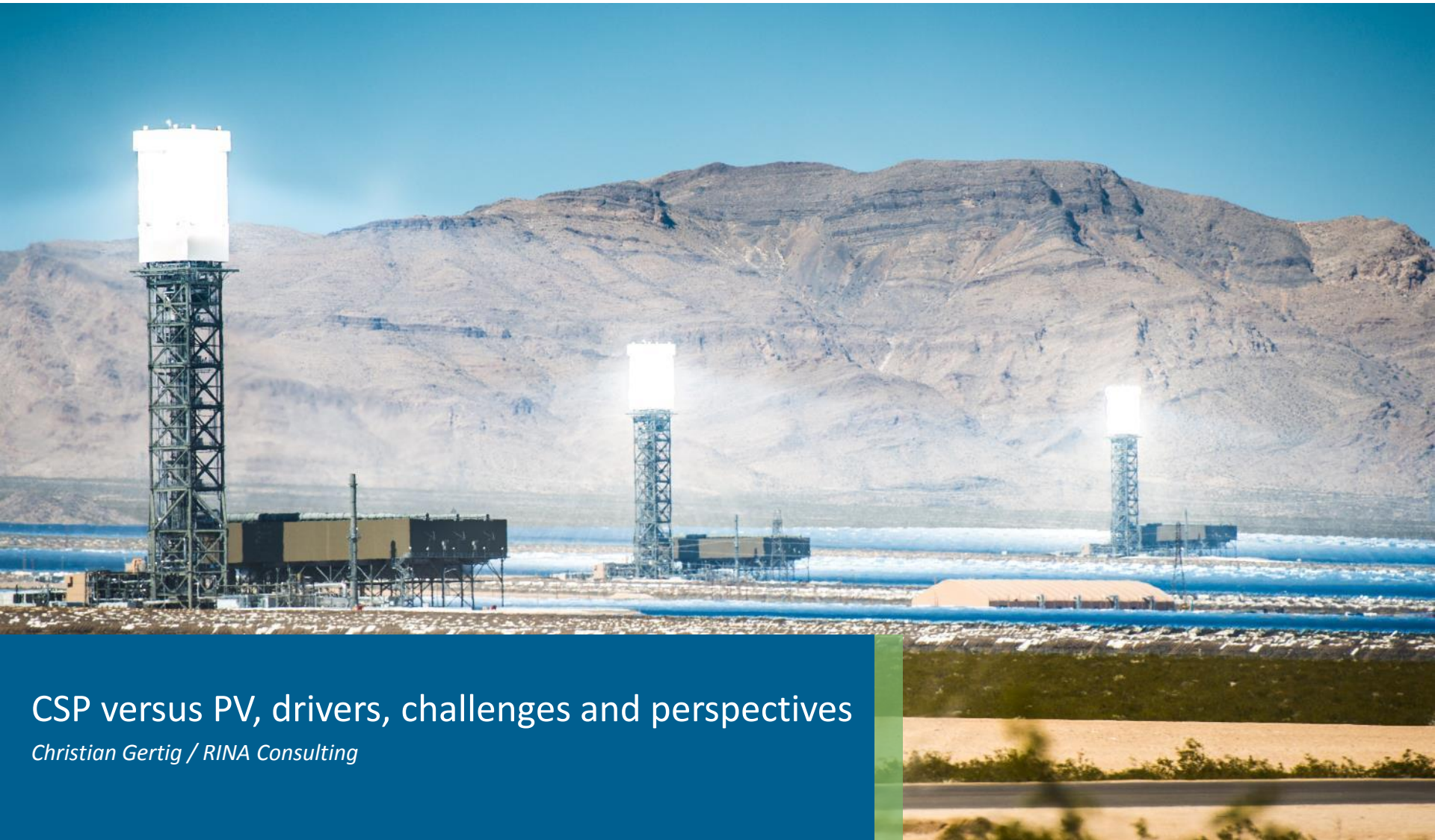




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# CSP versus PV, drivers, challenges and perspectives

*Christian Gertig / RINA Consulting*



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# Renewable energy sectors and services



# RINA



A RINA Company

Sectors

Solar



Wind



Bioenergy & environment



Energy storage



Hydro



Buildings & energy efficiency



Services

## Technical advisory & investment support

Due diligence | Environmental & social services | Technical advisory  
 Owner's / Lenders' engineering | Project feasibility studies | Project development services  
 Design & engineering services | Contract, risk & financial advisory | Grid connection support  
 Technical component reviews | Energy yield & resource analysis | Operational performance analysis  
 Energy efficiency services | Condition & performance assessment | Construction monitoring  
 Project management | End of warranty inspections | Asset management



DEVELOPMENT

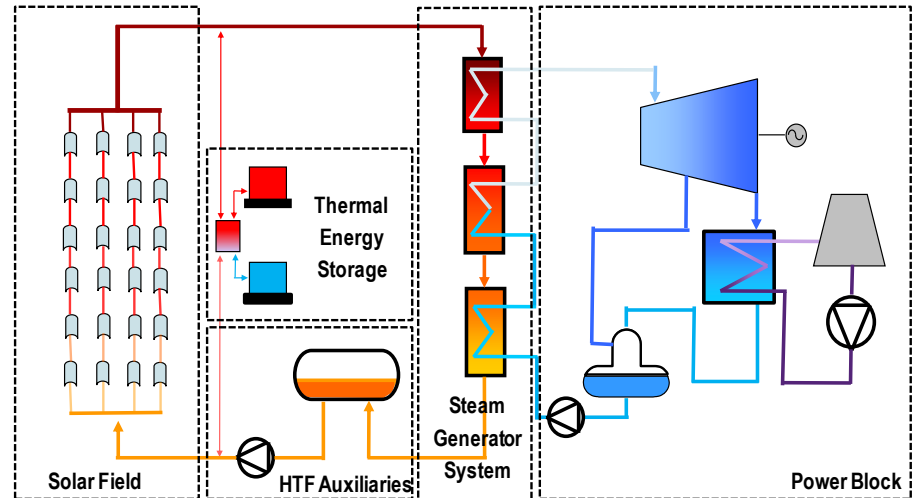
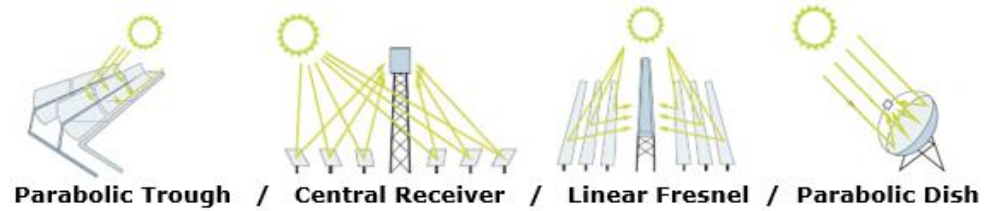
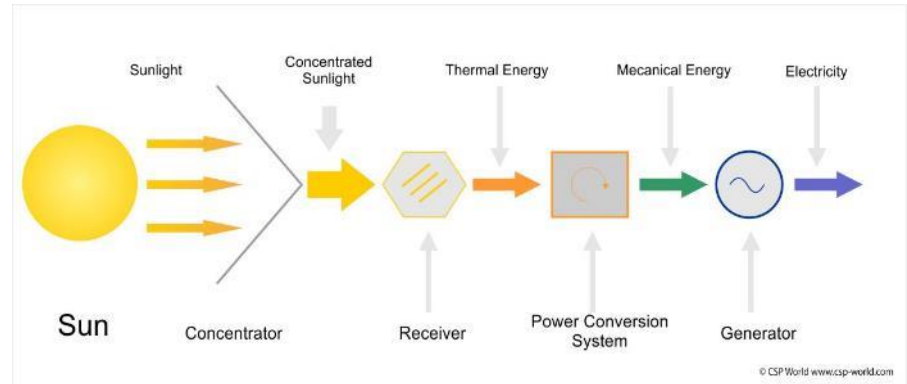
CONSTRUCTION

OPERATION



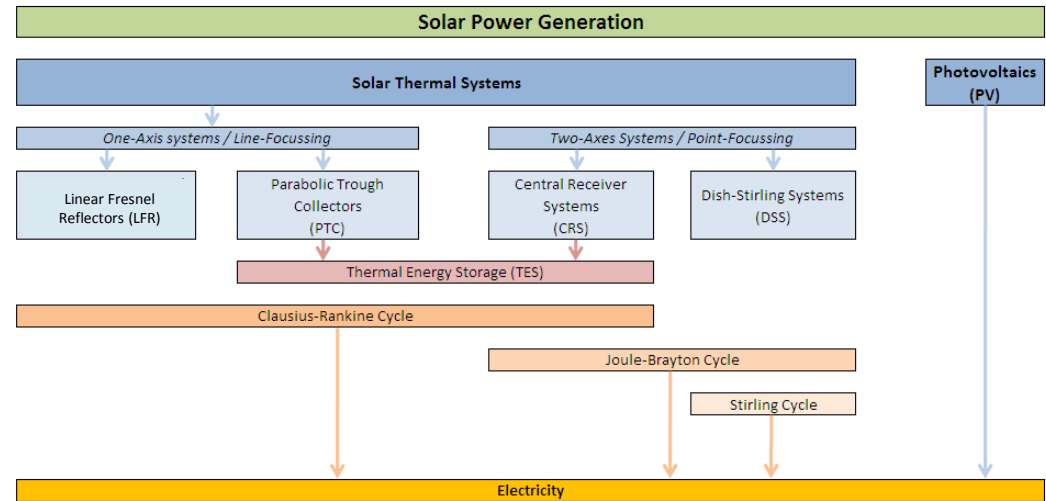


# Introduction Concentrating Solar Power (CSP)



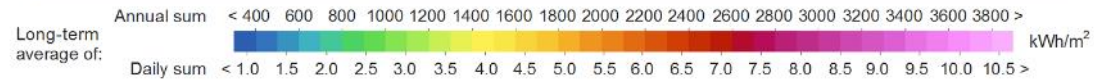
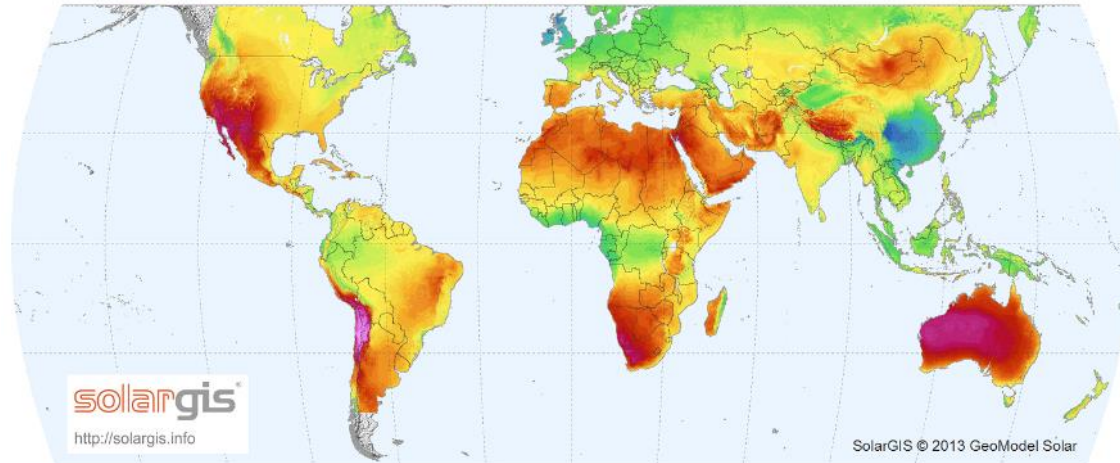


- + Cost-effective energy storage
- + Ancillary grid services
- + More local content
- + Hybridisation / Retrofitting
- + Potential for thermal applications
- ± Need for direct sunlight
- Higher LCOE (approx. x2...3)
- Higher CAPEX and OPEX
- Longer development and construction times
- Less modular
- Higher risk / financing cost



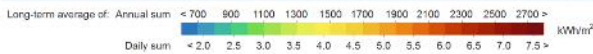
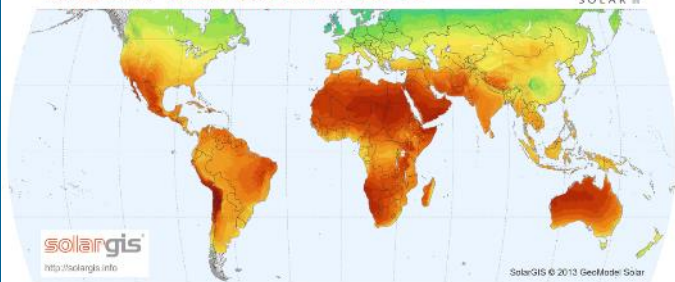
### WORLD MAP OF DIRECT NORMAL IRRADIATION

GeoModel SOLAR



### WORLD MAP OF GLOBAL HORIZONTAL IRRADIATION

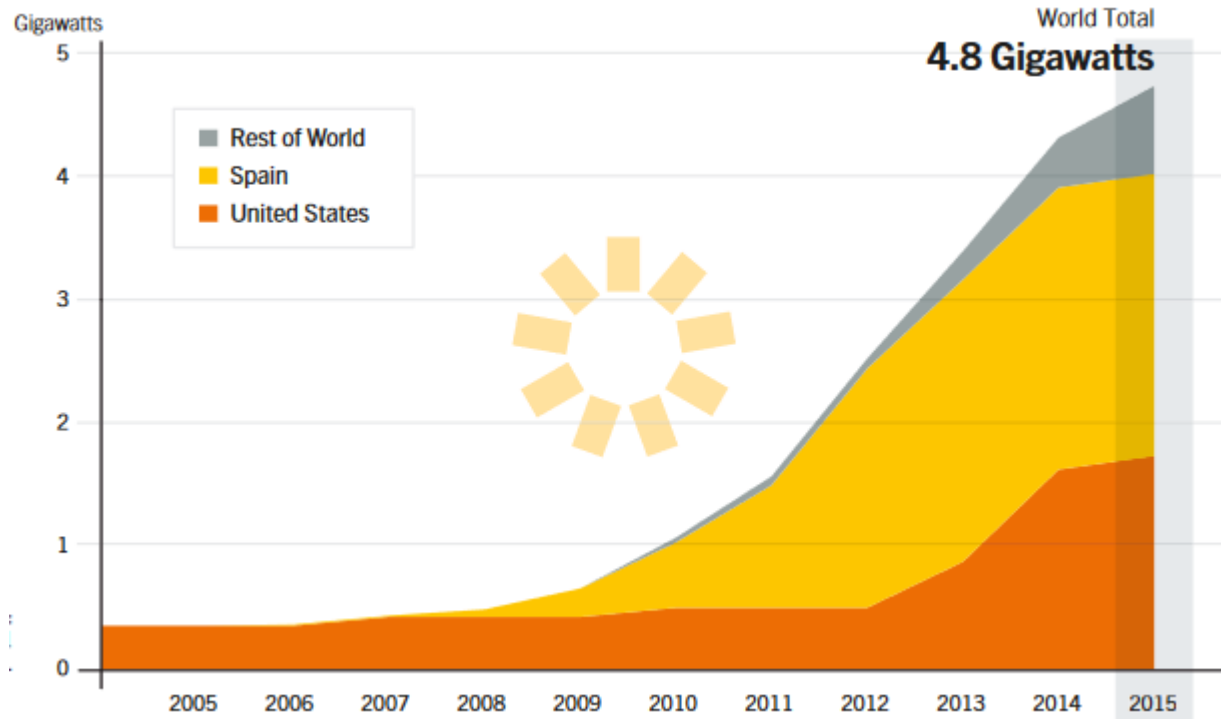
GeoModel SOLAR



GHI Map for comparison



Solar CSP Global Capacity<sup>1</sup> and annual additions 2005-2015  
+420 MW in 2015



CSP cap = 2% of PV cap



### Global Capacity around 5GW

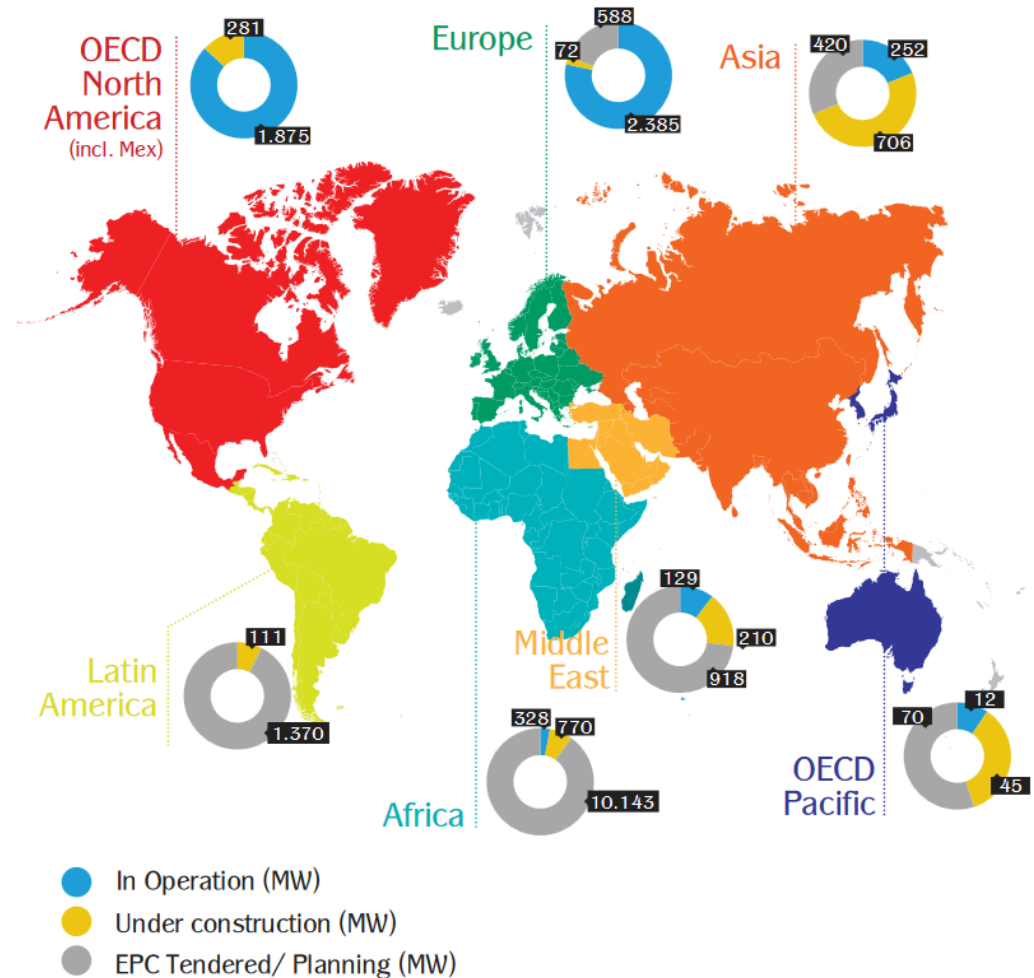
Most CSP installed in Spain (2,362MW) but stagnating

Second highest capacity in the US (1,832MW), little advances

South Africa (200MW) continuous growth

Morocco (181MW) fostering CSP for future

Strong growth markets in future:  
China, Saudi Arabia, Chile, UAE, Algeria, Israel



Source: ESTELA, Greenpeace – Solar Thermal Electricity Global Outlook 2016

Technical Data/Requirements	Units	Variant 1	Variant 2	Variant 3	Variant 4	CSP+10h sotrage	PV+10h storage
DC Plant Capacity	kWp	121000	121000	121968	121968	SM=2.4	200000
AC Plant Capacity	kW	100000	100000	100000	100000	100	100000
Mounting Structure	-	Fix Tilt 25	1 - Axis Tracker	Fix Tilt 25	1 - Axis Tracker	CRS	1 - Axis Tracker
DC Voltage Level	V	1000	1000	1500	1500	-	1500
<b>25 Year Lifetime Generation</b>	<b>GWh</b>	<b>4,591.73</b>	<b>5,353.27</b>	<b>4,644.61</b>	<b>5,416.07</b>	<b>7,841.15</b>	<b>8,437.07</b>

## Scenario 1

LCOE in \$/kWh		0.0284	0.0318	0.0354	0.0309	0.0814	0.0471
Incl. CAPEX	NPV Estimate in M\$	112.3	117.7	111.2	111.8	490.8	279.5
Incl. O&M	NPV Estimate in M\$	33.8	35.8	32.9	35.0	107.1	87.5
Excl. Transmission	NPV Estimate in M\$	-	-	-	-	-	-
Excl. Other Investment (Land Acquisition & Consultant Fees)	NPV Estimate in M\$	-	-	-	-	-	-
Excl. Taxes & Duties	NPV Estimate in M\$	-	-	-	-	-	-
Excl. Recurrent Expenditures (Auditing)	NPV Estimate in M\$	-	-	-	-	-	-
Excl. Contingencies	NPV Estimate in M\$	-	-	-	-	-	-
Excl. Grid Losses	NPV Estimate in M\$	-	-	-	-	-	-

## Scenario 2

LCOE in \$/kWh		0.0550	0.0492	0.0548	0.0481	0.1129	0.0631
Incl. CAPEX	NPV Estimate in M\$	112.3	117.7	111.2	111.8	490.8	279.5
Incl. O&M	NPV Estimate in M\$	33.8	35.8	32.9	35.0	107.1	87.5
Incl. Transmission	NPV Estimate in M\$	10.4	10.4	10.4	10.4	10.4	10.4
Incl. Other Investment (Land Acquisition & Consultant Fees)	NPV Estimate in M\$	6.4	6.4	10.1	10.1	30.2	20.1
Incl. Taxes & Duties	NPV Estimate in M\$	22.7	23.8	22.8	23.9	35.8	35.8
Incl. Recurrent Expenditures (Auditing)	NPV Estimate in M\$	0.6	0.6	0.6	0.6	0.6	0.6
Incl. Contingencies	NPV Estimate in M\$	18.8	18.8	18.8	18.8	37.7	37.7
Incl. Grid Losses	NPV Estimate in M\$	13.0	15.2	13.2	15.4	22.2	24.6

Suitability:

Not suitable in coastal regions, needs flat terrain and accessibility, grid connection

Economies of scale:

Non-modularity and high overhead costs make development of small plants challenging

Supply chain development:

Commercial availability of cost-effective supply chain will drive down cost

Challenges:

Incentive schemes not valuing dispatchability, political instability, closed markets, weak grids, only few regions with high DNI levels

Threats:

Battery technology uptake will make PV and wind dispatchable and more attractive

**Conclusion:**

**Short term uptake, mid-term challenges, long-term complementary to PV and wind, as well as niche applications**





[www.rinagroup.org](http://www.rinagroup.org)



China's 13<sup>th</sup> Five Year Plan for Electricity targets 5GW of CSP

Supply Chain already established with about 30 CSP mirror and about 20 CSP receiver manufacturers

First 20 demonstration projects announced with 1.35GW capacity

Chinese CSP Reflector Suppliers

No	公司名称	Company Name	City
1	大明	Daming Glass	Hangzhou
2	中海阳rayspower 禅德	SUNDHY (rayspower)	Chengdu
3	晶泰	JingTai Glass	Xuzhou
4	台玻悦达	Taiwanglass Yueda	Yancheng
5	利虎	Lihu	Taiyuan
6	瑜阳	Yuyang solar	Qinhuangdao
7	圣普	Sunpno	Wuhan
8	众顺	zhongshun	Shenyang
9	中利	Sinoy	Qingdao
10	衡水众业光能	Zhongye	Hengshui
11	兆阳	Terasolar	Beijing
12	金格兰	King	Beijing
13	兰州大成	DCTC	Lanzhou
14	隆泰美东	Meidong	Dongguan
15	京澄玻璃	ICMirror	Jiangyin
16	高盛玻璃	GSGlass	Zibo
17	深圳市杰之洋	JZYGlass	Shenzhen
18	大河镜业	Dahe	Shaoxing
19	新逻辑	Xinology	Shenzhen
20	安比斯	NBS glass	Suzhou
21	中金盛唐	Sinogold	Beijing
22	北京天羿洁源	xinhouyi	Beijing
23	华援	Huayuan	Dezhou
24	奇威特	Vicot	Dezhou
25	睿一镜业	Oruii	Qingdao
26	天顺	Tianshun	Beijing
27	中能阳光	CE	Dongguan

Source: OST Energy Market Analysis

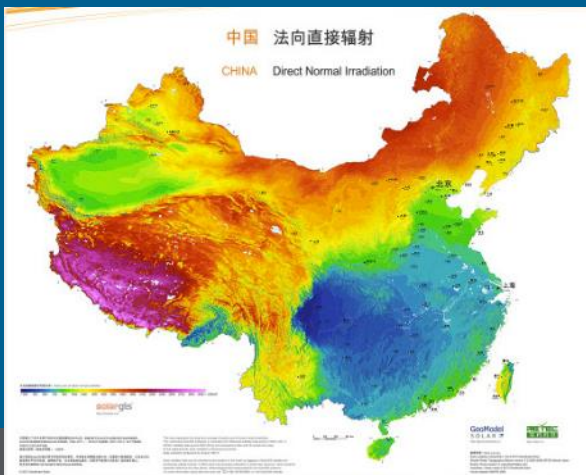
Chinese CSP PTC Receiver Suppliers

No	公司名称	Company Name	City
1	力诺太阳能;	LINUO Solar	Jinan
2	汇银集团-威海金太阳;	Huiyin Group	Weihai
3	皇明;	Himin	Dezhou
4	兰州大成;	DCTC	Lanzhou
5	桑普(北大所);	Sunpu	Beijing
6	常州龙腾;	Royal Tec	Changzhou
7	深圳唯真;	Weizhen	Shenzhen
8	康达机电;	Camda	Shenzhen
9	北京天瑞星;	Beijing TRX	Beijing
10	南京三乐电子;	Sanle	Nanjing
11	北京有色金属研究总院;	Grimm	Beijing
12	青岛奥博新能源科技;	Qdabo	Qingdao
13	陕西宝光集团;	Baoguang	Baoji
14	北京中航空港;	CE	Beijing
15	国能阳光	CE	Beijing
16	中金盛唐新能源	Sinogold	Beijing
17	南京旭城新能源		Nanjing
18	青岛奥凯利新能源	OKL	Qingdao
19	德州华园新能源	Hyne	Dezhou
20	四川拜尔光热	Bay Energy	Devang

Source: OST Energy Market Analysis

Serial	Project	Project Owner	Technology	The Amount of Thermal Storage	Scale of technology and investment	The construction status
1	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
2	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
3	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
4	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
5	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
6	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
7	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
8	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
9	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
10	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
11	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
12	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
13	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
14	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
15	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
16	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
17	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
18	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
19	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%
20	Delinghe 100MW CSP project	Delinghe Energy	Parabolic trough	100MW	100MW	100%

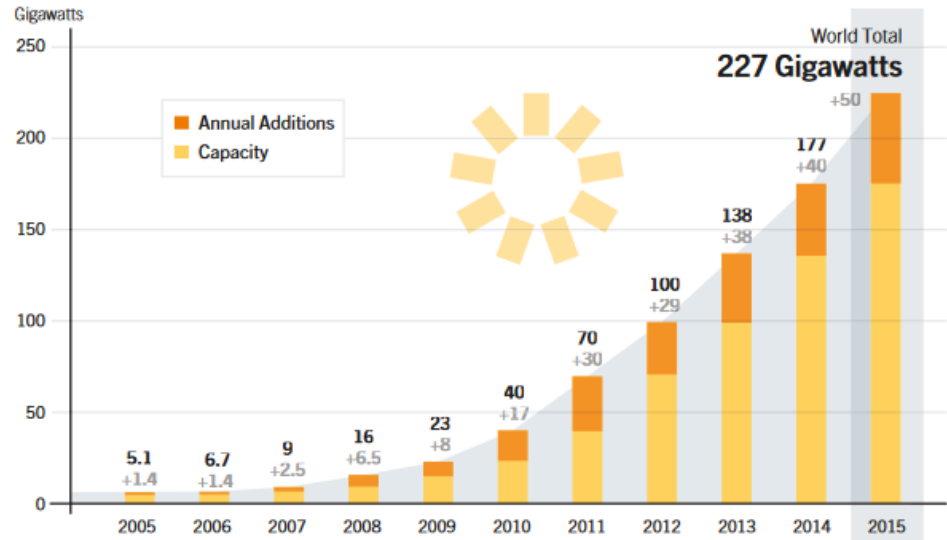
Source: China National Solar Thermal Alliance



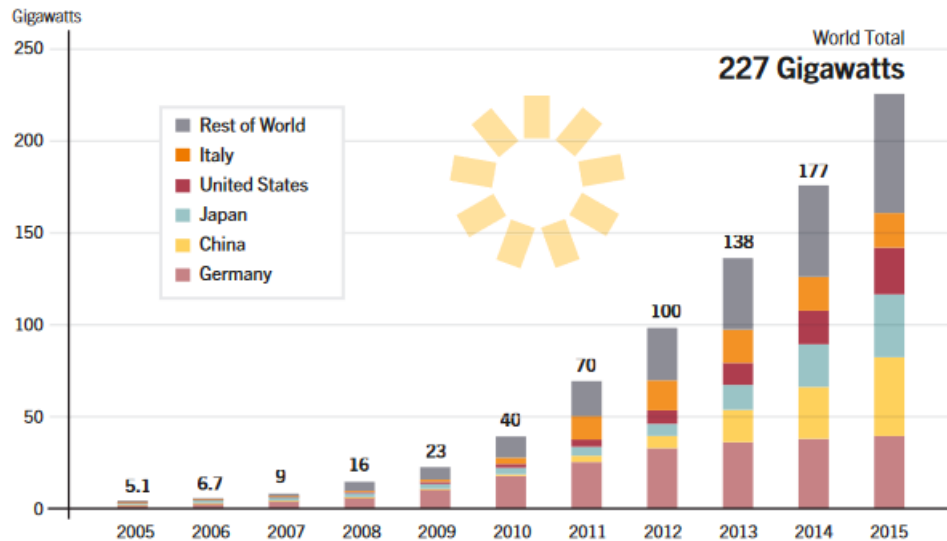
# Solar PV Global Installed Capacity 2005 to 2015

Solar PV Global Capacity<sup>1</sup> and annual additions 2005-2015

+50 GW for 2015



Solar PV Global Capacity<sup>1</sup> Per Country/Region for the same period  
China, Japan and US



Source: 1\_www.ren21.net, GSR2016



Very high potential in Australia, North and West China, Mongolia and India

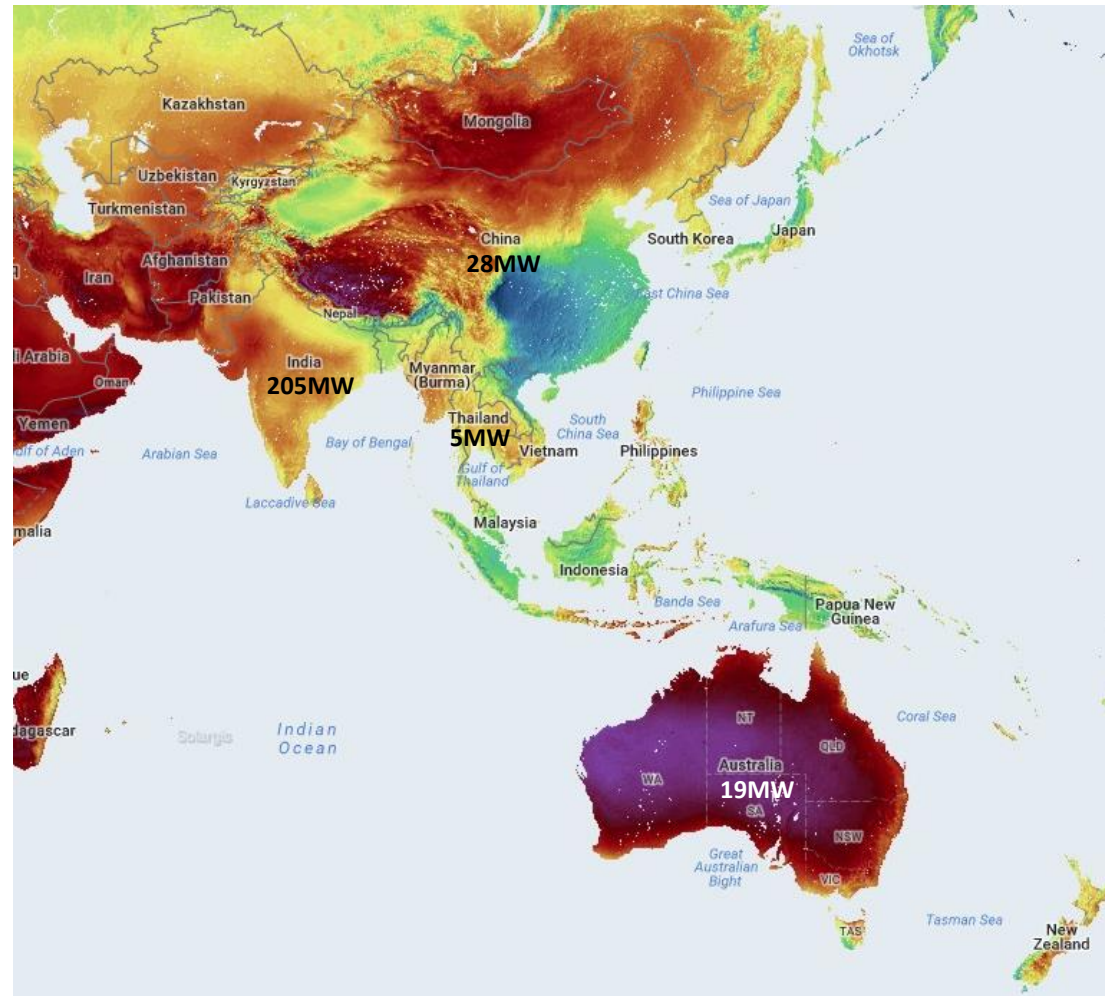
Australia making only small advances

India started promising but stagnating since 2 years

Thailand CSP discontinued

China is rising hope for global CSP industry

Central Asia has good future potential



Source: SolarGIS

Solar CSP Global Capacity<sup>1</sup> and  
annual additions 2005-2015  
+420 MW in 2015

All installed cap in 2015 have thermal energy storage

Came on line in 2015:

Morocco: Noor 1 plant (160 MW) part of 500 MW Noor-Ouarzazate  
SAf: Kaxu solar one (100 MW)  
Bokpoort (50 MW)  
Khi Solar one (50 MW) early 2016  
US: Crescent Dunes (110 MW) following record 2014 record year (0.8 GW)  
Spain: 0 MW

Early 2016

Egypt: 14 bidders for a 50 MW cap  
Algeria: plan for 2GW projects CSP by 2030  
ME: start of 120 MW Israel Ashalim Plot B + 110 MW in 2018  
SAr: 50 MW planned for 2017 and 2018  
  
China CSP target of 5-10 GW by 2020. 50 MW Qinghai in 2018.  
Chile: Atacama 1 with 110 MW under construction

Source: 1\_www.ren21.net, GSR2016