



European Commission
FP7 Grant Agreement
No: 609837



**STAGE-
STE**

EERA

Key contributions of STAGE- STE international coordination

*Latest joint efforts between Research and
Industry for strengthening European CSP
leadership (STAGE-STE Workshop)*

*European Economic and Social Committee
Brussels, January 23rd, 2018*

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*Comité économique et social européen
European Economic and Social Committee*

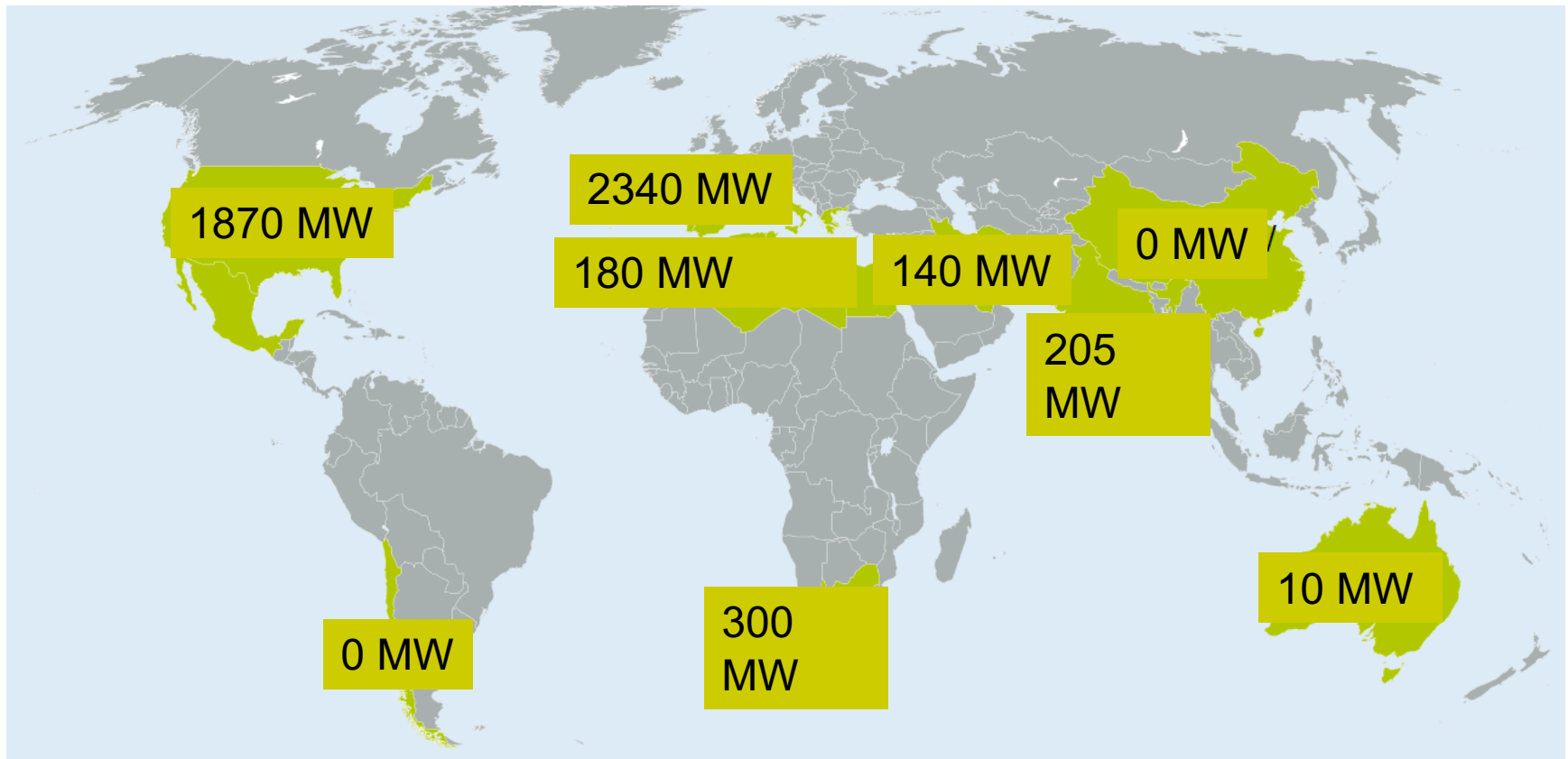
International Cooperation

- STAGE-STE provided a basis for worldwide cooperation



Worldwide CSP Development

>5 GW in operation, >2 GW in construction, >3 GW in development

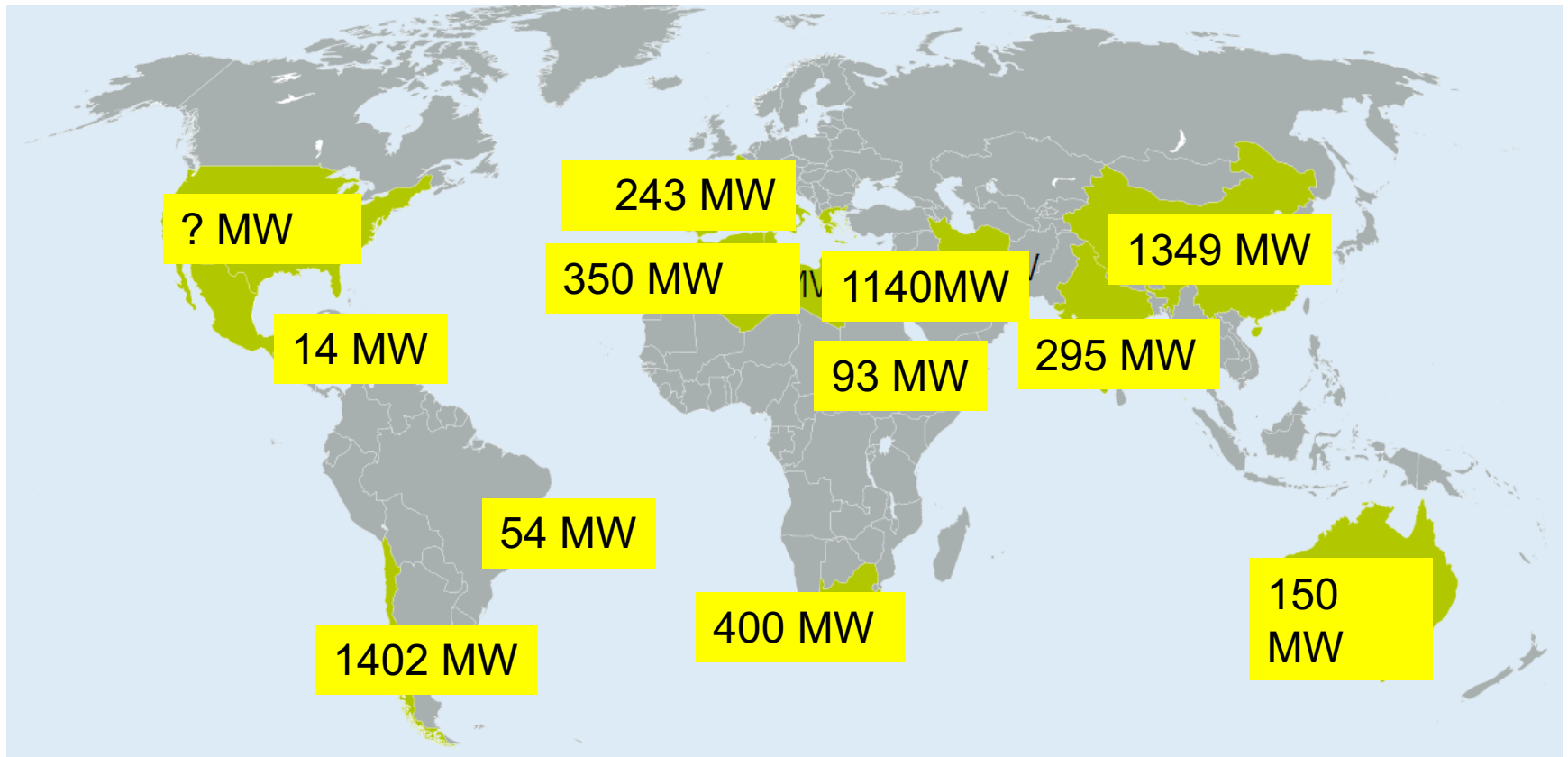


Source: SolarPaces.org

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Worldwide CSP Development

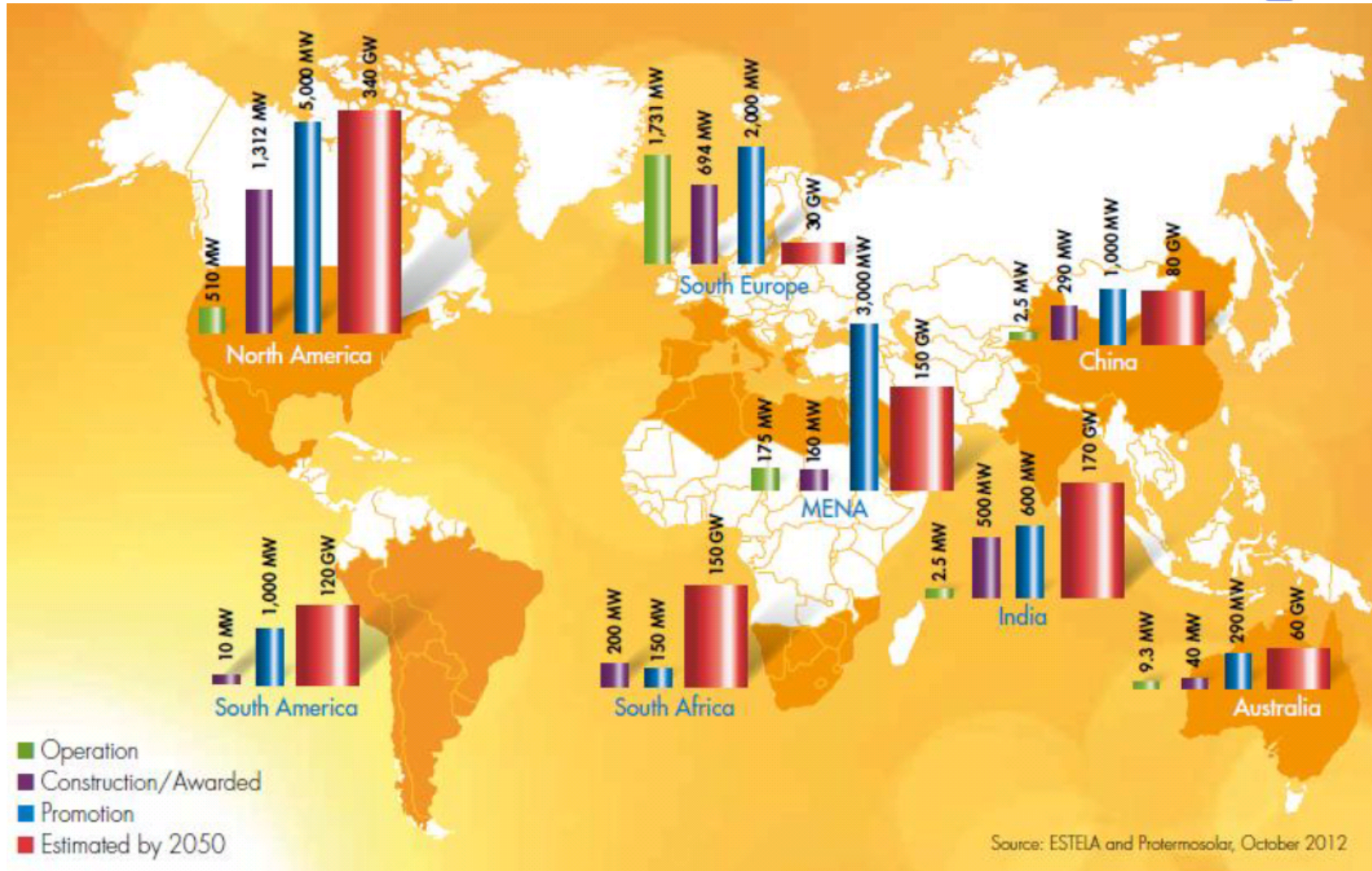
>5 GW in operation, >3 GW in construction, >2 GW in development



Source: SolarPaces.org

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Market Potentials and Resource



Cost Drivers

- **Technology**

*Solar field
Optical concentrators*



*larger aperture and concentration factor
improved optics and tracking
advanced manufacturing
wireless and better control
O&M procedures (cleaning)*

Thermal storage



*direct storage and higher temperatures
adapted storage and construction materials
charging and discharging process*

System



Higher efficiencies and new designs

- **Project development**

Reduction of 25%



standardization and reduction of risks

- **Financing**

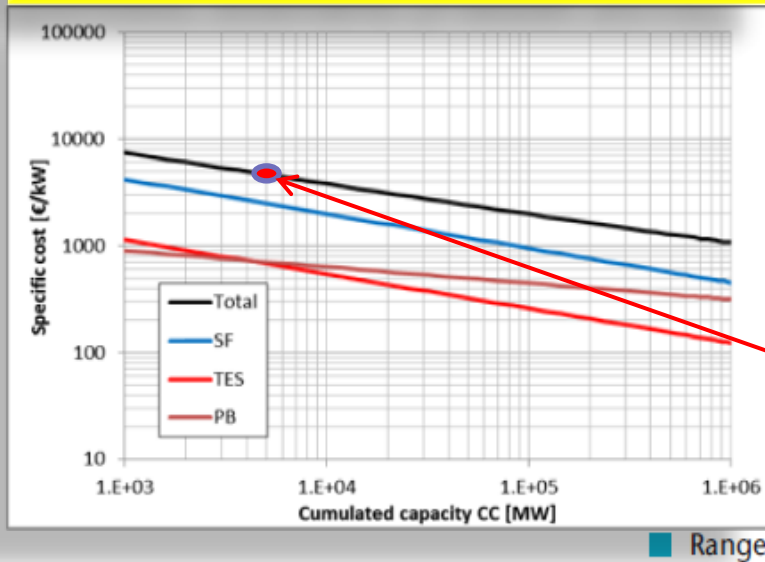
Sustainable financing



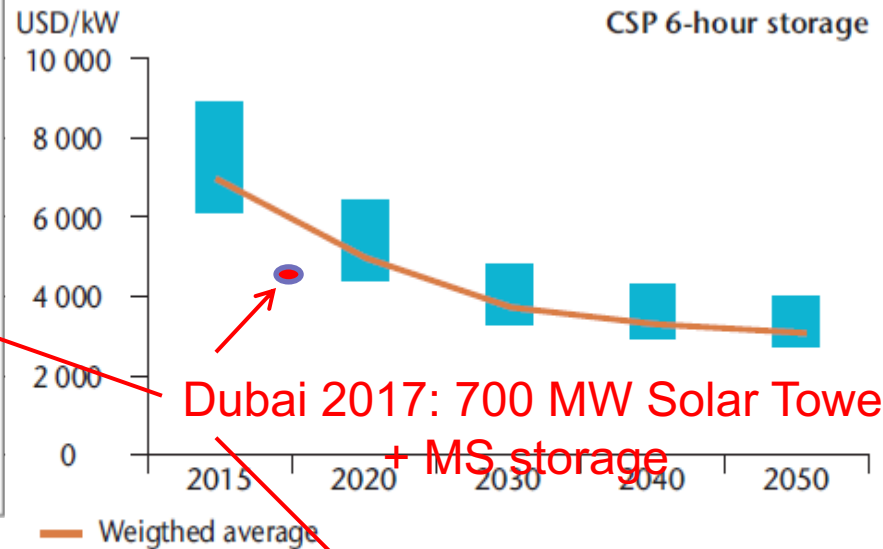
risk perception, guarantees, long term PPA

Cost Development

Optimistic Scenario (Platzer 2015)



IEA Technology Roadmap 2014



Dubai 2017: 700 MW Solar Tower + MS storage

| USD/MWh | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|---------|------|------|------|------|------|------|------|------|
| Minimum | 146 | 116 | 96 | 86 | 72 | 69 | 66 | 64 |
| Average | 168 | 130 | 109 | 98 | 80 | 77 | 72 | 71 |
| Maximum | 213 | 169 | 124 | 112 | 105 | 101 | 96 | 94 |

Note: All LCOE calculations in this table are based on 8% real discount rates as in ETP 2014 (IEA, 2014b).

Country View South Africa

- Paving the way**

Regulated market NERSA

Possibility for IPP to generate and sell to ESKOM

Clear strategy to introduce RE in Int. Resource Plan

Renewable Energy Independent Power Producer Procurement Programme (REIPPPP) in 2011

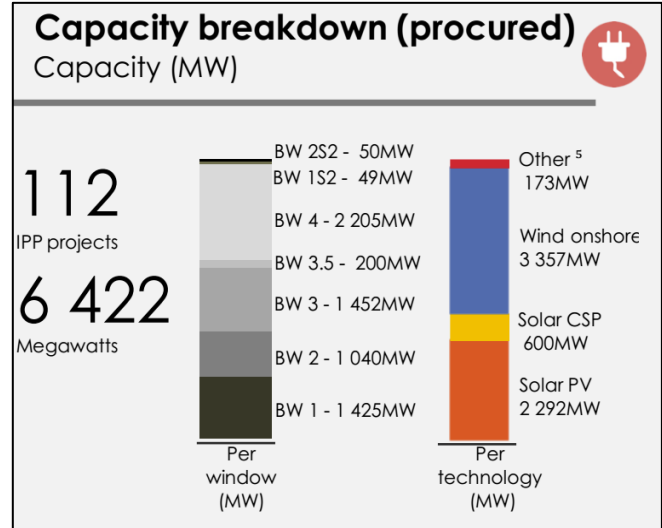
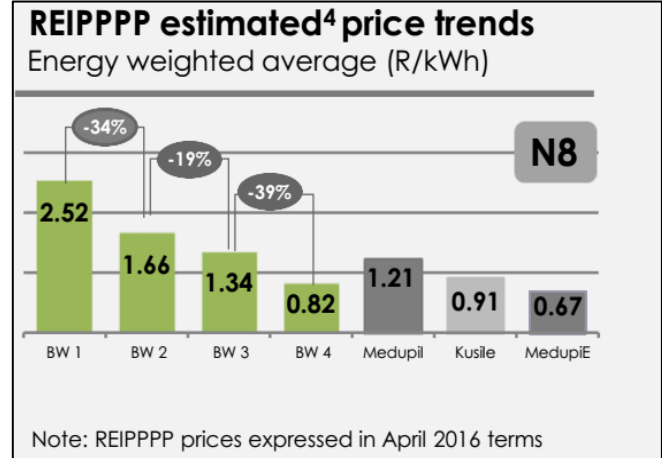
- Bid windows:**

Capacity assignments for different RE (PV, Wind, CSP, Bio, Hydro, Landfill)

*Strong learning effects lead to decreasing price
BW1 -> BW4 decrease of 67% (RE), 50% (CSP)*

- Policy risks**

Nuclear risk due to untransparent government decision



Country View South Africa

- **South Africa has a pipeline of CSP projects**

Four bidding processes -> 50% decrease in cost due to learning effects

600 MW CSP since REIPPP 2011 - and 450 MW more expected -> 65% cost decrease

| In Operation | | | | |
|---------------------------|--------------------|------------------|-------------|-----------------------------------|
| Khi Solar One | Upington | Central receiver | 50 MW | Abengoa Solar |
| | Water/Direct steam | Steam Rankine | Dry cooling | 2.0h Saturated steam |
| KaXu Solar One | Pofadder | Parabolic trough | 100 MW | Abengoa Solar |
| | Thermal oil | Steam Rankine | Dry cooling | 2.5h Molten salt, 2-tank indirect |
| Bokpoort | Groblershoop | Parabolic trough | 50 MW | Acwa Power |
| | Dowtherm A | Steam Rankine | Wet cooling | 9.3h Molten salt, 2-tank indirect |
| Under construction | | | | |
| Xina Solar One | Pofadder | Parabolic trough | 100 MW | Abengoa Solar |
| | Thermal oil | Steam Rankine | Unknown | 5h Molten salt, 2-tank indirect |
| Kathu Solar park | Kathu | Parabolic trough | 100 MW | Engie |
| | Thermal oil | Steam Rankine | Unknown | 4.5h Molten salt, 2-tank indirect |
| Ilanga 1 | Groblershoop | Parabolic trough | 100 MW | Emvelo and Cobra |
| | Upington | Steam Rankine | Unknown | 4.5h Molten salt, 2-tank indirect |

Country View: Morocco

- **Government policy**

- Objective of raising the RE share to 42 % of installed electric power by 2020 and 52 % by 2030

- Dedicated auctions for CSP and PV

- **Drivers for RE**

- Substitution of imported energy

- Local value generation

- Demand growth

| Renewable Energy projects | Installed capacity | Per KWH price in electricity purchase contract | Developer |
|---------------------------|--------------------|--|------------------------------------|
| Taza wind park | 150 MW | 0,57 Dh (0,05 US\$) / KWh | EDF/MITSUI |
| Tarfaya wind park | 301 MW | 0,72 Dh (0,07 US\$ / KWh) | Nareva-Engie |
| Integrated wind project | 850 MW | 0,31 Dh (0,03 US\$ / KWh) | Nareva-Siemens Enel Green Power |
| Noor O I csp | 160 MW | 1,5 Dh (0,15 US\$ / KWh) | Acwa Power |
| Noor O II csp | 200 MW | 1,4 Dh (0,14 US\$ / KWh) | Acwa Power |
| Noor O III csp | 150 MW | 1,4 Dh (0,14 US\$ / KWh) | Acwa Power |

| Site/power plant | Power in MW | Technology | Commissioning date |
|------------------|-------------|-------------------|--------------------|
| Ouarzazate | Total: 580 | | |
| NOORo I | 160 | CSP | 2015 |
| NOORo II | 200 | CSP | 2017/18 |
| NOORo III | 150 | CSP (solar tower) | 2017/18 |
| NOORo IV | 70 | PV | 2018 |
| Midelt | up to 600 | CSP / PV** | by 2019 |
| Tata | up to 600 | CSP / PV** | by 2019 |
| Ain Béni Mathar | 420 | CSP / gas* | by 2020 |
| Sebkhate Tah | 500 | CSP / PV** | by 2020 |
| Foum Al Oud | 500 | CSP / PV** | by 2020 |
| Boujdour | 100 | CSP / PV** | by 2020 |

Country View Chile

- **Chile is a perfect country for CSP technology**

DNI resource is the best in the world > 3500 kWh/m²a

Chile has no substantial conventional energy resources

- **Liberalized market:**

Independent Power Producers may sell to public and private sector

Customers in private sector look for short term contracts

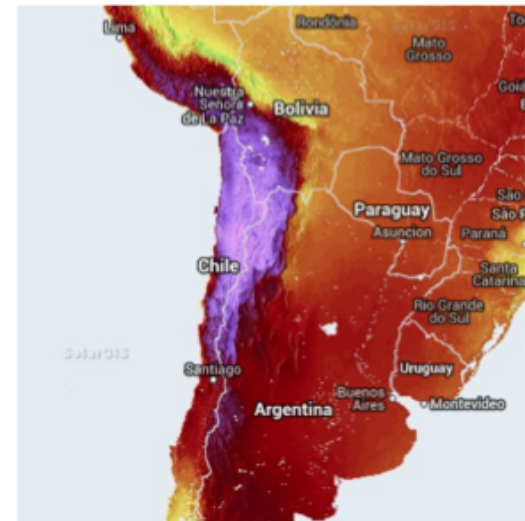
Energy auctions 2016 and 2017 for 2021+ resulted in extremely low bids (PV down to 21.5 USD/MWh)

- **Project pipeline:**

Atacama 1 Solar Tower project of Abengoa is delayed

Solar Reserve did not win a PPA in spite of world record low bid of <50 USD/MWh!

No support mechanism for technology or storage results in development w/o strategy



Country View China

- **After PV boom China wants to be world leader in CSP technology**

DNI resource in China not perfect in preferred area

Industry stimulation program with 1 GW CSP

- **Diversity of Technology:**

Parabolic Trough, Linear Fresnel, Solar Tower

Different Heat Transfer Media

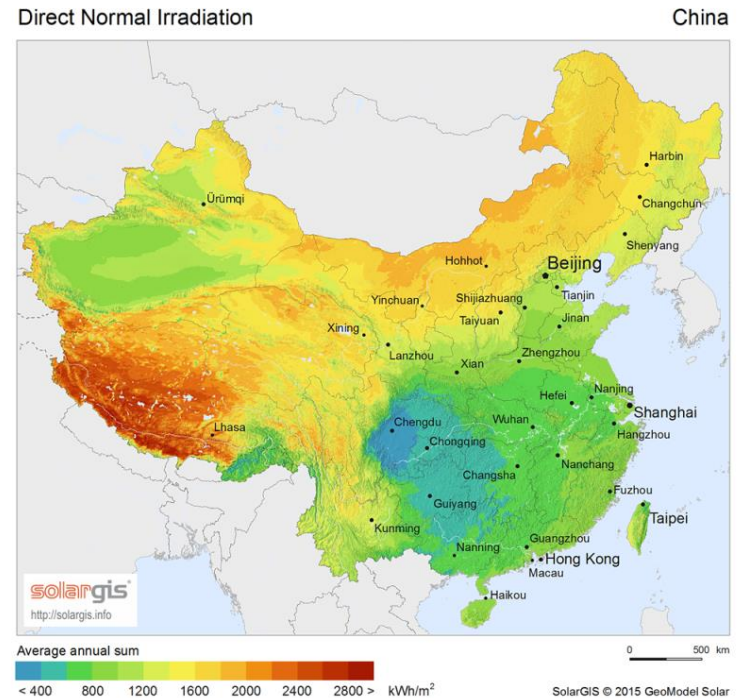
- **Storage capacity highly valued:**

20 Projects with storage capacities of 4 – 16 hours

FiT 1st round (min 4h storage) CSP 22ct/kWh

FiT PV projects 10.5-14 ct/kWh

Sufficient profit for companies – no focus on lowest generation costs!



Conclusions

- **Storage is a unique selling point (USP)**

Example RSA: structure of FIT stimulate storage

- **Hybridisation with PV**

- firm and dispatchable supply with good economy

- Chile auction offer 2017: less than 50 USD/MWh

- **High DNI countries for market introduction**

- lower difference market price and generation cost

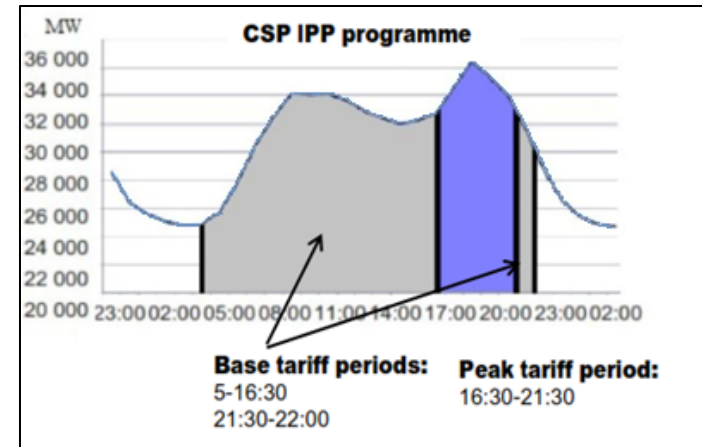
- **Larger projects bring costs down**

- Projects of 200 MW and more now developed

- **Clear national policy supports CSP**

- Example China: Largest technology development program worldwide (>1 GW 1st round)

- **Cost reduction better than most projections !**



Conceptual image of the new plant (image: DEWA)