

Concentrated Solar Power Modular Power Tower

November 7, 2012



imagination at work

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Today's agenda

- GE & eSolar
- Our scalable approach
- Direct steam experience
- Hybrid power plants
- Thermal storage development
- Summary

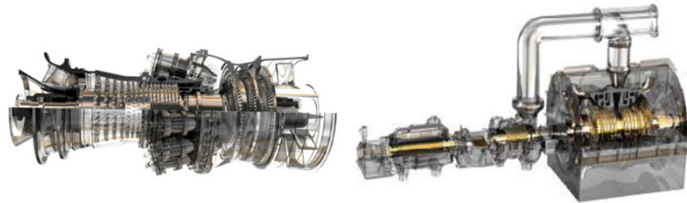


GE alliance with eSolar

Integrated solar combined cycle and concentrated solar plants



- Leading-edge GT technology
- 100+ year ST experience
- Strategic equity investment



- Proven solar technology
- Unique modular, scalable design
- Rapid installation
- Advanced control/ optimization software

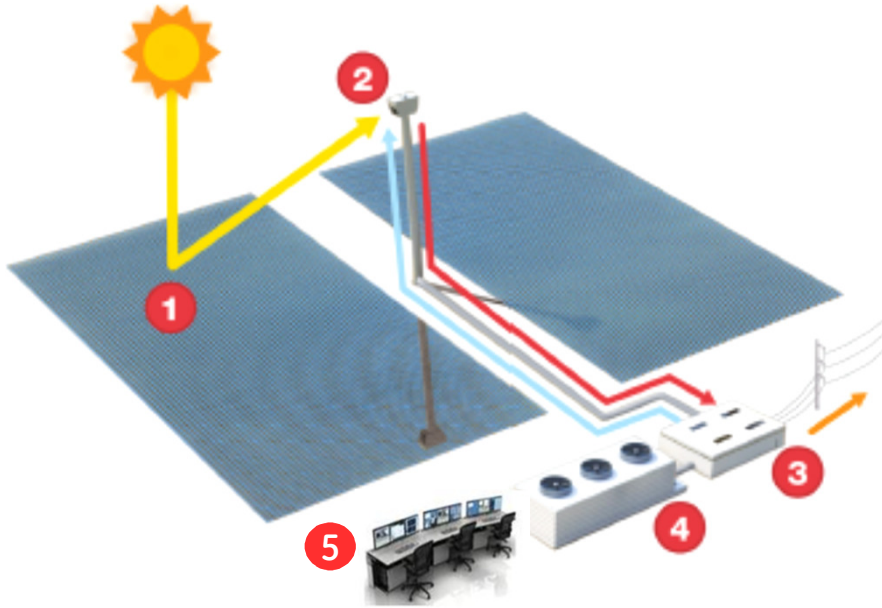


Working to deliver integrated technology solutions



Modular CSP Tower Technology

eSolar CSP Technology – Overview



- 1 Solar Collection System (SCS) – Two sub-fields of dual axis heliostats (~25,000/ tower)
- 2 Solar Receiving System (SRS) – collects energy from SCS to generate superheated steam in receiver on 65m tower

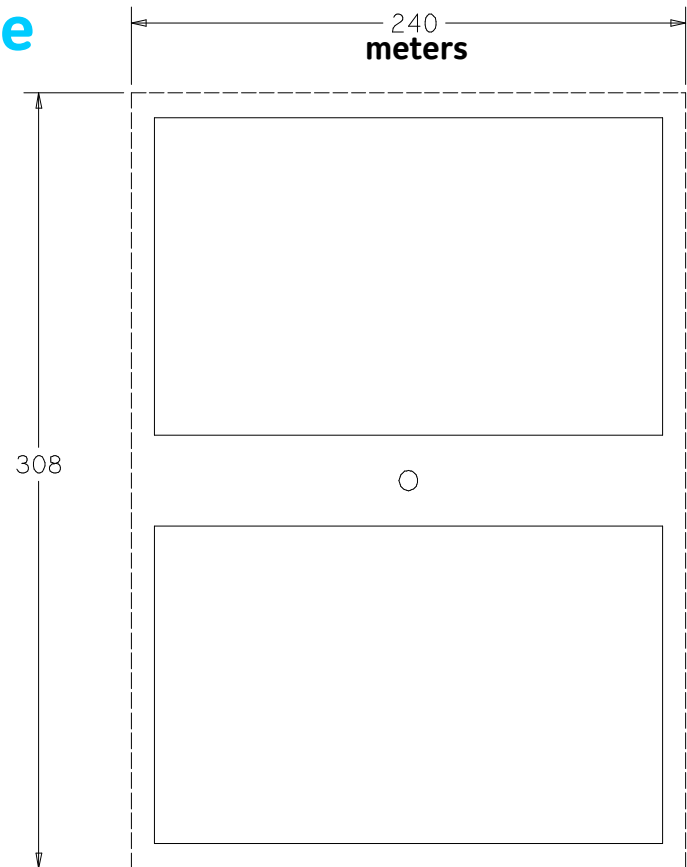
- 3 Steam turbine generator or combined cycle power island
- 4 Cooling towers or air cooled condensers
- 5 Control & Optimization System “SPECTRA”



50MWe reference field layout

For 2400 Annual DNI/ 1.1 solar multiple

- 2 subfields of 84 rows, 133 heliostats per row
- 22,340 heliostats per tower
- 10m perimeter around field
- 18.3 acres (7.4 hectares) per tower
- 10 towers
- 223,400 total heliostats
- 183 acres (74 hectares)
- 3.7 acres/MWe



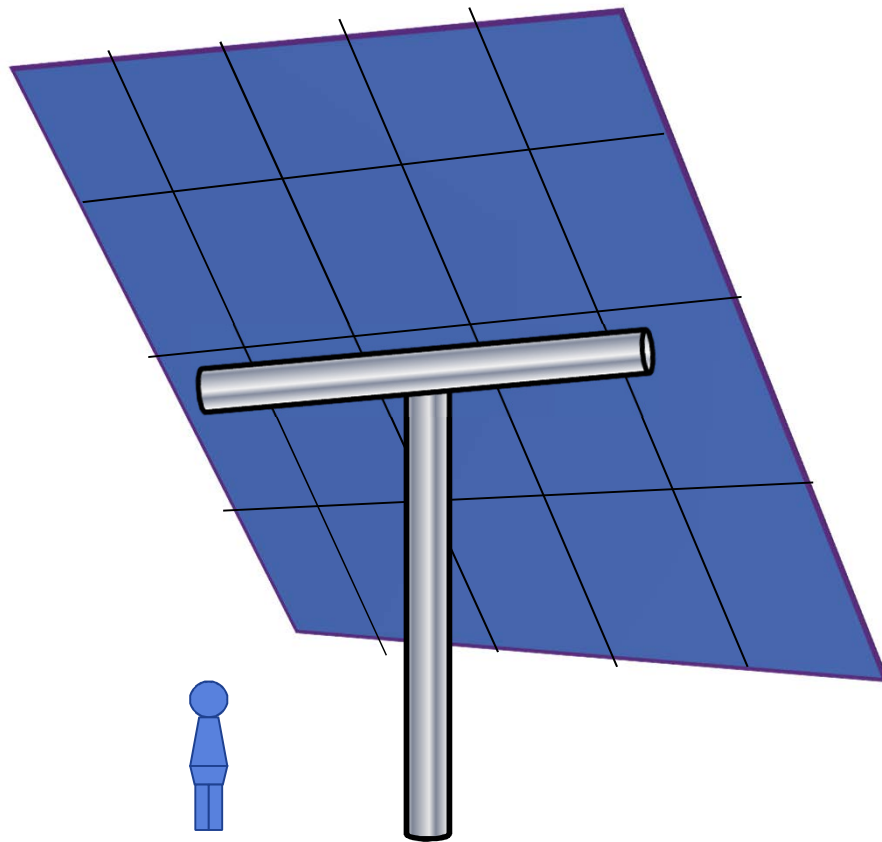
Differentiating features

Modular tower technology

- **Scalability** ... single module size for multiple configurations
 - Capacity factor (20 - 30%)
 - Solar multiple (1.0 - 1.3)
 - Overall plant size (up to ~100MW)
- **Lower tower heights** (versus single tower plants)
- **Fault tolerance** (no single point tower failure)
- **Standardized design** ... reduces project specific engineering cost/risk



Large heliostats ... high material & construction cost requirements



- Large heliostats can be greater than 100m²
- Size drives higher wind loads ... requires robust structure and foundation
- Large, powerful actuators required for aiming accuracy
- Heavy lifts in the field required to set heliostats

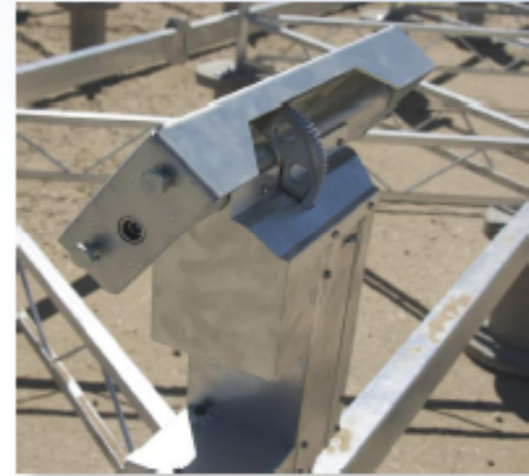
Smaller profile heliostats ... lower costs



eSolar uses small, flat mirrors about the size of a flat screen TV



Heliostats are small and low to the ground ... much lower wind forces result in less steel and complexity



Actuator designed for reliable, accurate operation and cost

Heliostat Technology



- Low profile installation (requiring much less steel & no ground penetration)
- Rapid field deployment (one subfield in ~2-3 weeks w/o heavy equipment)
- Breakthrough software control of mirror calibration and tracking
- Semi-automated cleaning



Before calibration



After calibration



Cleaning unit

External direct steam receiver



- 11'x11'x20', 45 tons
- Factory assembled, lifted in one piece
- Natural circulation vertical drum
- 440°C, 60bar outlet steam

Operating eSolar Technology

5MWe Sierra Plant

- Proven technology demonstrated at scale
- On-line since 2009 in Lancaster, CA.

B&W External Receiver



Acme Bikaner, India Project

- Located approximately 40km north of Bikaner, Rajasthan
- Construction began early in 2010 ... Commissioning completed in April of 2011



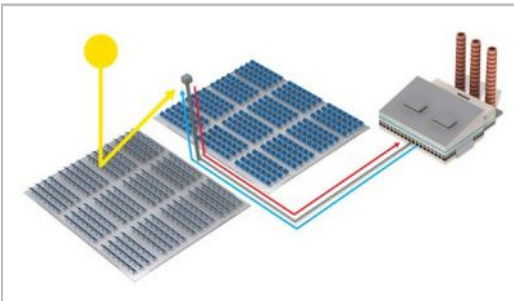
Integrated Solar Combined Cycle

Modular tower CSP offering ... application flexibility



ISCC

- Initial offerings 10%-15% of plant rating ... driving for greater solar fraction
- ~8% increase in fuel efficiency with solar contribution

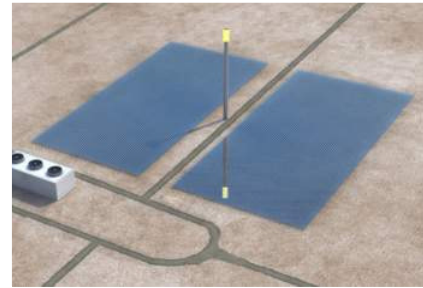


Hybrid Fossil

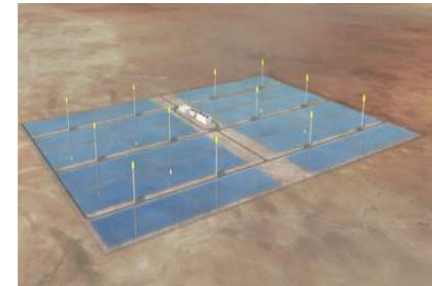
- Initial offerings 10%-15% of plant rating ... driving for greater solar fraction
- Solar integrated into feedwater heating
- ~8% increase in fuel efficiency

Stand Alone

- Direct steam without storage available today
- 100MWe maximum per power block
- Molten Salt storage available for strategic pilot



5MWe Module



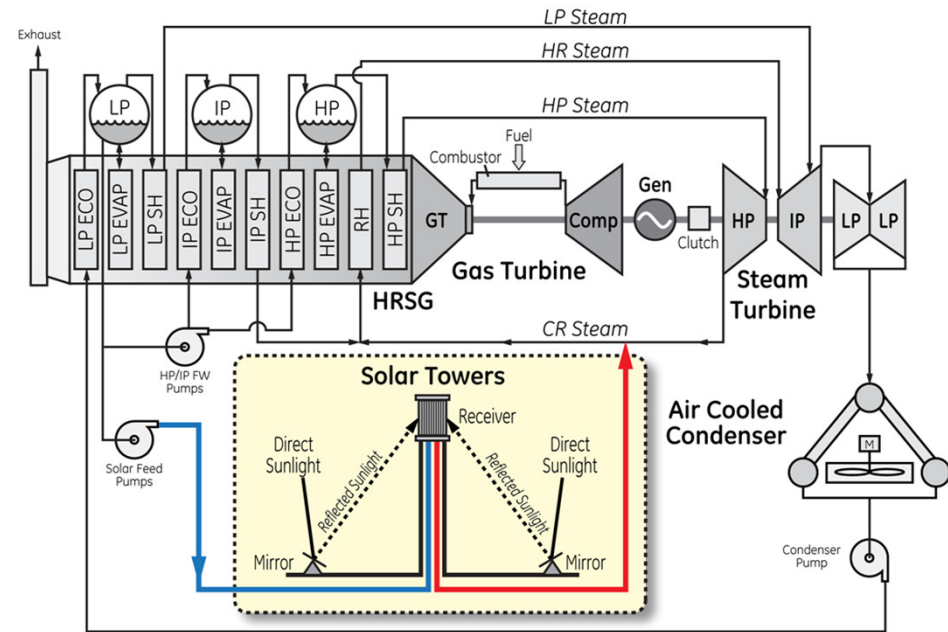
50MW plant



Multi-plant CSP Farm



Integrated Solar Power Plants ... hybrid approach



- Stronger financial viability ... leverages capex investment in power block
- Mitigates concerns over generation volatility of solar
- Complex technical integration ... requires deep equipment/plant expertise
- Enhances fuel efficiency of host plant when solar is available

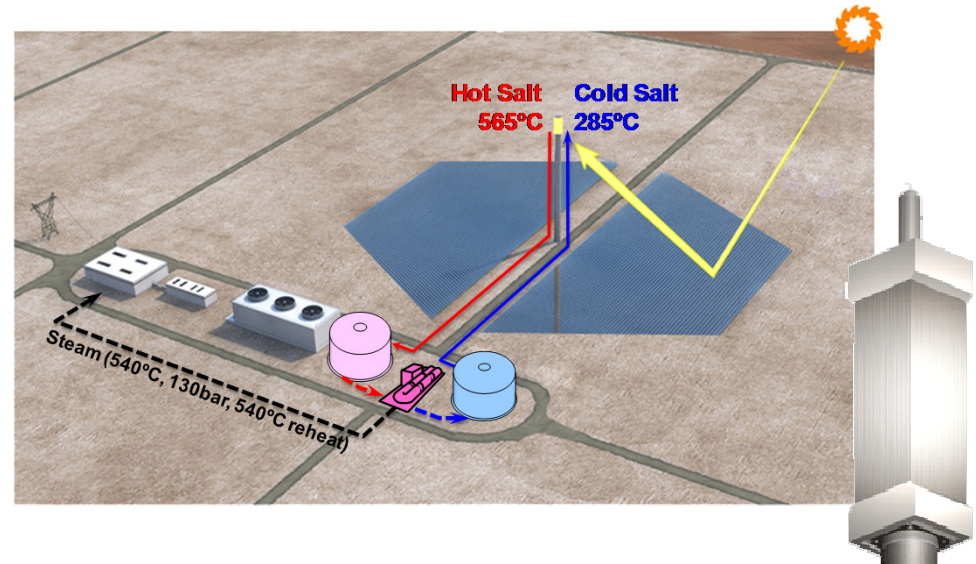
Projects drive volume on standard components ... cost maturity

Thermal Storage

Modular Molten Salt Technology

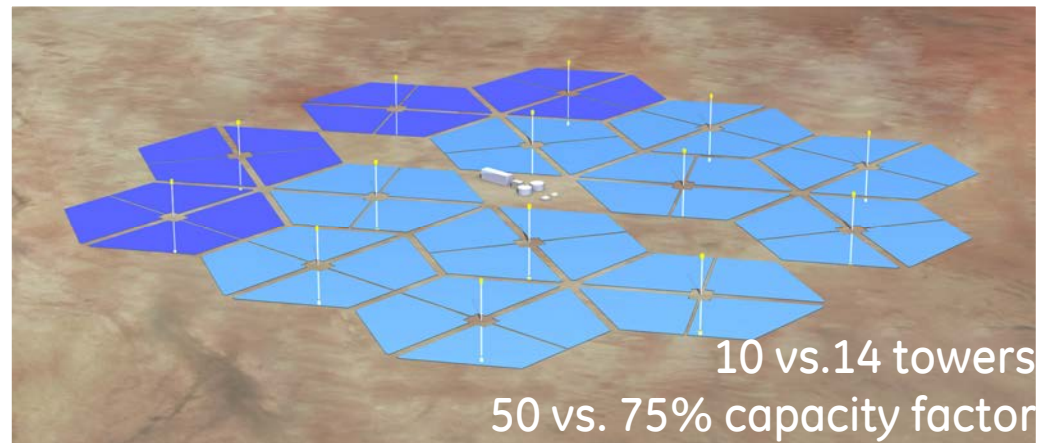
Thermal module

- 92,568 heliostats in a hexagonal field
- 100m monopole tower
- 50 MW_t shippable molten salt receiver generating 565°C steam



Reference 100-MW plant

- 10 to 14 thermal modules (depending on desired Capacity Factor)
- Two 39m by 17m tanks to store up to 13 hours of hot and cold salt
- 275 MW_t steam generator powered by hot salt to drive a conventional 100MW steam turbine, when power is needed



Localization Opportunity

CSP localization considerations

- **Material/components**
 - Helio­stat Frame
 - Cables/general electronics
 - Receiver towers
 - Mirrors- would require significant volume and possibly a vendor JV
- **Construction and assembly labor**
 - EPC scope/installation/civil work
 - On-site reflector assembly (mirrors adhered to frames in controlled environment)
- **Localization- needs to be cost competitive or factored into evaluation**
- **Volume of projects is essential**
 - Sustainable pipeline needed to support localized vendors

Summary

- Ready to serve growing demand for solar generation
- GE & eSolar bring a unique, scalable, modular solution to the CSP industry
- Hybrid solar plants ... a catalyst for the CSP deployment
- Components support strong localization potential

GE Energy

Thank You!



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