



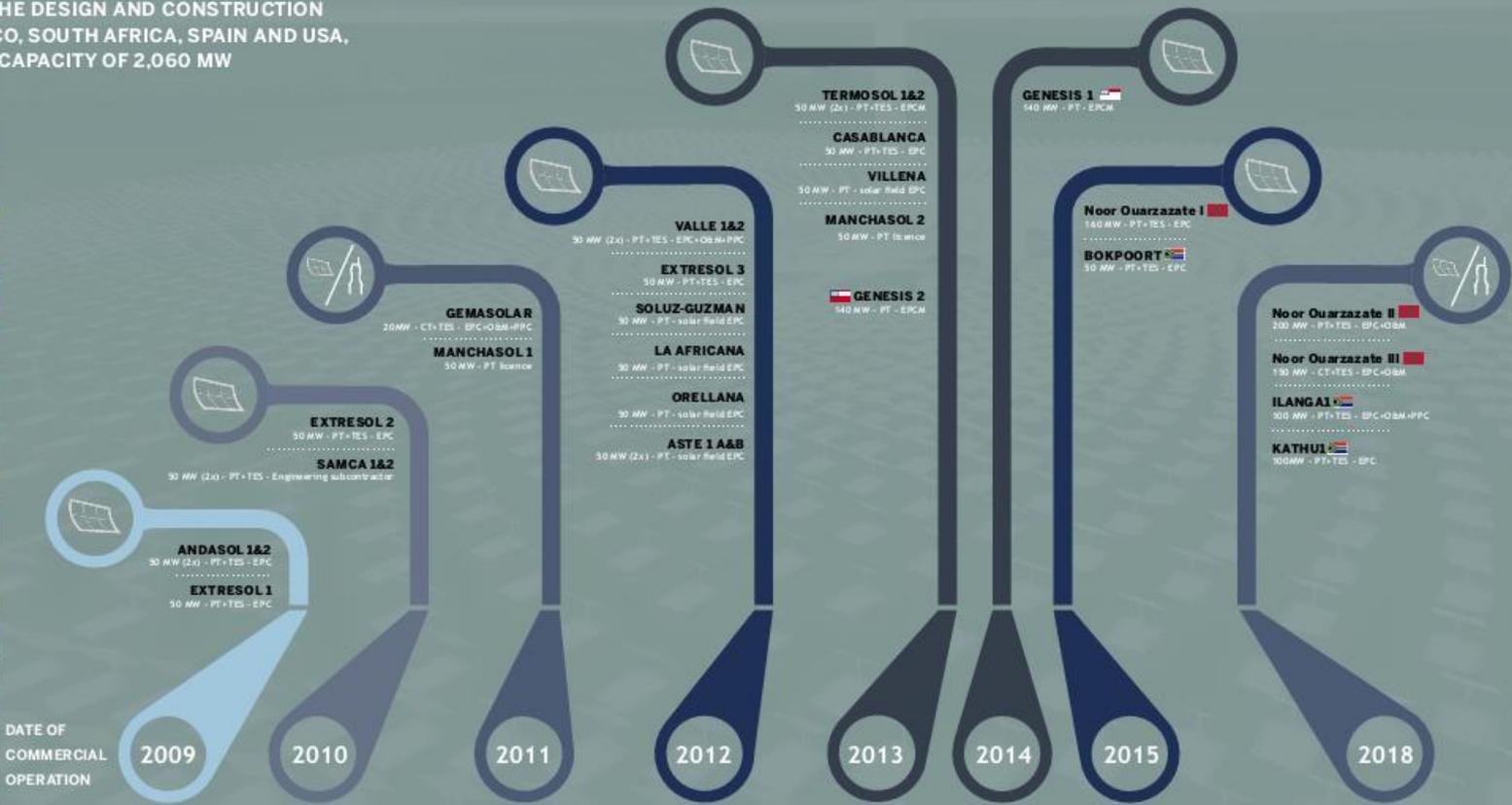
SOLAR THERMAL POWER PLANTS

SENER experience in solar thermal power (CSP)

29 PLANTS

2,060 MW TOTAL

SENER PARTICIPATES IN THE DESIGN AND CONSTRUCTION OF 29 PLANTS IN MOROCCO, SOUTH AFRICA, SPAIN AND USA, WITH A TOTAL INSTALLED CAPACITY OF 2,060 MW



All the plants are located in Spain except the ones marked with flags.

PT: parabolic trough technology | CT: molten salts central tower technology | TES: molten salts thermal storage system | EPC: engineering, procurement and construction | EPC+M: EPC management | O&M: operation & maintenance | PPC: SENER participation in the project company



List of references in CSP

PROJECT		CLIENT	STATUS	START OP.	TECHNOLOGY	ROLE
MOROCCO						
NOOR	3	ACWA POWER	In Operation	2018	CT + TES	EPC Risk sharing partner (50%) and technology provider
	2	ACWA POWER	In Operation	2018	PT + TES	EPC Risk sharing partner (50%) and technology provider
	1	ACWA POWER	In Operation	Dec. 2015	PT + TES	EPC risk sharing partner (25%) and responsible for 80% of power plant design: collector solar field + HTF system + molten salts storage + power block
SOUTH AFRICA						
KATHU		Kathu Solar Park Ltd	In Operation	2018	PT + TES	EPC Risk sharing partner (50%) and technology provider
ILANGA 1		Karoshhoek Solar One Ltd (SENER 7% stake shareholding)	In Operation	Dec. 2018	PT + TES	EPC risk sharing partner (28%) and responsible for 100% of power plant design: collector solar field + HTF system + molten salts storage + power block O&M risk sharing partner (28%) for the 20 years term.
BOKPOORT		ACWA POWER	In Operation	Dec. 2015	PT + TES	EPC risk sharing partner (30%) and responsible for 80% of power plant design: collector solar field + HTF system + molten salts storage + power block
USA						
GENESIS	2	Nextera	In Operation	Nov. 2013	PT	Partial EPCM and responsible for complete design: collector solar field + HTF system + power block
	1	Nextera	In Operation	Mar. 2014	PT	
SPAIN						
CASABLANCA		ACS Cobra	In Operation	Sep. 2013	PT + TES	EPC risk sharing partner (20%) and responsible for complete design: collector solar field + HTF system + molten salts storage + power block
VILLENA		FCC-SERIDOM	In Operation	Aug. 2013	PT	Responsible for collector solar field engineering, supply, erection & commissioning

PROJECT		CLIENT	STATUS	START OP.	TECHNOLOGY	ROLE
SPAIN						
TERMOSOL	2	Nextera (FPL)	In Operation	Aug. 2013	PT + TES	EPCM and responsible for complete design: collector solar field + HTF system + molten salts storage + power block
	1	Nextera (FPL)	In Operation	Aug. 2013	PT + TES	
MANCHASOL	2	ACS Cobra	In Operation	Oct. 2013	PT	Solar Field License
	1	ACS Cobra	In Operation	Dec. 2011	PT	
LA AFRICANA		TSK - ORTIZ	In Operation	Nov. 2012	PT	Responsible for collector solar field engineering, supply, erection & commissioning
SOLUZ GUZMAN		FCC & SERIDOM & ABANTIA	In Operation	Sep. 2012	PT	Responsible for collector solar field engineering, supply, erection & commissioning
ASTE	1A	Elecnor	In Operation	Sep. 2012	PT	Responsible for collector solar field engineering, supply, erection & commissioning
	1B	Elecnor	In Operation	Sep. 2012	PT	
ORELLANA		Acciona Energia	In Operation	Aug. 2012	PT	Responsible for collector solar field engineering, supply, erection & commissioning
EXTRESOL	3	ACS Cobra	In Operation	Jul. 2012	PT + TES	EPC risk sharing partner (20%) and responsible for complete design: collector solar field + HTF system + molten salts storage + power block
	2	ACS Cobra	In Operation	Oct. 2010	PT + TES	
	1	ACS Cobra	In Operation	Dec. 2009	PT + TES	
VALLE	2	Torresol (60% SENER, 40% Masdar)	In Operation	Jan. 2012	PT + TES	EPC risk sharing partner (50%, leading) and responsible for complete design: collector solar field + HTF system + molten salts storage + power block
	1	Torresol (60% SENER, 40% Masdar)	In Operation	Jan. 2012	PT + TES	
GEMASOLAR		Torresol (60% SENER, 40% Masdar)	In Operation	May. 2011	CT + TES	EPC risk sharing partner (50%, leading) and responsible for complete design: tower + heliostat solar field + molten salts storage + power block
SAMCA	2	Samca Renovables	In Operation	Oct. 2010	PT + TES	Responsible for complete design: solar field (except PT collectors) + HTF system + molten salts storage + power block
	1	Samca Renovables	In Operation	Oct. 2010	PT + TES	
ANDASOL	2	ACS Cobra	In Operation	Jul. 2009	PT + TES	EPC risk sharing partner (20%) and responsible for: BOP and molten salts storage design + solar field and HTF system supervision
	1	ACS Cobra	In Operation	Feb. 2009	PT + TES	

*PT Plants Manchasol I & II (Spain), have installed SENERTROUGH collectors (ACS Cobra purchaser of the license).

NOOR III CENTRAL RECEIVER PLANT - 150 MWe

GENERAL DATA

Location	Ouarzazate, Morocco
Owner/Client	ACWA POWER
Role of SENER	EPC Risk Sharing Partner (50%) and Technology Provider
Status	In Operation
Start of operation	2018

TECHNICAL DATA

Technology	Central tower
Generation capacity	150 MWe (gross)
Thermal storage	2,770 MWt
Number of heliostats	7,400 (HE 54)
Heat transfer fluid	Molten nitrate salts (300°C - 565°C)



NOOR II PARABOLIC TROUGH PLANT - 200 MWe

GENERAL DATA

Location	Ouarzazate, Morocco
Owner/Client	ACWA POWER
Role of SENER	EPC Risk Sharing Partner (50%) and Technology Provider
Status	In Operation
Start of operation	2018

TECHNICAL DATA

Technology	Parabolic trough collector, SENERTrough2®
Generation capacity	200 MWe (gross)
Number of loops	425
Thermal storage	2 groups of tanks (6 hrs/group)
Main cooling method	Air cooled condensers



NOOR I PARABOLIC TROUGH PLANT - 160 MWe

GENERAL DATA

Location	Ouarzazate, Morocco
Owner/Client	ACWA POWER
Role of SENER	EPC Risk Sharing Partner (25%) + Responsible for 80% of the Power Plant Design
Status	In Operation
Start of operation	December 2015

TECHNICAL DATA

Total mirror surface	1.308.000 m ²
Number of SCA/loops	1.600/400 (SENERtrough)
Field surface area	400 Ha
Nominal solar field thermal output	680 MWt
Thermal storage capacity	1.490 MWht
Turbine capacity	160 MWe



KATHU PARABOLIC TROUGH PLANT - 100 MWe

GENERAL DATA

Location	Kathu, South Africa
Owner/Client	Kathu Solar Park Ltd.
Role of SENER	EPC Risk Sharing Partner (50%) and Technology Provider
Status	In Operation
Start of operation	2018

TECHNICAL DATA

Technology	Parabolic trough collector, SENERTrough2®
Generation capacity	100 MWe net power
Thermal storage	1,550 MWt (4,5 hours)
Number of loops	250
Main cooling method	Air cooled condenser
Heat transfer fluid	Thermal Oil



ILANGA 1 PARABOLIC TROUGH PLANT - 100 MWe

GENERAL DATA

Location	Upington, Northern Cape, South Africa
Owner/Client	Karoshhoek Solar One Ltd (SENER 7% stake shareholding)
Role of SENER	EPC Risk Sharing Partner (28%) + Responsible for 100% of the Power Plant Design + O&M risk sharing partner (28%) for 20 years term
Status	In Operation
Start of operation	December 2018

TECHNICAL DATA

Total mirror surface	869,800 m ²
Number of SCA/loops	1,064/266 (SENERtrough)
Field surface area	335 Ha
Nominal solar field thermal output	463.7 MWt
Thermal storage capacity	1,250 MWht
Turbine capacity	100 MWe



BOKPOORT PARABOLIC TROUGH PLANT - 50 MWe

GENERAL DATA

Location	Bokpoort, Northern Cape, South Africa
Owner/Client	ACWA POWER
Role of SENER	EPC Risk Sharing Partner (30%) + Responsible for 80% of the Power Plant Design
Status	In Operation
Start of operation	December 2015

TECHNICAL DATA

Total mirror surface	588.600 m ²
Number of SCA/loops	720/180 (SENERtrough)
Field surface area	350 Ha
Nominal solar field thermal output	290 MWt
Thermal storage capacity	1.300 MWht
Turbine capacity	50 MWe



GENESIS 1 & 2 PARABOLIC TROUGH PLANTS - 2x 140 MWe

GENERAL DATA

Location	Blythe, California (USA)
Owner/Client	NextEra Energy Sources, LLC
Role of SENER	Partial EPCM + Responsible for Complete Design
Status	In Operation
Start of operation	March 2014 - November 2013

TECHNICAL DATA

Total mirror surface	2×850.000 m ²
Number of SCA/loops	2×920/230 (SENERtrough)
Field surface area	2×360 Ha
Nominal solar field thermal output	2×380 MWt
Thermal storage capacity	N/A
Turbine capacity	2×140 MWe



Source: US Department of Energy

CASABLANCA PARABOLIC TROUGH PLANT 50MWe

GENERAL DATA

Location	Talarrubias, Badajoz (Spain)
Owner/Client	COBRA Sistemas y Redes (ACS)
Role of SENER	EPC Risk Sharing Partner (20%) + Responsible for Complete Design
Status	In Operation
Start of operation	September 2013

TECHNICAL DATA

Total mirror surface	510.000 m ²
Number of SCA/loops	624/156 (SENERtrough)
Field surface area	195 Ha
Nominal solar field thermal output	262 MWt
Thermal storage capacity	1.010 MWht (7h)
Turbine capacity	50 MWe



VILLENA PARABOLIC TROUGH PLANT 50MWe

GENERAL DATA

Location	Villena, Alicante (Spain)
Owner/Client	FCC & SERIDOM
Role of SENER	Engineering, Supply, Erection & Commissioning of Solar Field Loops (collectors, piping & control)
Status	In Operation
Start of operation	August 2013

TECHNICAL DATA

Total mirror surface	344.000 m ²
Number of SCA/loops	420/105 (SENERtrough)
Field surface area	150 Ha
Nominal solar field thermal output	140 MWt
Thermal storage capacity	N/A
Turbine capacity	50 MWe



TERMOSOL 1 & 2 PARABOLIC TROUGH PLANTS - 2x 50 MWe

GENERAL DATA

Location	Navalvillar de Pela, Badajoz (Spain)
Owner/Client	Planta Termosolar Extremadura (FPL)
Role of SENER	EPCM + Responsible for Complete Design
Status	In Operation
Start of operation	August 2013 - August 2013

TECHNICAL DATA

Total mirror surface	2×523.000 m ²
Number of SCA/loops	2×640/160 (SENERtrough)
Field surface area	2×207 Ha
Nominal solar field thermal output	2×262 MWt
Thermal storage capacity	2×1.300 MWhth (9h)
Turbine capacity	2×50 MWe
Thermal cycle efficiency	38%
Annual normal direct radiation	2.082 KWh/m ²



LA AFRICANA PARABOLIC TROUGH PLANT 50MWe

GENERAL DATA

Location	Posadas, Córdoba (Spain)
Owner/Client	MAGTEL - TSK - ORTIZ
Role of SENER	Engineering, Supply, Erection & Commissioning of Solar Field Collectors
Status	In Operation
Start of operation	November 2012

TECHNICAL DATA

Total mirror surface	549.360 m ²
Number of SCA/loops	672/168 (SENERtrough)
Field surface area	215 Ha
Nominal solar field thermal output	262 MWT
Thermal storage capacity	N/A
Turbine capacity	50 MWe



SOLUZ GUZMAN PARABOLIC TROUGH PLANT 50MWe

GENERAL DATA

Location	Palma del Río, Córdoba (Spain)
Owner/Client	FCC & ABANTIA & SERIDOM
Role of SENER	Engineering, Supply, Erection & Commissioning of Solar Field Loops (Collectors, piping & control)
Status	In Operation
Start of operation	September 2012

TECHNICAL DATA

Total mirror surface	315.000 m ²
Number of SCA/loops	384/96 (SENERtrough)
Field surface area	120 Ha
Nominal solar field thermal output	140 MWt
Thermal storage capacity	N/A
Turbine capacity	50 MWe



ASTE 1A & 1B PARABOLIC TROUGH PLANTS - 2x 50 MWe

GENERAL DATA

Location	Alcazar de San Juan, Ciudad Real (Spain)
Owner/Client	ELECNOR (participation of AMB-UMBRO y ARIES)
Role of SENER	Engineering, Supply, Erection & Commissioning of Solar Field Collectors
Status	In Operation
Start of operation	September 2012 - September 2012

TECHNICAL DATA

Total mirror surface	2x393.000 m ²
Number of SCA/loops	2x480/120 - 156 2 nd phase (SENERtrough)
Field surface area	2x180 Ha
Nominal solar field thermal output	2x140 MWt (262 MWt 2 nd phase)
Thermal storage capacity (2 nd phase)	2x1.010 MWht (7h)
Turbine capacity	2x50 MWe



ORELLANA PARABOLIC TROUGH PLANT 50MWe

GENERAL DATA

Location	Orellana, Badajoz (Spain)
Owner/Client	ACCIONA ENERGÍA
Role of SENER	Engineering, Supply, Erection & Commissioning of Solar Field Collectors
Status	In Operation
Start of operation	August 2012

TECHNICAL DATA

Total mirror surface	405.500 m ²
Number of SCA/loops	416/124 (SENERtrough)
Field surface area	186 Ha
Nominal solar field thermal output	140 MWt
Thermal storage capacity	N/A
Turbine capacity	50 MWe



EXTRESOL 1, 2 & 3 PARABOLIC TROUGH PLANTS - 3x 50 MWe

GENERAL DATA

Location	Torre de Miguel Sesmero, Badajoz (Spain)
Owner/Client	COBRA Sistemas y Redes (ACS)
Role of SENER	EPC Risk Sharing Partner (20%) + Responsible for Complete Design
Status	In Operation
Start of operation	December 2009 - October 2010 - July 2012

TECHNICAL DATA

Total mirror surface	3×510.000 m ²
Number of SCA/loops	3×624/156 (SENERtrough)
Field surface area	3×198 Ha
Nominal solar field thermal output	3×262 MWt
Thermal storage capacity	3×1.010 MWhth (7h)
Turbine capacity	3×50 MWe
Thermal cycle efficiency	38%
Annual normal direct radiation	2.166 KWh/m ²



VALLE 1 & 2 PARABOLIC TROUGH PLANTS - 2x 50 MWe

GENERAL DATA

Location	San José del Valle, Cádiz (Spain)
Owner/Client	Arcosol 50, S.A. (100% TORRESOL) Termesol 50, S.A. (100% TORRESOL)
Role of SENER	EPC Risk Sharing Partner (50% leading) + Responsible for Complete Design
Status	In Operation
Start of operation	January 2012 - January 2012

TECHNICAL DATA

Total mirror surface	2×510.000 m ²
Number of SCA/loops	2×624/156 (SENERtrough)
Field surface area	2×198 Ha
Nominal solar field thermal output	2×262 MWt
Thermal storage capacity	2×1.010 MWhth (7h)
Turbine capacity	2×50 MWe
Thermal cycle efficiency	38%
Annual normal direct radiation	2.057 KWh/m ²



GEMASOLAR - CENTRAL RECEIVER PLANT 19.9 MWe

GENERAL DATA

Location	Fuentes de Andalucía, Sevilla (Spain)
Owner/Client	TORRESOL
Role of SENER	EPC Risk Sharing Partner (50% leading) + Responsible for Complete Design
Status	In Operation
Start of operation	May 2011

TECHNICAL DATA

Total mirror surface	310.000 m ²
Number of heliostats	2.650 (SENER Mechanism)
Field surface area	185 Ha
Nominal receiver capacity	120 MWt
Tower height	140 m
Thermal storage capacity	670 MWhth (15h)
Turbine capacity	19.9 MWe
Thermal cycle efficiency	40%
Annual normal direct radiation	2.172 KWh/m ²



SAMCA 1 & 2 PARABOLIC TROUGH PLANTS - 2x 50 MWe

GENERAL DATA

Location	La Florida, Badajoz (Spain) La Dehesa (Mérida), Badajoz (Spain)
Owner/Client	SAMCA Renovables
Role of SENER	Responsible for Complete Design (except PT Collectors)
Status	In Operation
Start of operation	October 2010 - October 2010

TECHNICAL DATA

Total mirror surface	2×550.000 m ²
Number of SCA/loops	2×672/168
Field surface area	2×215 Ha
Nominal solar field thermal output	2×262 MWt
Thermal storage capacity	2×1.010 MWhth (7h)
Turbine capacity	2×50 MWe
Thermal cycle efficiency	38%



ANDASOL 1 & 2 PARABOLIC TROUGH PLANTS - 2x 50 MWe

GENERAL DATA

Location	Aldeire, Granada (Spain)
Owner/Client	Andasol-1 Central Termosolar Uno, S.A. Andasol-2 Central Termosolar Dos, S.A. (100% COBRA-ACS)
Role of SENER	EPC Risk Sharing Partner (20%) + Responsible for BOP and TES Design + Collector and HTF supervision
Status	In Operation
Start of operation	February 2009 - July 2009

TECHNICAL DATA

Total mirror surface	2×510.000 m ²
Number of SCA/loops	2×624/156
Field surface area	2×198 Ha
Nominal solar field thermal output	2×262 MWt
Thermal storage capacity	2×1.010 MWhth (7h)
Turbine capacity	2×50 MWe
Thermal cycle efficiency	38%
Annual normal direct radiation	2.127 KWh/m ²



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