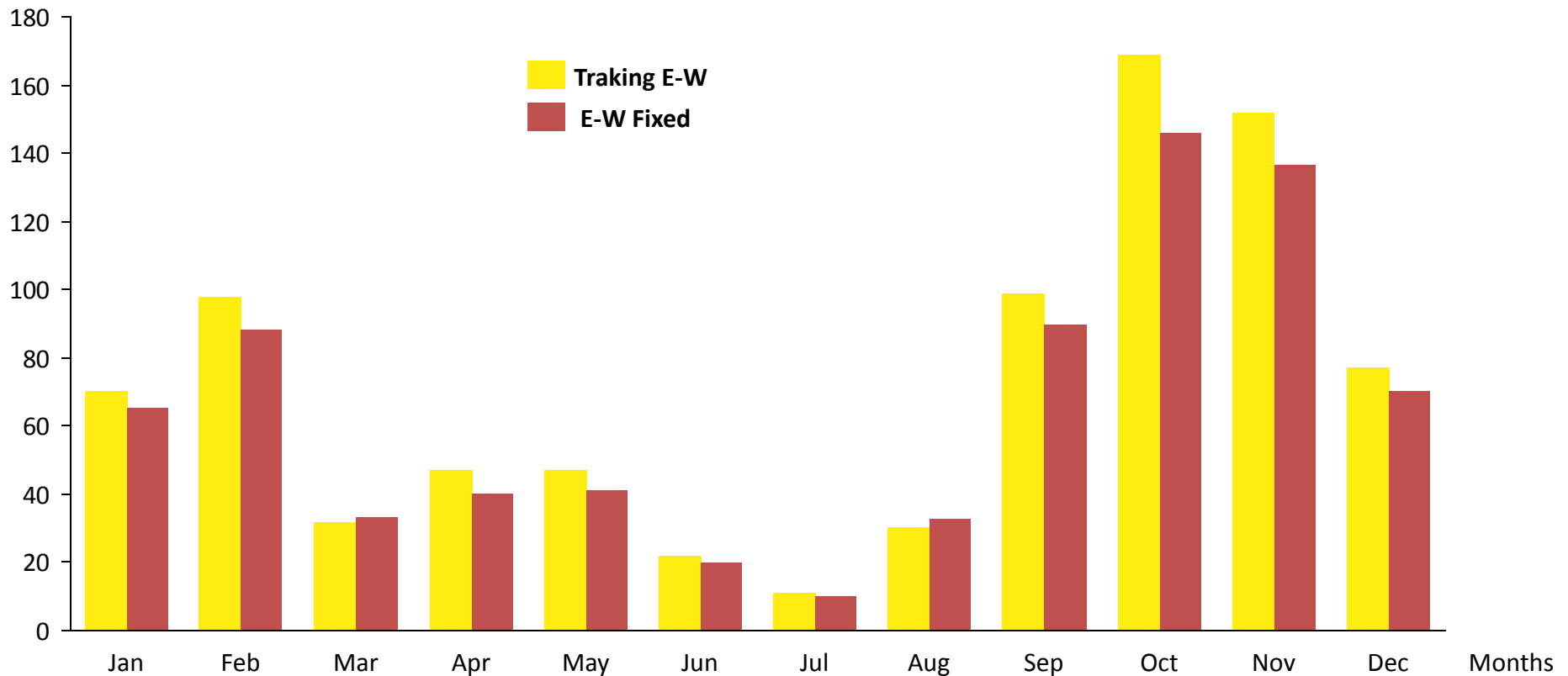
**East/west oriented system is inferior to the north oriented system!**

## 2.3 Tracking (E-W) vs E-W fixed (10° tilt)

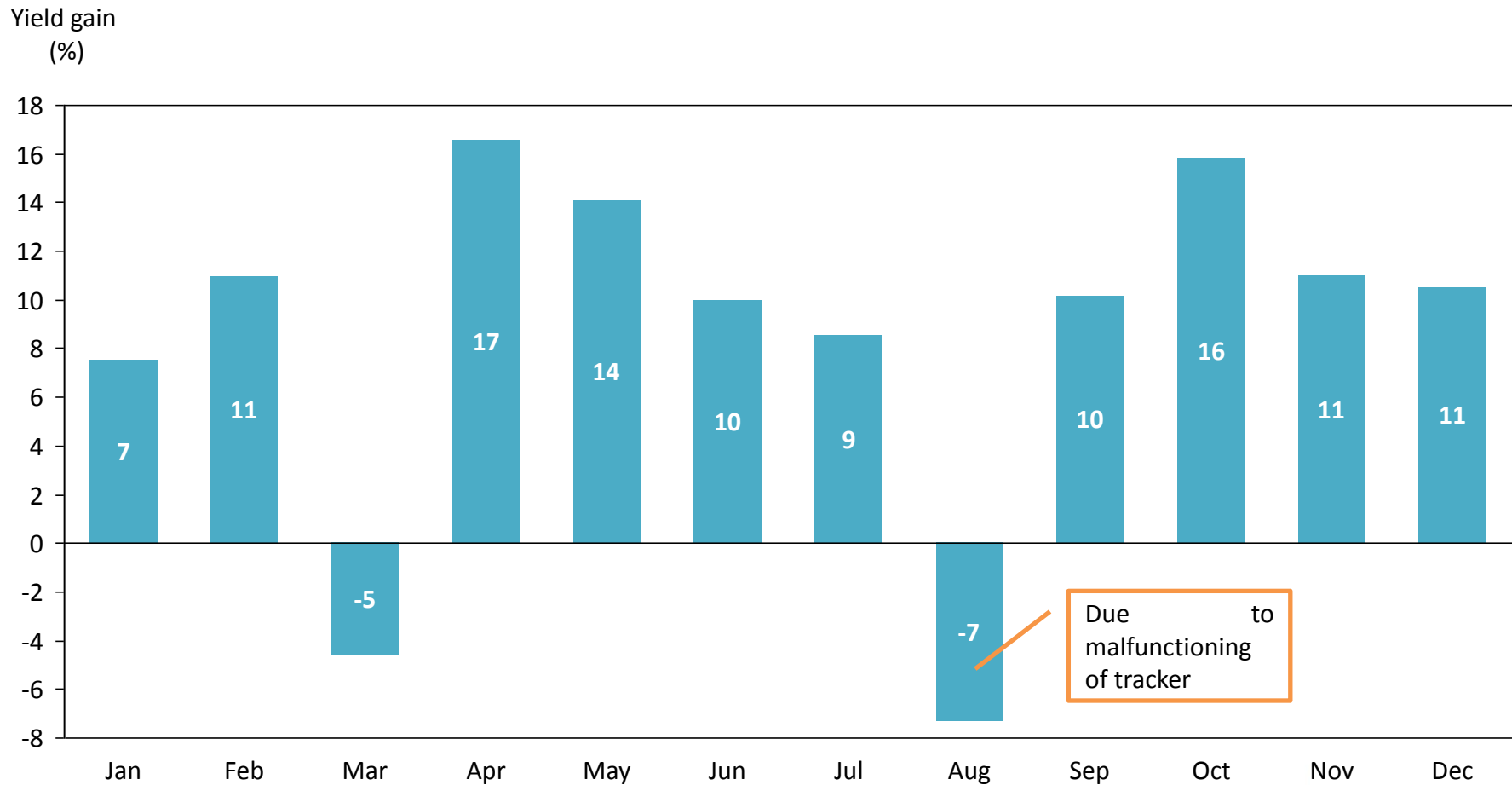


# East-west tracking yields more compared to east/west tilt

Specific yield  
(kWh/kW<sub>p</sub>/m)



# East-west tracking preforms better when compared with east/west tilt





Ha Khensa

Re a leboha

Siyathokoza

Enkosi

**Thank you!**

Re a leboga

Ro livhuha

Siyabonga

Dankie

