

Worldwide Deployment of CSP

Seminario “Concentración Solar de Potencia,
una Opción Clave para la Transición Energética”

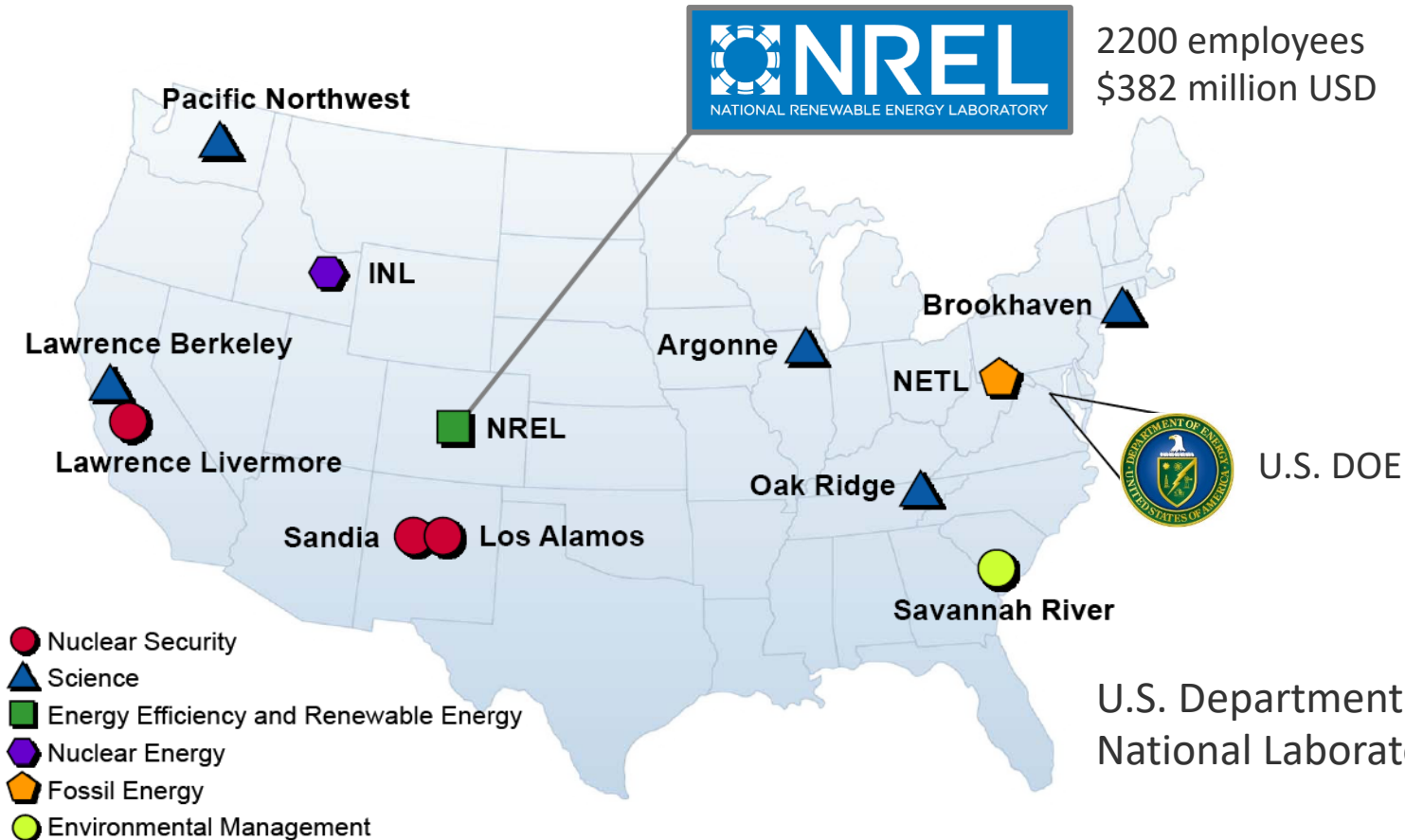
Santiago, Chile
April 25, 2019

Mark Mehos
Thermal Sciences Group Manager
National Renewable Energy Laboratory
mark.mehos@nrel.gov



Crescent Dunes Solar Energy Facility, USA

National Renewable Energy Laboratory



Outline

- Background discussion
- Worldwide deployment of CSP

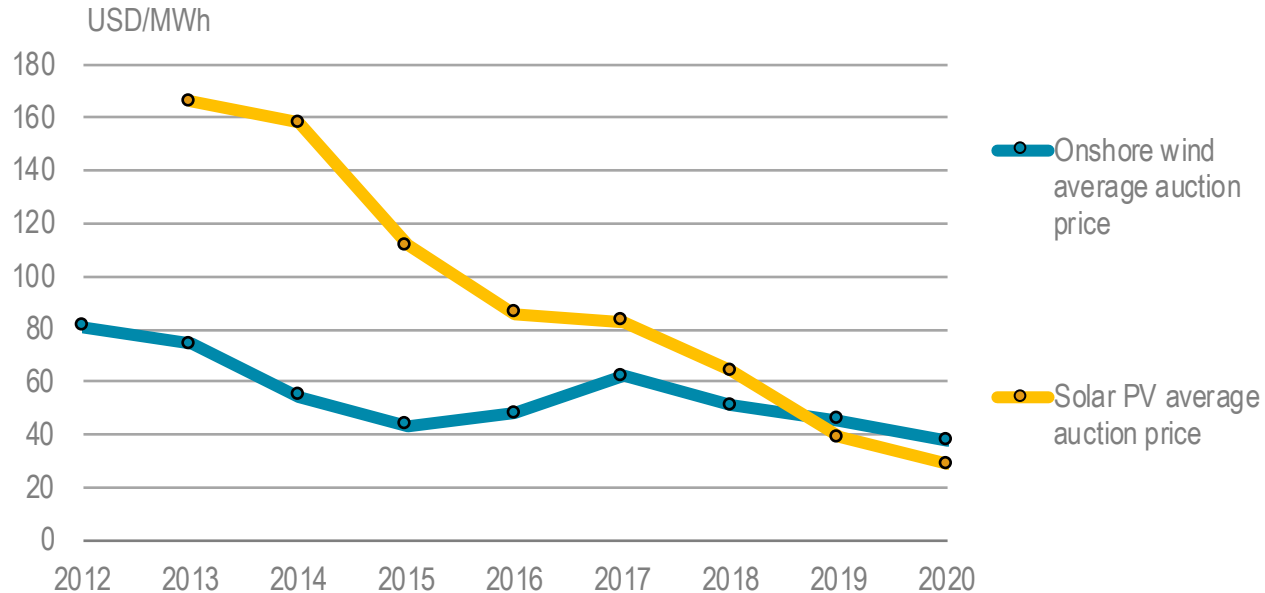
Morocco's 510 MW Noor Solar Complex at Ouarzazate

(photo credit SolarPACES and SENER)



Competition driving down costs of PV and wind

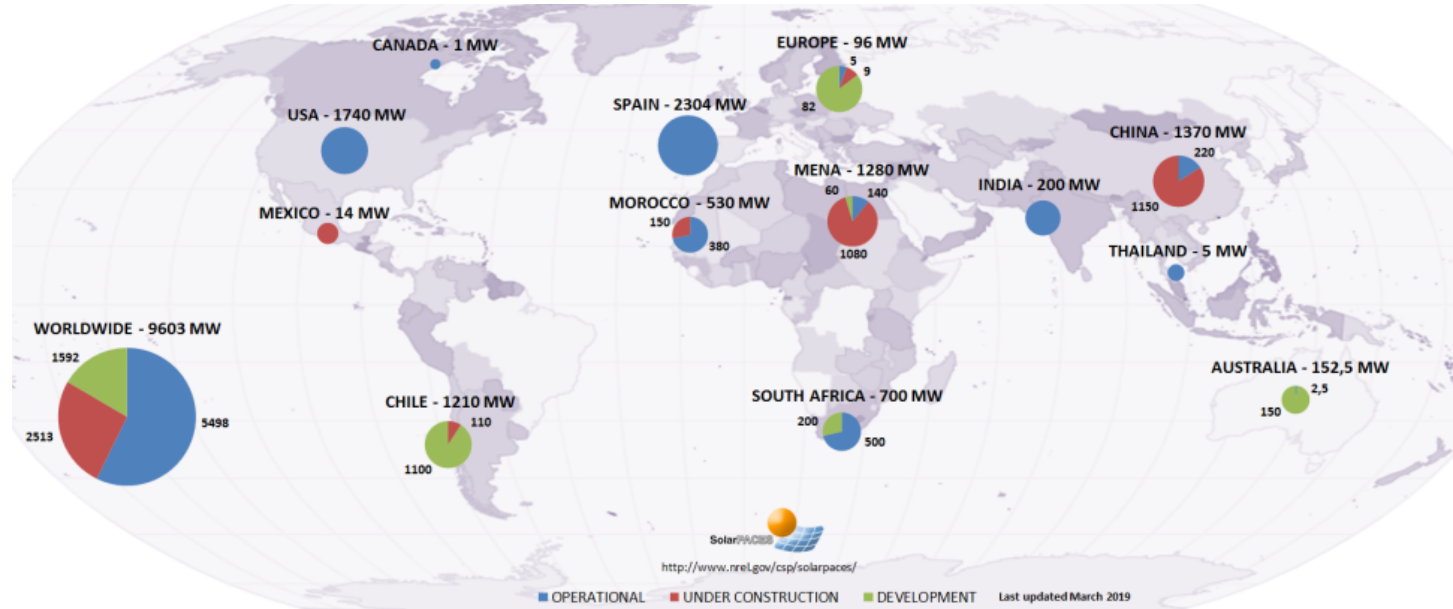
Announced wind and solar PV average auction prices by commissioning date



Source: RE Market Report 2017

CSP SolarPACES Project Database

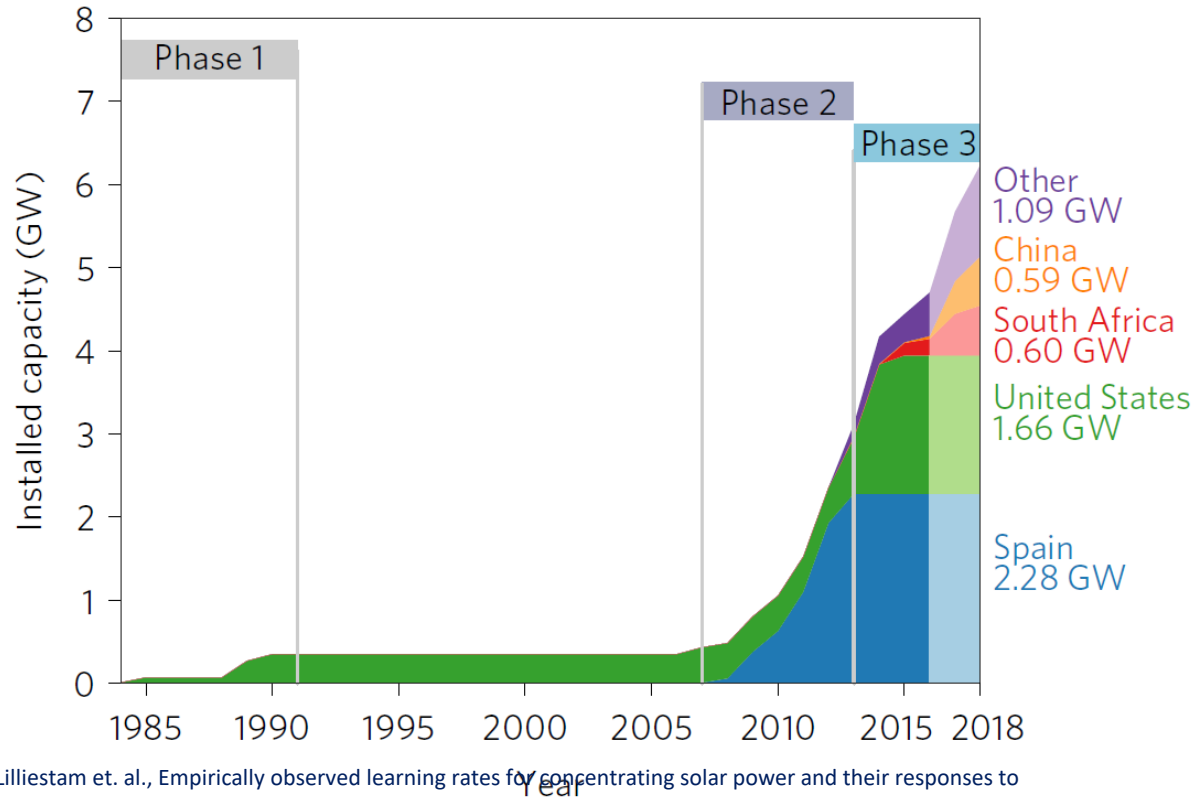
Projects by Status



Cumulative capacity operational: 5.5 GW;

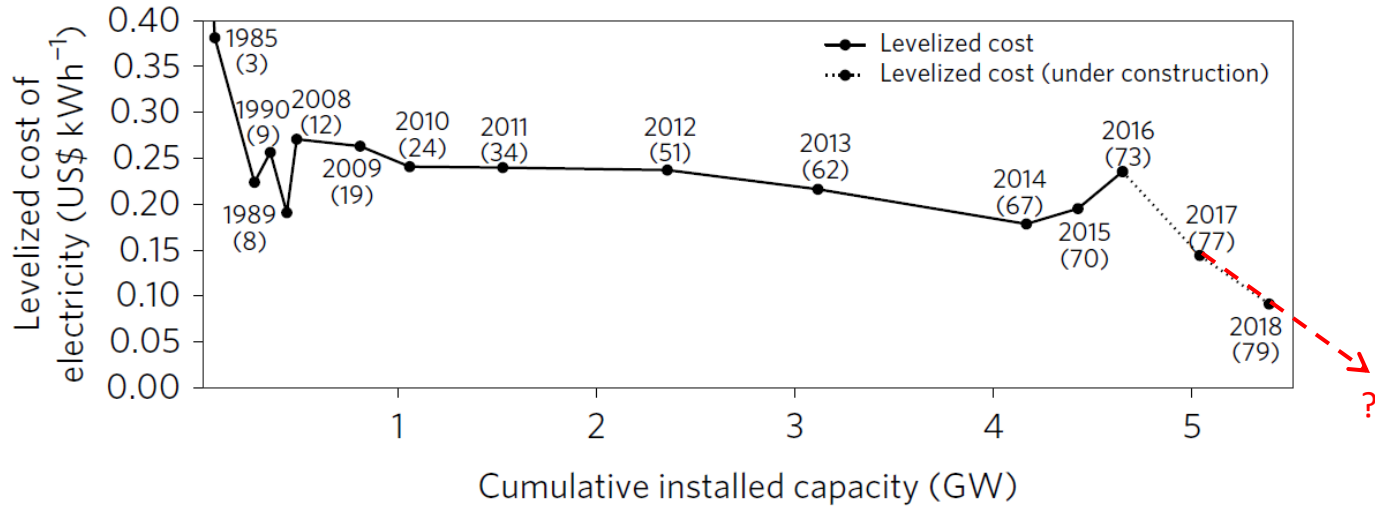
<https://www.solarpaces.org/csp-technologies/csp-projects-around-the-world/> or
<https://solarpaces.nrel.gov/>

Global Expansion of CSP



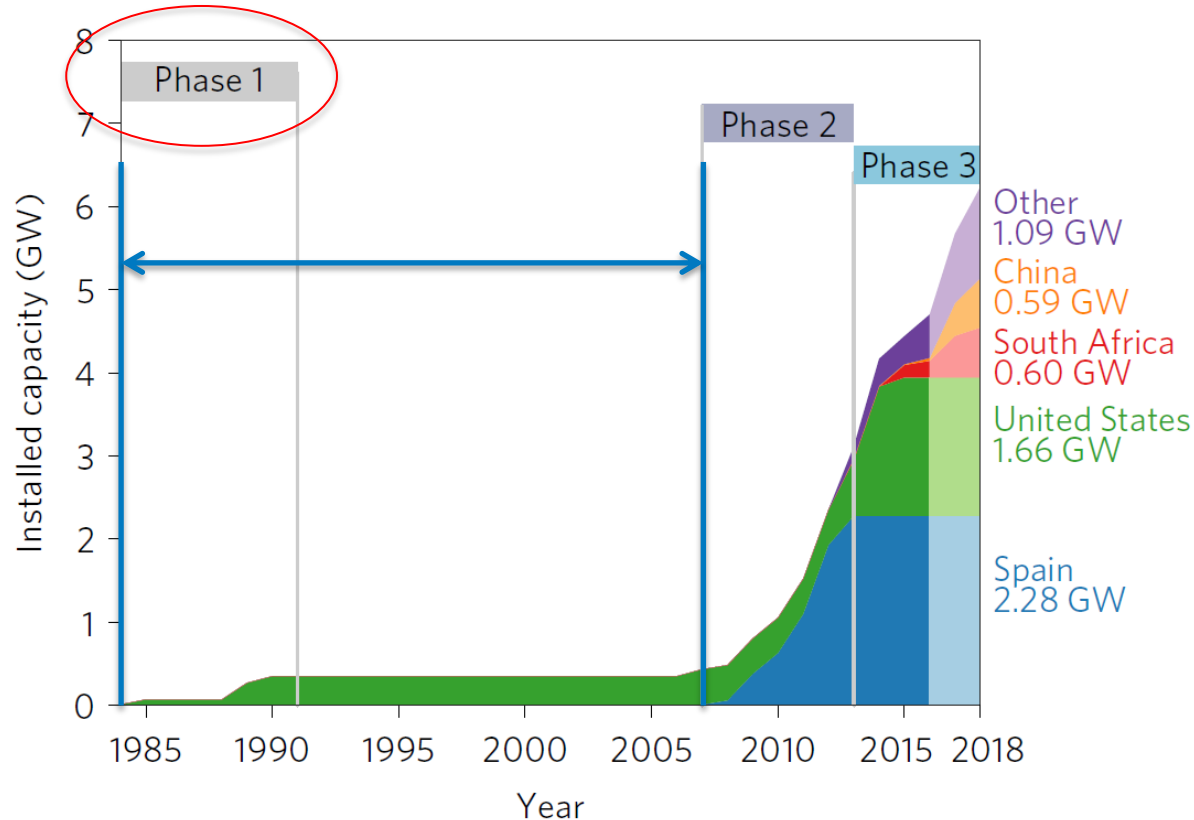
Source: Lilliestam et. al., Empirically observed learning rates for concentrating solar power and their responses to regime change", Nature Energy, 2017

Cost Reduction Impact of Policy and Learning



Source: Lilliestam et. al., Empirically observed learning rates for concentrating solar power and their responses to regime change", Nature Energy, 2017

Global Expansion of CSP

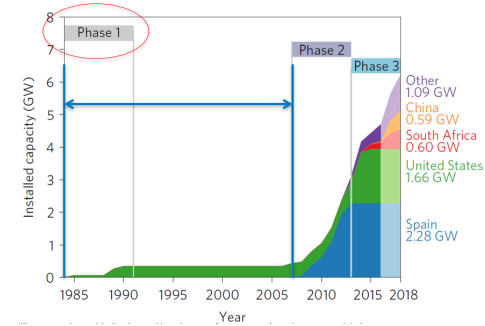


Source: Lilliestam et. al., Empirically observed learning rates for concentrating solar power and their responses to regime change", Nature Energy, 2017

Phase I: U.S. Deployment – The Early Years



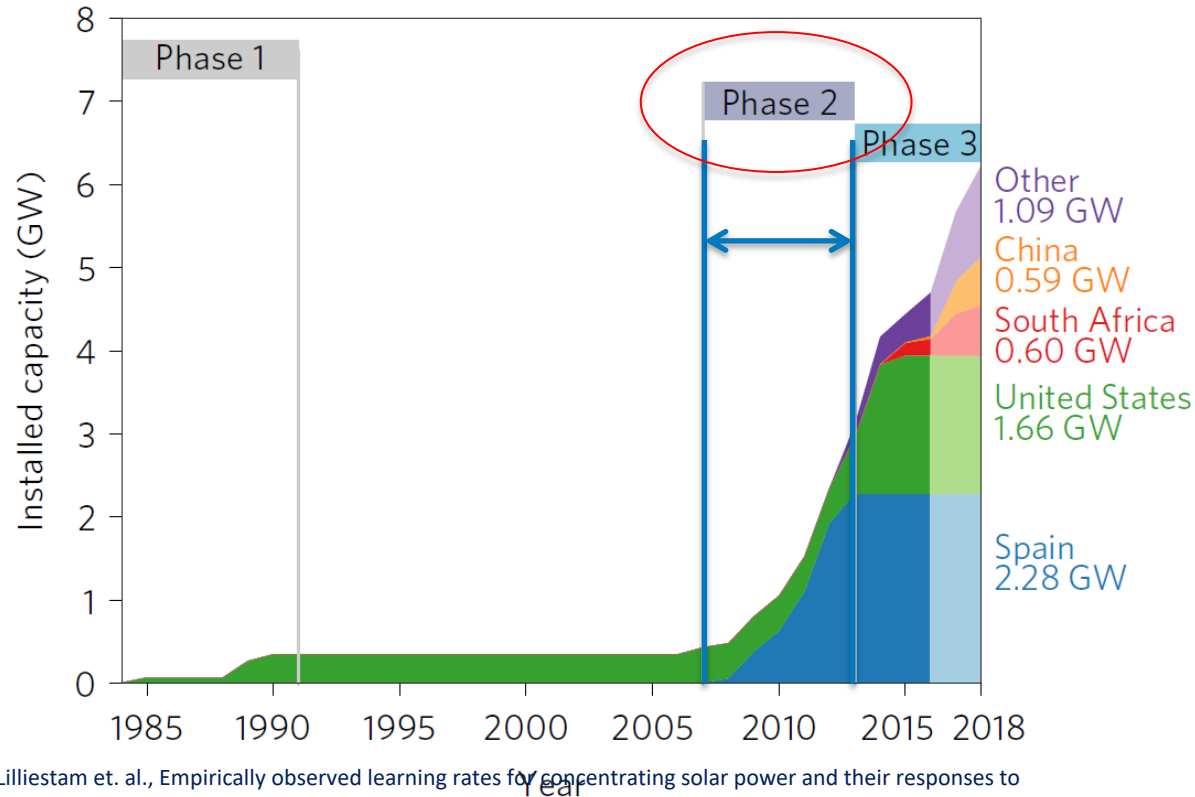
SEGS I-IX
1984-1991



Nevada Solar One
2007

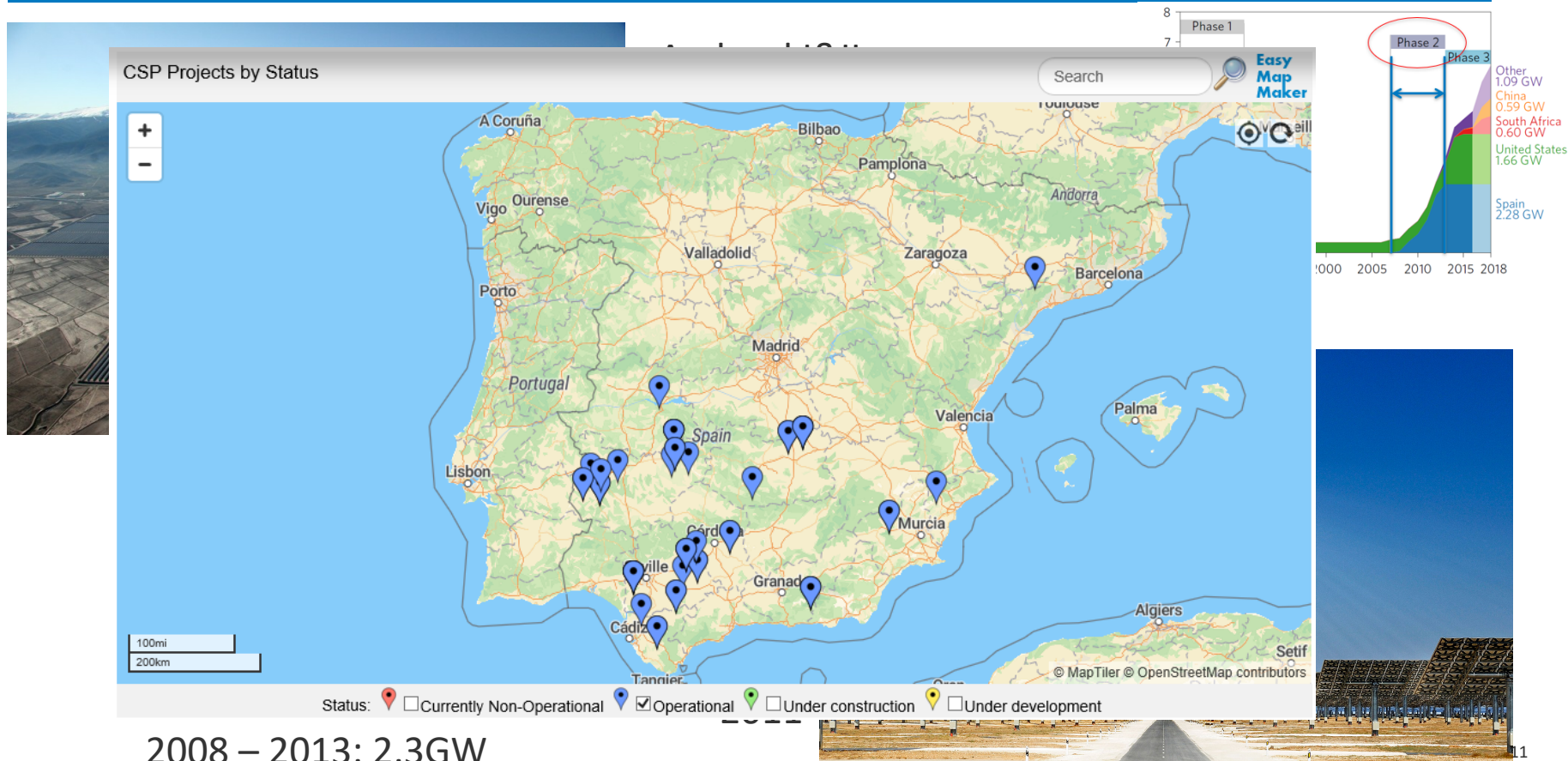


Global Expansion of CSP



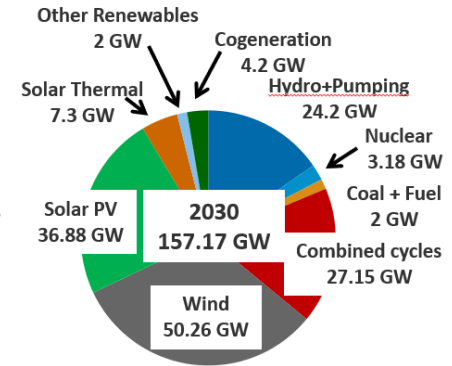
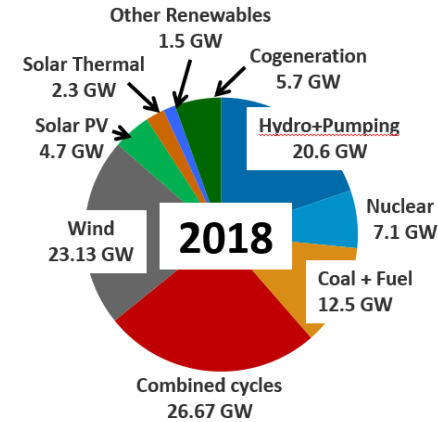
Source: Lilliestam et. al., Empirically observed learning rates for concentrating solar power and their responses to regime change", Nature Energy, 2017

Phase II: Spain – Building an Industry

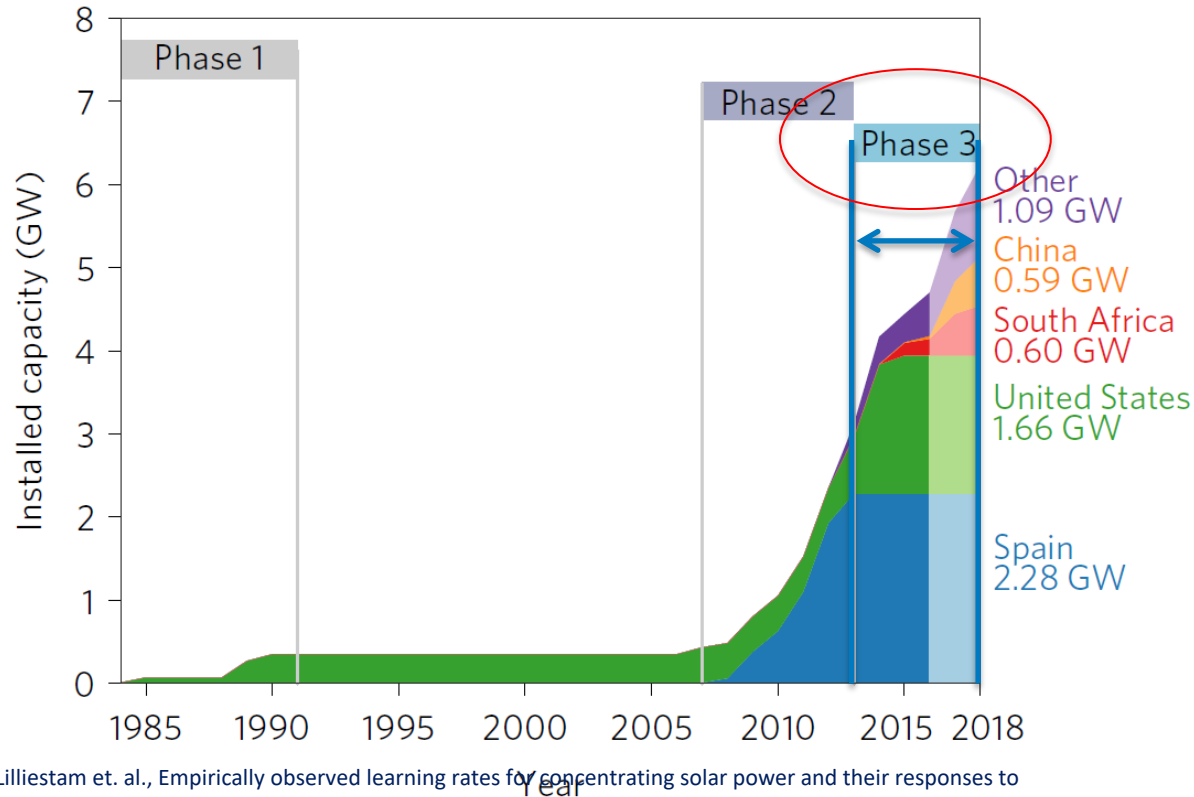


Update on the situation of STE in Spain

- The Spanish government published in February 2019 the Integrated National Plan for Energy and Climate (PNIEC) 2021-2030, giving a firm support to renewable energies:
 - ✓ 74% of electricity will be produced with renewable energies
 - ✓ 42% of overall energy consumption will be supplied by renewable energy
 - ✓ A total investment of 236.124 M€ will be required between 2021 and 2030 (80% private and 20% public) to achieve the proposed objectives

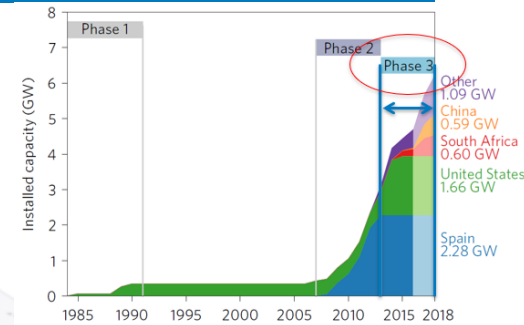
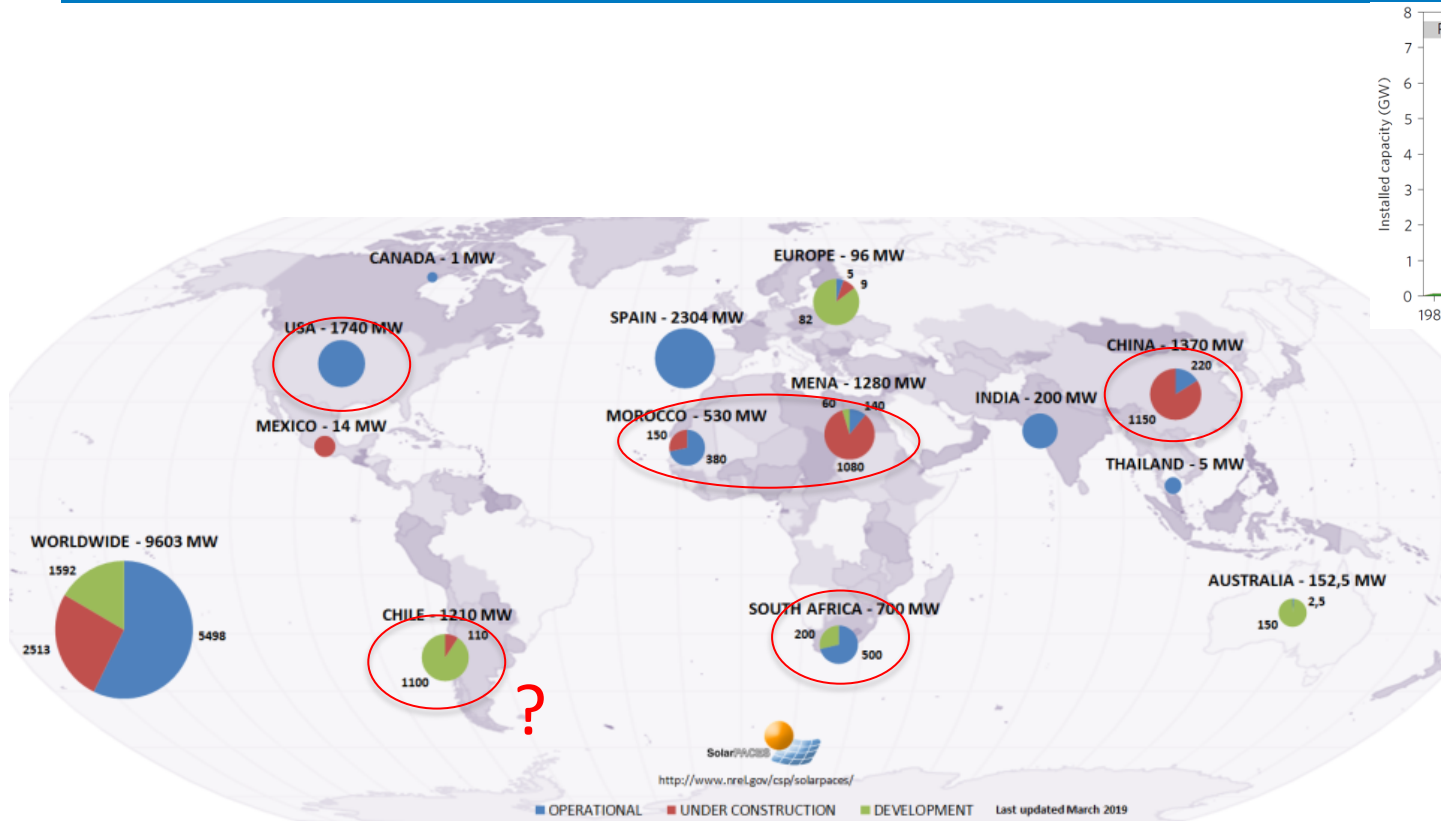


Global Expansion of CSP



CSP SolarPACES Project Database

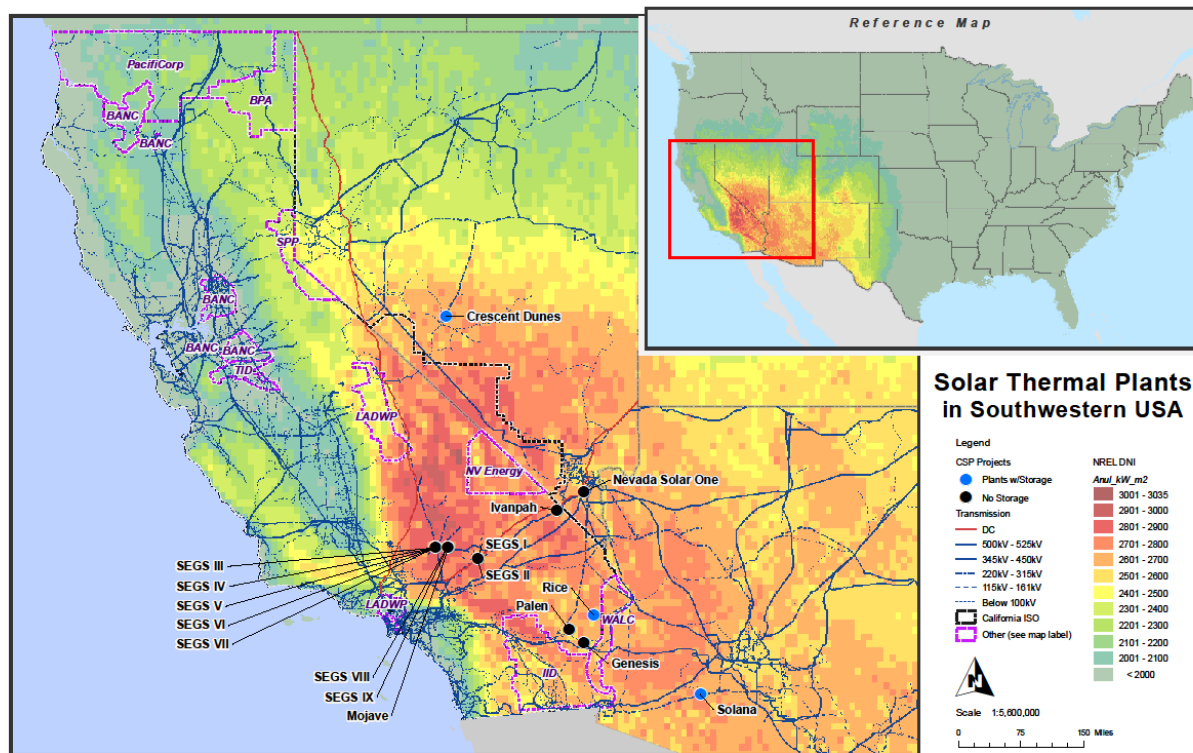
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United States – Mix of Policies Revives CSP

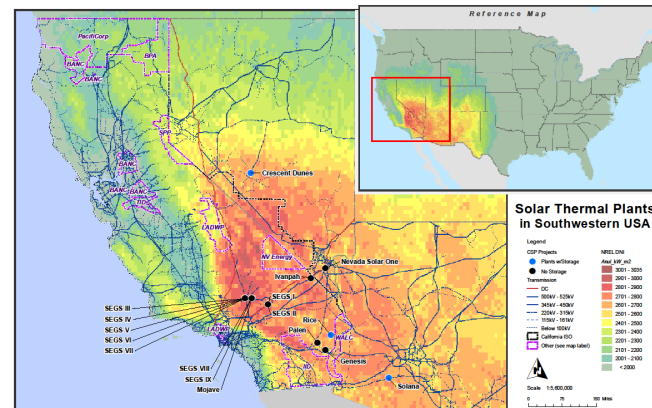
- Surge in U.S. CSP deployment driven by:
 - State Renewable Portfolio Standards
 - Federal Loan Guarantee Program
 - Federal Investment Tax Credit



Ivanpah I-III
2014

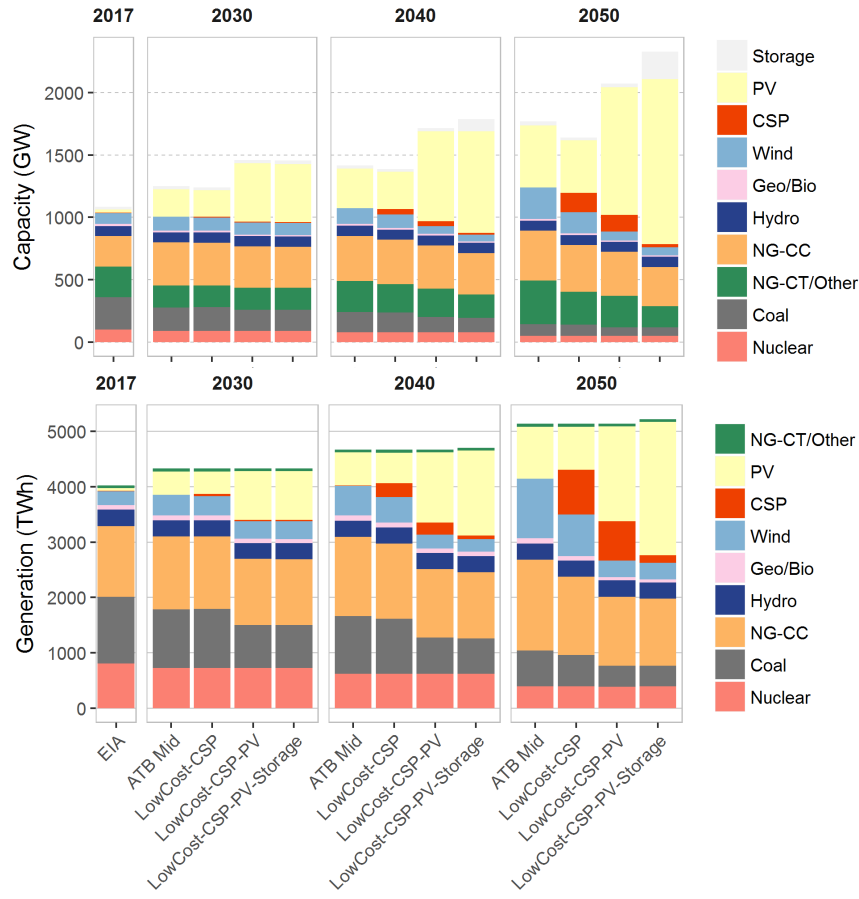


Crescent
Dunes
2015



Scenarios indicate solar growth if DOE's solar cost targets are achieved

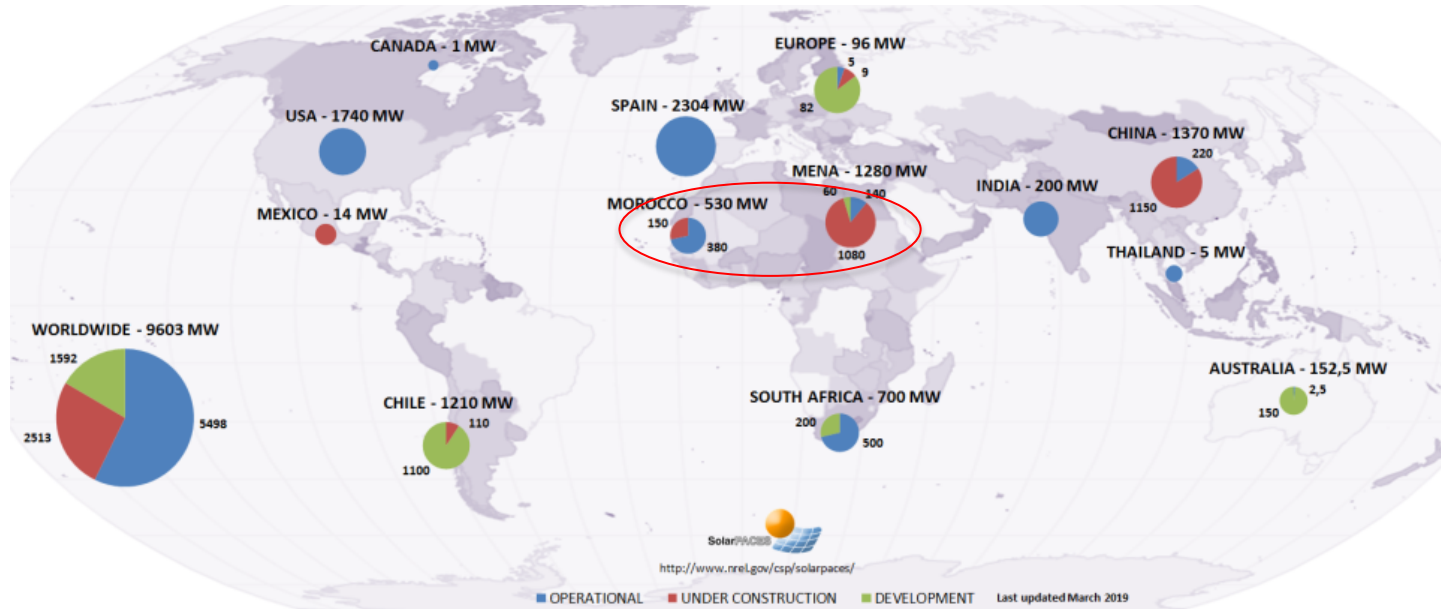
Preliminary Results—Do Not Distribute or Cite



- PV plays an increasing role in capacity and generation mixes through 2050 in all scenarios, with more significant expansion if low cost target is achieved;
- When assuming the Low-Cost trajectory, CSP-TES installations come online in the late 2020s and grow steadily through 2050;
- Under the Low-Cost trajectory for battery storage, synergies between batteries and PV lead to increased deployment of both, largely at the expense of low-cost CSP-TES.

CSP SolarPACES Project Database

Projects by Status

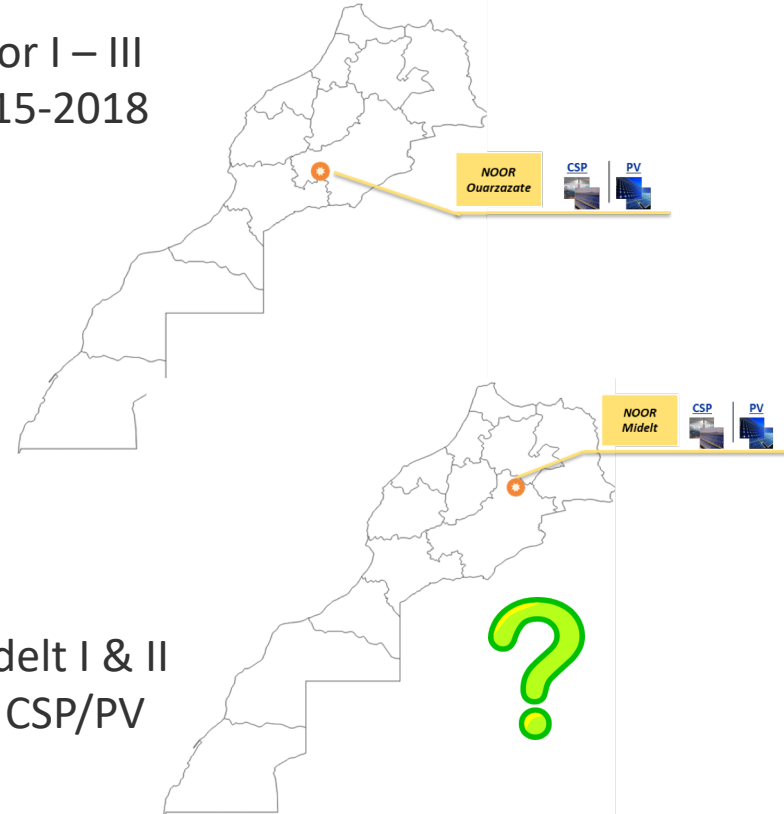


Cumulative capacity operational: 5.5 GW;

NOOR, a Multi-Site and Multi-Technology Plan



Noor I – III
2015-2018



Noor Midelt I & II
“hybrid” CSP/PV

DEWA 950MW CSP/PV Power Park

DEWA, ACWA, and Silk Road Fund reach financial close on 950MW CSP and PV solar park

By Tom Kenning

Dubai Electricity and Water Authority (DEWA) and a consortium led by Saudi Arabia's ACWA Power and Chinese government-owned Silk Road Fund, have achieved financial close on the 950MW fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park.

The lending group to the project, which is spread between 700MW of concentrated solar power (CSP) and 250MW of PV, includes Agricultural Bank of China, Bank of China, China Everbright Bank, China Minsheng Bank, Commercial Bank of Dubai, Commercial Bank International, Industrial and Commercial Bank of China, Natixis, Standard Chartered Bank and Union National Bank. Furthermore, Bank of China, Commercial Bank of Dubai, Emirates NBD Bank, First Abu Dhabi Bank, Mashreq Bank and Union National Bank have provided long-term loans.

The solar park is due to produce 5GW by 2030 with investments totalling AED50 billion (US\$13.6 billion).

950 MW

3 x 200 MW through

1 x 100 MW Tower

1 x 250 MW PV



上海电气
SHANGHAI ELECTRIC



هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority



DEWA 950MW CSP/PV Power Park

DEWA, ACWA, and Silk Road Fund financial close on 950MW power park

By Tom Kenning

Dubai Electricity and Water Authority (DEWA) and a consortium of Chinese government-owned Silk Road Fund, ACWA Power and Chinese government-owned Silk Road Fund, have reached financial close on the 950MW fourth phase of the Mohammed bin Rashid Al Maktoum Solar Park.

The lending group to the project, which is spread between 250MW of CSP and 250MW of PV, includes Agricultural Bank of China, Bank of China, China Minsheng Bank, Commercial Bank of Dubai, Industrial Bank of China, Natixis, Standard Chartered Bank, Bank of China, Commercial Bank of Dubai, Mashreq Bank and Union National Bank have provided financing for the project.

The solar park is due to produce 5GW by 2030 with investment of 10 billion).

950 MW

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1 x 100 MW To

250 MW PV



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Saudi Arabia targets 2.7 GW Concentrated Solar Power in 2030

Saudi Arabia targets 2.7 GW Concentrated Solar Power in 2030

The Renewable Energy Project Development Office of Saudi Arabia (REPDO) published the "Saudi Arabia's Renewable Energy Program 2030" earlier on January 9th, the country's renewables target for 2023 has been revised up from 9.5 GW to 27.3 GW, and that for 2030 set at 58.7 GW, of which 40GW PV, 16GW Wind and 2.7GW CSP.



With 11 solar tenders planned for this year, Saudi Arabia may be raising its game in the solar market. And for CSP niche, together with countries like UAE, Morocco, the planning of 2.7GW in 2030 in KSA will make Middle East & North Africa (MENA) region the leading CSP (Concentrated Solar Power) market globally.

Projects will be deployed in 35+ parks spread across the Kingdom

سيتم تنفيذ المشاريع في أكثر من ٣٥ موقع موزعة في جميع أنحاء المملكة



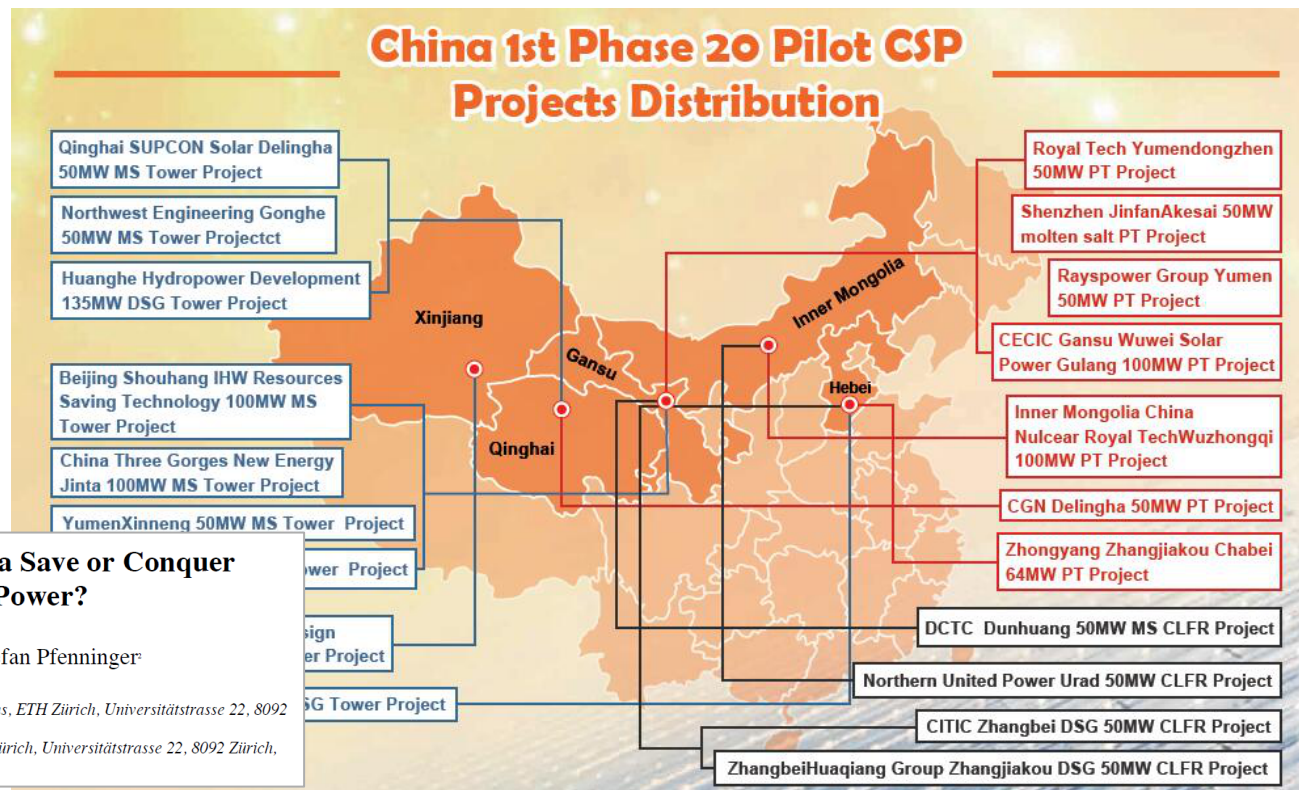
هيئة كهرباء
& Water Authority



China

As of February 2019

- 4 plants, with a total capacity of 210MW
- 6 additional plants (350MW) expected by end of 2019



The Dragon Awakens: Will China Save or Conquer Concentrating Solar Power?

Johan Lilliestam^a, Lana Ollier^b, Stefan Pfenninger

^aRenewable Energy Policy Group, Institute for Environmental Decisions, ETH Zürich, Universitätsstrasse 22, 8092 Zürich, Switzerland.

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中国科学院电工研究所

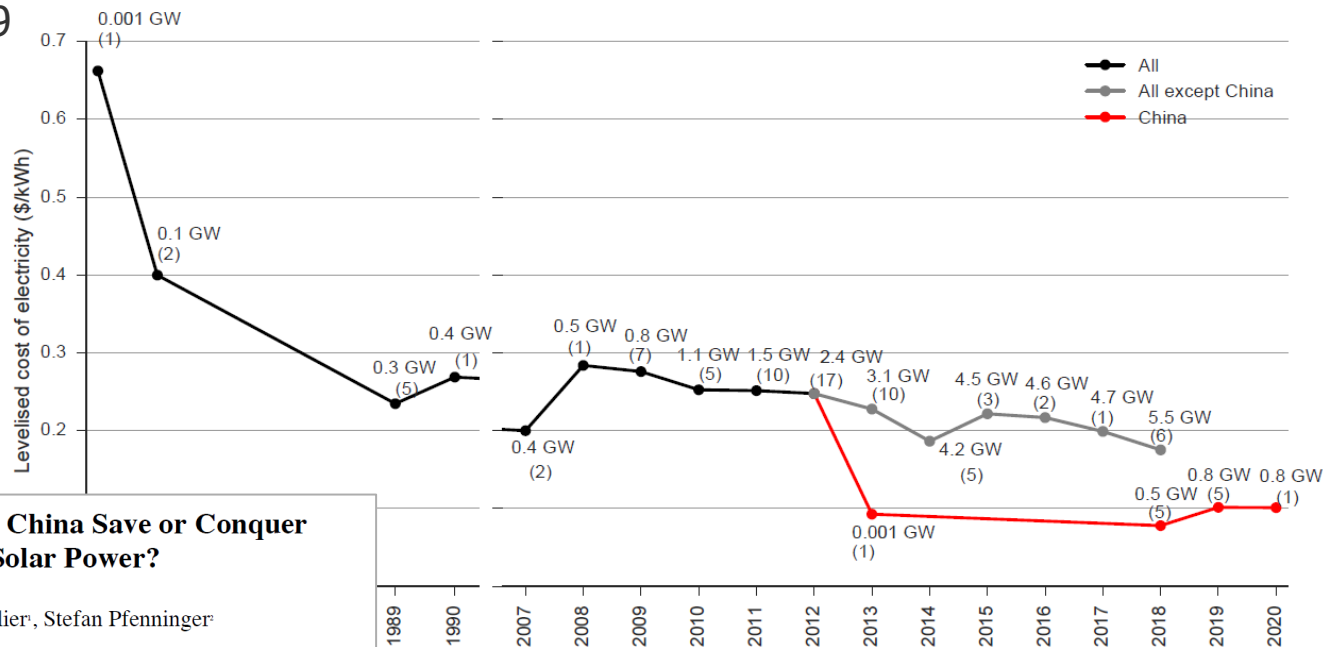
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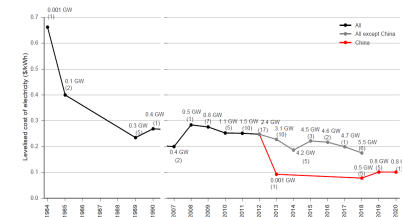
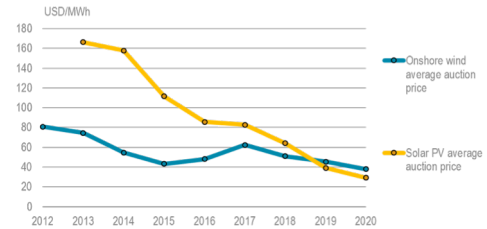
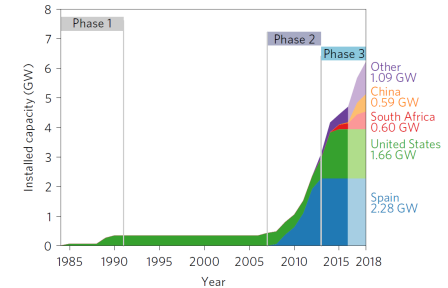
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Summary

- Worldwide deployment of CSP has ebbed and flowed over time, resulting in learning (and relearning) under each deployment phase.
- Solar photovoltaics and wind have seen substantial reductions in cost/price, resulting in competitive pressure on CSP.
- The cost of CSP has dropped dramatically in recent years, driven by competition in new markets and – for now - the introduction of new Chinese players driven by Chinese policy.





Thank you

www.nrel.gov

Mark S. Mehos
mark.mehos@nrel.gov
www.nrel.gov/csp

