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# CSP Perspectives in Asia Pacific

*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

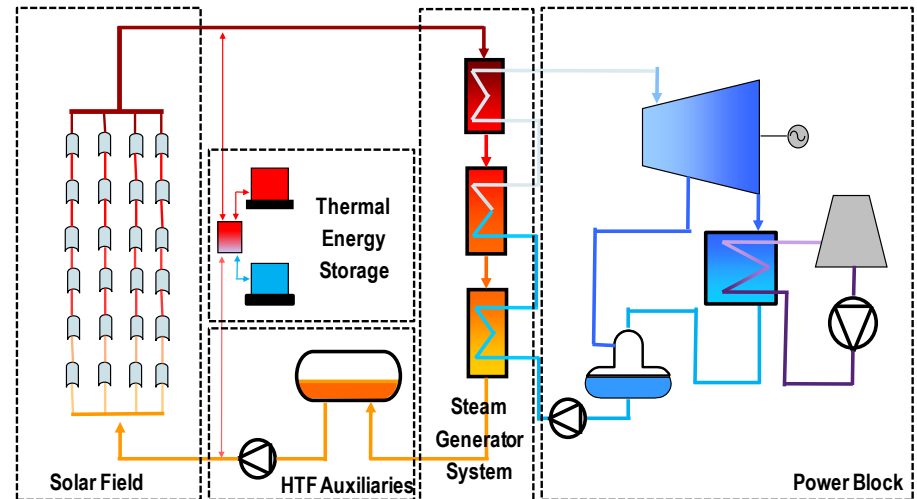
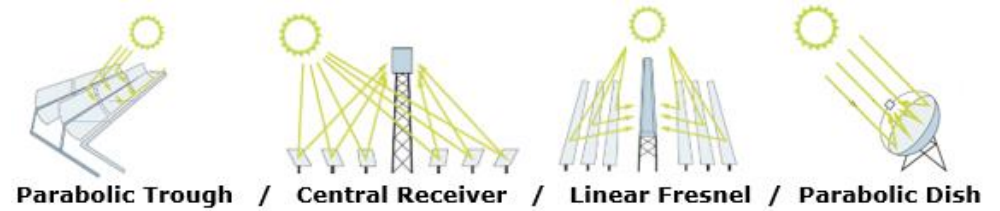
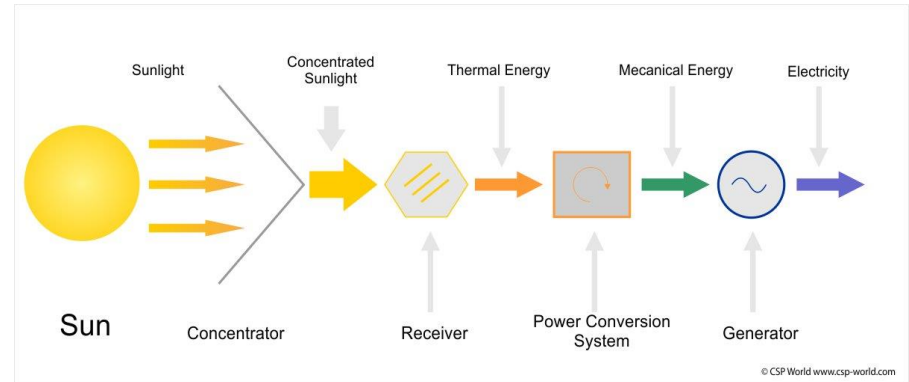
DEVELOPMENT

CONSTRUCTION

OPERATION

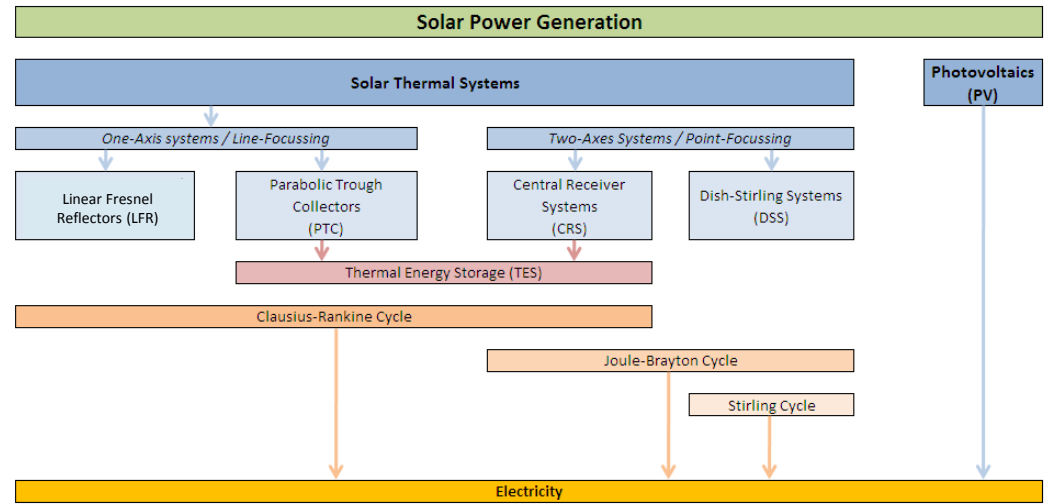


# Introduction Concentrating Solar Power (CSP)



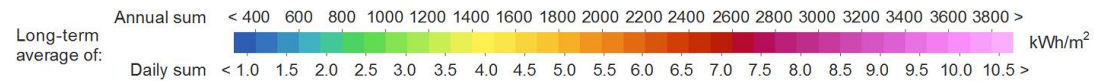
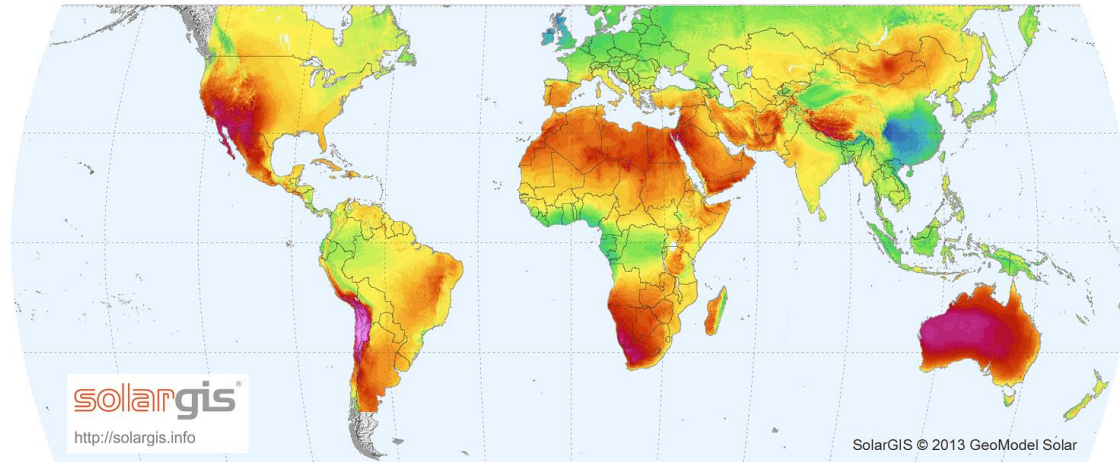


- + Cost-effective energy storage
- + Ancillary grid services
- + More local content
- + Hybridisation / Retrofitting
- + Potential for thermal applications
- ± Need for direct sunlight
- Higher LCOE (approx. x2...3)
- Higher CAPEX and OPEX
- Longer development and construction times
- Less modular
-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



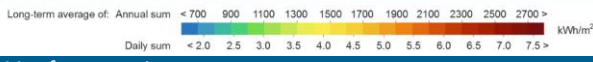
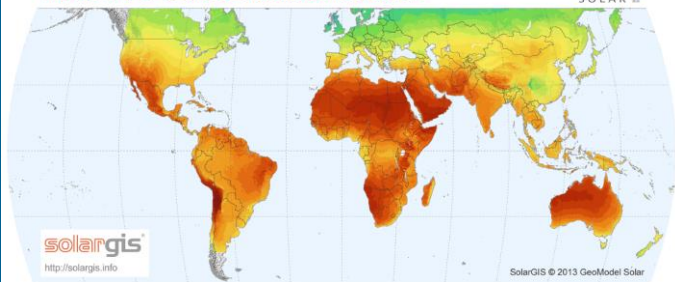
### WORLD MAP OF DIRECT NORMAL IRRADIATION

GeoModel SOLAR



### WORLD MAP OF GLOBAL HORIZONTAL IRRADIATION

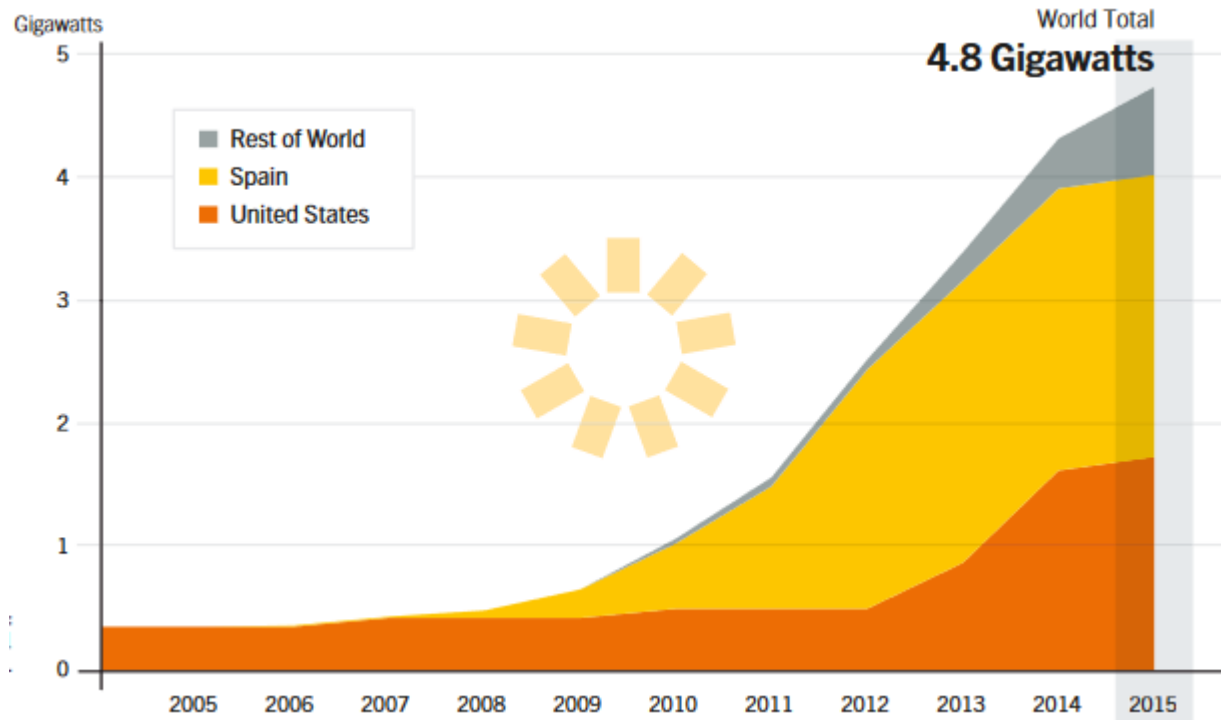
GeoModel SOLAR



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

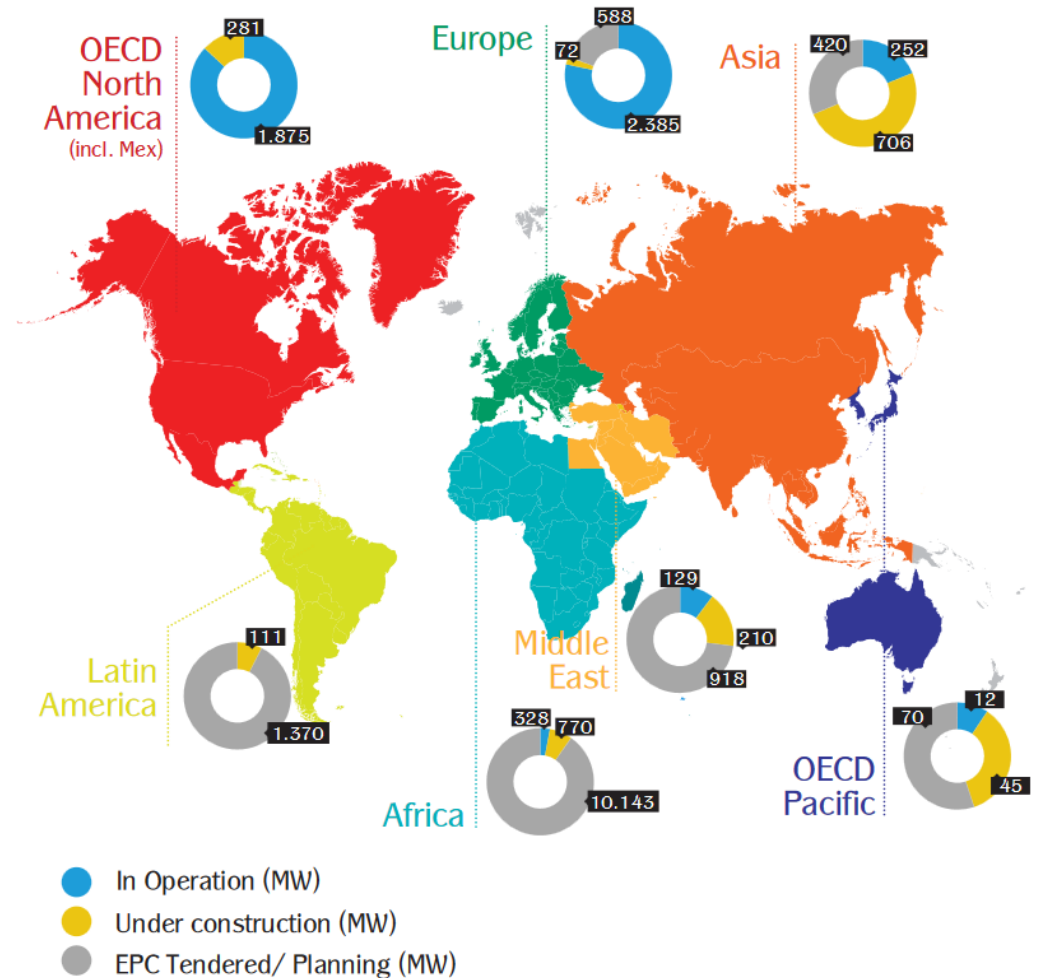
Most CSP installed in Spain (2,362MW) but stagnating

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



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

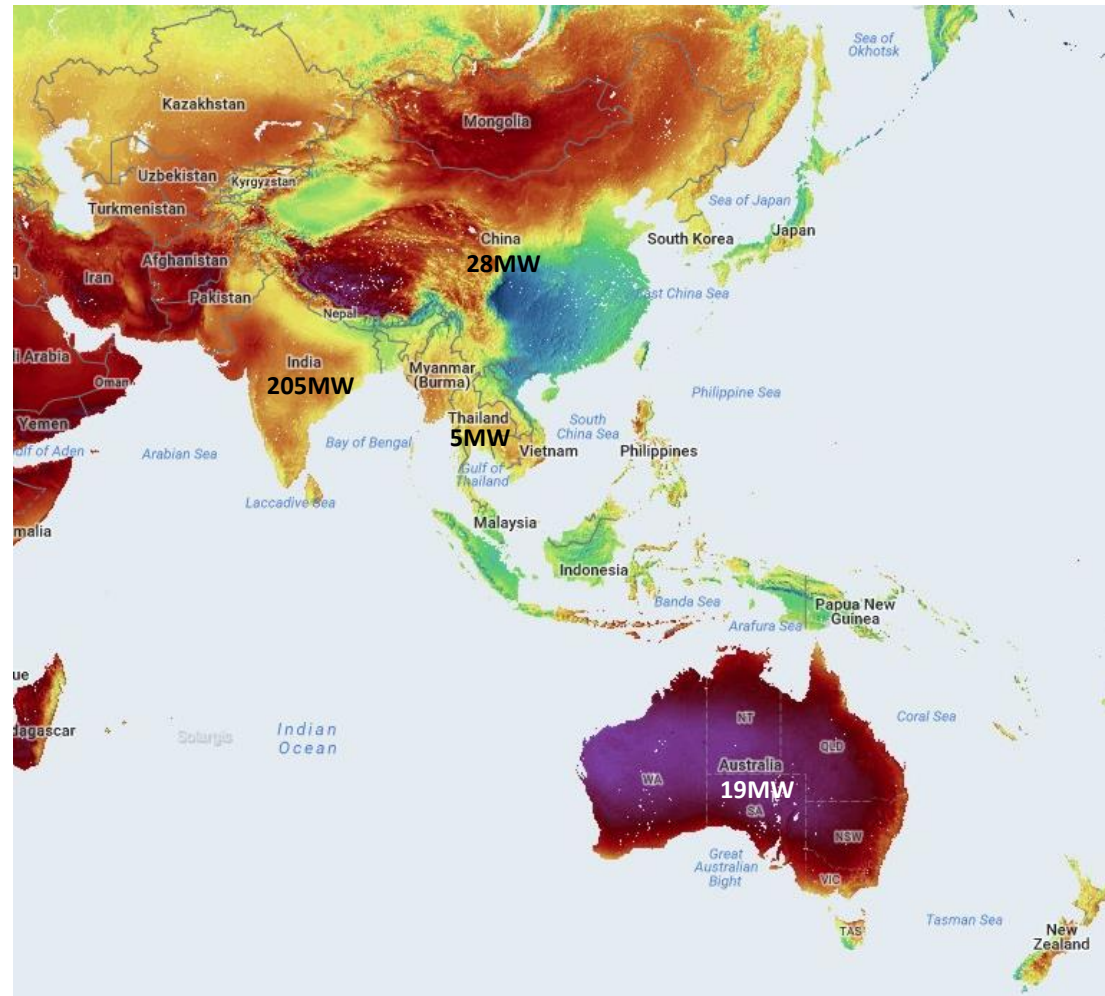
Australia making only small advances

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



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

Source: OST Energy Market Analysis

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	Sunppo	Wuhan
8	众顺	zhongshun	Shenyang
9	中利	Sinoy	Qingdao
10	衡水众业光电	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

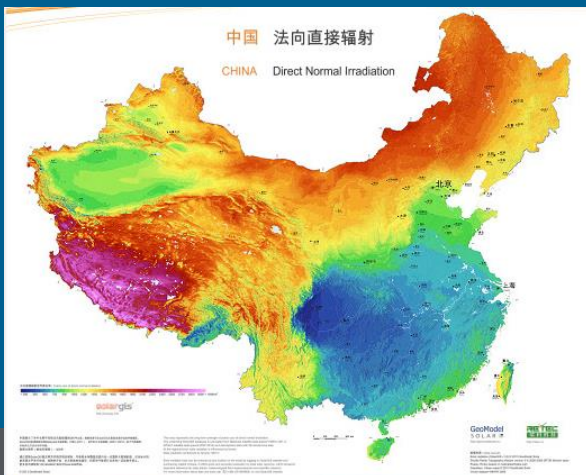
Chinese CSP PTC Receiver Suppliers

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(北太所);	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;		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	Deyang

Source: OST Energy Market Analysis

Number	Project	Project Owner	Technology	The length of thermal storage	Source of technology and system integration enterprise	The system conversion efficiency (estimated by enterprise)
<b>Tower Plants</b>						
1	Qinghai Sapon 100MW Solar Technology Tower CSP	Qinghai Sapon Dalingha Co. Ltd	Molten salt Tower, Molten salt (TES)	6h	Zhejiang Sapon Solar Technology Co. Ltd	19%
2	Daohang 1000MW Molten Salt tower CSP project	Shougang HFR Resources being Technology Co., Ltd	Molten salt Tower, Molten salt (TES)	11h	Shougang HFR Resources being Technology Co., Ltd	16.01%
3	Qinghai Gonghe 100MW Molten Salt Tower CSP plant	Northwest Institute of survey and design of China Hydro-power Consulting Group	Molten salt Tower, Molten salt (TES)	6h	Zhejiang Sapon Solar Technology Co. Ltd, Northwest Institute of survey and design of China Hydro-power Consulting Group	15.54%
4	Hami 100MW CSP project	Northwest Electric Power Design Institute of China Power Engineering Consulting Group	Molten salt Tower, Molten salt (TES)	9h	Zhejiang Sapon Solar Technology Co. Ltd, Northwest Electric Power Design Institute of China Power Engineering Consulting Group	15.50%
5	Dalingha Qinghai 135MW DNG Tower CSP project	Huanghe Hydro-power Development Co., Ltd	DNG Tower, Molten salt (TES)	3.7h	BrightSource (US) Power Engineering Consulting Group, Institute of China Power Engineering Consulting Group	19%
6	Golden tower 1000MW Molten Salt Tower CSP project	China Three Gorges Corporation	Molten salt Tower, Molten salt (TES)	10h	Resources being Technology Co., Ltd, Northwest Institute of survey and design of China Hydro-power Consulting Group	15.82%
7	Mangji 100MW DNG Tower CSP project	Da Xin Engineering Management (Group) Co., Ltd, Institute of Electrical Engineering of	DNG Tower, Molten salt (TES)	4h	Institute of Electrical Engineering of CEA	17%
8	Yumen 50MW Molten Salt Tower CSP project	Yumen Xinrong Thermal power Co. Ltd	Molten salt Tower, Molten salt (TES)	6h	Shanghai Passol renewable Energy Company, Yumen Xinrong Thermal power Co., Ltd	18.50%
9	Yumen 100MW Molten Salt Tower CSP project	Beijing Guodian Electric Power Co., Ltd	Molten salt Tower, Molten salt (TES)	10h	Shougang HFR Resources being Technology Co., Ltd	16.50%
<b>parabolic trough Plants</b>						
1	Yumen Town East 100MW CSP project	Royal Tech CSP Limited	Thermal oil parabolic trough, molten salt (TES)	7h	Royal Tech CSP Limited	24.6%
2	China Abenat 50MW Molten Salt CSP parabolic trough (concentration plant)	Shen-ruo gen Technology Co., Ltd	Molten salt parabolic trough, molten salt (TES)	15h	Tianjin Binai concentrating solar power association Co., Ltd	21%
3	China Yumen East town 100MW parabolic trough power plant	Paragener Energy Group Co., Ltd	Thermal oil parabolic trough, molten salt (TES)	7h	Paragener Energy Group Co., Ltd	24.60%
4	Yuan Middle River 100MW thermal oil parabolic trough CSP project	Inner-Mongolia royal tech new energy Co., Ltd	Thermal oil parabolic trough, molten salt (TES)	4h	Changzhou royal tech solar thermal equipment Co., Ltd, Inner-Mongolia diqun new energy Co., Ltd	26.76%
5	Yumen Thermal Solar Energy Development Co., Ltd CSP project	CCN Dalingha Solar Energy Development Co., Ltd	Thermal oil parabolic trough, molten salt (TES)	9h	CCN Solar Energy Development Co., Ltd	14.07%
6	Ordos 100MW thermal oil parabolic trough CSP project	ORCEP Gasco water solar technology Co., Ltd	Thermal oil parabolic trough, molten salt (TES)	7h	Changzhou royal tech solar thermal equipment Co., Ltd, ORCEP Solar Technology Co., Ltd	14%
7	60MW Molten salt parabolic trough CSP Project	Zhongyong Zhangjiaohe (China) Energy Co., Ltd	Molten salt parabolic trough, molten salt (TES)	16h	Tianruan Group (Zhejiang) Zhangjiaohe (China) Energy Co., Ltd	21.50%
<b>Flat-plate</b>						
1	Daohang 100MW Molten Salt Fresnel CSP plant	Laoshan Daohang Technology Co., Ltd	Molten salt Fresnel	13h	Laoshan Daohang Technology Co., Ltd	16.70%
2	Yue 50MW Fresnel CSP projects	Huailong North United Power Co., Ltd	Thermal oil Fresnel	6h	China Shuangfang Group Chem Energy Technology Research Institute	18.50%
3	GTCC Zhanbei 100MW DNG Fresnel CSP project (phase 1) Hengshui	GTCC Group Zhongtai new energy company	DNG Fresnel, All solid state Fresnel (TES)	14h	Beijing Terrestrial Photovoltaic Technology Co., Ltd	10.50%
4	Zhuangzi 100MW CSP project	Zhuangzi Huaying Zhongyong Co., Ltd	DNG Fresnel, All solid state Fresnel (TES)	14h	Beijing Terrestrial Photovoltaic Technology Co., Ltd	11.90%

Source: China National Solar Thermal Alliance





Suitability for APAC:

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

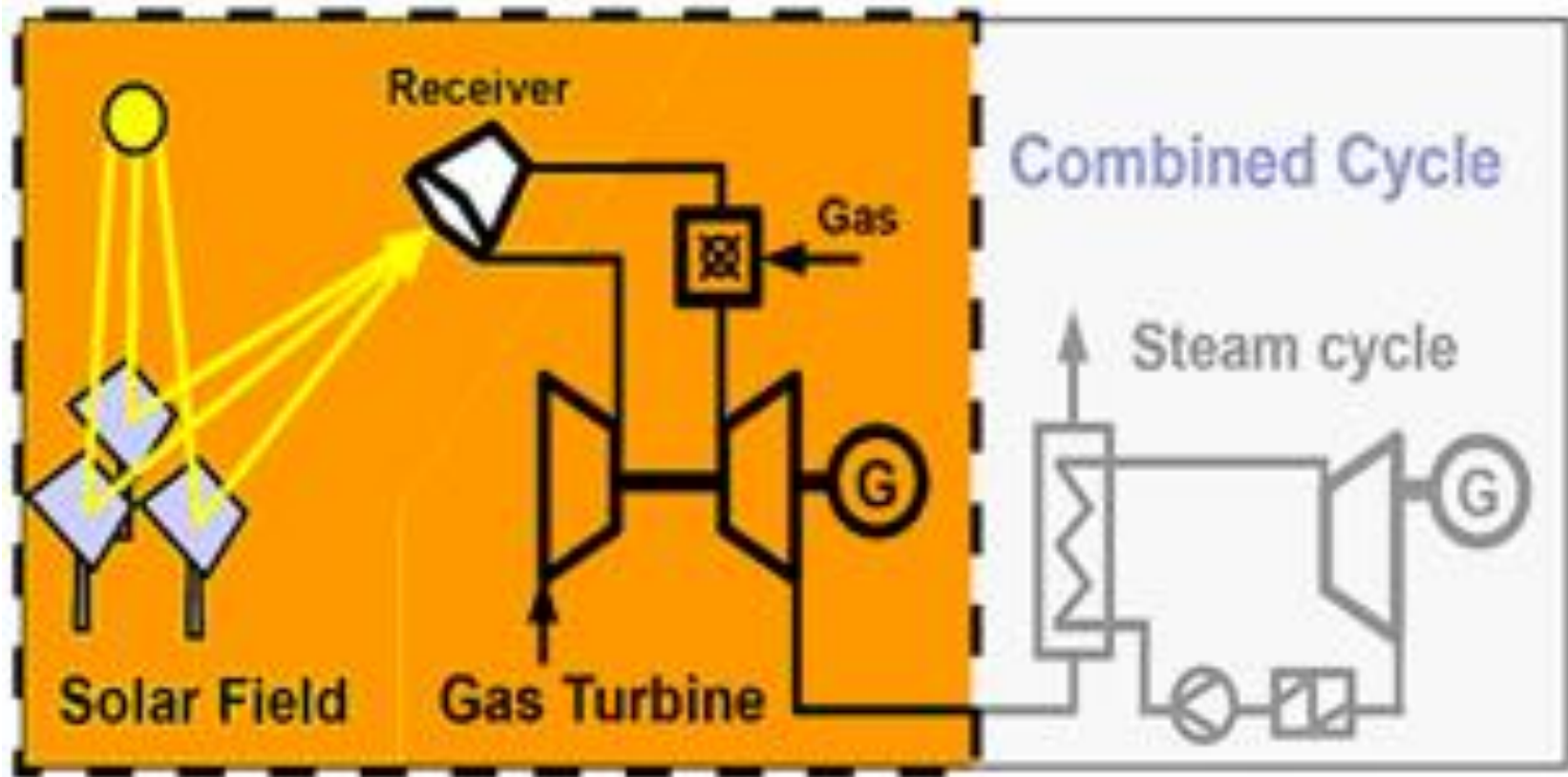
Threats:

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**

- New concentrator concepts, new HTF's, new storage media
- Standardisation, modularisation and hybridisation into new applications
- Higher temperature cycles, e.g. Brayton or combined cycles



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



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