Concentrating Solar Power – Global Status

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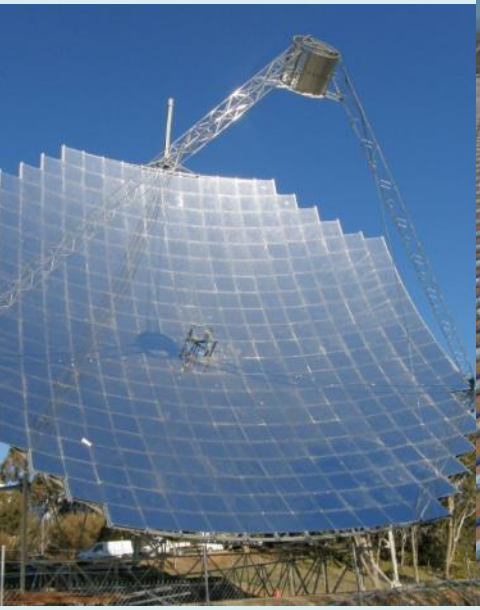
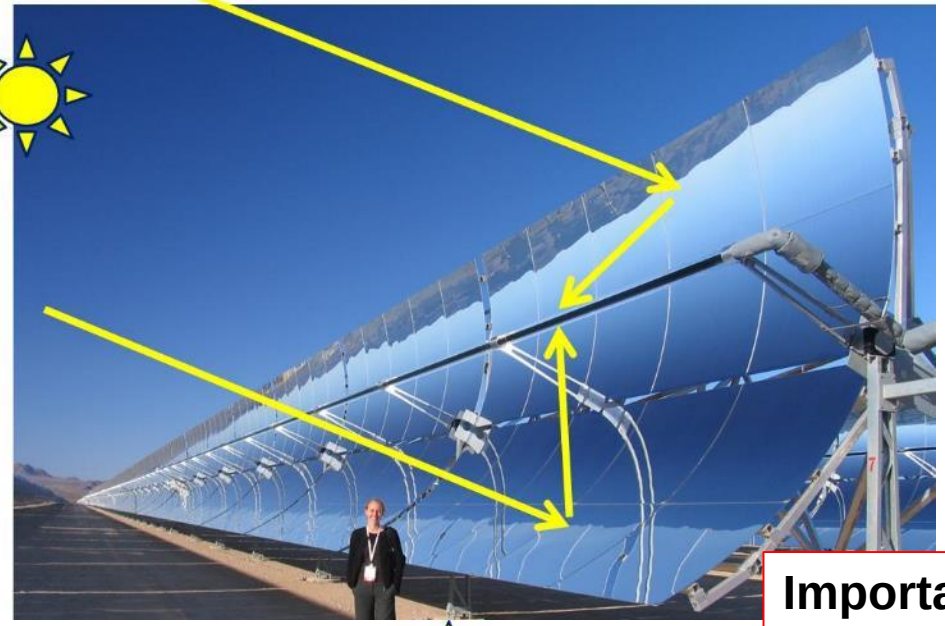
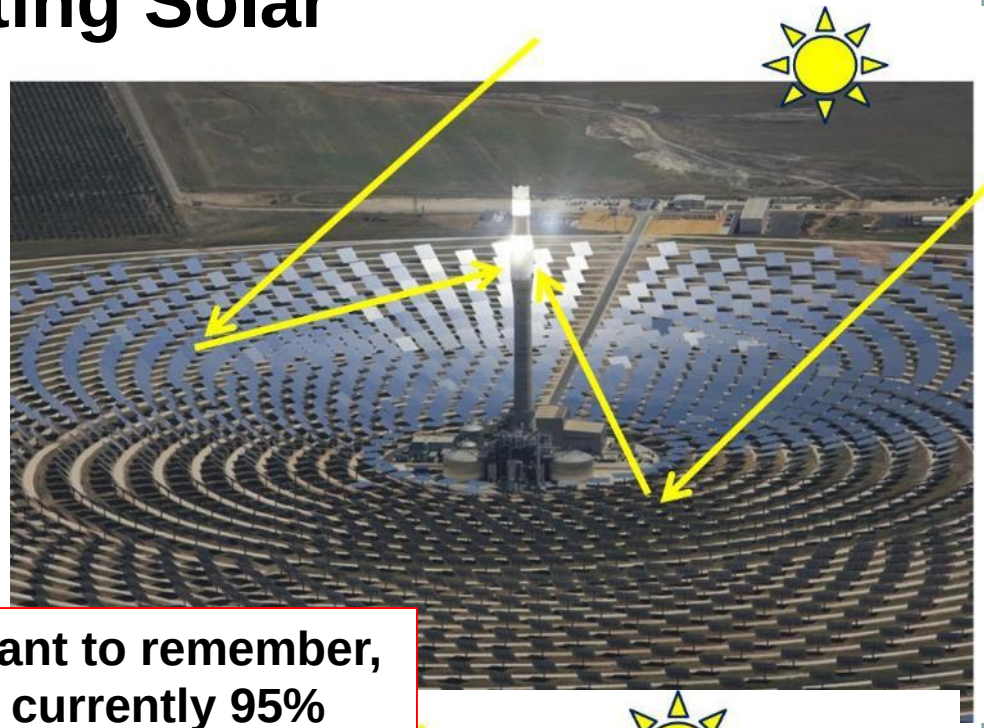
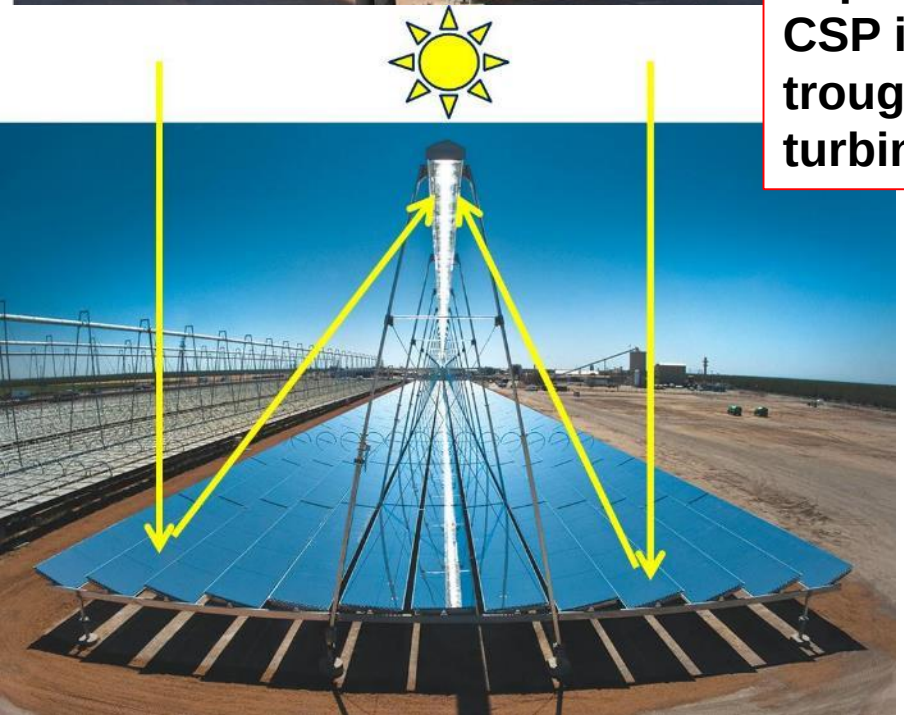


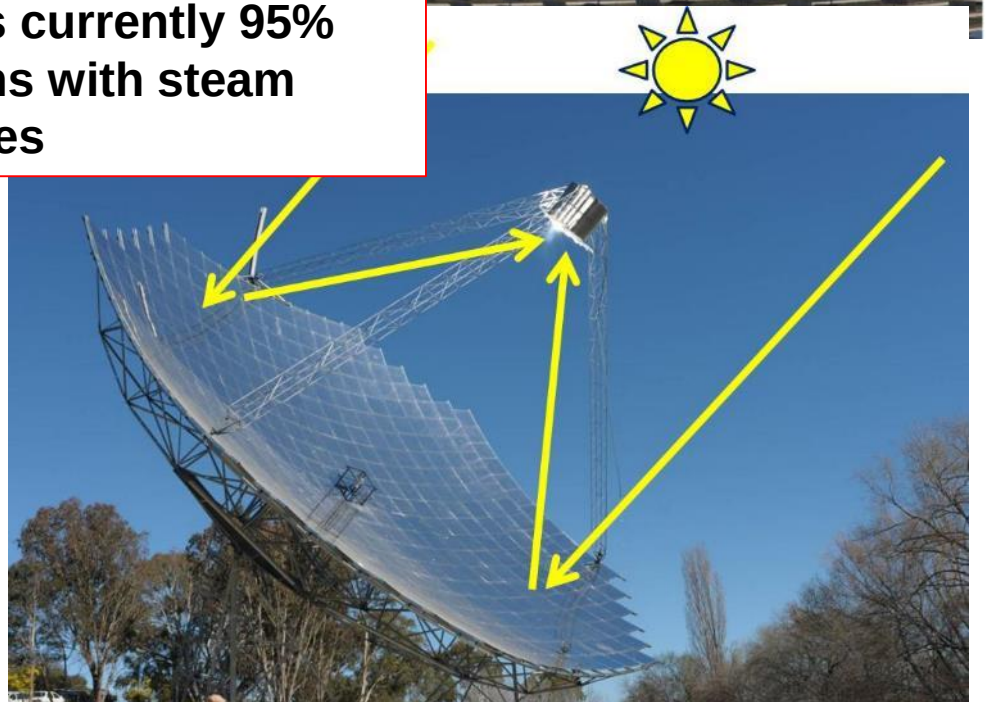
Concentrating Solar



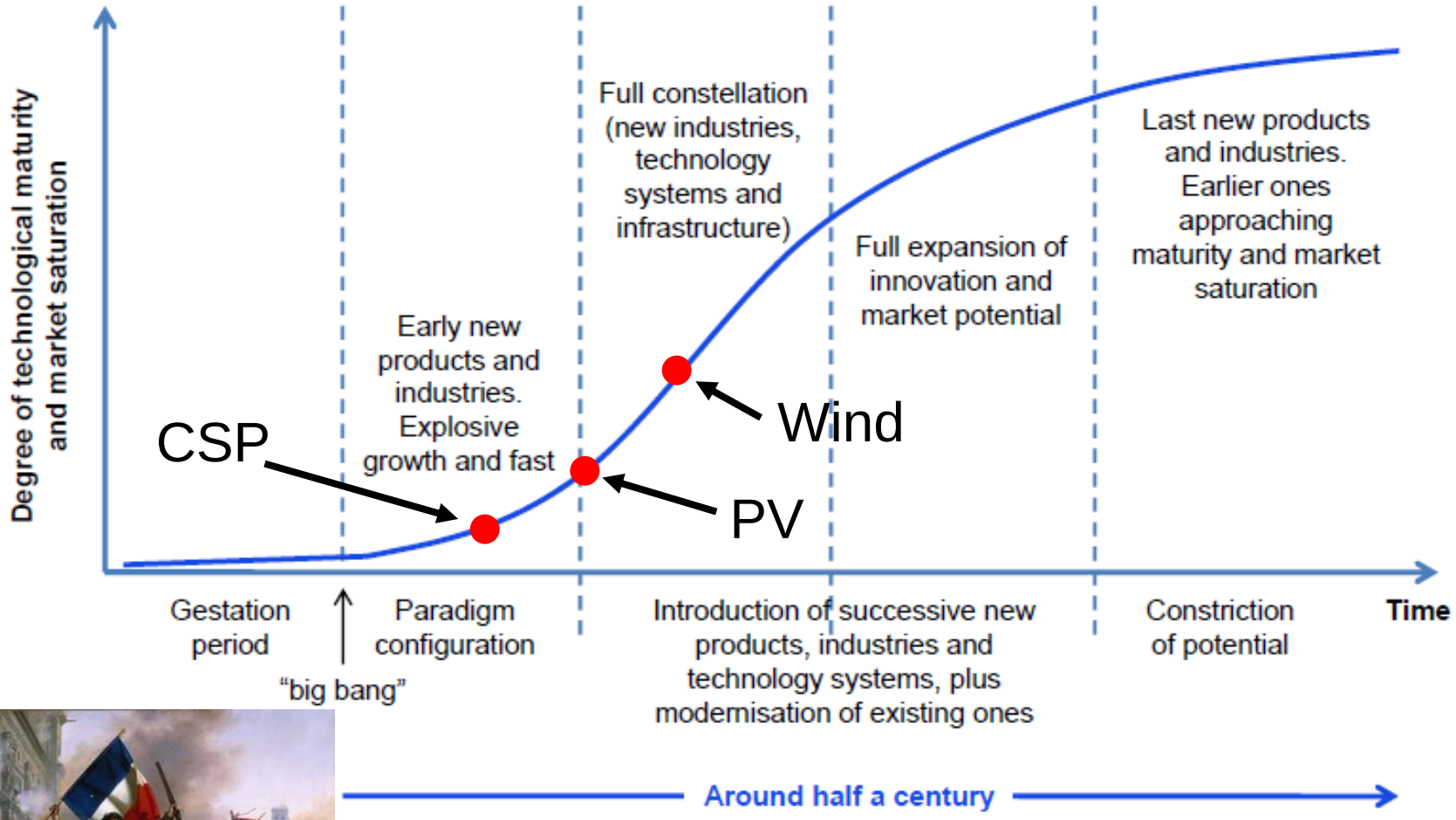


Important to remember, CSP is currently 95% troughs with steam turbines



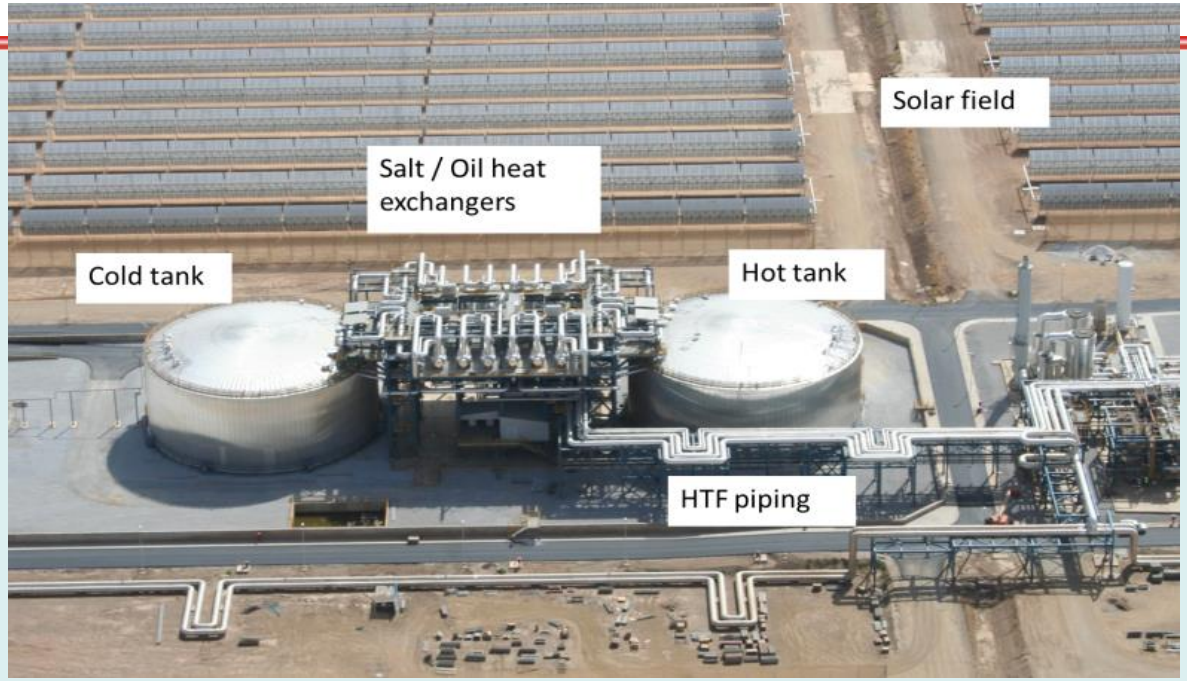


Lifecycle of an energy technology revolution



PÉREZ C. (2002), *Technological Revolutions and Financial Capital. The Dynamics of Bubbles and Golden Ages*, Edward Elgar, Cheltenham.

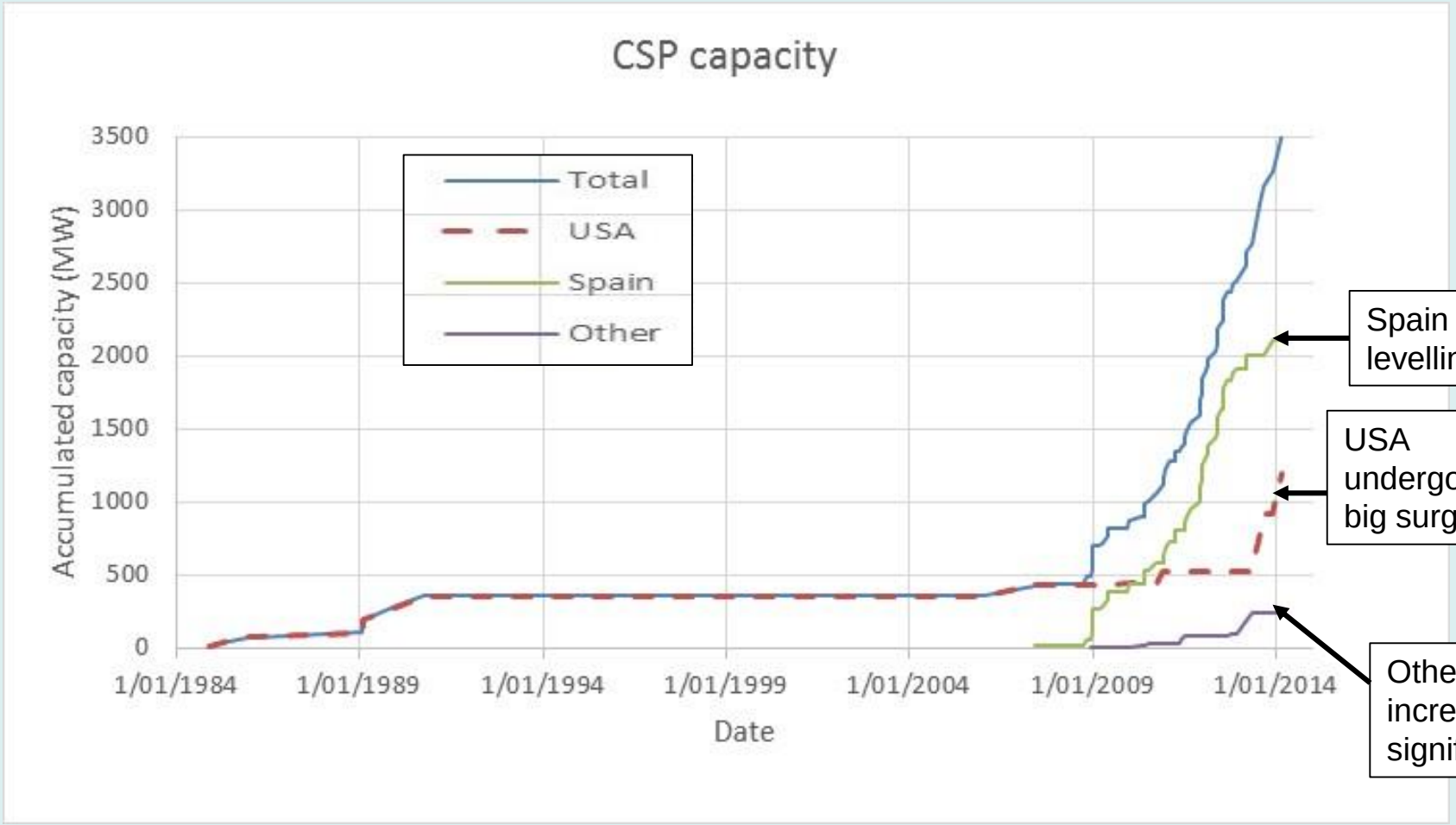
Proven Thermal Energy Storage is CSP's big competitive advantage



Background pic, Andasol 3 courtesy Ferrostaal

- Thermal storage is "integrated" – improves output, little or no extra cost
- Two tank molten salt is proven / standard (62% plants in Spain)
- A Higher temperature range makes it cheaper
- Some storage actually reduces CSP LCOE.
- A CSP system could simultaneously offer electricity storage at 30 - 40% round trip efficiency

History of CSP deployment

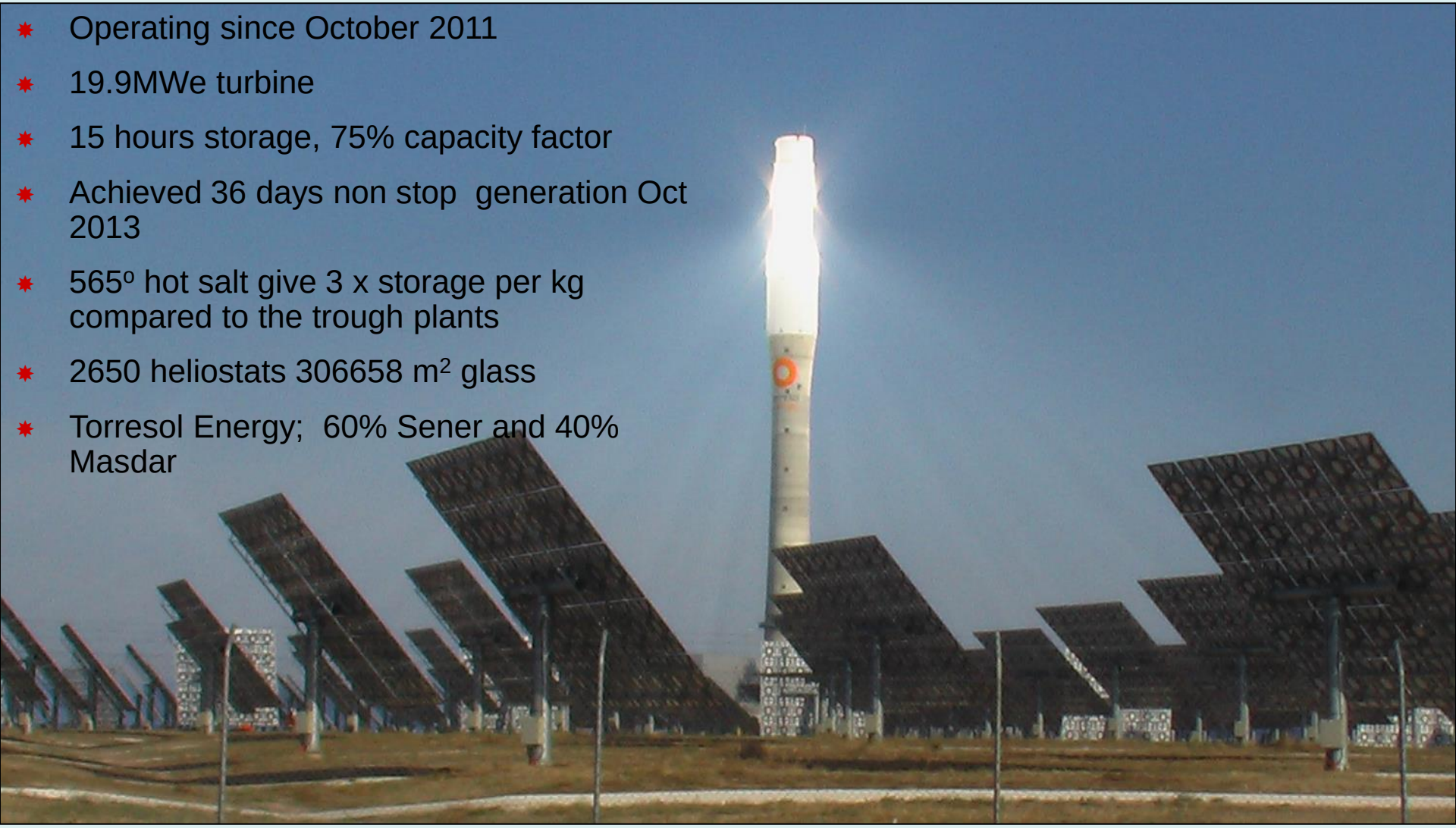


Andasol 3 – a typical Spanish trough plant

- Typical Spanish 50MW$_e$ trough plant
- 7.5hrs molten salt storage
- New high efficiency MAN turbine
- Construction around 18 months from ground breaking to on grid

Gemasolar, near Seville celebrates 2 years

- Operating since October 2011
- 19.9MWe turbine
- 15 hours storage, 75% capacity factor
- Achieved 36 days non stop generation Oct 2013
- 565^{o} hot salt give 3 x storage per kg compared to the trough plants
- 2650 heliostats 306658 m^2 glass
- Torresol Energy; 60% Sener and 40% Masdar



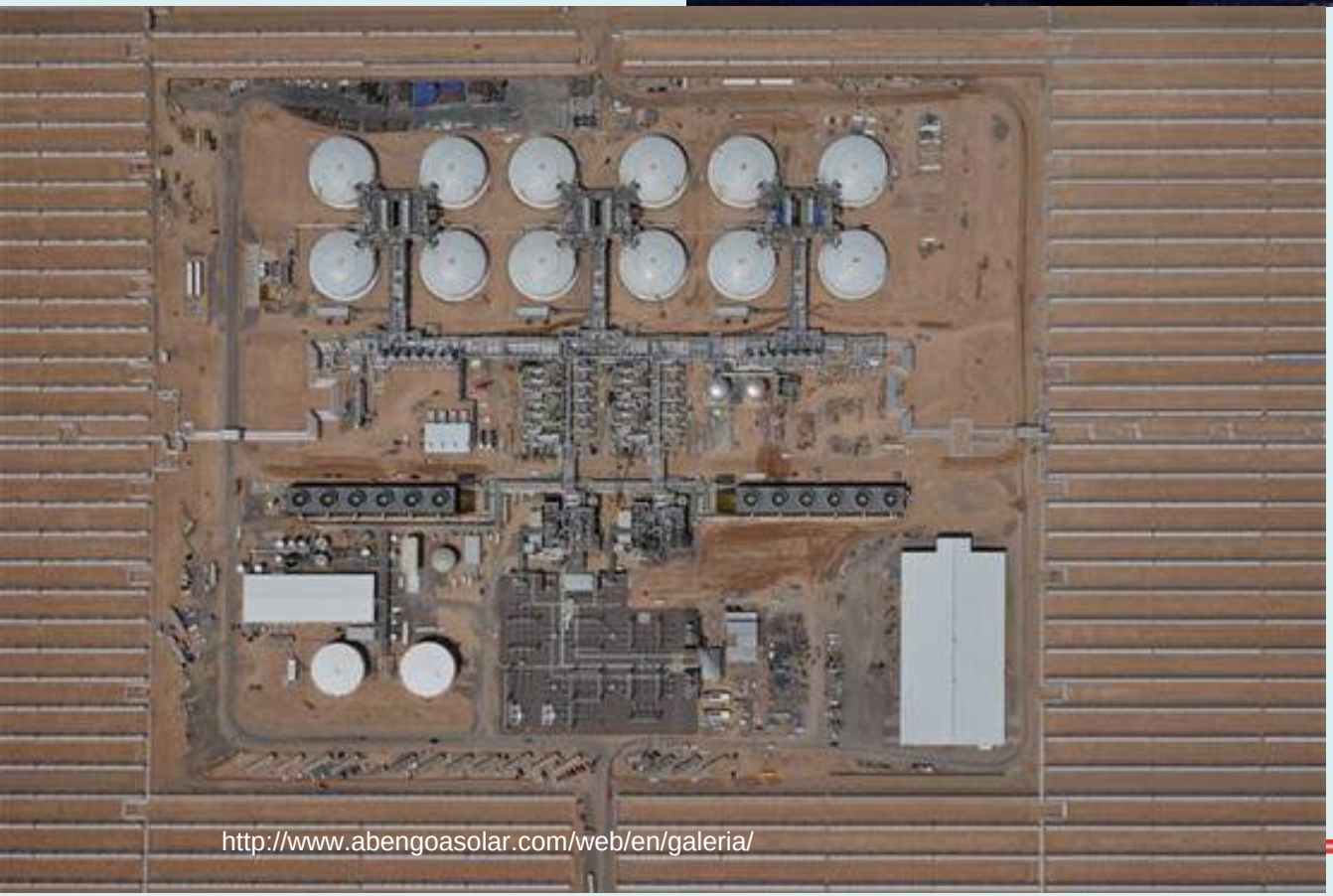
Brightsource's Ivanpah 400MW$_e$ system under final stages of commissioning

http://www.brightsourceenergy.com/ivanpah-update

Solar Reserve's Crescent Dunes project

- Nevada, north of Las Vegas
- 110MW$_e$ with 10 hours molten salt energy storage
- Biggest ever tower system
- Commissioning underway 2014

Abengoa's Solana system started operation October 2013



http://www.abengoasolar.com/web/en/galeria/

280 MW trough plant with six hours of thermal storage.
70 miles southwest of Phoenix, Arizona.
Construction began at the end of 2010.

India’s first plant; Godawari 50MW trough system working well since May 2013

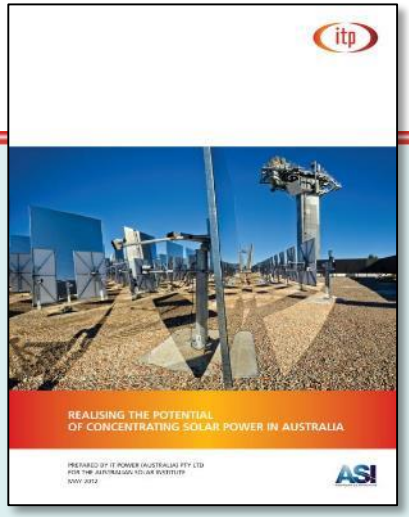
Kogan Creek Solar Boost will be Australia's first commercial CSP plant

- CS Energy and AREVA Solar
- South West Queensland
- 44 MW_e solar thermal addition to 750 MW coal-fired Power Station
- AREVA Solar CLFR Technology
- 500 metres x 600 metres (30 hectares)
- 14 x 500 metre long Solar Steam Generators (SSGs)
- $104.7 million

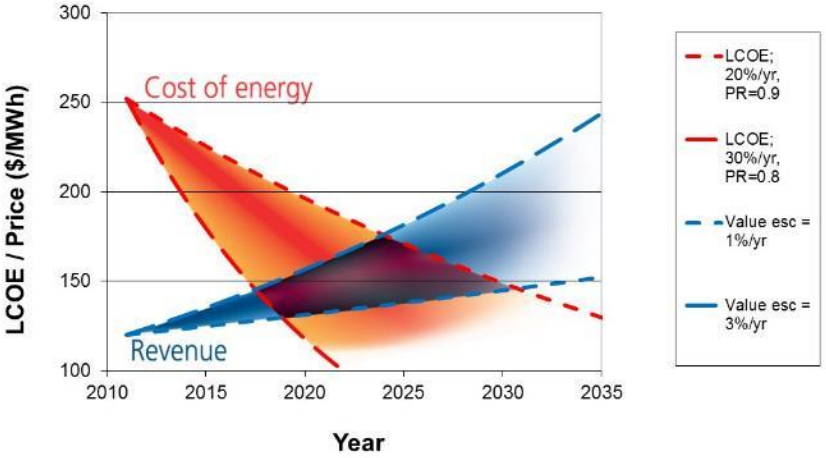
Key International CSP market developments

- Spain: projects approved for old FIT gradually finish then slow .
- USA: 5 plants under commissioning /construction to 1.28GW$_e$, announcement of a new Abengoa / Brightsource tower system.
- India: 20GW Solar by 2022 JNNSM, first phase 470MW$_e$ CSP under construction – first 50MW plant on line June 2013.
- South Africa: 1 GW CSP by 2030, 200MW allocated to 1x trough and 1 x tower projects under construction, others coming.
- Saudi Arabia: 25GW target for CSP by 2030.
- Italy: Generous FIT; aiming for 250MW$_e$ by 2020, proposals to 400MW for Sicily and Sardinia.
- Morocco: 42% solar by 2020, first 160MW of CSP underway at 500MW Ouazazate site.
- Chile? Others?

Key findings from ITP's 2012 study of CSP for Australia



- Around 15GW could be realistically installed without major grid extensions
- In a competitive market, a system configured for peaking operation could earn 2 x pool average
- A "baseline" trough plant with no storage in Longreach would have an LCOE of $250/MWh
- Maximum current income from such a system would be around $110/MWh
- An optimum level of energy storage reduces LCOE
- Cost and value will converge in 6 -18 years
- http://www.australiansolarinstitute.com.au/reports/



100% renewables scenarios need CSP with storage

- Australian Energy Market Operator, 2013 study of 100% renewables
- CSP with storage is needed for meeting demand at all times and managing the system

e 12: Annual energy generation by technology, Scer

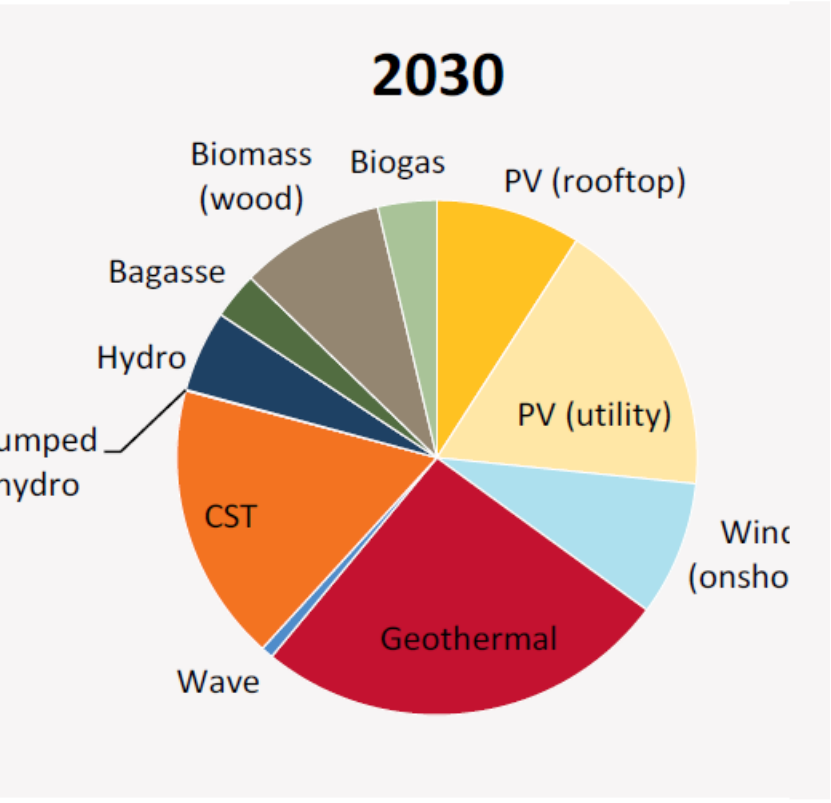
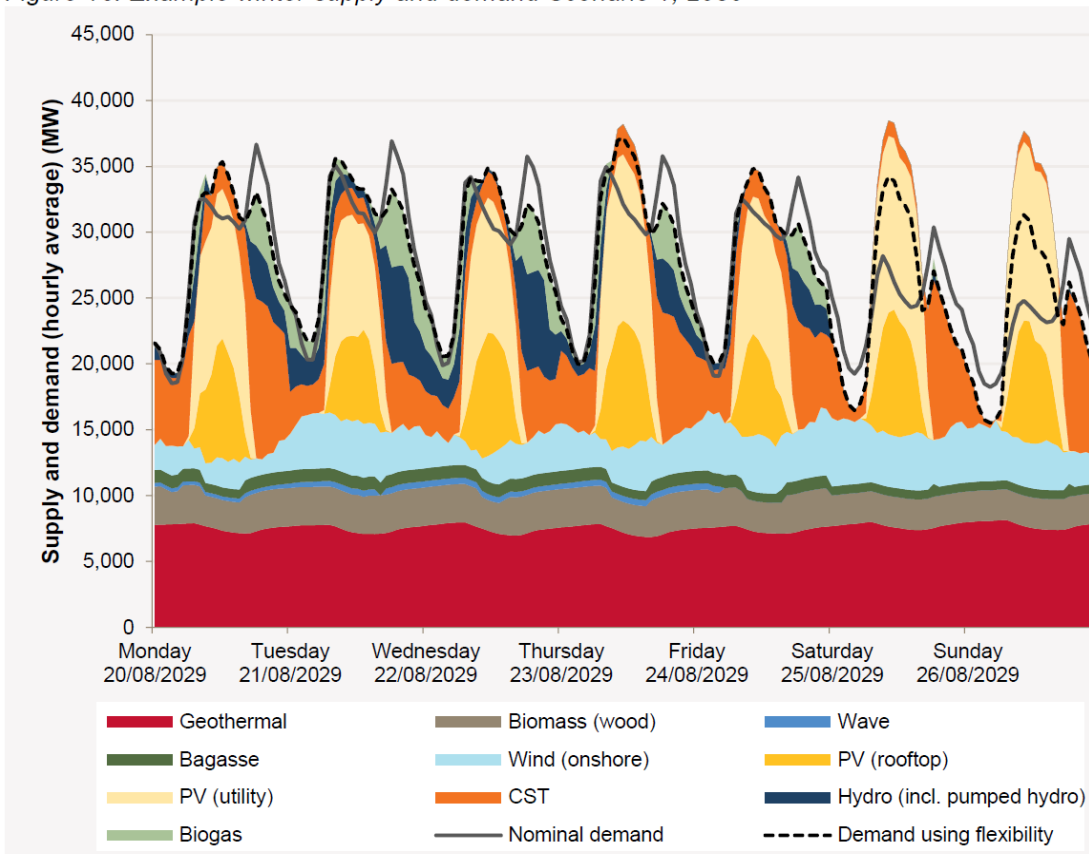


Figure 16: Example winter supply and demand Scenario 1, 2030



CSP Value Proposition

- CSP offers:
  - Green electricity (same as wind or PV)
  - Community / society benefits (greater share of investment in regional areas)
  - Hybridisation with fossil fuels
  - Option / hedging value
- Using thermal energy storage adds:
  - Moving energy sales to high demand periods,
  - Ancillary services (frequency control, voltage control, system stability, black start etc)
  - Whole electrical network avoided cost.

CSP in context – the next big thing?