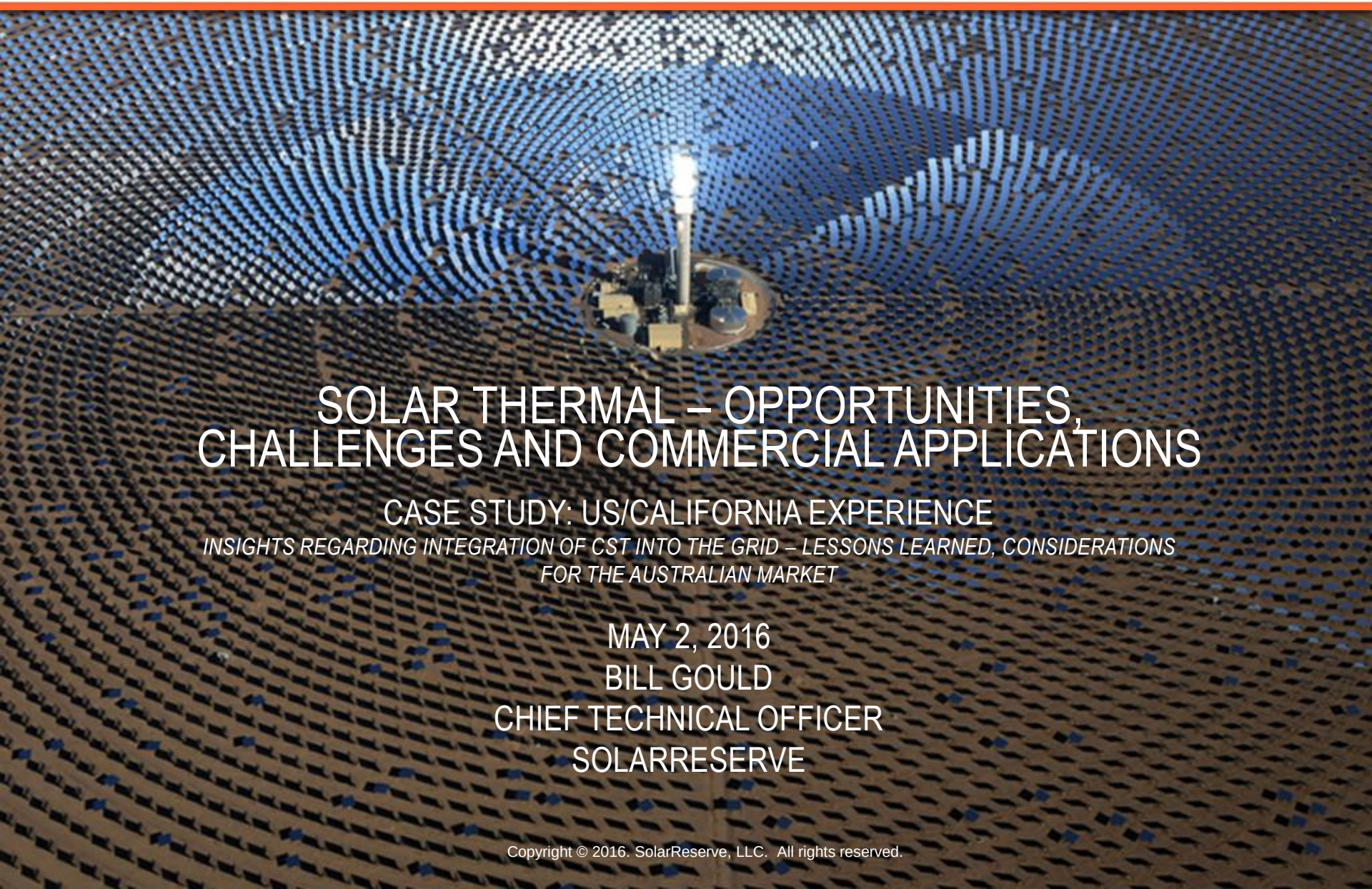
SOLARRESERVE®



SOLAR THERMAL – OPPORTUNITIES, CHALLENGES AND COMMERCIAL APPLICATIONS

CASE STUDY: US/CALIFORNIA EXPERIENCE

INSIGHTS REGARDING INTEGRATION OF CST INTO THE GRID – LESSONS LEARNED, CONSIDERATIONS FOR THE AUSTRALIAN MARKET

MAY 2, 2016

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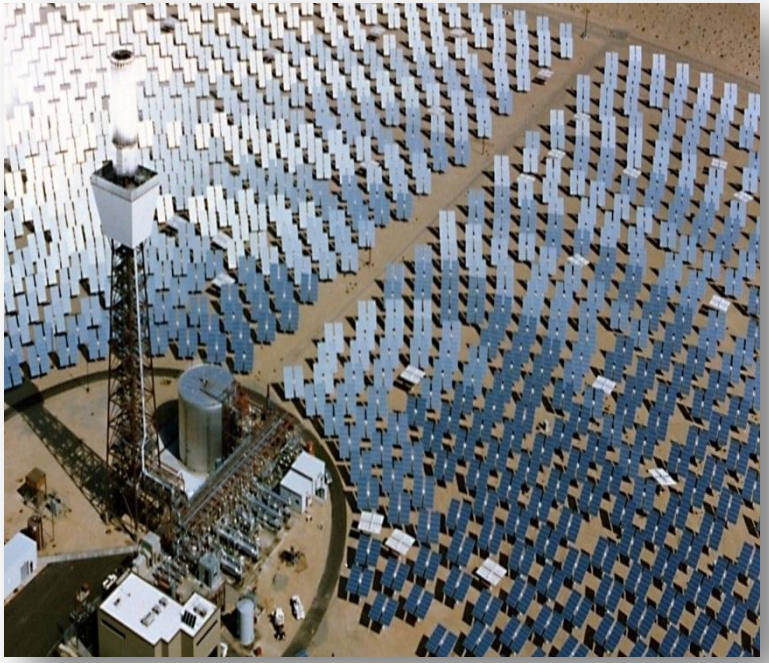
SOLARRESERVE

Data from Early Power Tower Pilot Projects in California Clearly Demonstrated Advantages of Molten Salt Technology Over Direct Steam

Solar One 10 MW Direct Steam
(1979-1984)



Solar Two 10 MW Molten Salt
(1994-1999)

"While Solar One successfully demonstrated power tower technology, it also revealed the disadvantages of a water/steam system, such as the intermittent operation of the turbine due to cloud transients and the lack of efficient thermal storage."

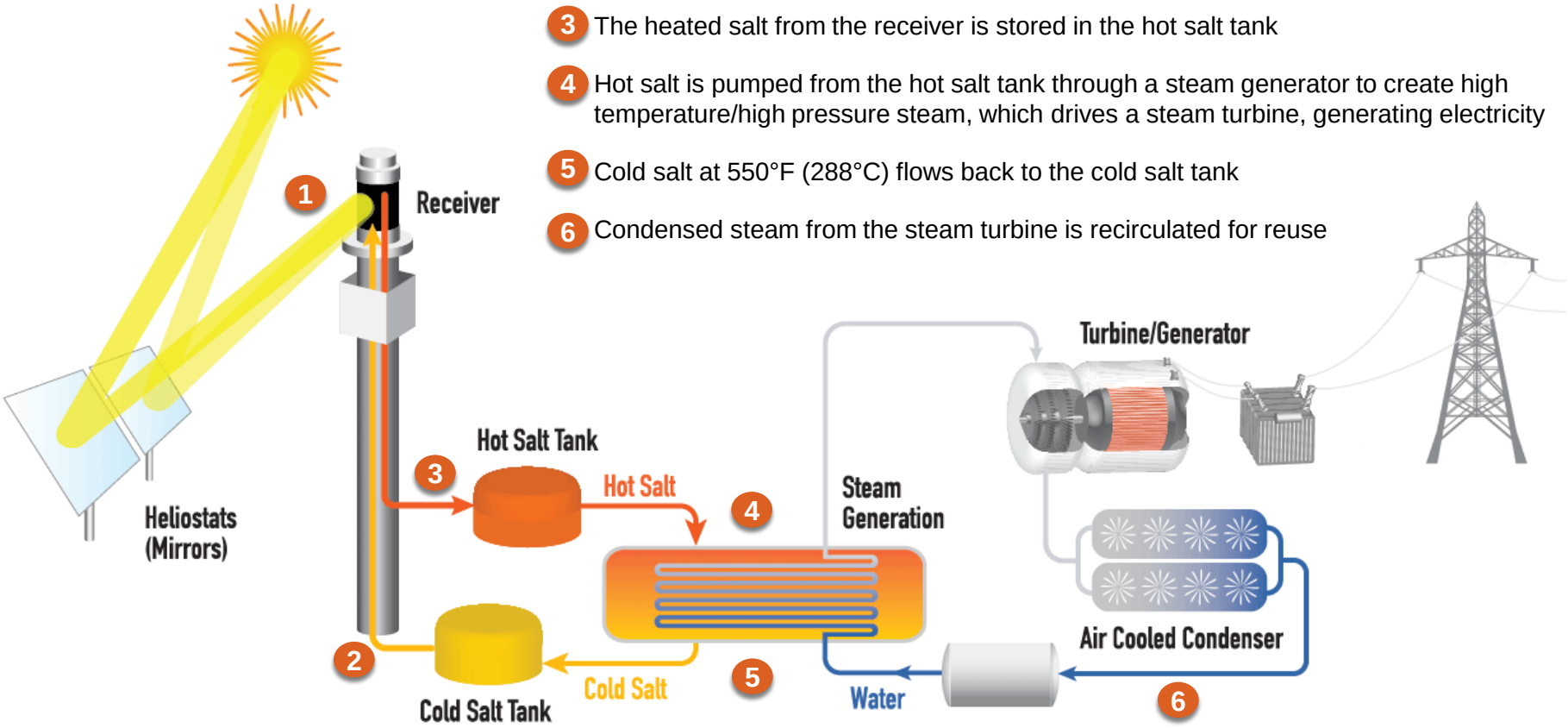
Hugh E. Reilly and Gregory J. (2001), An Evaluation of Molten-Salt Power Towers Including Results of the Solar Two Project, Sandia National Labs, SAND2001-3674


SolarReserve’s technology is the next generation up from Solar Two, incorporating lessons learned from that project

Unmatched Proprietary Energy Storage Technology

Sunlight heats the molten salt directly, resulting in the most efficient and economical energy storage solution

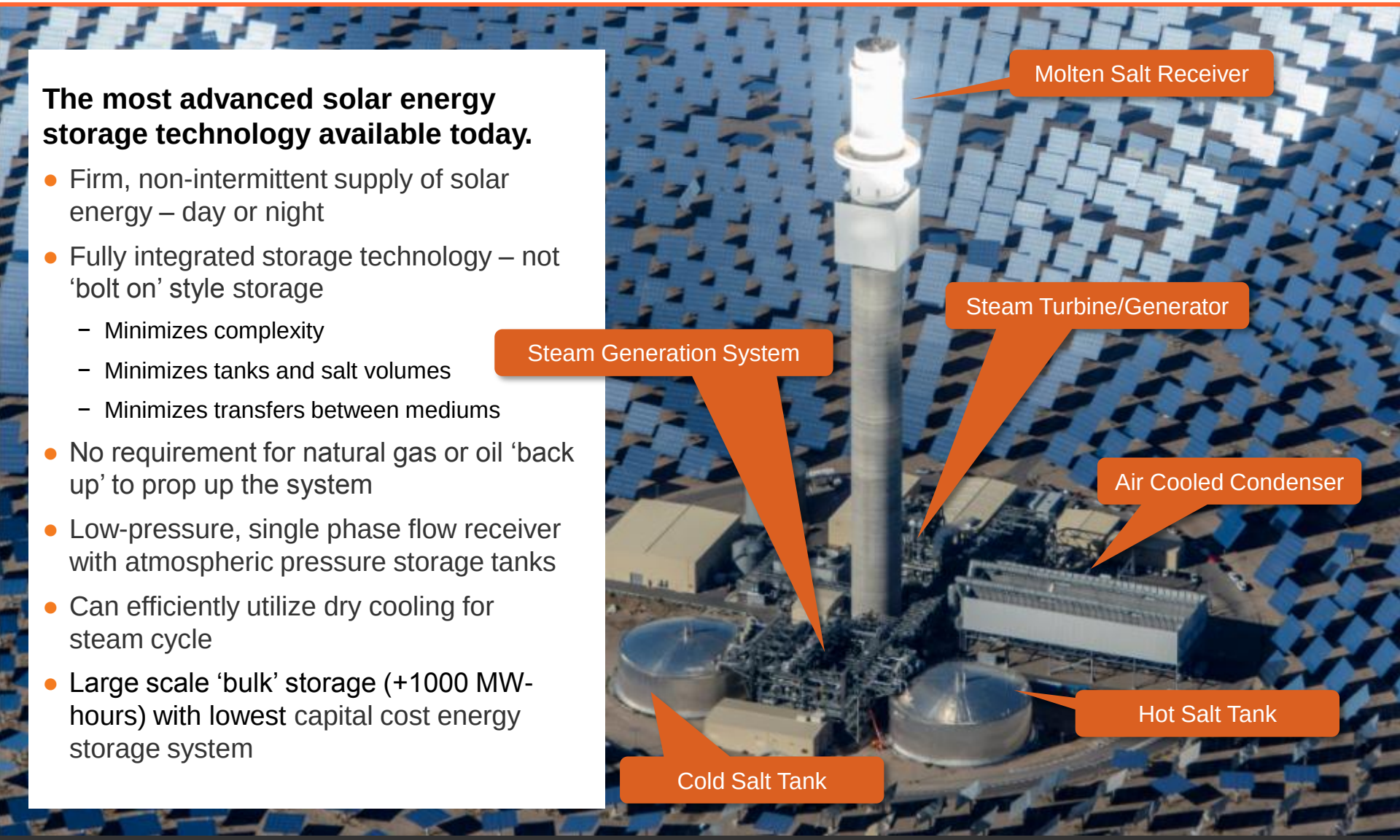
1. Sunlight is concentrated and directed from a large field of heliostats to a receiver on a 640 foot tower
2. Liquid salt from the cold salt tank is pumped through the receiver where it is heated to 1050°F (566°C)
3. The heated salt from the receiver is stored in the hot salt tank
4. Hot salt is pumped from the hot salt tank through a steam generator to create high temperature/high pressure steam, which drives a steam turbine, generating electricity
5. Cold salt at 550°F (288°C) flows back to the cold salt tank
6. Condensed steam from the steam turbine is recirculated for reuse



SolarReserve – “Next Generation” in Solar Technology

The most advanced solar energy storage technology available today.

- Firm, non-intermittent supply of solar energy – day or night
- Fully integrated storage technology – not ‘bolt on’ style storage
  - Minimizes complexity
  - Minimizes tanks and salt volumes
  - Minimizes transfers between mediums
- No requirement for natural gas or oil ‘back up’ to prop up the system
- Low-pressure, single phase flow receiver with atmospheric pressure storage tanks
- Can efficiently utilize dry cooling for steam cycle
- Large scale ‘bulk’ storage (+1000 MW-hours) with lowest capital cost energy storage system



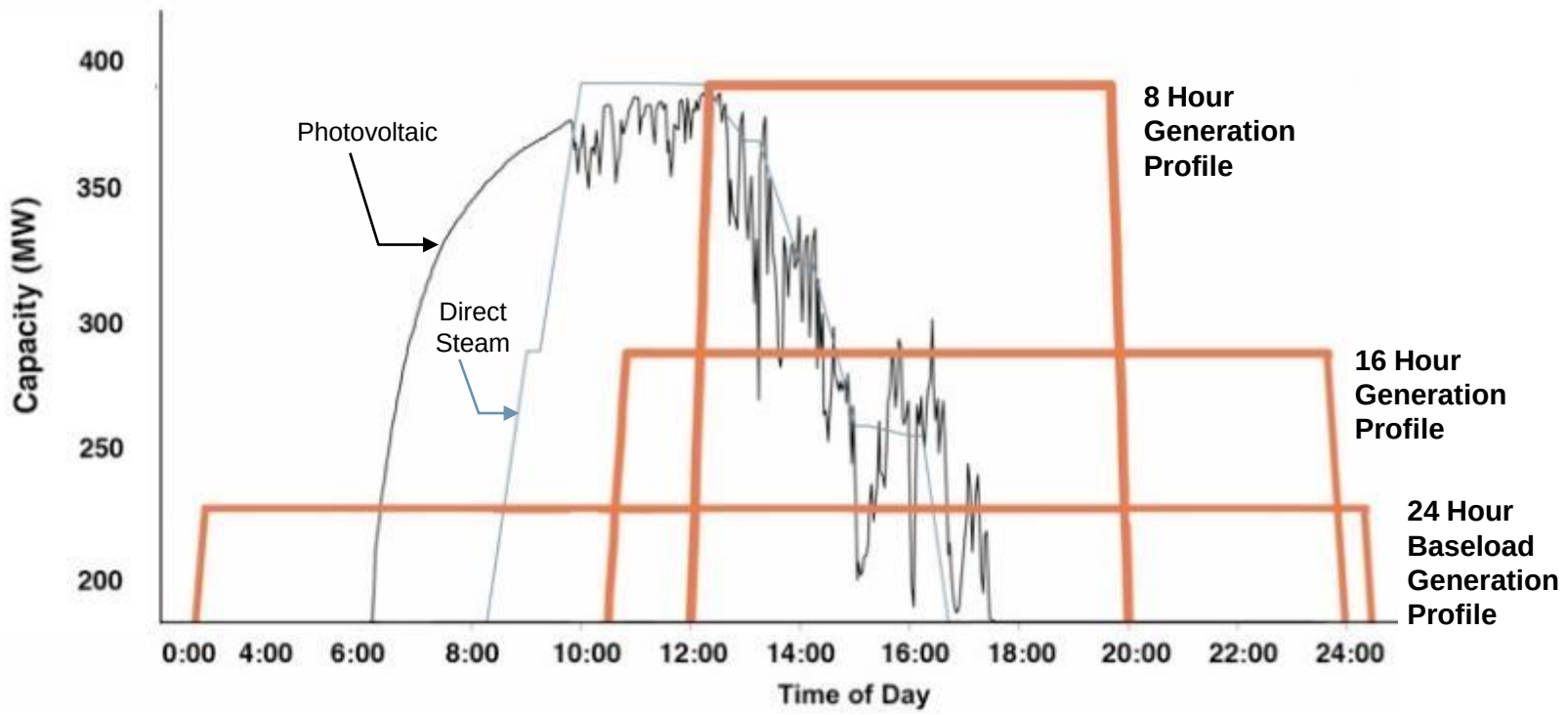
The Benefits of Solar Thermal with Integrated Storage

- Operates like a conventional power generation asset with no back-up fossil fuel system required
- Load-shifting to peak periods, ancillary services and zero fuel price risk over project life provides significant value
- A more stable and secure output alleviates intermittency issues and more fully utilizes transmission assets
- Integrated molten salt in tower configuration stores energy more efficiently and cost effectively than other solar thermal storage solutions
- Storage technology provides large scale solar storage option (+1000 MW-hours) at a fraction of the cost of utility scale battery storage
- Produces twice the output of similar sized solar projects without storage

Other than CSP with storage, no other solar technology can operate like a conventional power plant.

SolarReserve's solar thermal with storage facility deploys the only commercially viable renewable technology that can displace fossil fuel generation

Dispatchable Generation Delivers Firm Output On Demand



Integrated energy storage provides the ability to shift electricity generation to meet different profile needs and deliver firm reliable power at high capacity value

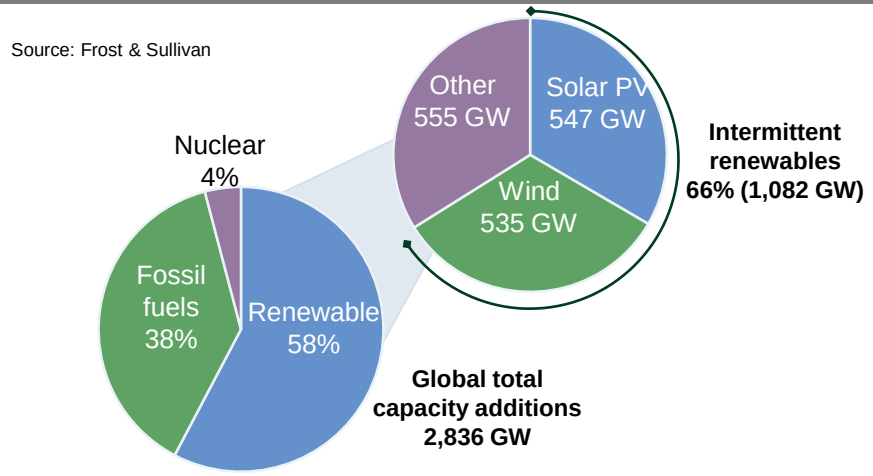

The Value of CSP with Storage

Within the Rapidly Growing Renewable Energy Market, Solar Thermal with Integrated Storage Plays a Key Role

Global energy market context

- The installed capacity of renewable energy is forecast to more than double by 2025 to reach 3,203 GW or 39% of global installed capacity
- The highest share of total renewable energy capacity additions is expected to come from solar power, representing 35.1% of additions through 2025 with wind energy following closely behind at 32.7%
- The addition of intermittent wind and solar PV resources will further stress transmission systems causing many load serving entities to seek a clean energy dispatchable solution to ensure electric reliability

Renewable capacity additions: 2012-2025



Solar thermal with storage deploys commercially viable technology that can displace fossil fuel generation

Energy storage allows the generator to control a plant's output and dispatch when electricity is at peak pricing

Storage allows the facility to produce more than twice as much net annual output as solar without storage

Solar thermal with storage can operate like a conventional power plant

Firm output ensures a more stable and secure transmission system

CSP with storage is set to realize falling installation costs as global deployment accelerates

While batteries are receiving significant attention in the media, they are far from competitive for larger scale applications.

Battery industry exhibits exuberance today…

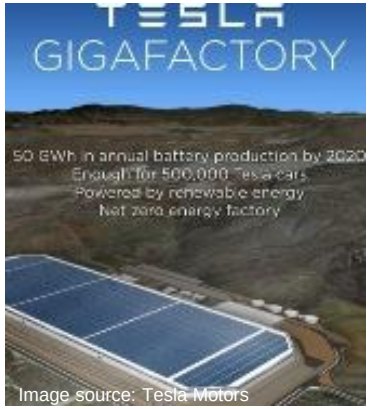


Image source: Tesla Motors

- Costs of mature technologies will be reduced (~30%) due to manufacturing volume
- Volume is driven primarily by electric vehicles, secondarily by grid-tied applications
- Viewed as "necessary" to support high penetration of renewables, particularly distributed generation
- R&D indicates major cost cuts (~70%) with new technologies

…but significant challenges remain

- Batteries currently face uncertainty in value propositions, revenue mechanisms, and lifetime cost and performance
- Modular batteries can't offer economies of scale to a project
- Batteries are expensive in the MWh dimension, so they are primarily focused on shorter-duration applications (up to 4 hours)
- Extreme cost pressure due to overly aggressive projections threatens profitability of all market participants
- Unresolved issues around O&M costs, lifecycle GHG implications, degradation and replacement, fire and safety risks

Example battery statistics

	Typical Lithium-Ion	Typical Flow Battery
Storage Duration	15 minutes to 4 hours, depending on the application	4 hours to 12 hours, typically for bulk energy storage
Round-Trip Losses	10%	25%
Capex per kWh	>$1,000 today $500 by 2020 Strongly dependent on the kW dimension in addition to the kWh dimension	>$800 today $400 in the long term Dependent on the kWh dimension primarily

Futuristic battery technologies promoting capital costs in the $160-$350 / kWh range are not commercially realistic while SolarReserve molten salt storage currently at ~$70/kWh

Storage- whether molten salt or batteries - can be applied to a range of applications but not necessarily *all* applications

Applications of Storage Technology

Power Quality	Reserves	Bulk Storage
Frequency regulation	Spinning reserves	Energy arbitrage
Transient stability	Non-spinning reserves	Time-shifting
Reactive power	Ramp rate control	Load-leveling
Voltage support	Black start	T&D deferral

Shortcomings of Comparing CSP + TES to PV + batteries

- Batteries are not necessarily “green” – batteries tied to the grid may have different GHG implications and rare earth raw materials include mining and disposal issues
- Lifetime cost and degradation rates of batteries are uncertain, whereas molten salt will not degrade over 30+ years
- At large scale, for long-duration storage coupled with generation, CSP with TES will handily beat PV with batteries on PPA price
- At large scale, if only short duration is needed to smooth out small intermittency effects, PV with batteries may well beat CSP with TES
- CSP with TES is commercially available today, whereas a similar-sized battery would be unprecedented (by an order of magnitude)

Crescent Dunes has 1,100 MWh of storage, about equal to ALL of the world’s utility-scale batteries in operation today, combined[1]

[1] US DOE Global Energy Storage Database

Framework: The Value of CSP with Storage

- CSP with storage delivers multiple value streams which are increasingly important in the changing energy landscape

Ancillary Services

- Frequency regulation
- Spinning reserve
- Non-spinning reserve
- Ramping support / load following
- Black start

Intrinsic Stability

- Fault ride-through capability
- Inertia / frequency response
- Voltage / VAR support

Energy and Capacity Value

- Time-shift generation to the highest-value times
- Replace conventional resources for flexibility and reliability
- Higher utilization of transmission assets
- Less fuel / O&M from startup / cycling the fleet
- No “round-trip” losses

Risk Management

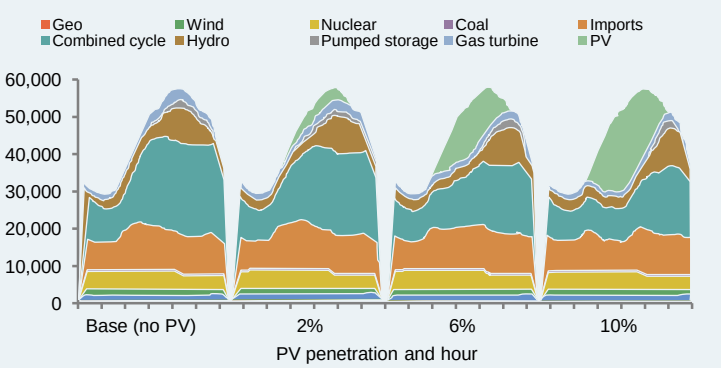
- Hedges:
  - Power price
  - Ancillary service price
  - Integration costs
- Improved forecast error
- Lower reserve requirements
- Long-term dispatch flexibility
- Stable lifetime performance and value

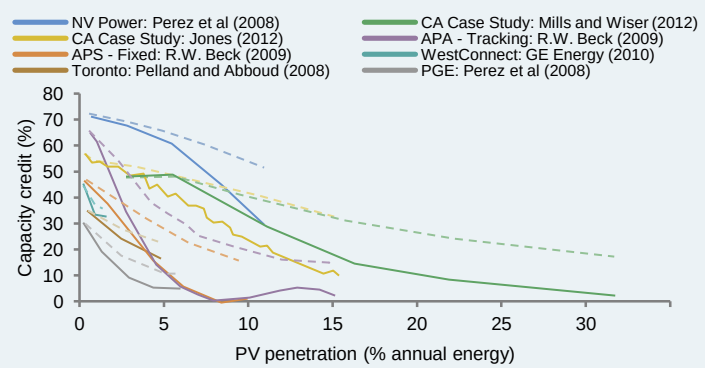
Operating Flexibility

- Responsive curtailment
- Slow the net load ramps
- Smooth intra-hour variability
- Ease the integration of intermittent renewables
- Integration with other thermal generators

Curtailment issues and shifting of the net load peak will reduce the value of renewables without storage in the future

- Studies have shown how the *value* of renewables without storage declines as penetration increase
- In contrast, *storage* allows CSP to deliver superior value over the long term





The future is here: Curtailment issues and ability to meet shifting peak demand are becoming increasingly critical in California and other global markets with high solar penetration

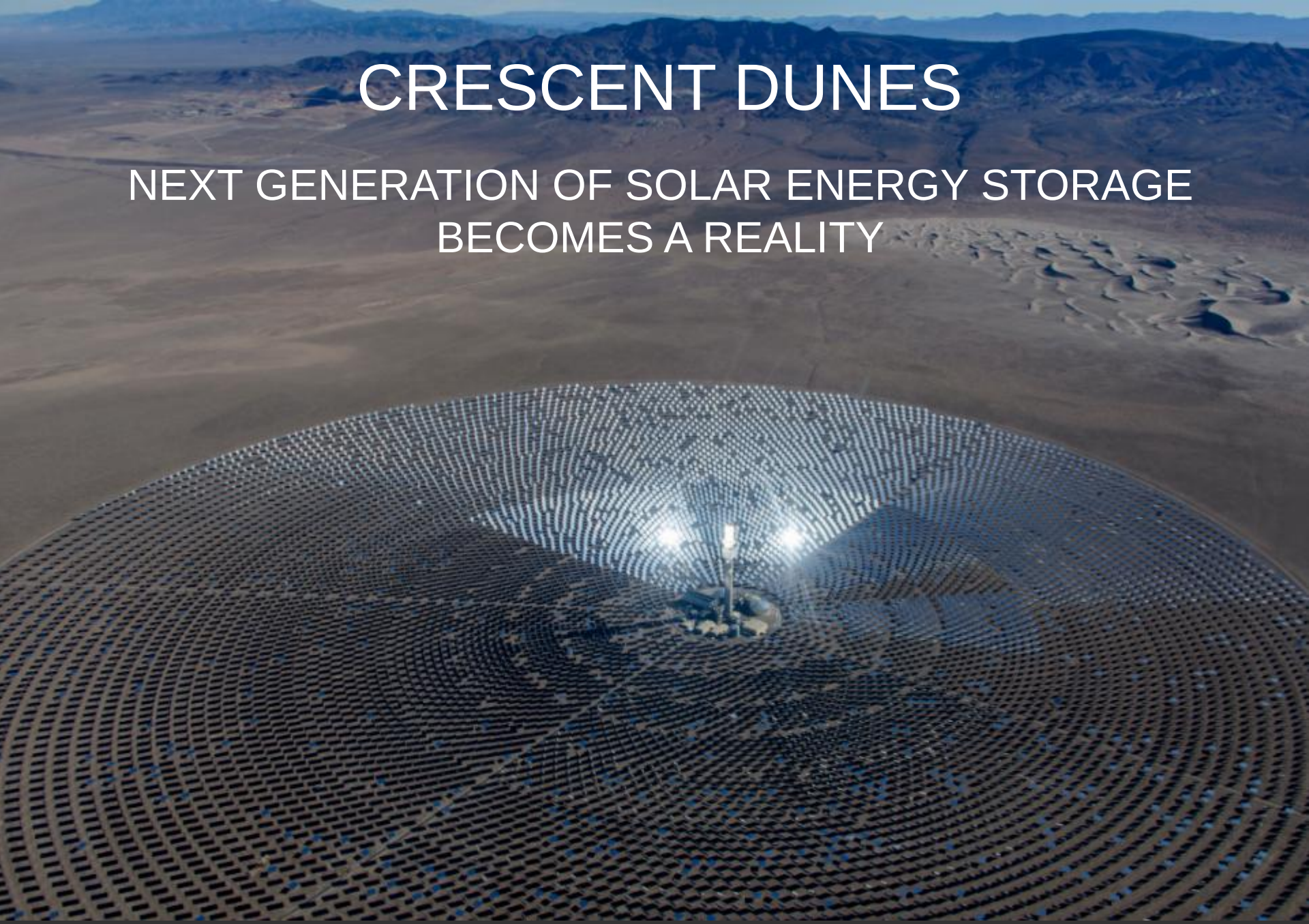
- Pacific Gas and Electric Company, one of the largest combination natural gas and electric utilities in the United States, provides service to approximately 16 million people throughout a 70,000-square-mile service area in northern and central California
- PG&E's peak demand period is now from **4 p.m. until 9 p.m**., having shifted from an early afternoon peak to an evening peak
- TOD adjustments once provided a substantial boost (about 25 percent) to solar projects, due to the much earlier peak period – but now that parts of the state are awash in new large-scale and rooftop PV, PG&E's TOD tables have been steadily adjusted:

Monthly Period	Peak	Mid-Day	Night
Jul – Sep	1.479	0.604	1.087
Oct – Feb	1.399	0.718	1.122
Mar – Jun	1.270	0.280	1.040

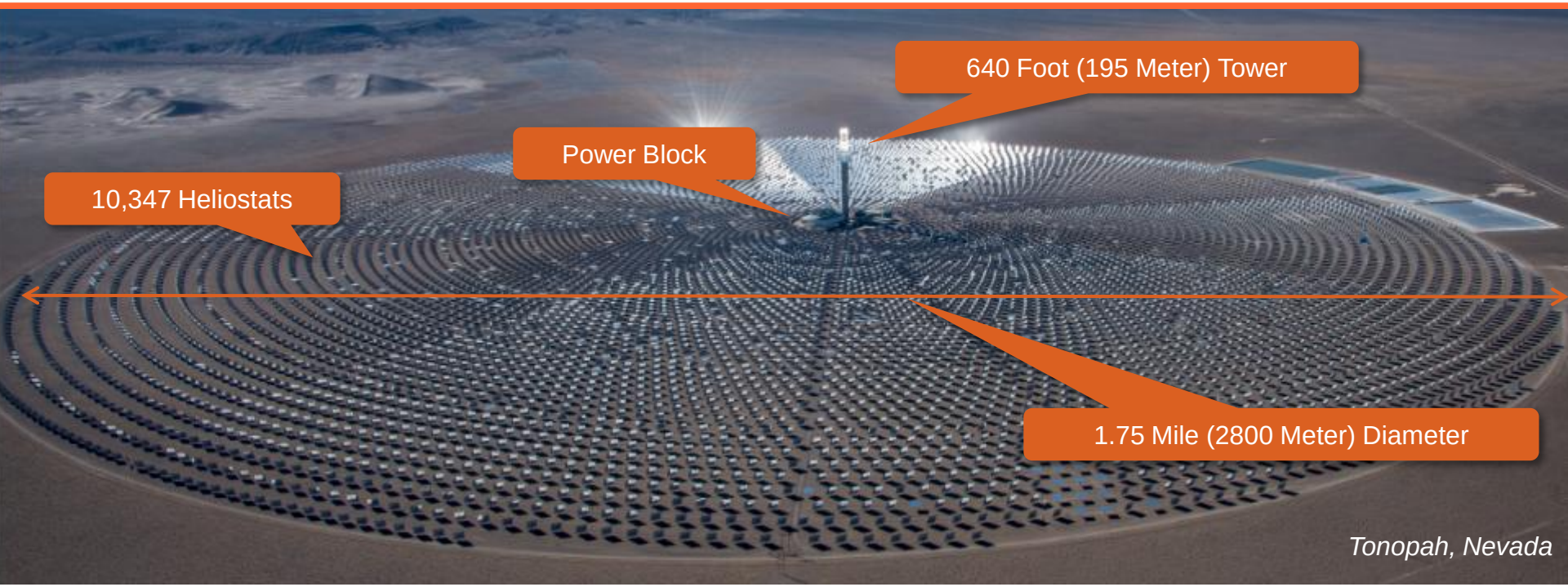
- On the other side of the world, South Africa's progressive renewable program has included bidding rounds for solar thermal plants with energy storage that can reliably meet peak demand, which extends **from 4:30 p.m. until 9:30 p.m.**

CRESCENT DUNES

NEXT GENERATION OF SOLAR ENERGY STORAGE BECOMES A REALITY

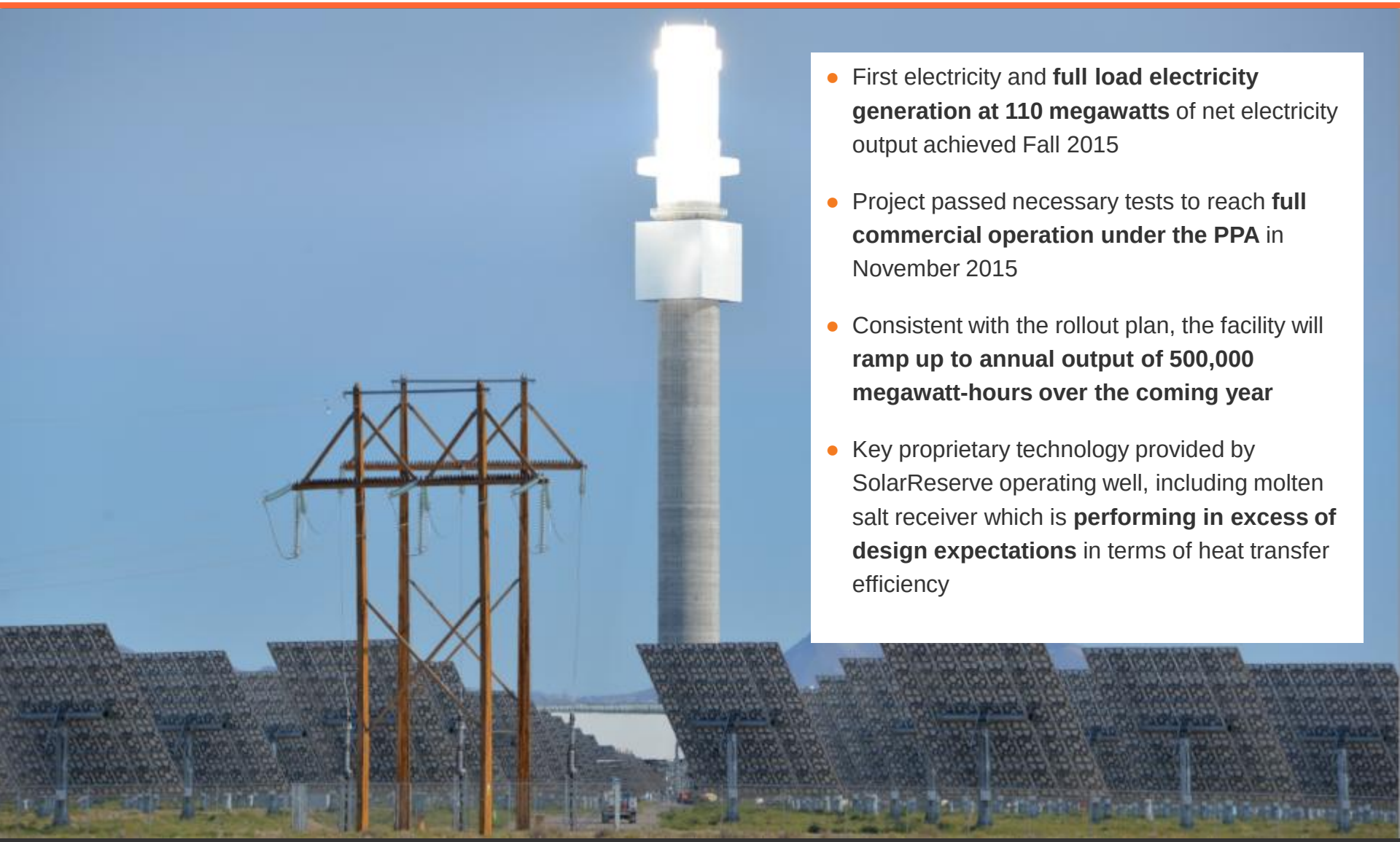


Crescent Dunes – Project Highlights



- **Technology:** SolarReserve's proprietary solar thermal energy storage technology that enables reliable, on-demand energy production – day and night.
- **Electricity Production:** 110 MW capacity delivering more than 500,000 megawatt hours of electricity per year to the Nevada energy market.
- **Storage:** Market leading energy storage provides 10 hours of full load electricity generation (1100 MW-hours of storage)
- **Equity Investment:** $260 million of private equity from SolarReserve (managing partner), ACS Cobra and Banco Santander.
- **Debt Financing:** Debt supported by U.S. Department of Energy Loan Guarantee Program.
- **Power Purchaser:** 25-year power contract with NV Energy, Nevada's largest utility, for 100% of output at a fixed price with 1% annual escalation, regardless of world fuel prices.

Crescent Dunes - 1100 MW-hours of Energy Storage in Operation



- First electricity and **full load electricity generation at 110 megawatts** of net electricity output achieved Fall 2015
- Project passed necessary tests to reach **full commercial operation under the PPA** in November 2015
- Consistent with the rollout plan, the facility will **ramp up to annual output of 500,000 megawatt-hours over the coming year**
- Key proprietary technology provided by SolarReserve operating well, including molten salt receiver which is **performing in excess of design expectations** in terms of heat transfer efficiency

Crescent Dunes – Local Economic Benefits

- **Job Creation**:
  - **1,050** construction workers on site at the peak period
  - **4,300** direct, indirect and induced jobs created by the project during construction
  - **26** states provided equipment and services
  - **60%** of the project subcontractors were Nevada based
- **Tax Revenues**: Project forecasted to generate more than $73 million in local and state tax revenues over first 20 years of operation
- **Operating Expenses**: During the 30+ year operating life, the project will expend more than $10 million per year in salaries and operating costs, much of this spent in the region
- **Capital Investment**: Project will generate in excess of $750 million private capital cost investment in Nevada

All 1.2 million square meters of glass was U.S. sourced, with assembly completed in an on-site manufacturing facility that employed local workers.

SolarReserve's CSP projects provide local economic benefits including a high level of content & service localization

Cost Reductions: Receiver

Cost Reductions: Heliostat Field

Cost Reductions: Balance of Plant

SOLARRESERVE®

Questions?

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