



# CSP Market Status

Solar Thermal Energy Research Group

Alberto Cuellar

Senior Renewable Energy Engineer

Mott MacDonald



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# Introduction to Mott MacDonald



# Who we are:

World class engineering,  
design, management  
& development  
consulting firm



USD1.7 billion turnover



Multidisciplinary



Multisector



Over 17,000 staff



Global presence



Employee owned



400  
AWARDS  
IN FIVE YEARS

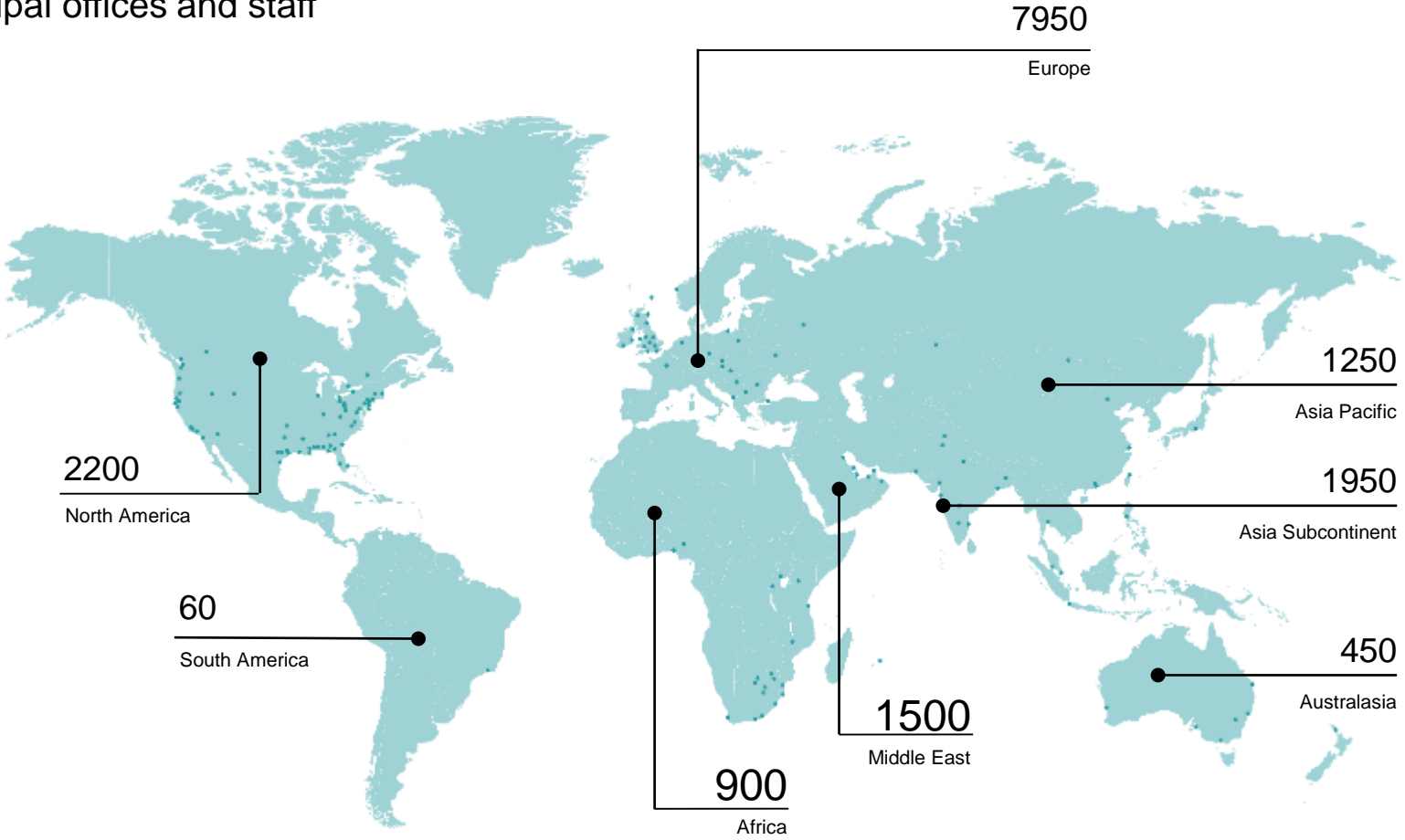


SUSTAINABLE  
SOLUTIONS

PROFESSIONAL  
EXCELLENCE

Ranked  
**14**  
ENR  
Engineering News-Record

# Principal offices and staff



## Key Services

Services	Owners / Investors	Governments & Utilities	Contractors & Suppliers	Banks & Funders
Project identification	■	■		
Feasibility & pre-investment studies	■	■		
Engineering design	■	■	■	
Procurement services	■	■		
Construction supervision	■	■	■	
Project management	■	■	■	
Contract administration	■	■		
Environmental & social studies	■	■	■	■
Due diligence & appraisals	■	■		■
Economic and financial analysis	■	■	■	■
Condition assessment / refurbishment	■	■	■	

# Mott MacDonald's Experience

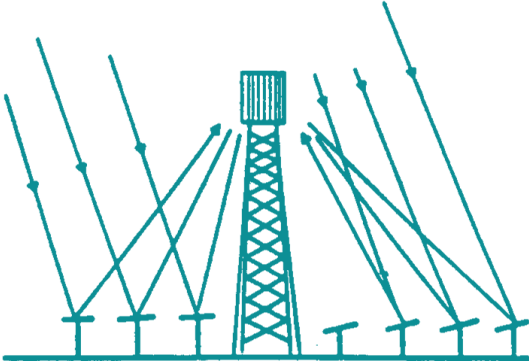


# Mott MacDonald's Experience

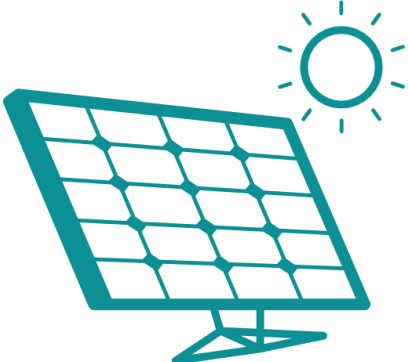
## Projects per technology



~70 GW



~2.5 GW



~8 GW



## A Sample of Mott MacDonald's Solar Experience

Project	Tech	Capacity	Country	Sponsors	Role
Khi	CSP	50MW	South Africa	Abengoa / IDC	LTA
Kilroot Battery Energy Storage System	Li-Ion Battery	10MW	North. Ireland	Confidential	TA
Metehara	PV	100MW	Ethiopia	Confidential	OE
Market Analysis and Technical Review of Battery Storage Technologies	Energy Storage	NA	UK/Global	Confidential	TA
Kesses	PV	40MW	Kenya	Confidential	TA
Windfarm with Storage	NaS Battery	34MW	Japan	Confidential	TA
Kruger National Park PV Projects	Hybrid PV	1.5MW/4 sites	South Africa	Dep. Of Tourism	OE
IFC Scaling Solar	PV	2x50MW	Zambia	Globeleq	OE
Kalangala	Hybrid PV	1.6MW	Uganda	Confidential	TA
Ilanga	CSP	100MW	South Africa	ACS / Emvelo / IDC / PIC / Investec	OE
Kinkai Salt Field Solar PV Project	PV	231MW	Japan	Setouchi Kirei	OE
Ayitepa	Wind	225MW	Ghana	Elegtra	LTA
Bridgeport Fuel Cell Project	MC Fuel Cell	15MW	USA	Confidential	OE
NamPower	CSP	TBD	Namibia	TBD	OE
Hokkaido Chitose Solar PV Battery Storage	Li-Ion Battery	11MW	Japan	Confidential	TA
Lake Turkana	Wind	310MW	Kenya	Aldwych/ LTWP	LTA & IE

# South African CSP Market



# South African CSP Market

## Status of the REIPPPP for CSP projects

- **Round 1 (awarded Dec 2011)**
  - Low competition and tight timelines: prices close to the tariff cap
- **Round 2 (awarded May 2012)**
  - Increased local content
- **Round 3 (awarded Oct 2013)**
  - Further increased in local content & TOD tariff
- **Round 3.5 (awarded Nov 2014)**
  - Increased competition and reduced tariffs offered
- **Round 4.5 (TBC)**
  - Plant capacity limit increased to 150MW
  - Tariff cap reduced
  - High competition expected with a predominant role of towers
  - Expected to award 3 projects



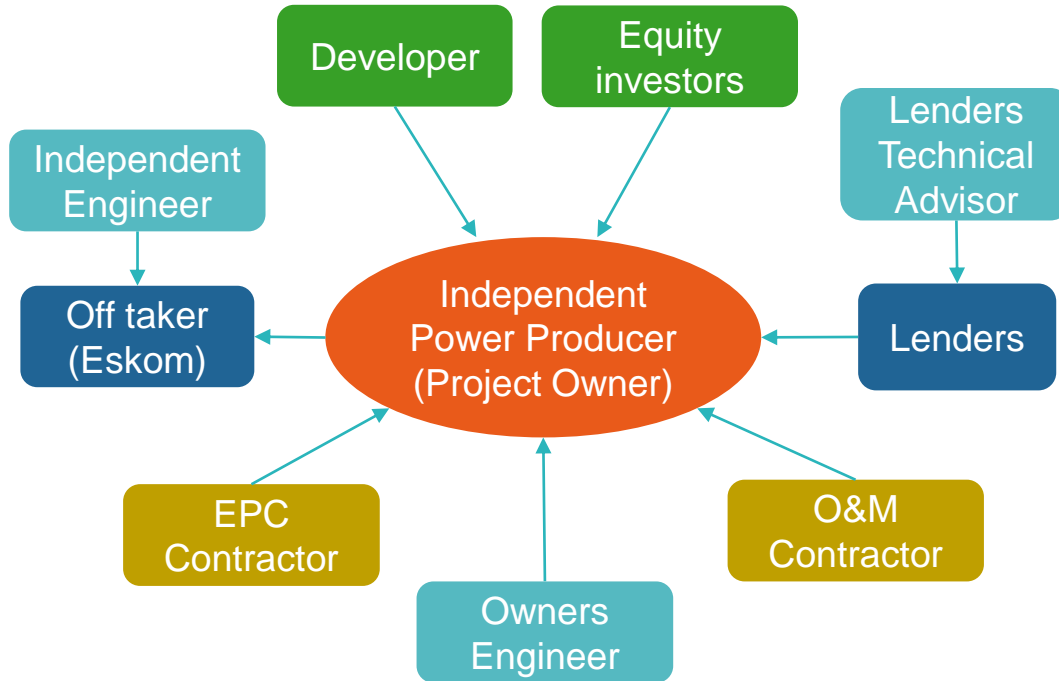
## South African CSP Market

### Technical Requirements of the REIPPPP for CSP Projects

Round	1	2	3	3.5	4.5
Max. capacity	100MW				150MW
Technology	Key design items with at least 2 commercial references for 24 months		Trough, Fresnel Central Receiver or 2 commercial references for 24 months	Trough, Fresnel Central Receiver or 1 commercial references for 12 months	No requirement
	Wet or dry cooling			Dry cooling	
EPC Contractor requirements	Track record of: - 2 similar projects - 1 similar scale - 1 similar scope				No track record required
Grid connection	Eskom-build, self-build or own-build				Self-build
Tariff	Single tariff		Time of Day (TOD) tariff		

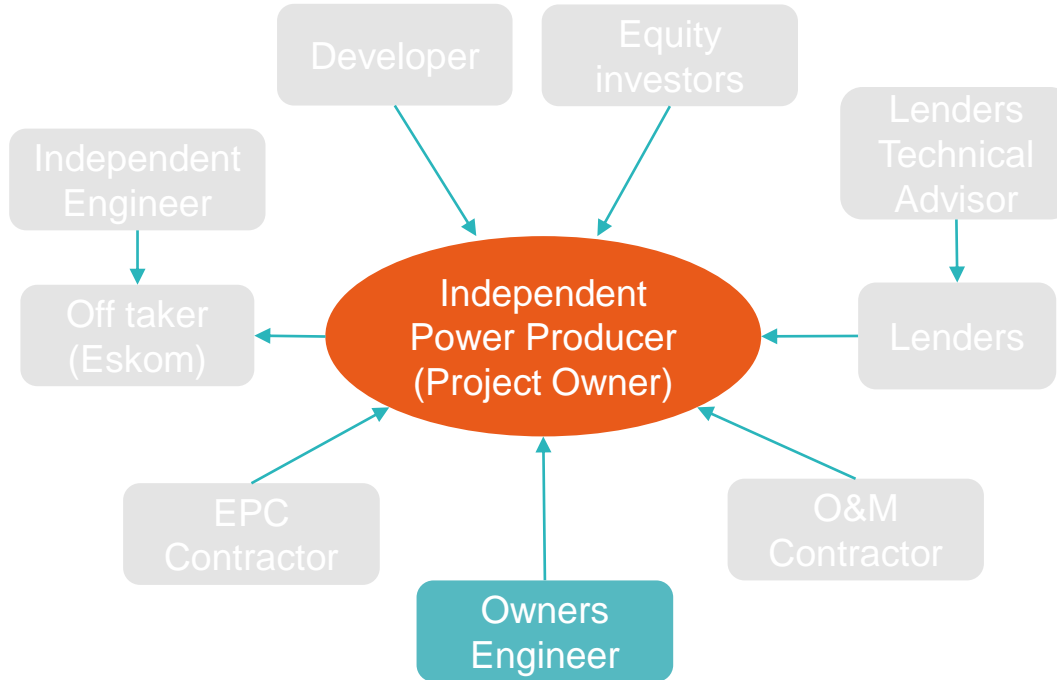
# South African CSP Market

## Typical Project Structure – Project Finance



# South African CSP Market

## Typical Project Structure – Project Finance



## Owners Engineer (OE)

### Development:

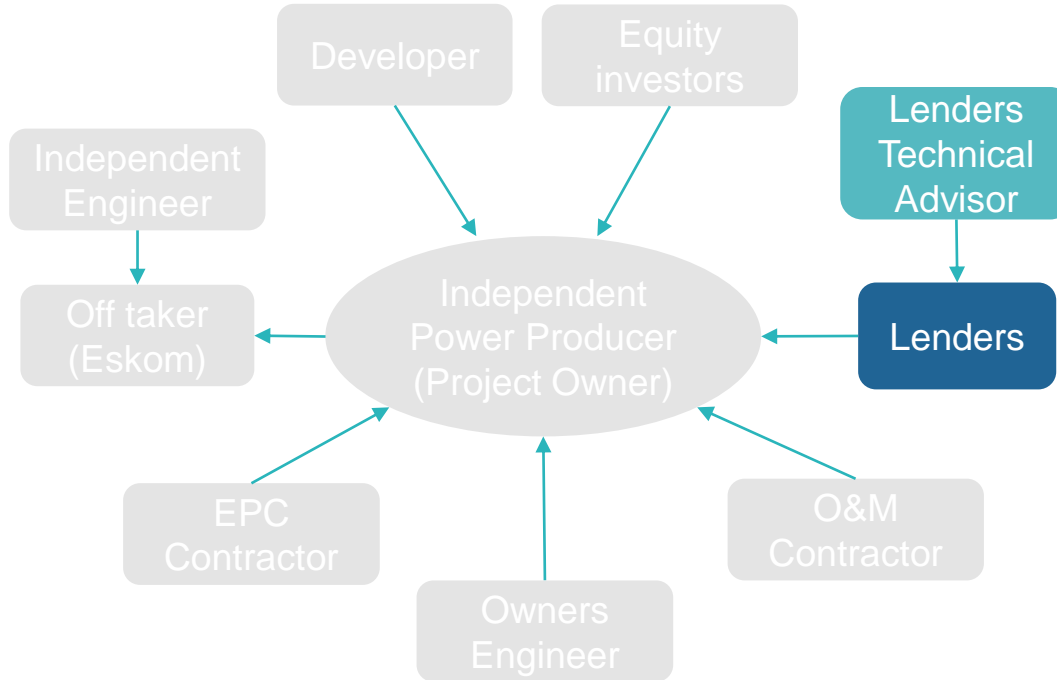
- Technical advice to developer/Owner
- Yield estimates
- Basic design
- Contracts review

### Construction:

- Design review
- Construction supervision
- Milestone sign-off
- Quality supervision (site and factory)
- Schedule supervision
- Performance testing
- Punch list

# South African CSP Market

## Typical Project Structure – Project Finance



## Lenders Technical Advisor (LTA)

### Development:

- Due diligence
- Technical fatal flaw
- Contracts review
- Yield forecast review

### Construction:

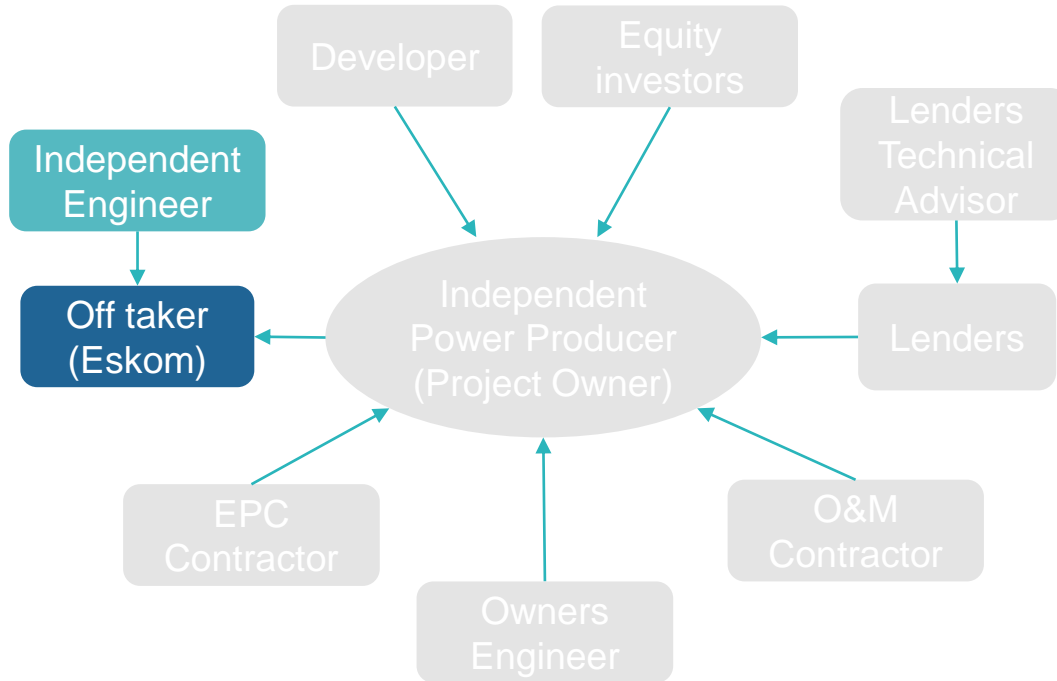
- Disbursement certificates
- Quality and schedule monitoring
- Performance testing review

### Operations:

- Performance monitoring
- O&M budget

# South African CSP Market

## Typical Project Structure – Project Finance



## Independent Engineer (IE)

### Construction:

- Construction monitoring
- Facility Completion sign-off



## South African CSP Market

### Awarded CSP projects

Project	Capacity	Bid round	Technology	TES	Status	MM Role
Khi	50MW	1 (single tariff)	Central Receiver	2 h	Operational	LTA
Kaxu	100MW	1 (single tariff)	Parabolic Trough	2.5 h	Operational	LTA
Bokpoort	50MW	2 (single tariff)	Parabolic Trough	9 h	Operational	LTA
XiNa	100MW	3 (TOD tariff)	Parabolic Trough	6 h	Construction	LTA
Ilanga	100MW	3 (TOD tariff)	Parabolic Trough	5 h	Construction	OE
Kathu	100MW	3.5 (TOD tariff)	Parabolic Trough	4.5 h	Construction	LTA
Redstone	100MW	3.5 (TOD tariff)	Central Receiver	12 h *	Financial Close	LTA

## South African CSP Market

### KHI – Upington Northern Cape

Central Receiver System

Size: 50 MW

Configuration: Direct Steam with Thermal Storage

Storage: Saturated Steam – 4h (624 MWh)

Cooling: Dry Cooling

Mirror Area: 0.57 M m<sup>2</sup> (Heliostat: 140 m<sup>2</sup> Multifaceted)

QTY Heliostats: 4120

Tower Height: 200 m

Estimated EPC Price: ~ 3.0 Billion ZAR

Construction Start (early works): April 2012

Commercial Operation: February 2016

Expected annual electricity generation: ~ 187 GWh



## South African CSP Market

### KAXU – Poffadder Northern Cape

Parabolic Trough System

Size: 100 MW

Configuration: Indirect with Thermal Storage

Storage: Moten Salt (20,000 tons) – 3 hrs (812 MWh)

Heat Exchanger: Flat plate heat exchanger

Cooling: Dry Cooling

Mirror Area: 0.82 M m<sup>2</sup> (Collector: 5.7 m / 681 m<sup>2</sup>)

QTY Loops: 300

Estimated EPC Price: ~ 6.0 Billion ZAR

Construction Start (early works): April 2012

Commercial Operation: February 2015

Expected annual electricity generation: ~ 330 GWh





## South African CSP Market

### BOKPOORT – Groblershoop Northern Cape

Parabolic Trough System

Size: 50 MW

Configuration: Indirect with Thermal Storage

Storage: Moten Salt (38,000 tons) – 9 hrs (1,300 MWh)

Heat Exchanger: Shell and Tube

Cooling: Wet Cooled

Mirror Area: 0.59 M m<sup>2</sup> (Collector: 5.7 m / 817 m<sup>2</sup>)

QTY Loops: 180

Estimated EPC Price: ~ 3.8 Billion ZAR

Construction Start : June 2013

Commercial Operation: February 2016

Expected annual electricity generation: ~ 235 GWh



## South African CSP Market

### XINA – Poffadder Northern Cape

Parabolic Trough System

Size: 100 MW

Configuration: Indirect with Thermal Storage

Storage: Moten Salt (48,000 tons) – 6 hrs (1,650MWh)

Heat Exchanger: Shell and tube

Cooling: Dry Cooling

Mirror Area: 0.85 M m<sup>2</sup> (Collector: 8.2 m / 1270 m<sup>2</sup>)

QTY Loops: 168 loops

Estimated EPC Price: ~ 7.5 Billion ZAR

Construction Start (early works): November 2014

Expected Commercial Operation: July 2017

Expected annual electricity generation: ~ 392 GWh





## South African CSP Market

### ILANGA – Upington Northern Cape

Parabolic Trough System

Size: 100MW

Configuration: Indirect with Thermal Storage

Storage: Moten Salt (38,000 tons) – 4.5 hrs (1,250MWh)

Heat Exchanger: Shell and tube

Cooling: Dry Cooling

Mirror Area: 0.87 M m<sup>2</sup> (Collector: 5.7 m / 817 m<sup>2</sup>)

QTY Loops: 266 loops

Estimated EPC Price: ~ 7.5 Billion ZAR

Construction Start: October 2015 - Under Construction

Expected Commercial Operation: November 2018

Expected annual electricity generation: ~ 375 GWh



## South African CSP Market

### KATHU – Kathu Northern Cape

Parabolic Trough System

Size: 100MW

Configuration: Indirect with Thermal Storage

Storage: Moten Salt (45,000 tons) – 5 hrs (1,500 MWh)

Heat Exchanger: Shell and tube

Cooling: Dry Cooling

Mirror Area: 1.0 M m<sup>2</sup> (Collector: 6.8 m / 1,047 m<sup>2</sup>)

QTY Loops: 250

Estimated EPC Price: ~ 9.6 Billion ZAR

Construction Start: May 2016 - Under Construction

Expected COD: September 2018

Expected annual electricity generation: ~ 415 GWh



## South African CSP Market

### REDSTONE – Potmasburg Northern Cape

Central Receiver System

Size: 100MW

Configuration: Direct Molten Salt with Thermal Storage

Storage: Molten Salt – 12 h (3,100 MWh)

Heat Exchanger: Shell and tube

Cooling: Dry Cooling

Mirror Area: ~1.1 M m<sup>2</sup> (Heliostat: TBC)

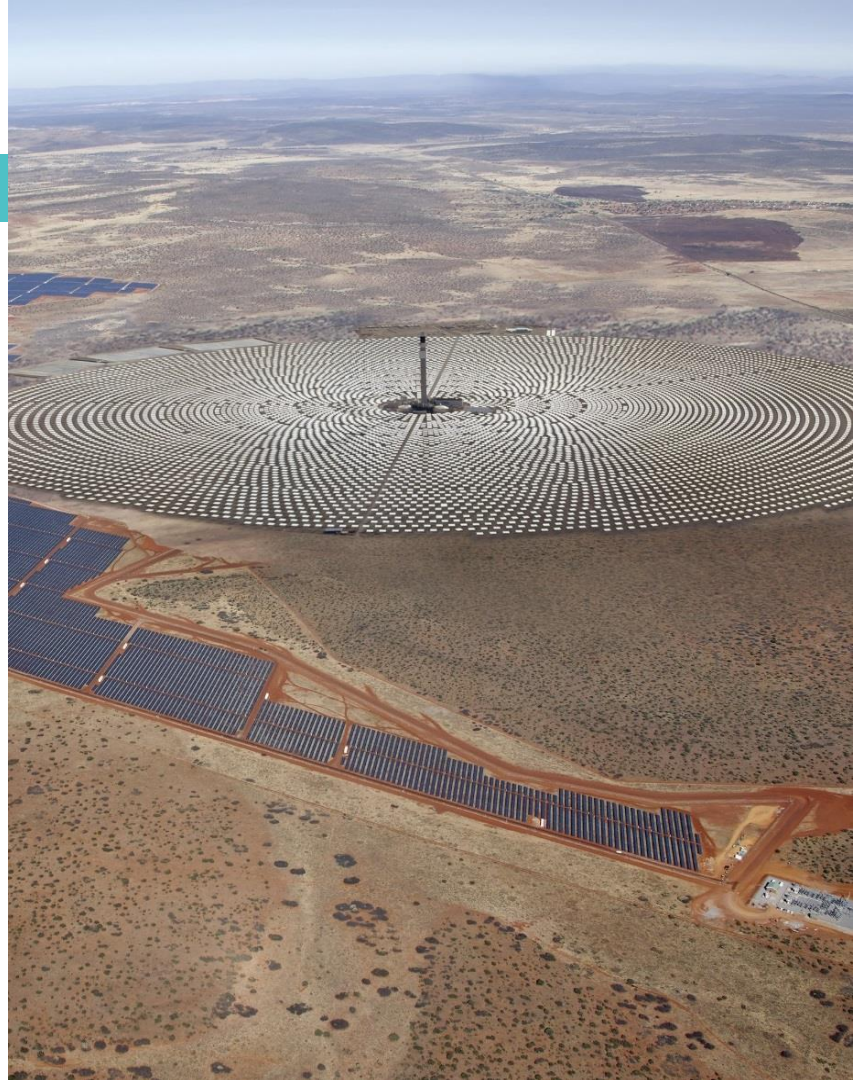
QTY Heliostats: TBC

Estimated EPC Price: ~ 7.2 Billion ZAR

Tower Height: ~200 m

Status: Waiting for PPA signature

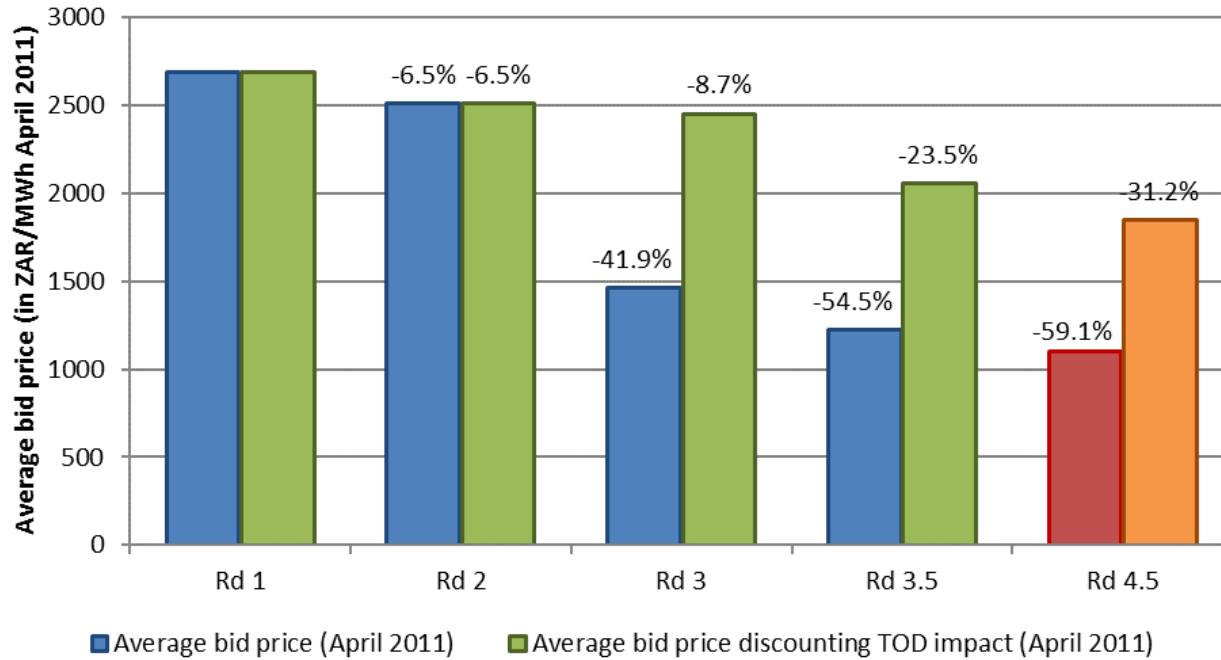
Expected annual electricity generation: ~ 490 GWh





# South African CSP Market

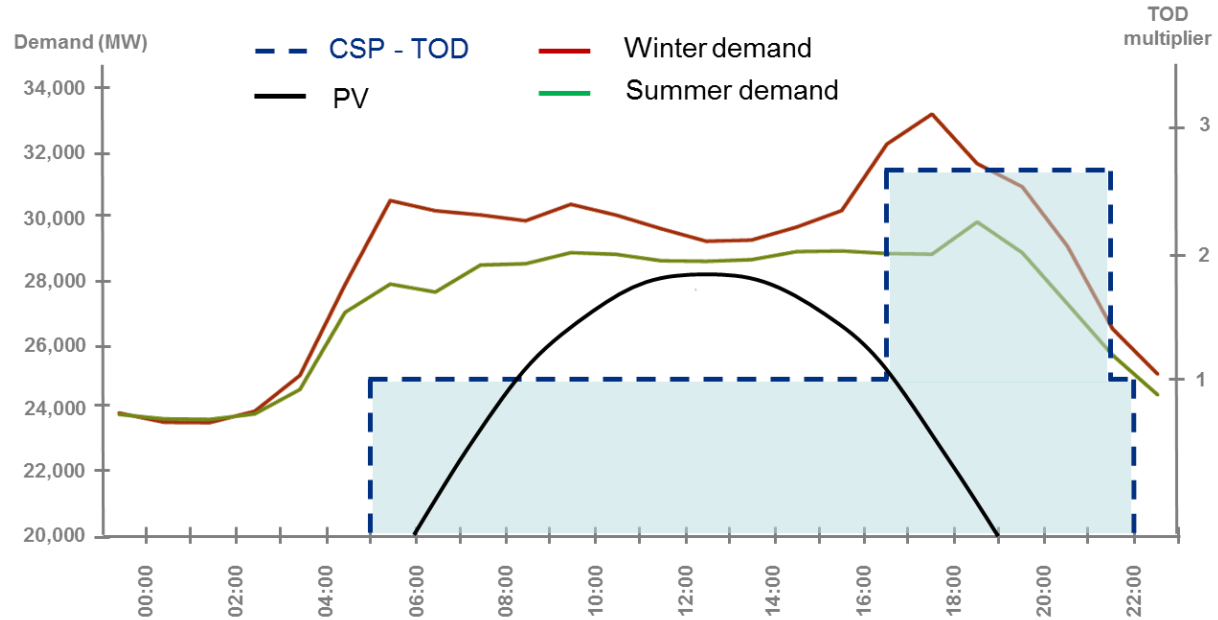
## Tarif Evolution



# South African CSP Market

## Time of Day Tariff Structure

- TOD encourage peak generation capitalizing the dispatchability offered by CSP
- Offers opportunities for both Eskom and project developers: win-win situation



## South African CSP Market

### Time of Day Tariff Structure – Impact on design

Projects have introduced a series of design optimizations:

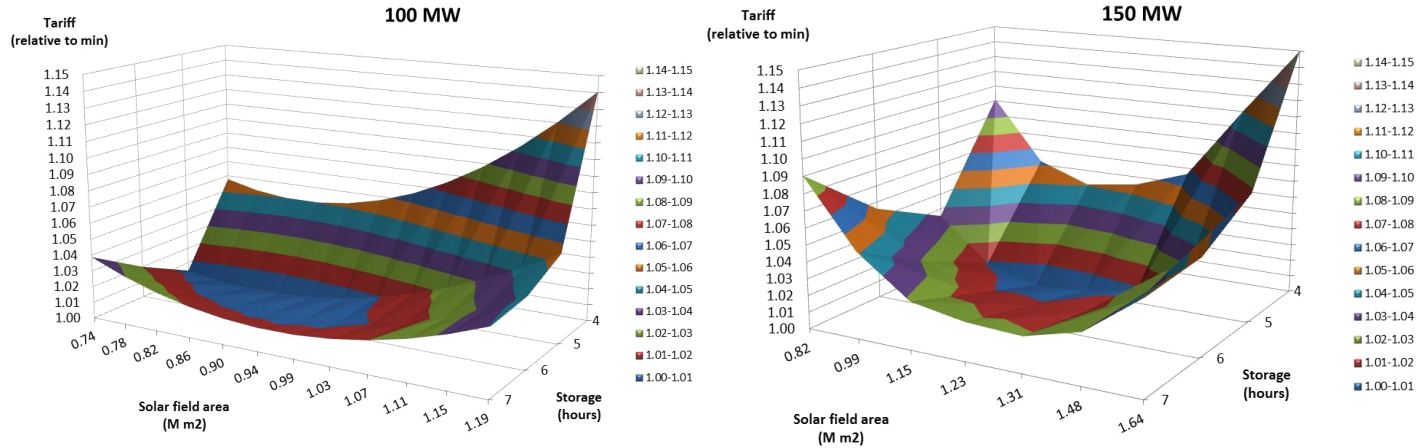
- Large storage which has resulted in large solar fields
- Optimal storage size dependent on the technology to maximise peak generation
- Solar towers allow for larger storages due to an easier and cheaper integration that offers operational flexibility advantages.
- With the 100MW capacity limitation trough projects opted for 5-6 hours storage while the only tower project awarded will implement 12 hours
- With the new 150MW capacity it is expected that trough projects will limit the storage to 5 hours while tower will still have the option to go for larger storages (subject to limitations in the solar field sizes due to increased optical losses)



# South African CSP Market

## Time of Day Tariff Structure – Impact on design

### Example of a parabolic trough project



Source: Mott MacDonald

#### Assumptions:

- Generic financial model
- 70:30 debt:equity ratio, 15% nominal equity IRR
- 17 years tenor, 9% all-in rate

## South African CSP Market

### Way Forward

- **Positive Technology Teething is being experienced resulting in cost reduction**
- **Clear policy is needed in order to continue the deployment of CSP in South Africa**
- **Activities are progressing in the greater international community**





Thank you

Alberto Cuellar

T +27 (0)21 820 5900

F +27 (0)21 418 6440

[alberto.cuellar@mottmac.com](mailto:alberto.cuellar@mottmac.com)

