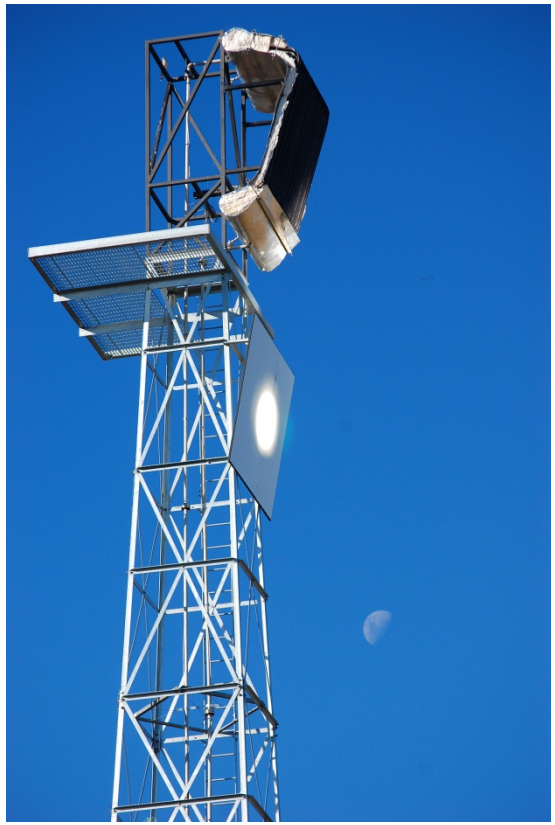
VastSolar

Commercially Sustainable CSP
Scalable, High Efficiency, Low Cost



Vast Solar Demonstration Facility, Forbes, NSW, Australia – December 2011

ASTRI Symposium

11 February 2015

Commercial in Confidence

Collaboration - strategic partners

Over 5 years, Vast Solar has developed key partnerships to support innovation & commercialisation

Australian Government ARENA

Australian Renewable Energy Agency

Australian Government CLEAN ENERGY FINANCE CORPORATION

Australian Government Green Bank

TWYNAM Agricultural Group

Investor

ŠKODA

ŠKODA POWER

Steam turbines & steam cycle design

METAUX SPECIAUX

Sodium supply

Creative Engineers

Sodium engineering, process design

EVANS & PECK think through the future

Project Governance

WorleyParsons resources & energy

Project design

UNSW THE UNIVERSITY OF NEW SOUTH WALES SYDNEY • AUSTRALIA

Australian National University

essential energy

Grid integration

GTEAM

Micro turbines

RRPROJECTS

Air cooled condensers

YOKOGAWA

Control System & Instrumentation

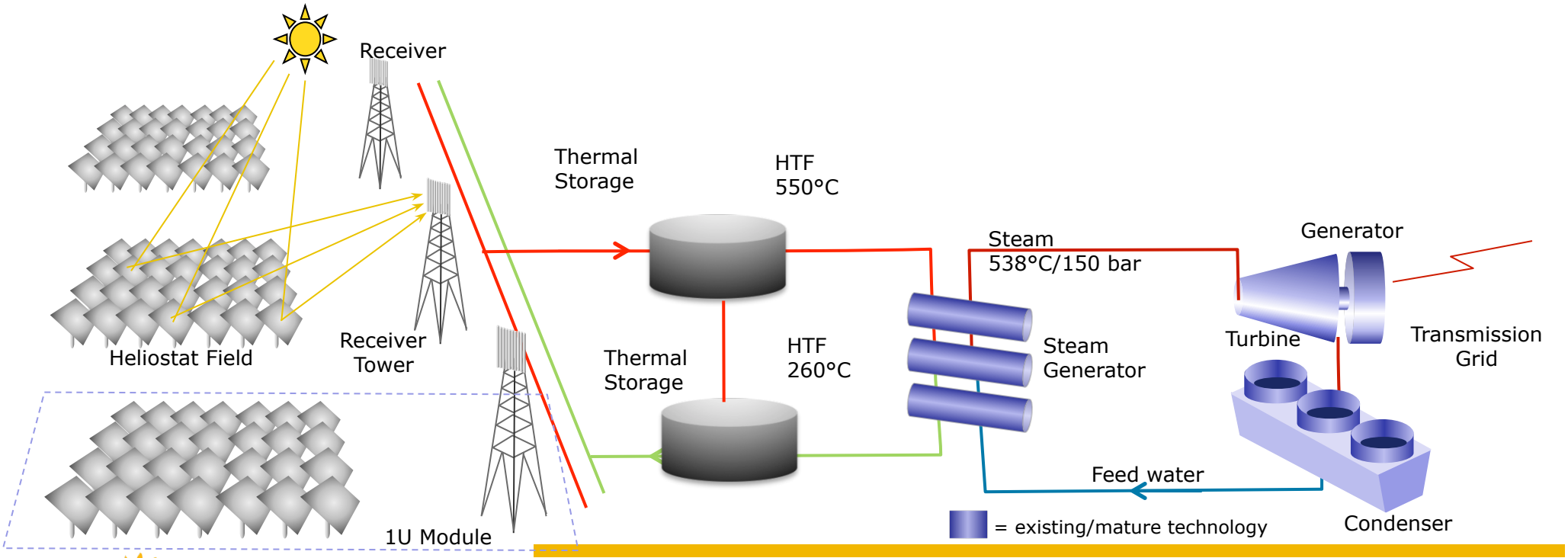
VastSolar

Low-cost, small module design

Competitive advantages in solar array and heat transfer systems, biodiversity and amenity

Key Differentiators

1. **Low cost heliostats = low cost solar energy:** Reduces cost of the largest capital component of the CSP plant
2. **Small modular solar array – high efficiency:** Modules 100x120m, 27m tower, ~300kWe
   No need for large EPC contractors, competitive subcontracting using local/regional contractors & trades
3. **High efficiency thermal energy transfer & storage:** High flux heat transfer medium = higher efficiency
   Small receiver reduces thermal shock issues and significantly reduces overall system costs



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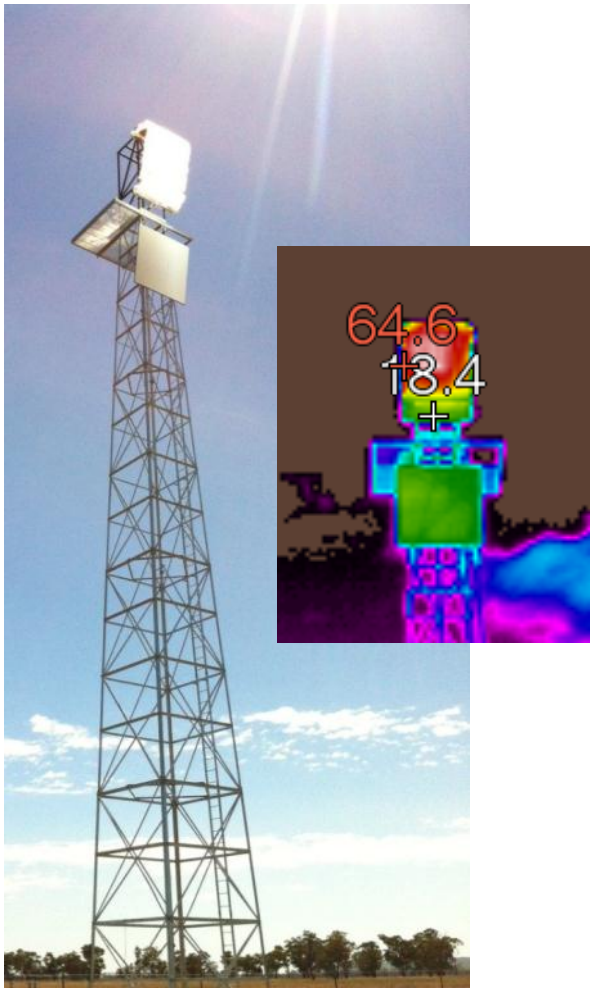
Research, Development & Demonstration Facility, Phase 1

200 heliostats, ; 300kW$_{th,}$ HTF cycle - completed December 2011 (Forbes, NSW)



Demonstration and test facility Forbes NSW

- 200 heliostats
- Thermal performance independently verified
- Mirror manufacture processed developed
- Control and communications systems

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Research, Development & Demonstration plant: Phase 2
'1U' Module – 1.2MWth system (2012-2014)

- 700 heliostats manufactured onsite - 'factory in the field' manufacturing system
- Solar array control, self-calibration and communications systems tested and refined
- Validation of performance projections
- Extensive third party technical due diligence

Jemalong 1U – February 2013

Partners: ARENA, Twynam Agricultural Group, ŠKODA POWER, VastSolar

Jemalong Solar Station Pilot Project

Forbes, NSW, Australia

6MWth (1.1MWe) grid connected power generation CSP pilot plant

- 5 Vast Solar modules –3,500 heliostats; 3 hours' thermal energy storage
- Construction completion Q2 2015, commissioning mid 2015

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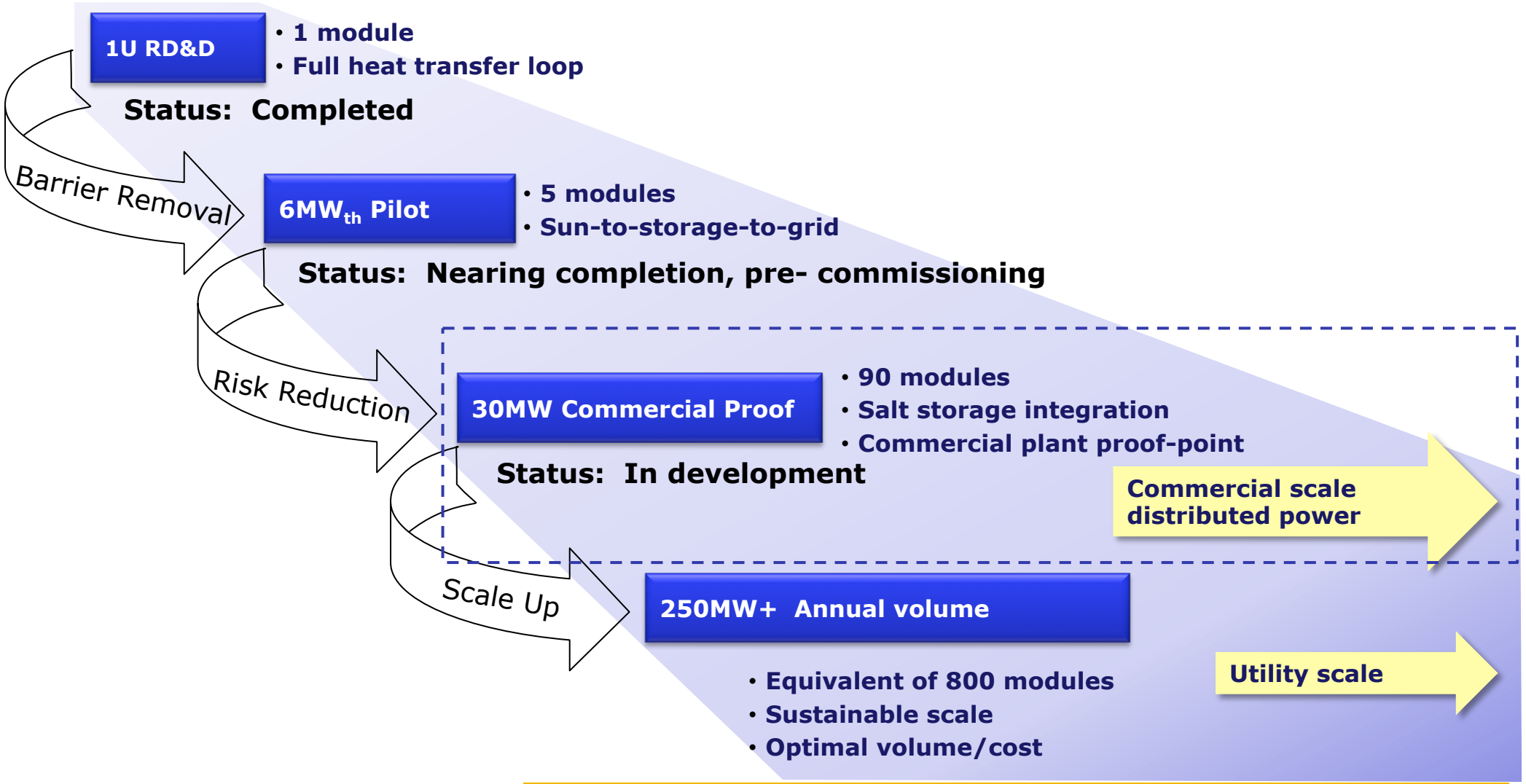
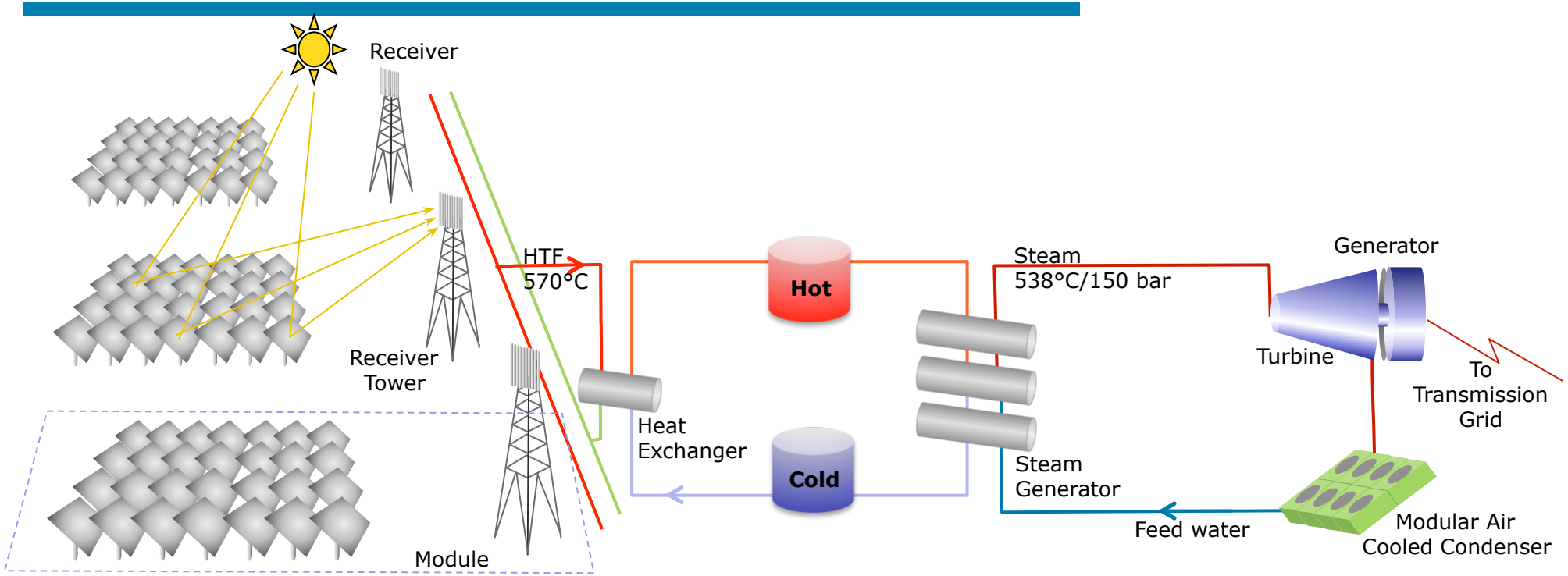
Commercialisation Program

Phased approach has progressively reduced risk and opened market opportunities



Vast Solar plant design

Focus on cost reduction in solar array and heat transfer systems



1. Solar Array	2. Sodium HTF	3. Molten Salt Storage	4. Conventional Steam Cycle
• 700 heliostat module • <130m focal distance • Low cost (<$100/m^2) 3.6m^2 heliostats • 30m towers • 2.25m^2 high flux receivers	• High thermal conductivity • Wide operating range (low melt point)	• High heat capacity • Proven technology • Multiple providers • Room for significant cost innovation	• Proven technology • Multiple suppliers, emerging low-cost providers • Innovations in deployment, packaging reducing cost • Oversupply as new coal build wanes • Wet or dry cooling

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Vast Solar Design Logic

Design parameters of the system were driven from fundamental optimisation decisions

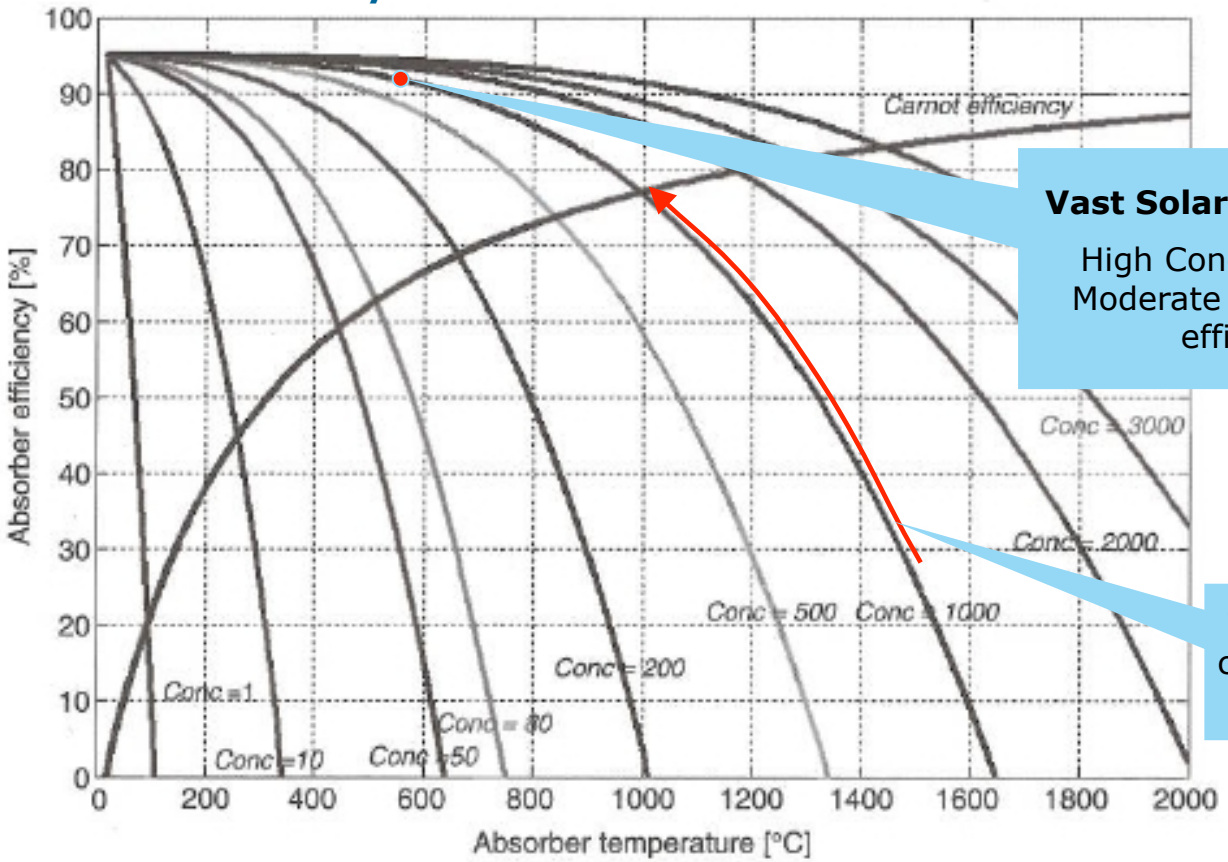
Objective: Deliver cost-effective dispatchable, large-scale solar power

What gives us the best performance thermal to electric conversion?	What is the most cost effective storage for this turbine?	How do we deliver the energy to our storage media?	What is the lowest cost way to collect the solar energy?
Steam Turbine	**Molten Salt**	**Sodium HTF**	**Modular Arrays**
+ Proven technology	+ Proven technology	+ High thermal conductivity	+ Smaller components reduce materials cost
+ Many suppliers	+ High heat capacity	+ Low freezing point (98°C)	+ Economies of scale through replication
+ Plant efficiency/capital cost ~538°C for 40-43% performance	+ Can deliver steam at 538°C	+ Enables distributed arrays	+ High array efficiency
	+ Low cost	- Reactive with water	+ Simplified deployment/ construction systems

Design Hits Receiver Efficiency Sweet-Spot

Modular array design and high thermal conductivity of heat transfer media deliver high receiver efficiencies

Receiver efficiency increases with concentration factor[1]



Vast Solar Design Point

High Concentration at Moderate Temp = High efficiency

700 heliostat array concentration factor ~1,000x

Note: 1 Efficiency of the solar receiver versus T_{abs} and versus solar concentration ratio, assuming T_{amb} = 20°C, φ=770 W/m^2 and α=ε=0.95. Handbook of Energy Efficiency and Renewable Energy

Vast Solar - cost reduction innovations

‘Root and branch’ reappraisal of how CSP systems are delivered

- 30 year utility grade components
- Modular systems to provide redundancy, replicability (volume)
- Commonly available materials and components
- Simple manufacturing, enabling high levels of automation at low tooling cost
- Simplicity and ease of deployment
- Automated O&M
- Collaboration with like-minded OEMs to drive out integration costs

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