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Victoria & Tasmania  
Section

# Advanced Solar Thermal Power Generation

SPE, 16 September 2009 by Steve Henzell, WorleyParsons





## ► Steve Henzell

- Manager of Select, Conceptual Design at WorleyParsons
- **Not** an expert in Advanced Solar Thermal
- An expert in conceptual design and project assessment

## ► Thanks to:

- Barry Lake, who is an expert in Advanced Solar Thermal
- Geoff Wearne and Rod Touzel who are experts in electrical transmission



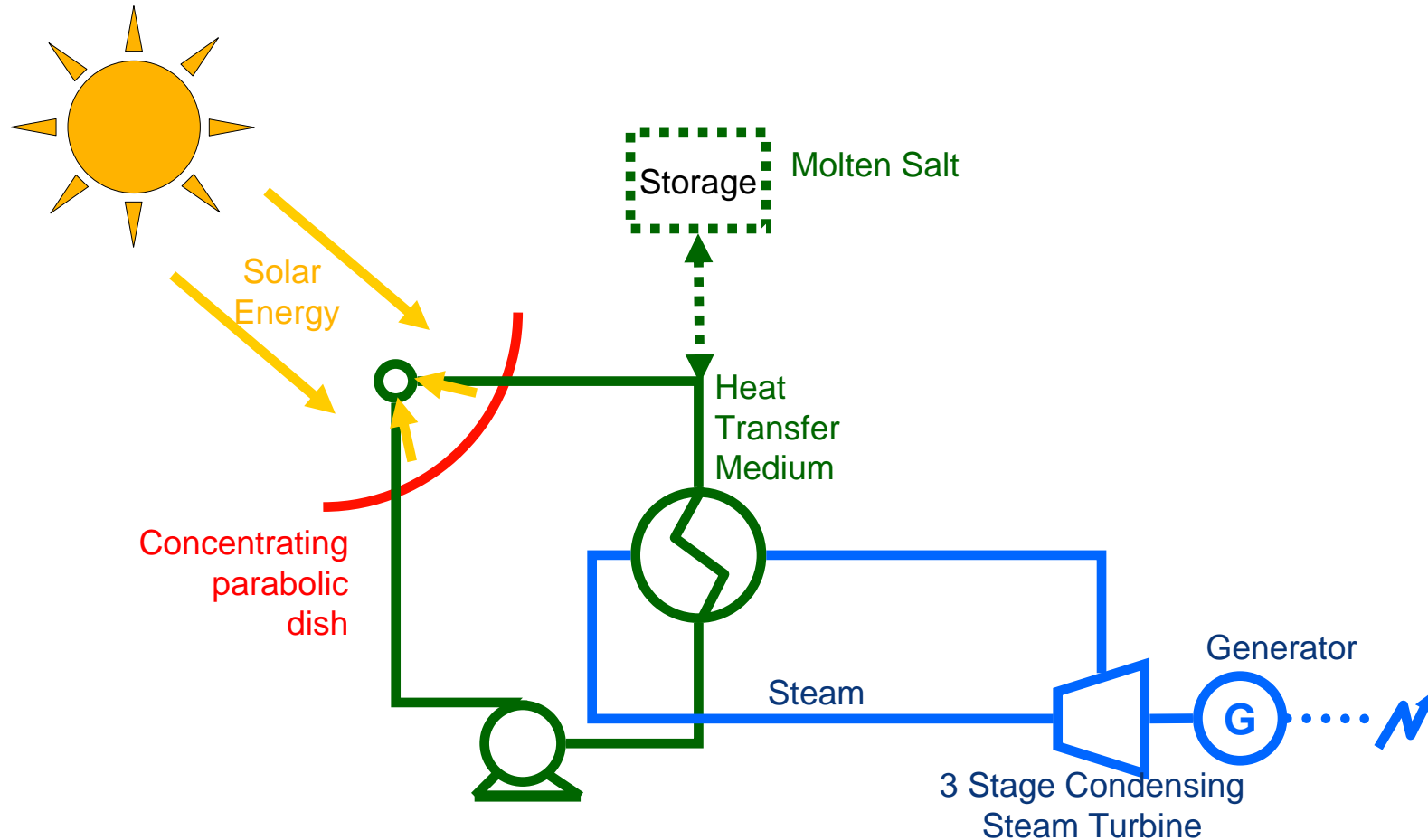
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- ▶ **Advanced Solar Thermal Power**
  - Explained
  - History of AST
  - WorleyParsons involvement in AST
  - Base load power plant
  - Alignment with power demand
- ▶ **Other AST initiatives**
- ▶ **Strengths and weaknesses of AST**
- ▶ **Other renewable energy sources**
- ▶ **Assessment of alternatives**
- ▶ **Common challenges for renewable energy**
- ▶ **What this means to the Oil & Gas industry**





### ► Solar Island

- Parabolic mirrors concentrate sunlight onto collector tubes
- Mirrors track the sun from East to West
- Oil is heated in the collector tubes

### ► Power Island

- Heated oil from the Solar Island heats water in a boiler to produce steam
- The steam drives a conventional turbine to generate power

### ► Storage

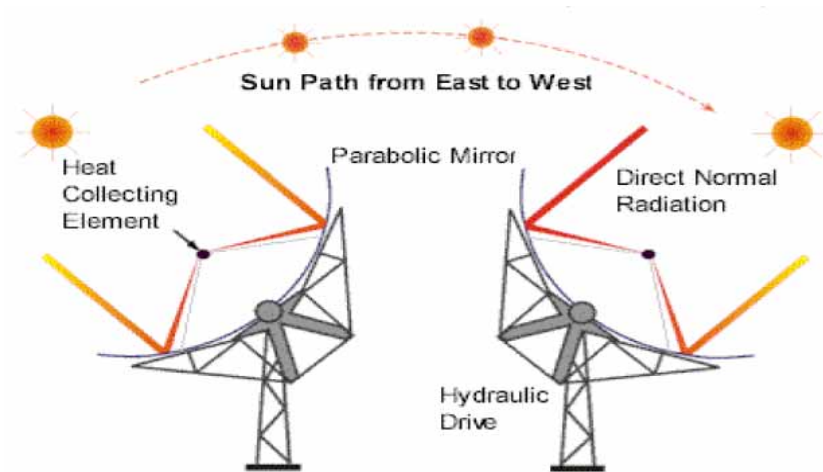
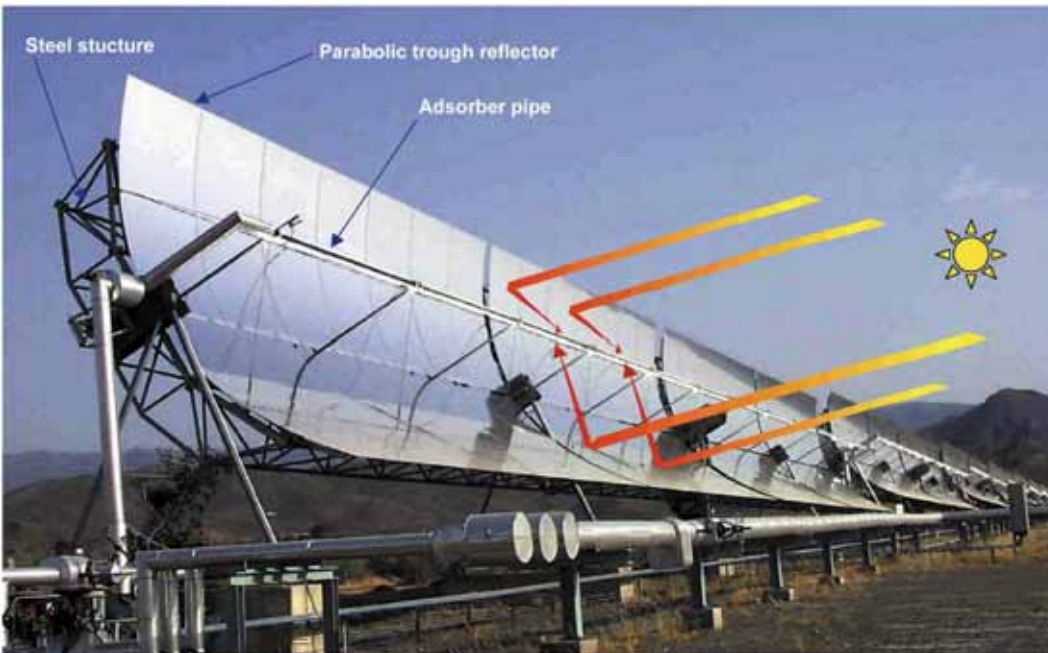
- Operating hours of the plant can be extended by storing heat in molten salt for later recovery
- Conventional technology in nuclear power generation







# Parabolic Troughs

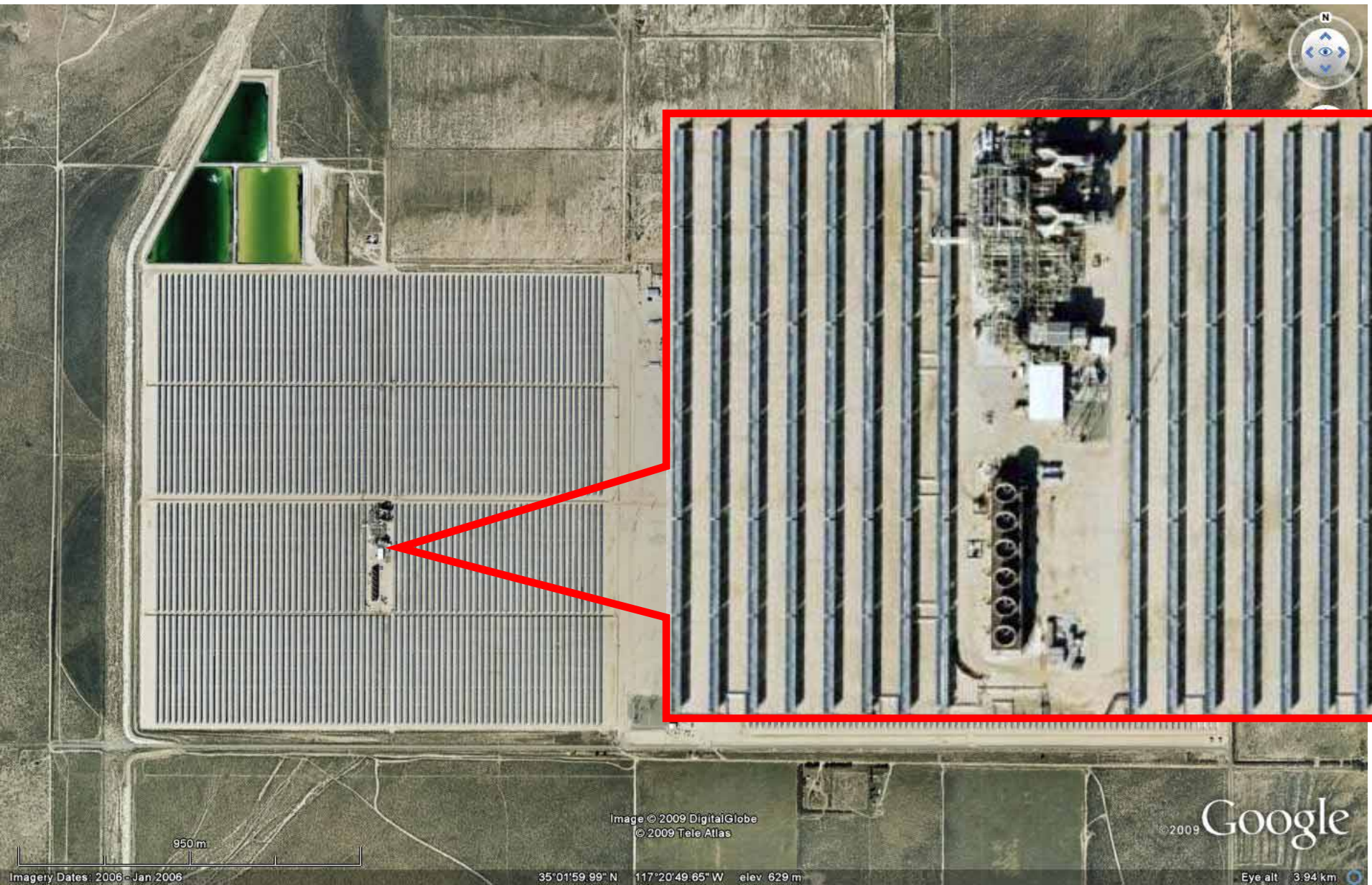




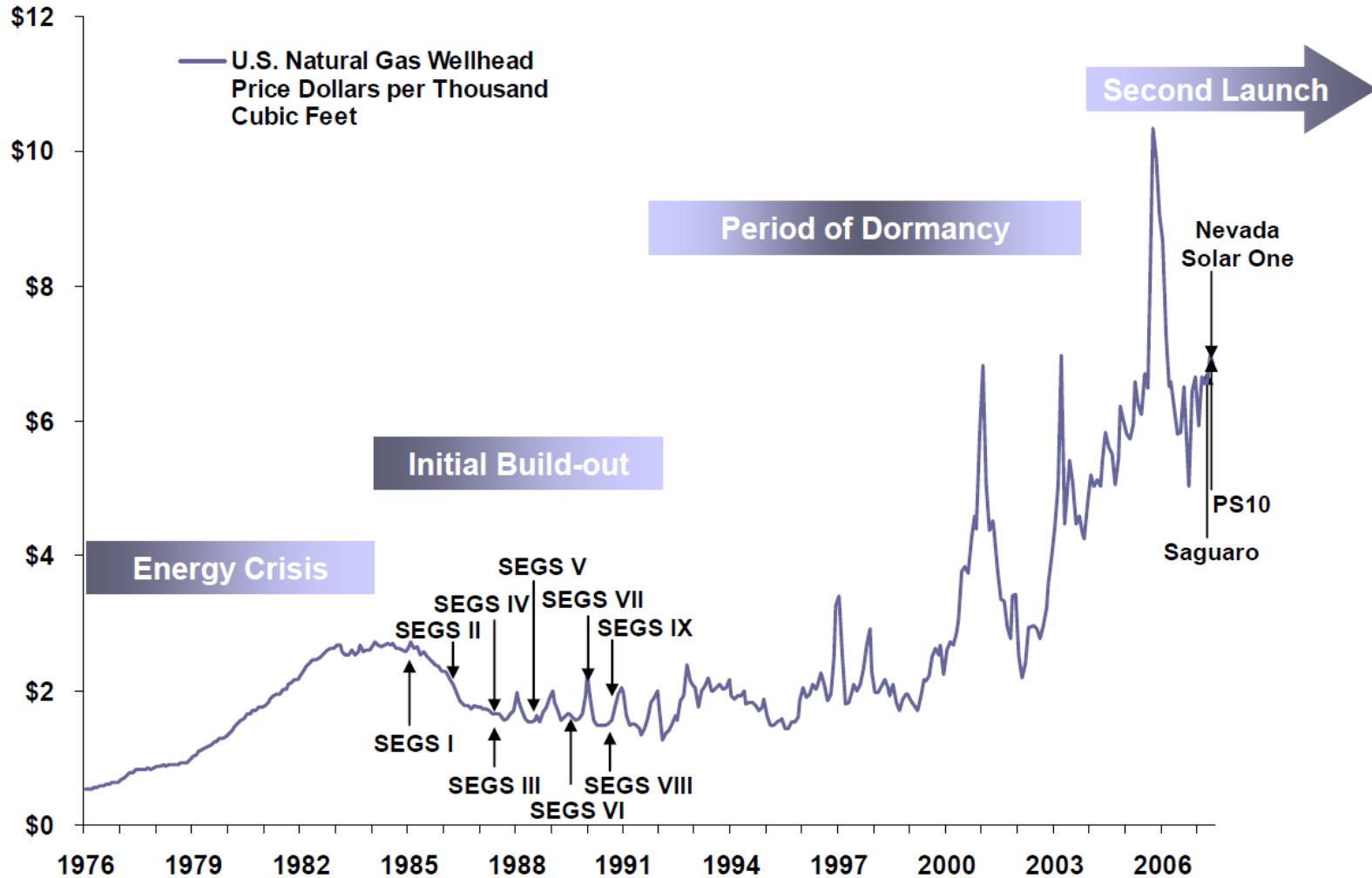
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# Concentrating Solar Power Station











- ▶ **Parabolic Trough**
  - Proven technology
  - SEGS plant
  - Andasol 1 and majority of Spanish projects
  - Maturity Scale: Highest
  
- ▶ **Central Receiver**
  - BrightSource (direct steam)
  - SolarReserve (molten salt)
  - eSolar (mini direct steam)
  - Maturity Scale: Medium
  
- ▶ **Compact Linear Fresnel Reflector (CLFR)**
  - Ausra
  - MAN
  - Maturity Scale: Medium





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# CSP - Parabolic Dish (Stirling Engine)





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# Power Tower (Central Receiver)







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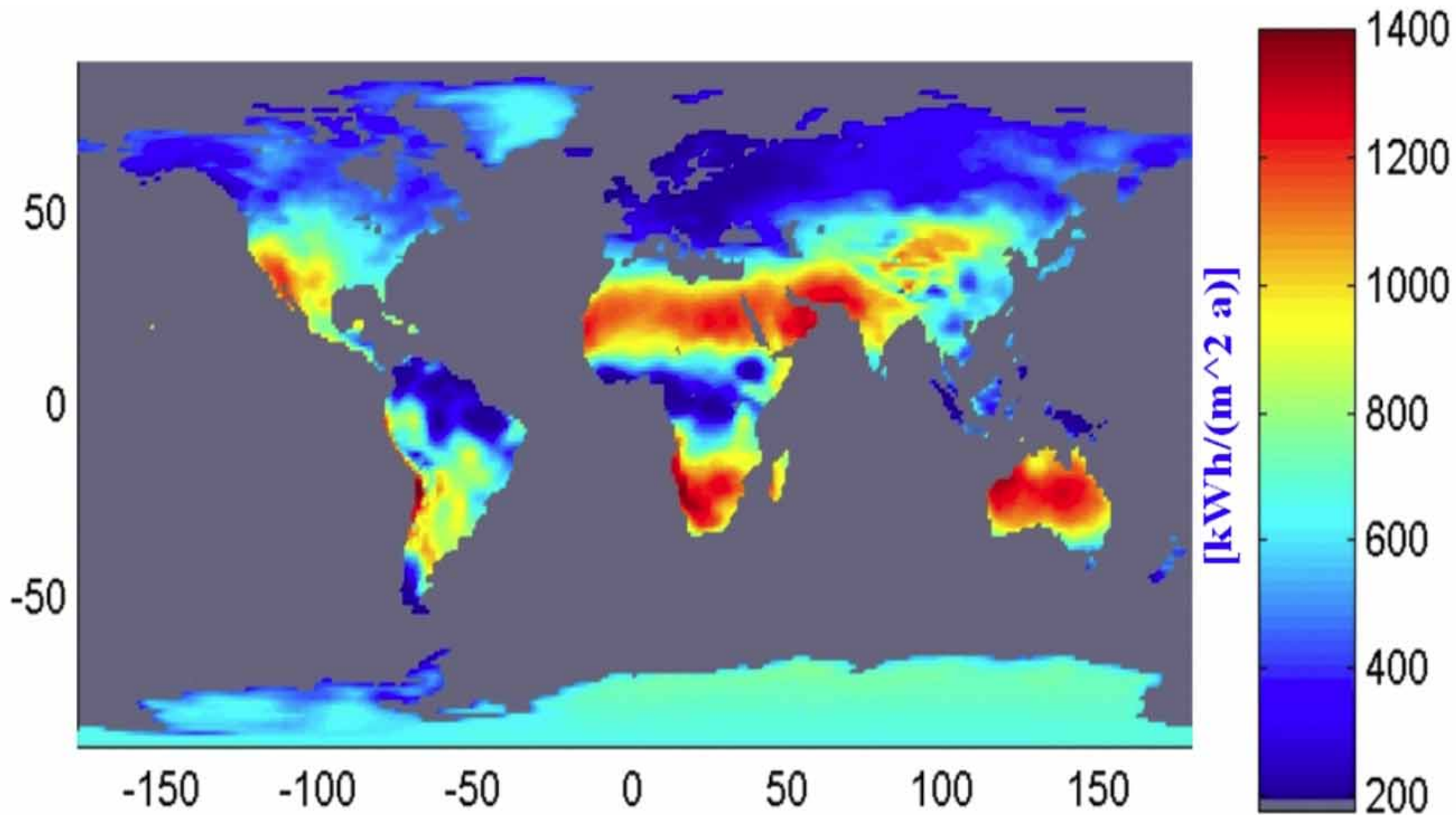
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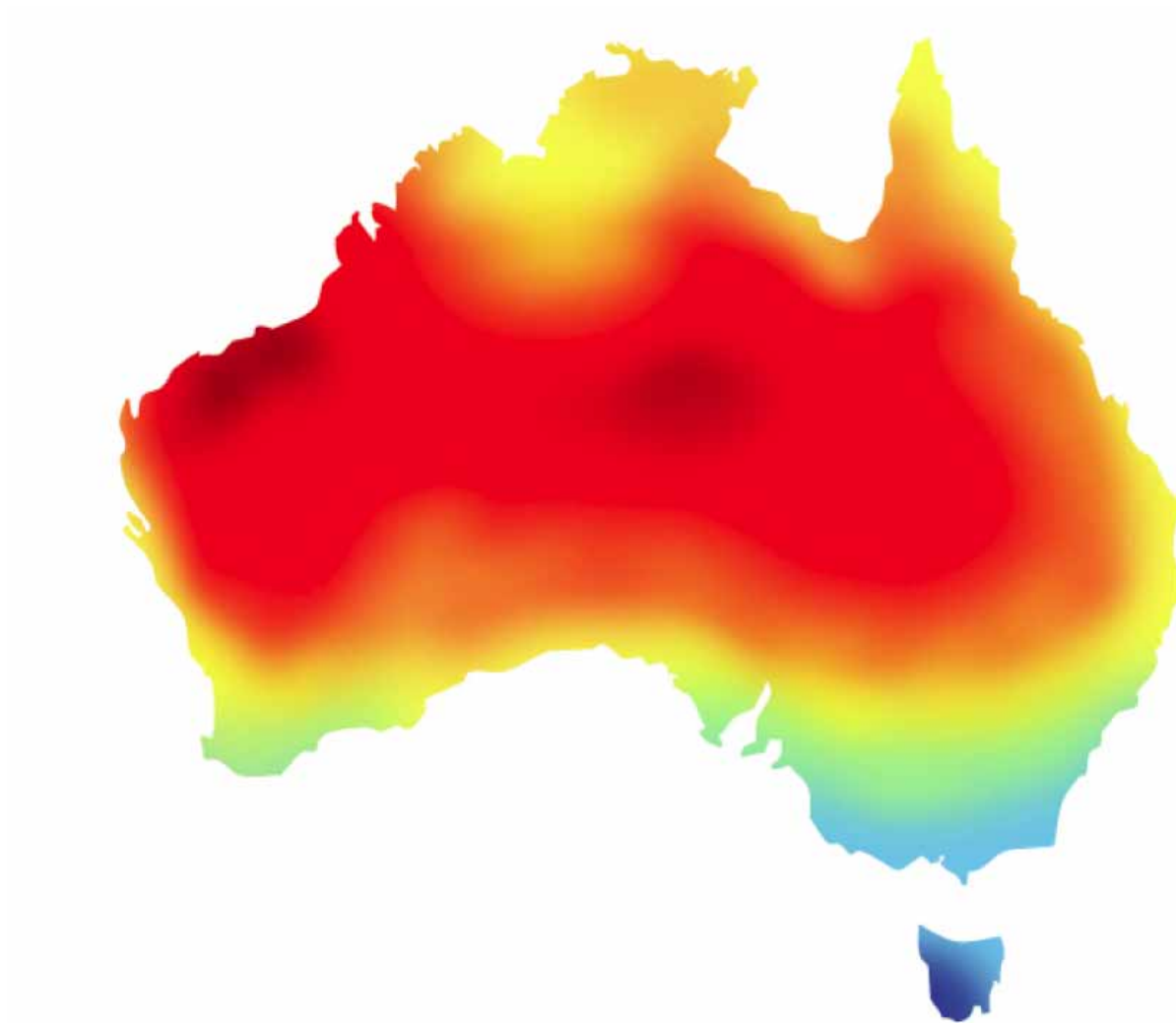
# Spain PS10 & PS20 Power Towers



Source: Koza1983





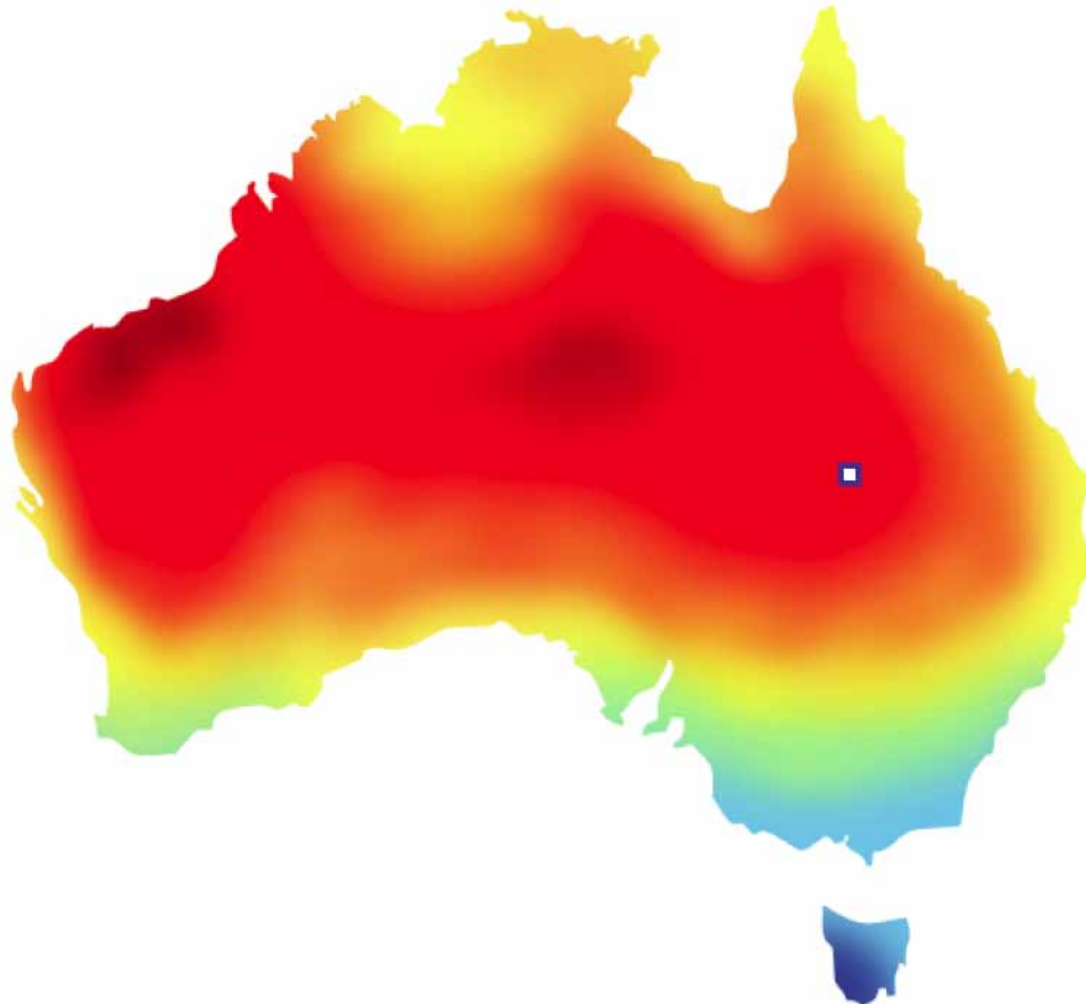


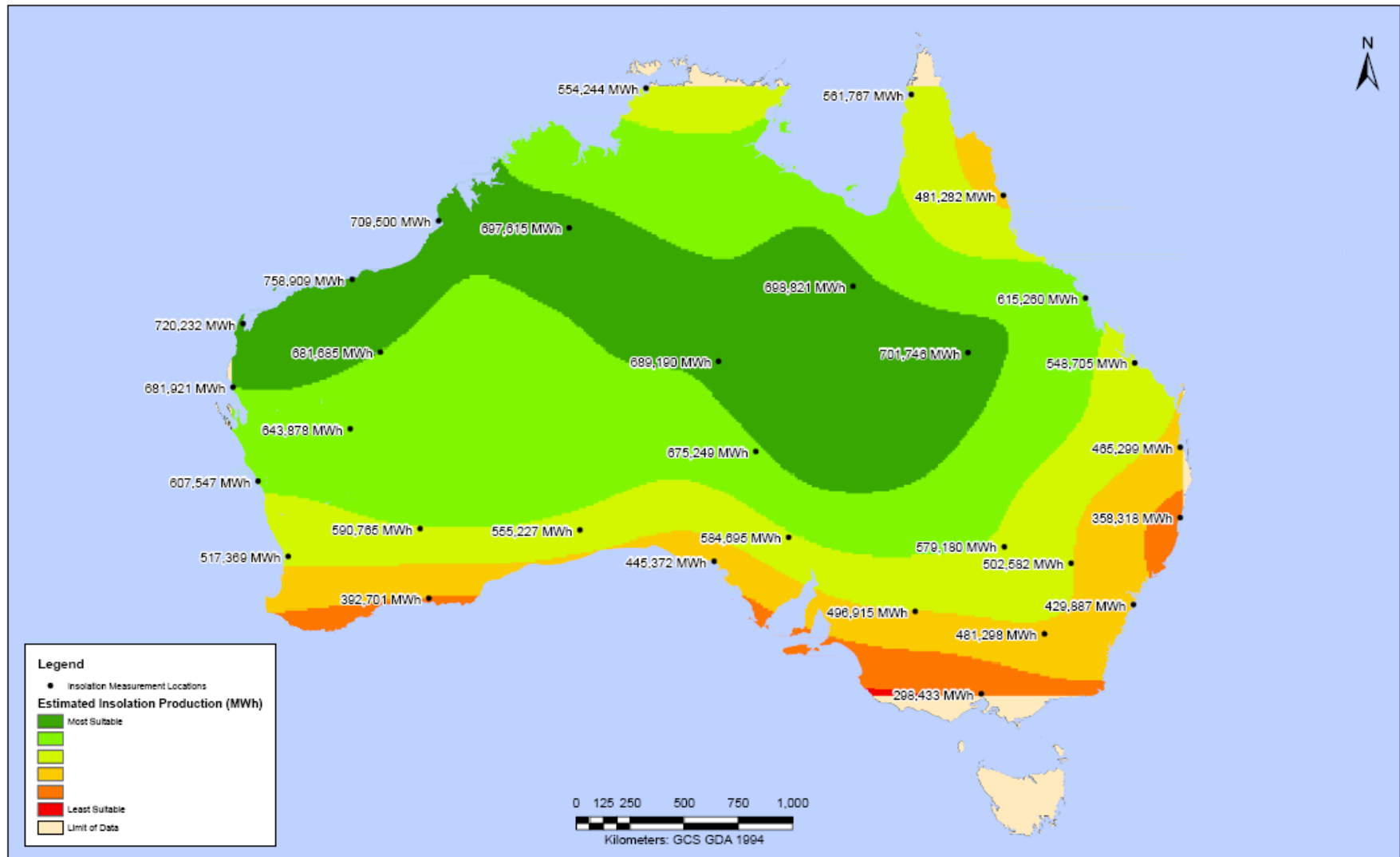


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# Australia's Power by 50km x 50km

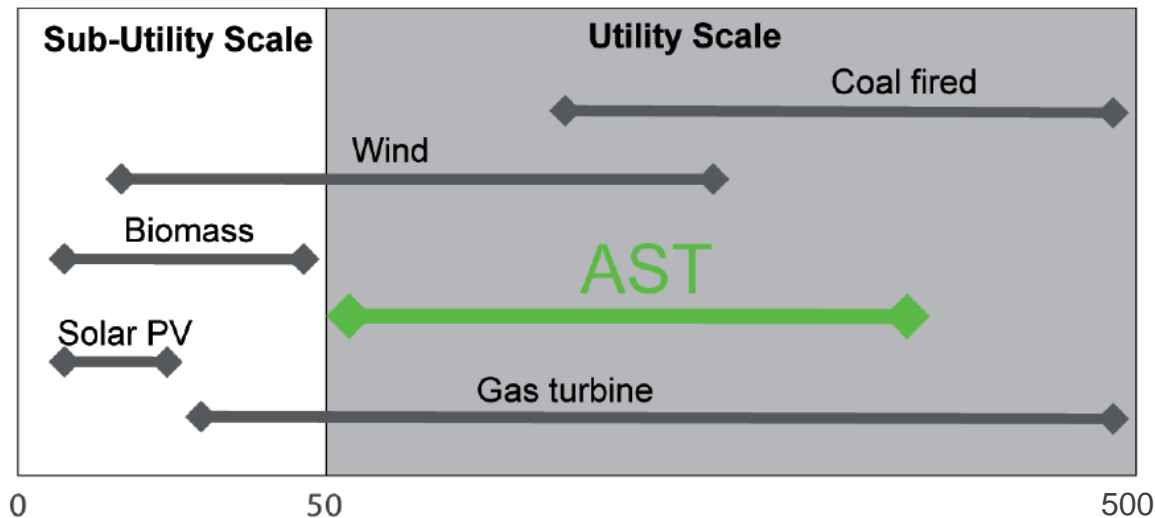








- ▶ Proven technology
  - Successfully operated and improved for over 20 years in California
- ▶ Ideally suited to areas of high solar intensity and little rain
  - Low environmental and social impact compared to other renewables
- ▶ Provides utility-scale power from 50 to 300 MW





- ▶ For the initial AST project in Australia, the criteria is:
  - Proven performance / low technical risk
  - Reliable revenue model
  - Industry experience in design, manufacture, construction and operation
  - Parabolic trough concentrator like SEGS
- ▶ For later generation AST projects may be a different technology:
  - Central Receiver
  - Compact Linear Fresnel Reflector
- ▶ 2<sup>nd</sup> generation would have:
  - Lower cost
  - Higher efficiency
  - More storage



## ► Solar Field

- Parabolic Troughs over 2 km x 3 km
- Solar Field Mirror Area: 1.5 million m<sup>2</sup>

**250 AFL football  
fields**

## ► Thermal Energy Storage

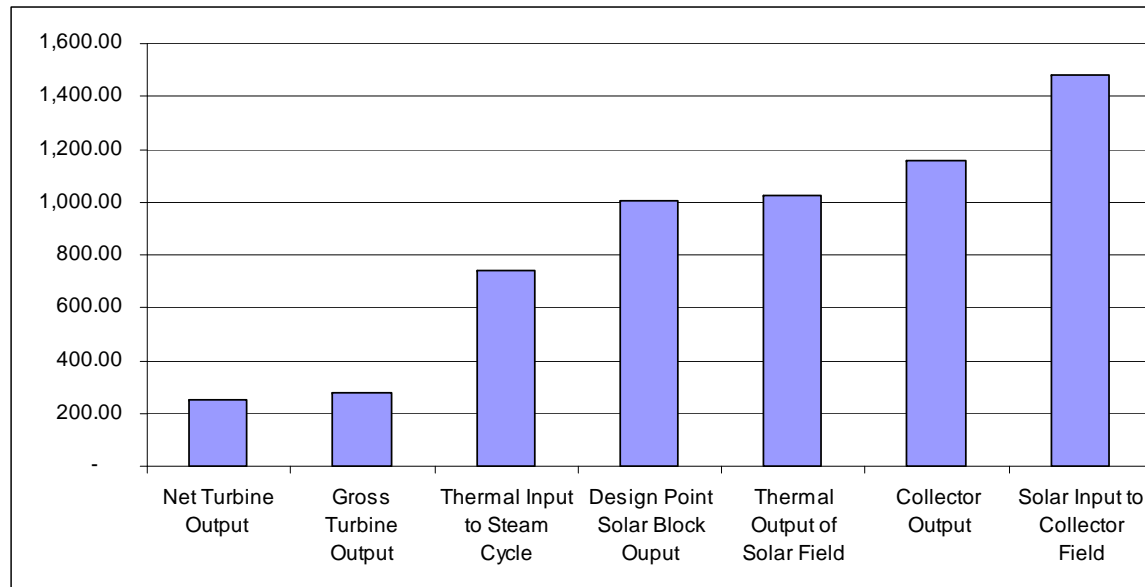
- Two tank molten salt storage
- 1¼ hr storage at full plant output

## ► Power Block

- Export Power 250 MWe
- Conventional Steam Cycle



System Performance	Unit	Value
Net Turbine Output	MWe	250.0
Parasitic Power	%	12.3
Gross Turbine Output	MWe	280.8
Steam Cycle Efficiency (Gross)	%	37.8
Thermal Input to Steam Cycle	MWt	742.8
Combined Solar Field Efficiency and Contingency	%	51.1
Solar Input to Collector Field	MWt	1,484





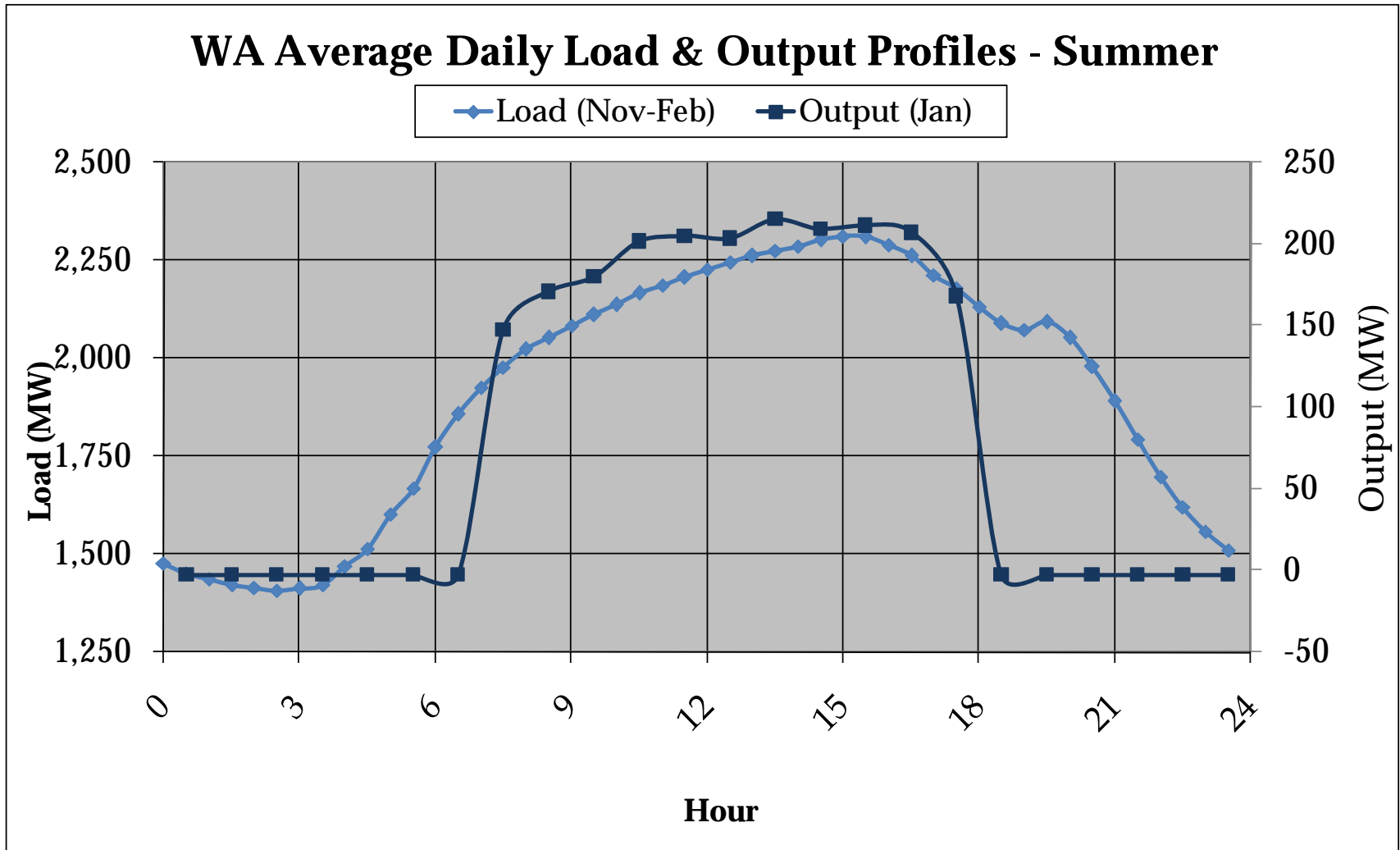


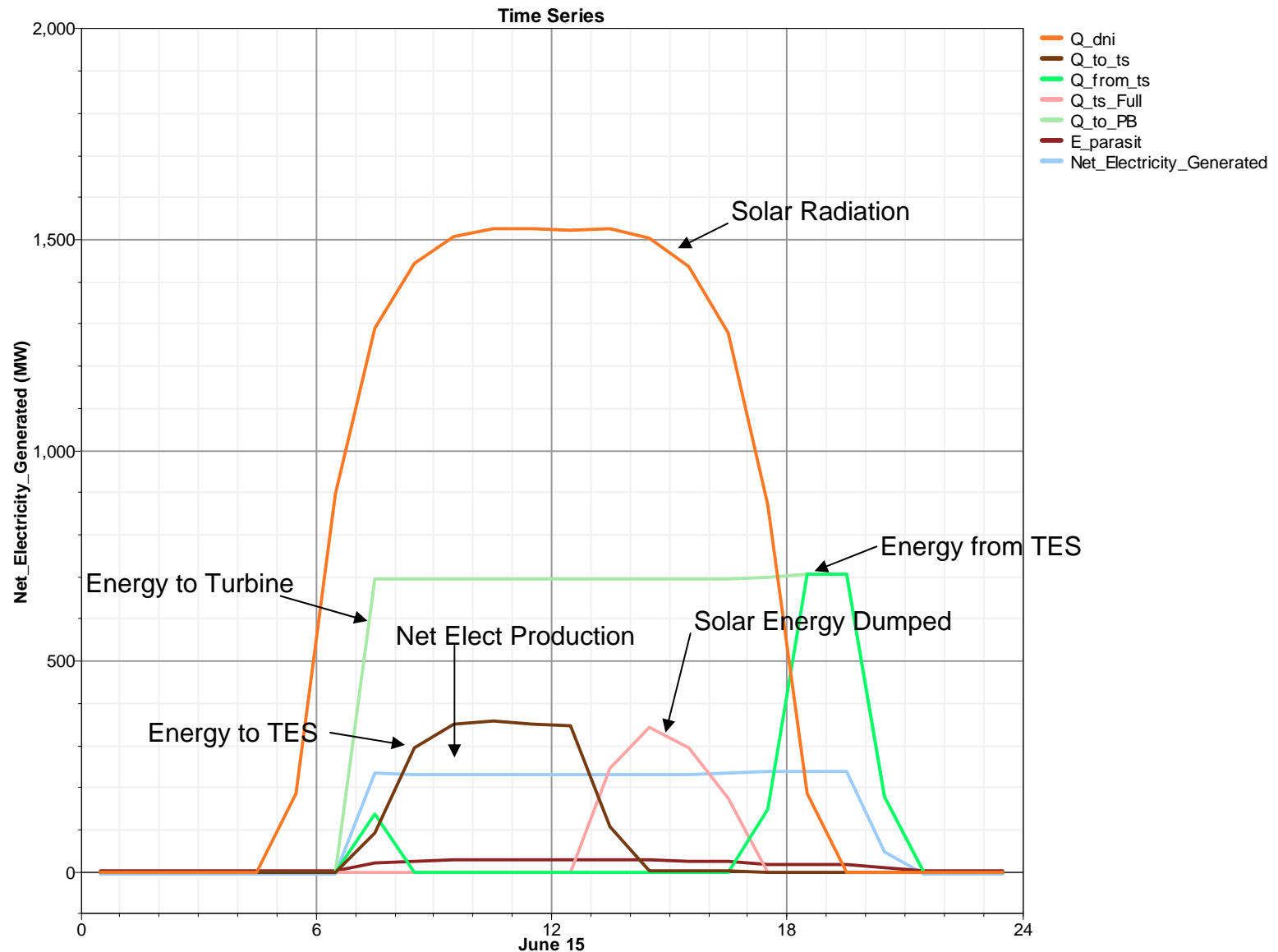
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# A Melbourne CBD AST









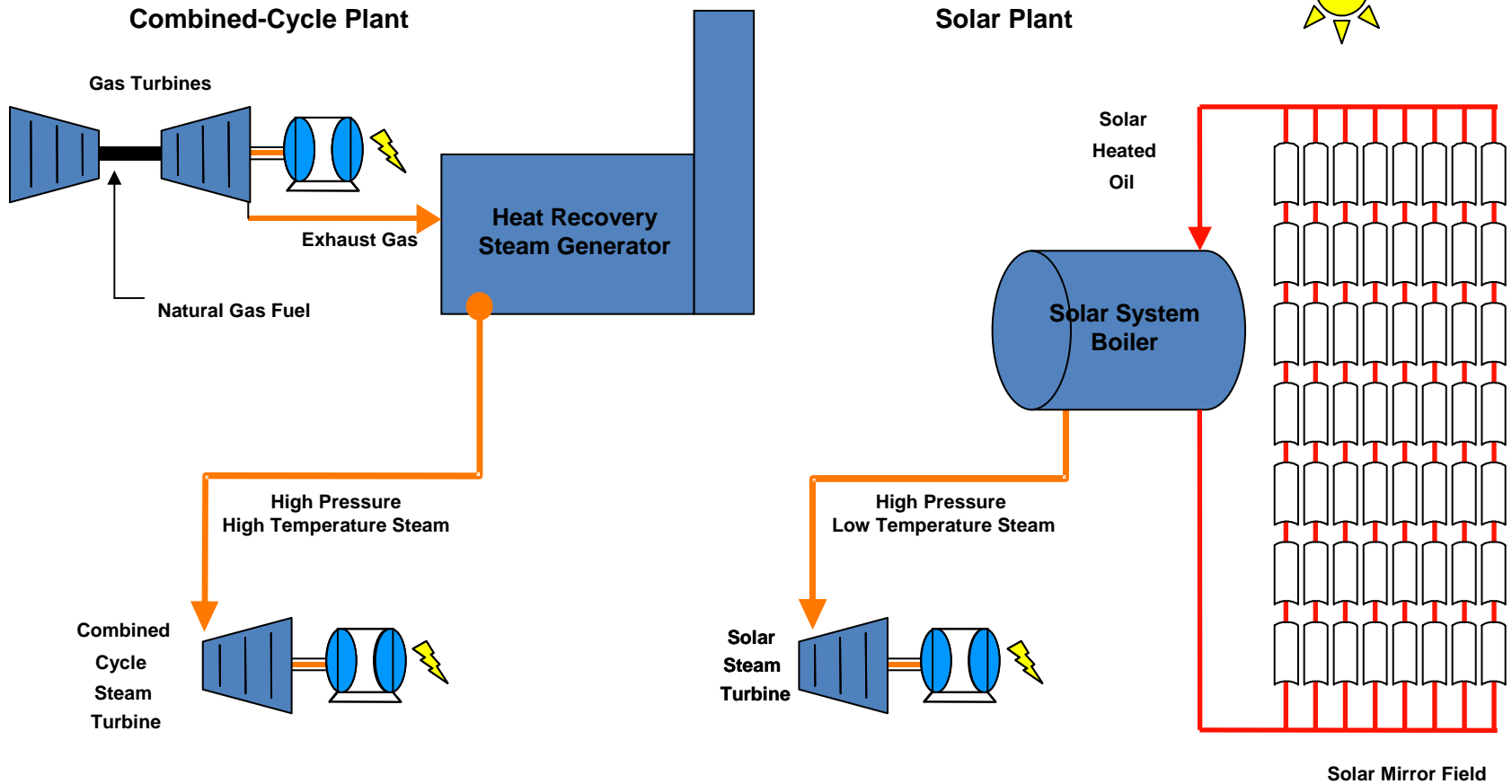
	Units	AST	Conventional Power Plant
HP Turbine Inlet			
Pressure	MPa	9.1	16.0
Temperature	°C	371	540
Reheat Temperature	°C	372	540
Auxiliary Power	MW	30.3	16.0

- ▶ Parabolic trough 260 to 400°C
- ▶ Heliostat with central receiver 500 to 800°C
- ▶ Dish concentrator 500 to 1200°C



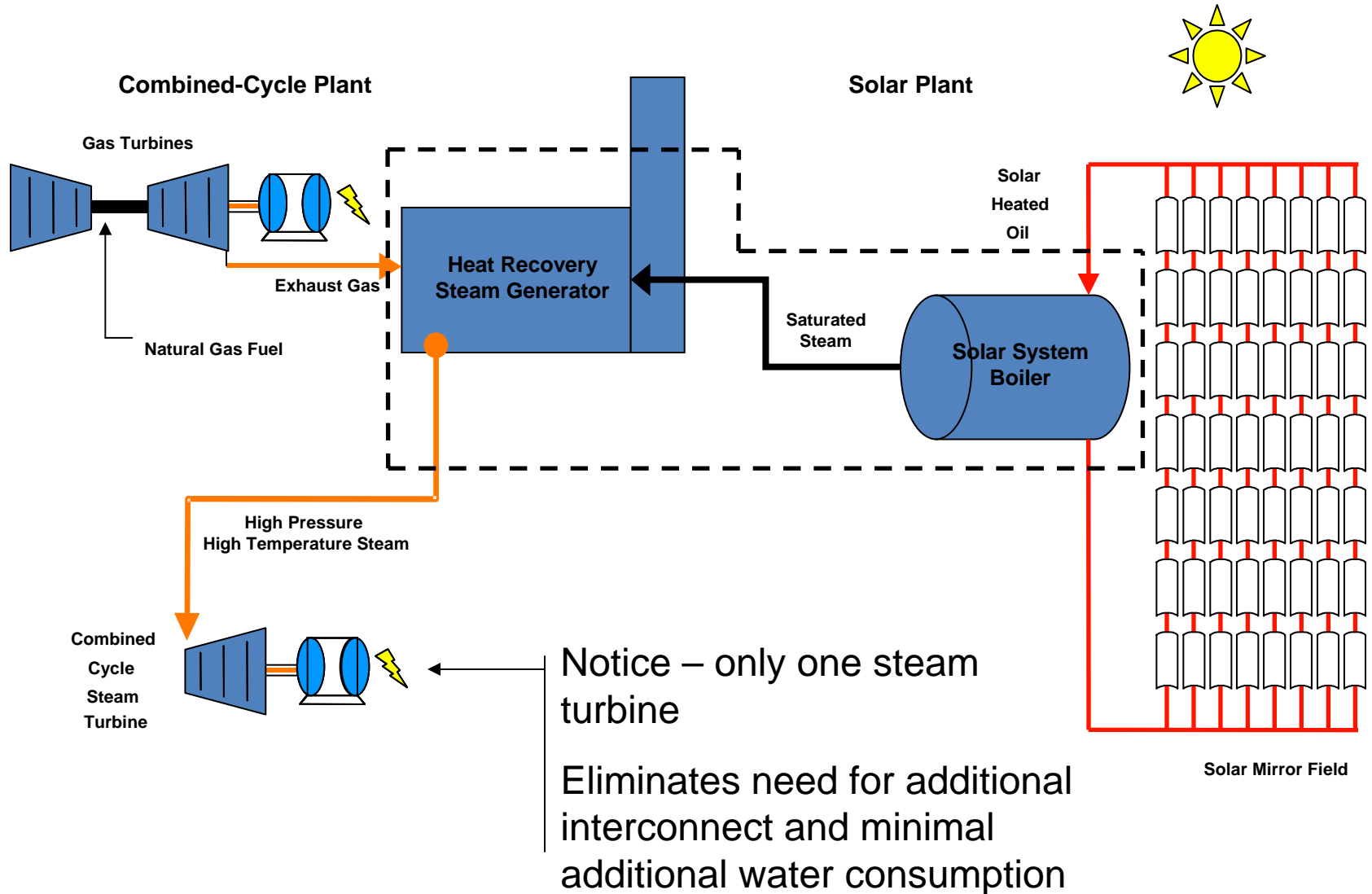


# Example of Separate Combined Cycle and CSP Plants





# Integrated Solar Combined Cycle







## ► AST has

- Peak load coincidence
- Output predictability
- Daytime dispatchability and supplies into the peak price market
- Ability to store energy as heat rather than electricity
- Renewable Energy Certificate eligibility
- Steam based generation offering greater potential for integration with gas/coal based power generation (ISCC)
- Future proofing against fuel cost rises
- Competitive against diesel fuelled power generation

## ► Challenges:

- Still expensive but long term capital cost reduction potential
- Best supply locations are remote from infrastructure and markets



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# Renewable Energy





- ▶ Wednesday 23<sup>rd</sup> September at Engineers Australia auditorium
- ▶ Gordon Keen, ExxonMobil
- ▶ By 2030, with projected economic and population growth, the world's total energy demand is expected to be approximately 35% higher than it was in 2005, despite significant gains in energy efficiency.
- ▶ Each year, ExxonMobil develops *The Outlook for Energy*, a broad, in-depth look at the long-term global trends for energy demand and supply, and their impact on emissions.
- ▶ This seminar will present key insights from *The Outlook for Energy* and will use these as a context to describe the Emissions Trading Scheme being developed in Australia.



## **CLIMATE CHANGE**

### **MRET**

Mandatory Renewable Energy Target (20/20)

### **CPRS**

Carbon Pollution Reduction Scheme

### **REDP**

Renewable Energy Development Program

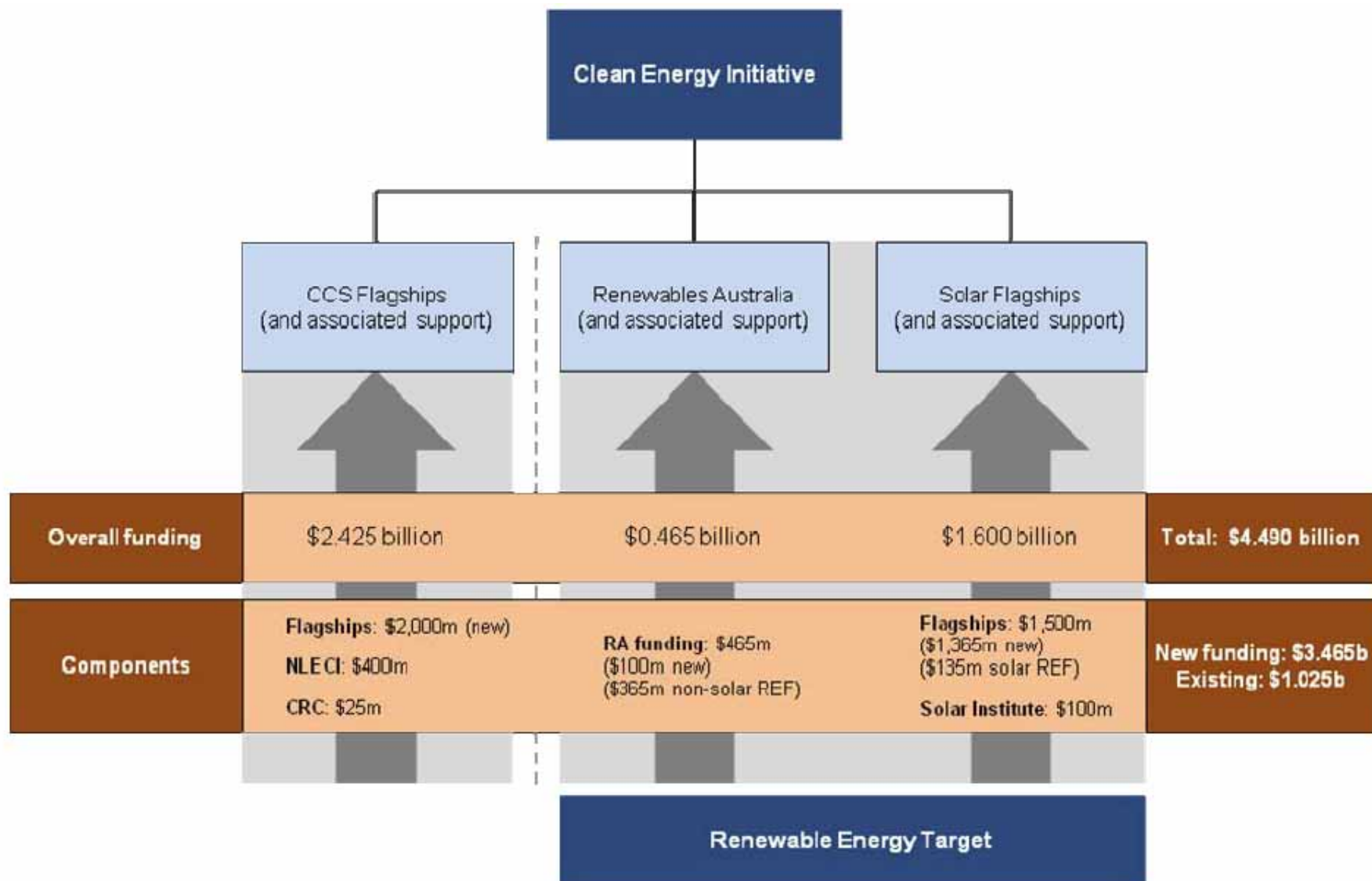
### **CEI**

Clean Energy Initiative

Solar Flagships



- ▶ Original MRET            9,500 GWh by 2010
- ▶ New MRET 20/20        45,000 GWh by 2020
- ▶ Applies to electrical power generation only
- ▶ Scheme favours lowest cost renewable energy technologies
  - Proven and mature
  - Wind, hydro, biomass, solar hot water
- ▶ Other government support for less mature technologies
  - Geothermal, solar thermal, solar PV, wave
- ▶ Clean Energy Initiative
  - Carbon Capture and Storage Flagships Program
  - Solar Flagships Program
  - Renewables Energy Australia







# WIND

Proven

Available now

The cheapest renewable

Variable

Highly visible



# The Modern Wind Turbine

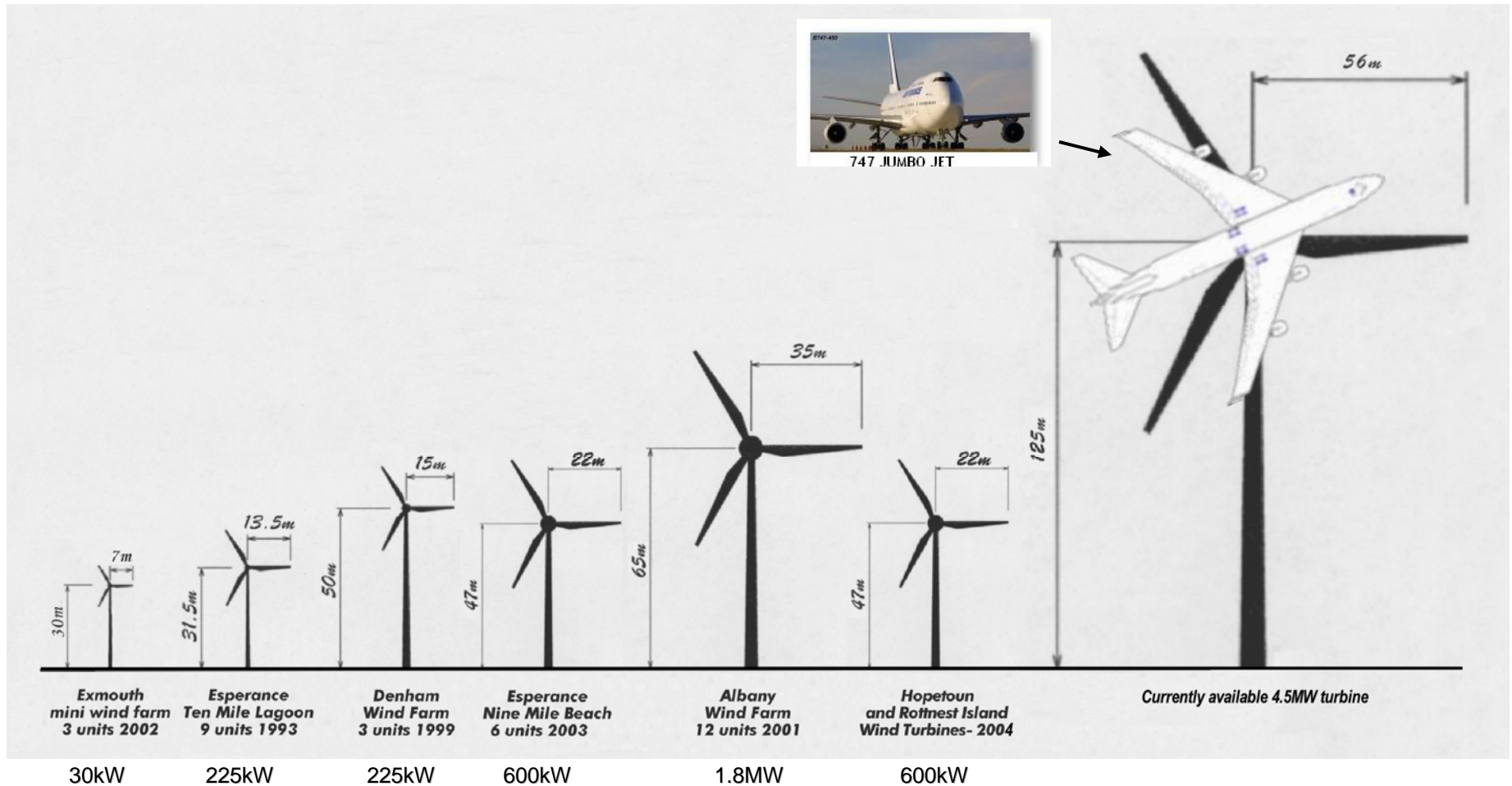


Most common design used now is;

- Three bladed
- Up-wind
- Horizontal axis
- Pitch controlled
- Steel, tubular tower
- Epoxy/polyester blades



# Wind Turbines Are Getting Bigger



Photos courtesy Verve Energy



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# Roaring 40s Cathedral Rocks Wind Farm





- ▶ Over 20 years turbines have increased from 25 kW to beyond 2500 kW. Wind turbines have grown larger and taller. Over the same period, their rotor diameters have increased eight-fold
- ▶ The cost of energy has reduced by a factor of more than five
- ▶ The largest turbine currently in operation is the Enercon E126, with a rotor diameter of 126 metres and a power capacity of 6 MW
- ▶ Offshore wind farms favour larger turbines and are pursuing designs of 5 MW and above
- ▶ Land turbines have standardised on turbine size in the 1.5 to 3 MW range





- ▶ 50 wind farms, 1,306 GW
- ▶ 6 projects, 555 MW during 2009
- ▶ Projects are getting bigger, more remote
  - Silverton, NSW 1000 MW+
  - Macarthur, VIC, 330 MW+
  - Hallett, SA, 130 MW
  - Coopers Gap, QLD, 500 MW



# Photovoltaics

PV

*Sunlight to Electricity*

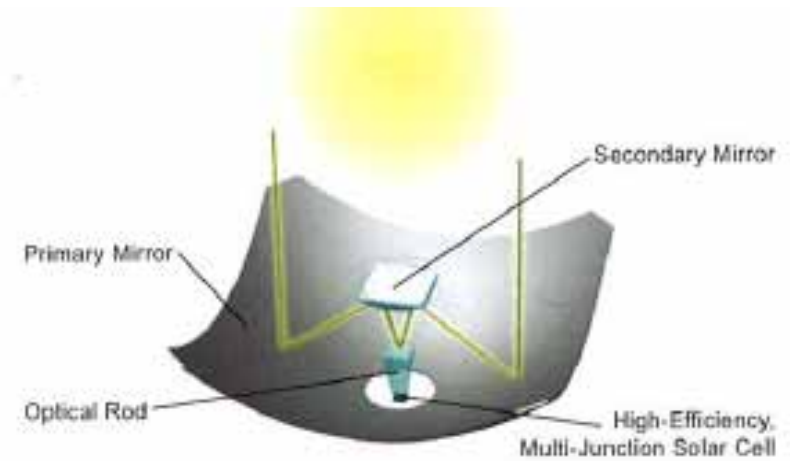


**Flat Plate PV**



**Concentrating PV**

**Thin Film PV**





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## Solar Systems Ltd. Dish/ PV





- ▶ Solar PV cost per delivered unit of energy has fallen by over 60% in the last 5 years
- ▶ Improvements in cell efficiency
  - 35% when measured over the whole module
  - Spin off from space program, providing high-reliability power to satellites
- ▶ Improved mechanical design
  - Simplified PV receivers
  - Improvements in construction methods

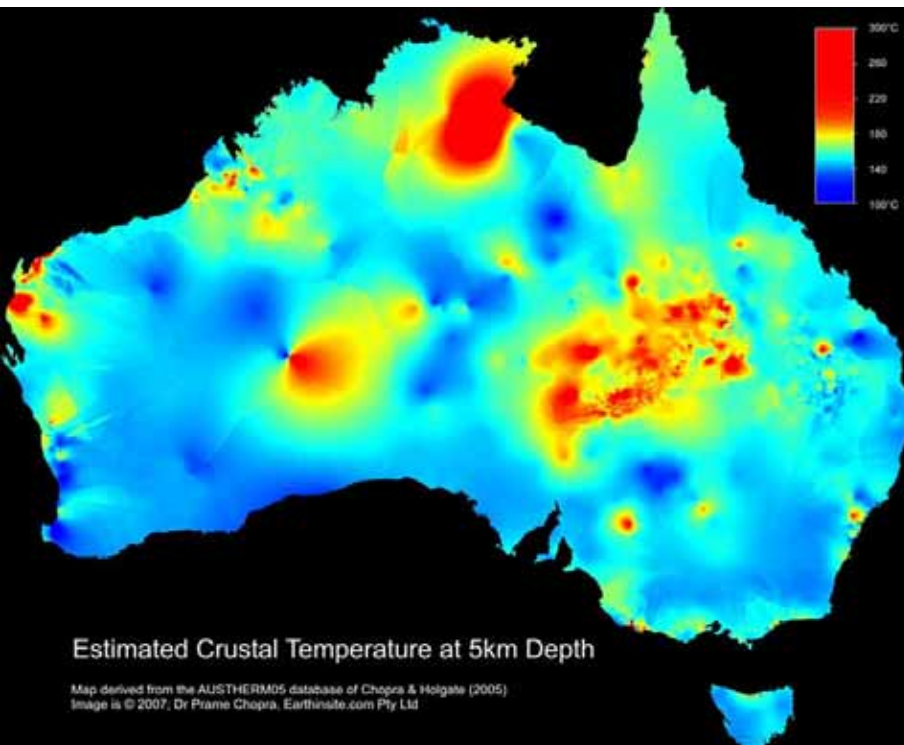




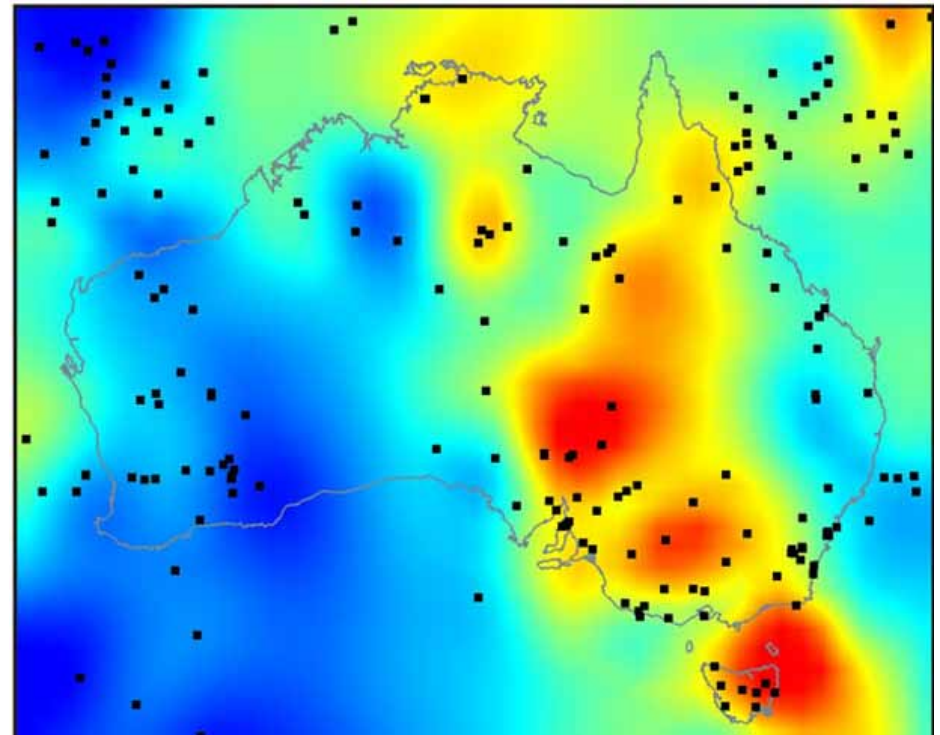
# HOT DRY ROCKS



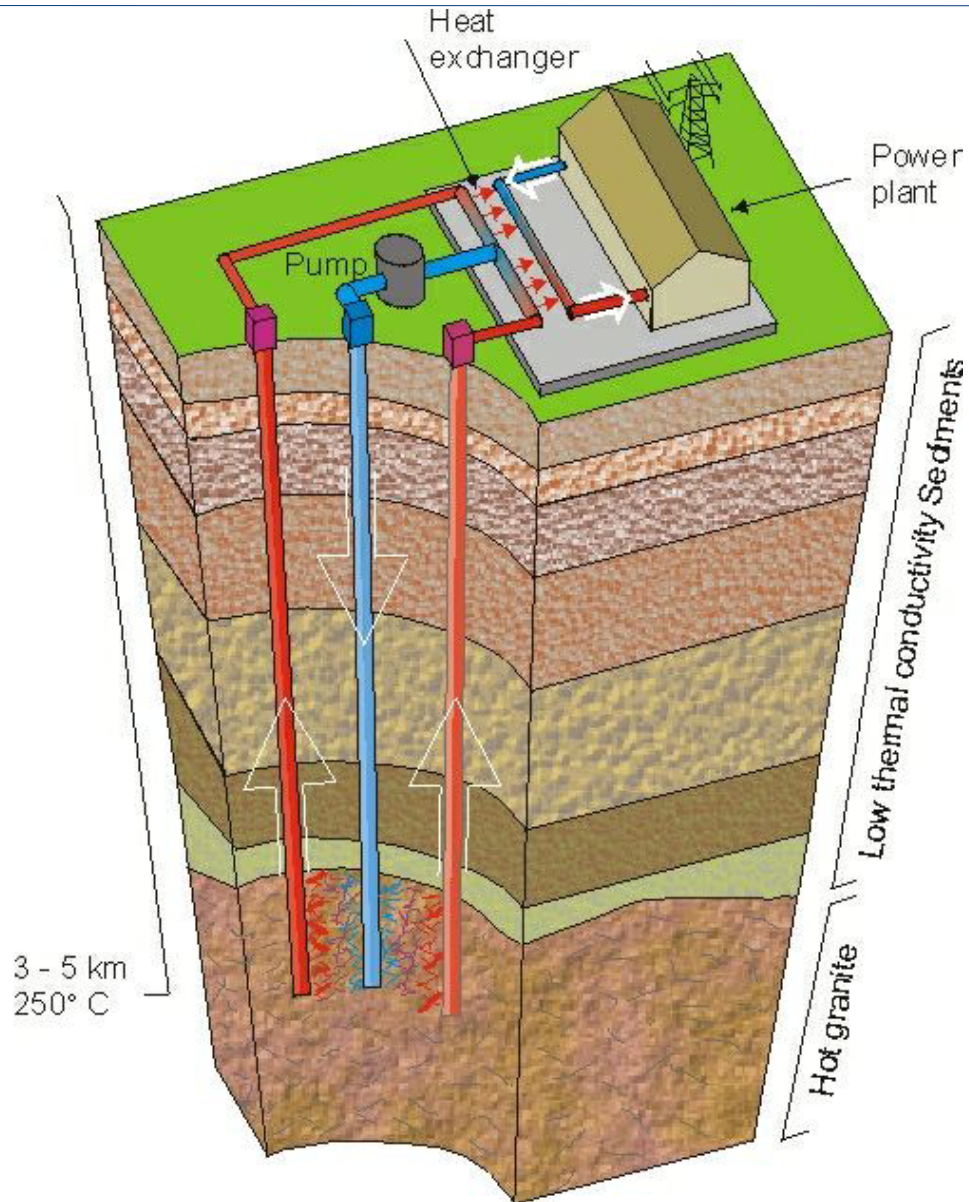
## Deep Temperatures



## Surface Heat Flow



Source: Geoscience Australia Geothermal Energy Project





# Geodynamics 1MW Pilot Plant



*Innamincka 1 MW Power Plant and Visitor Centre under construction*



*Turbine delivered*



- ▶ Technical limits for materials and equipment
- ▶ Failure of wellhead casing due to hydrogen embrittlement

Source: Geodynamics press releases





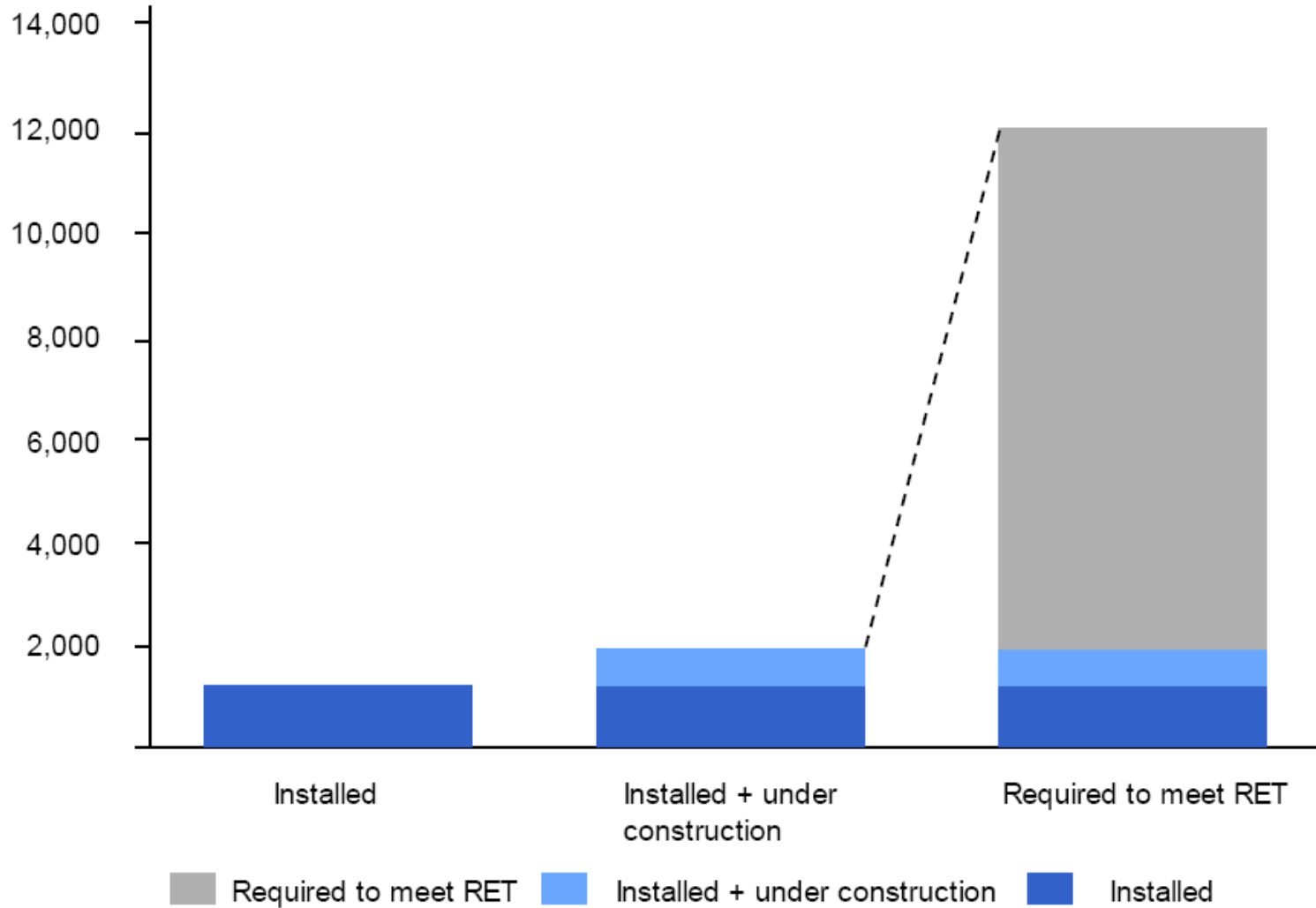
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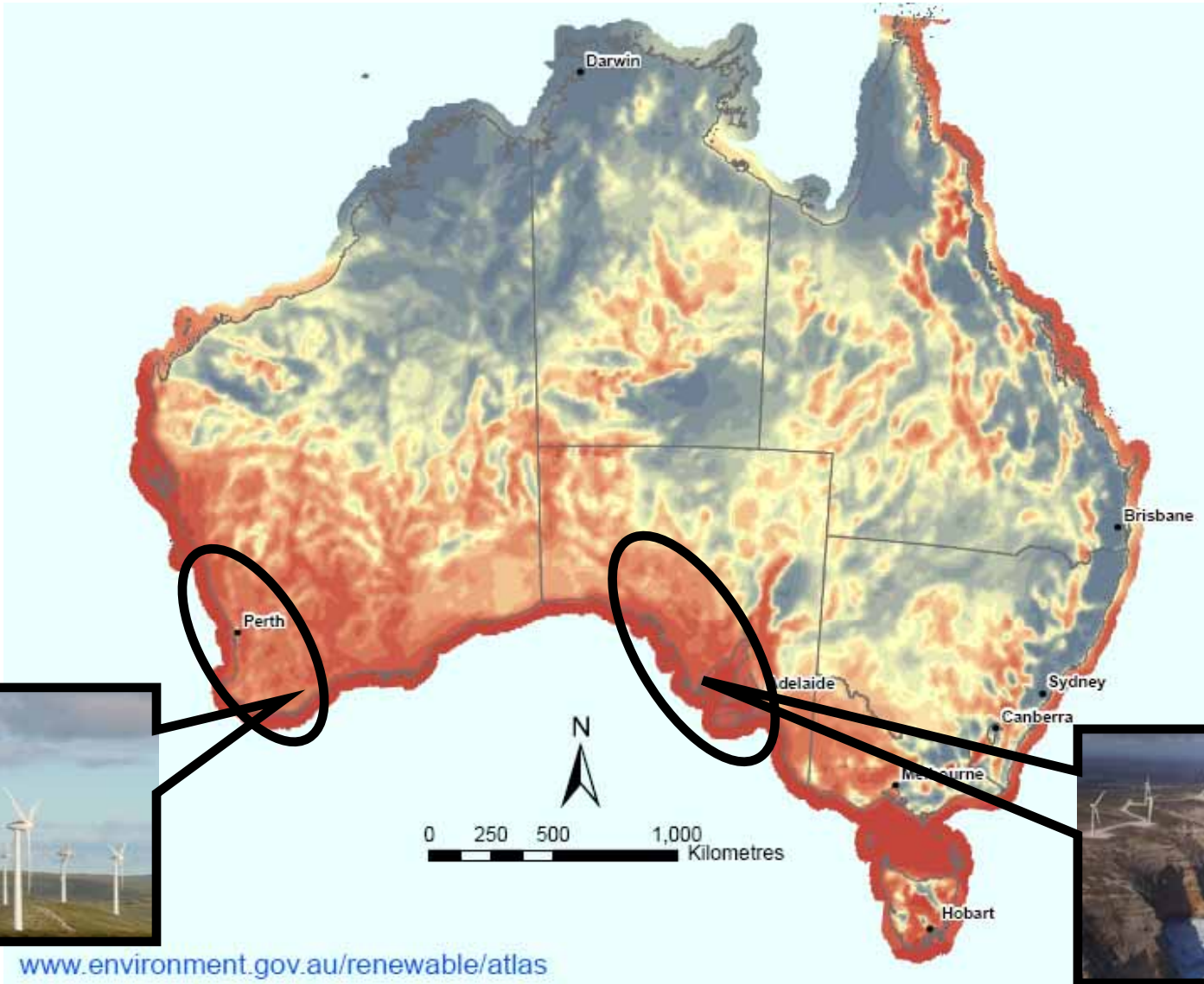
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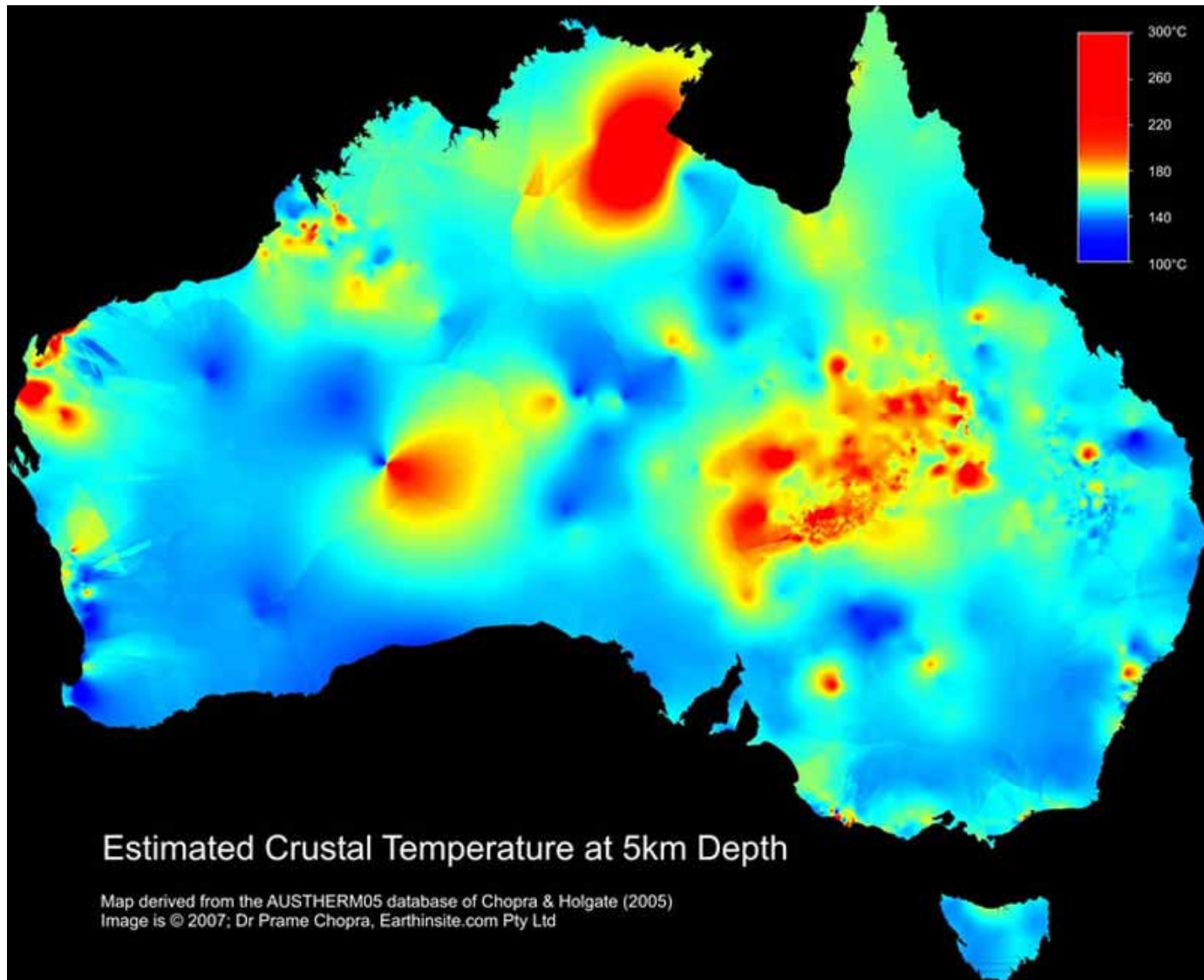
# Green Grid

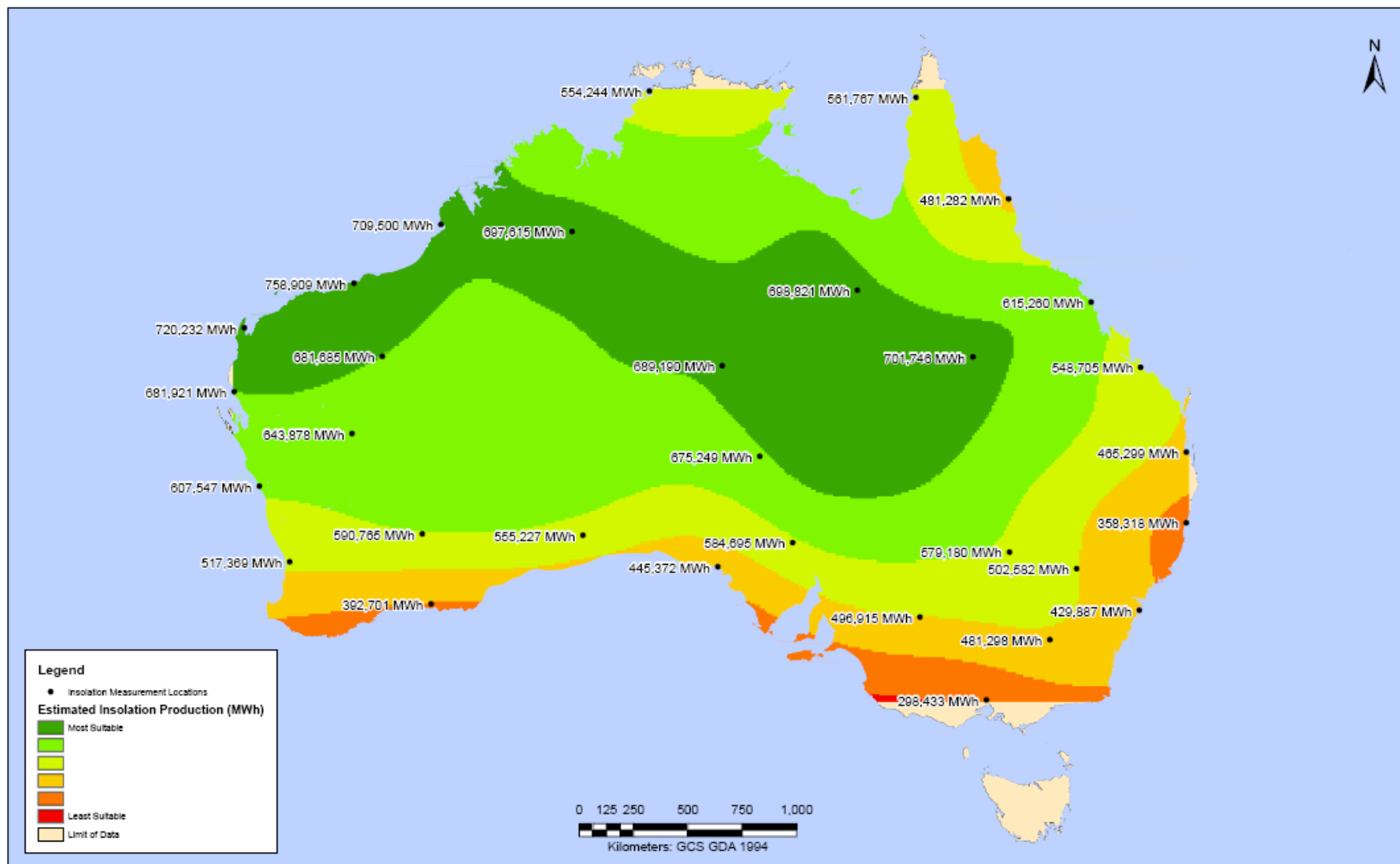


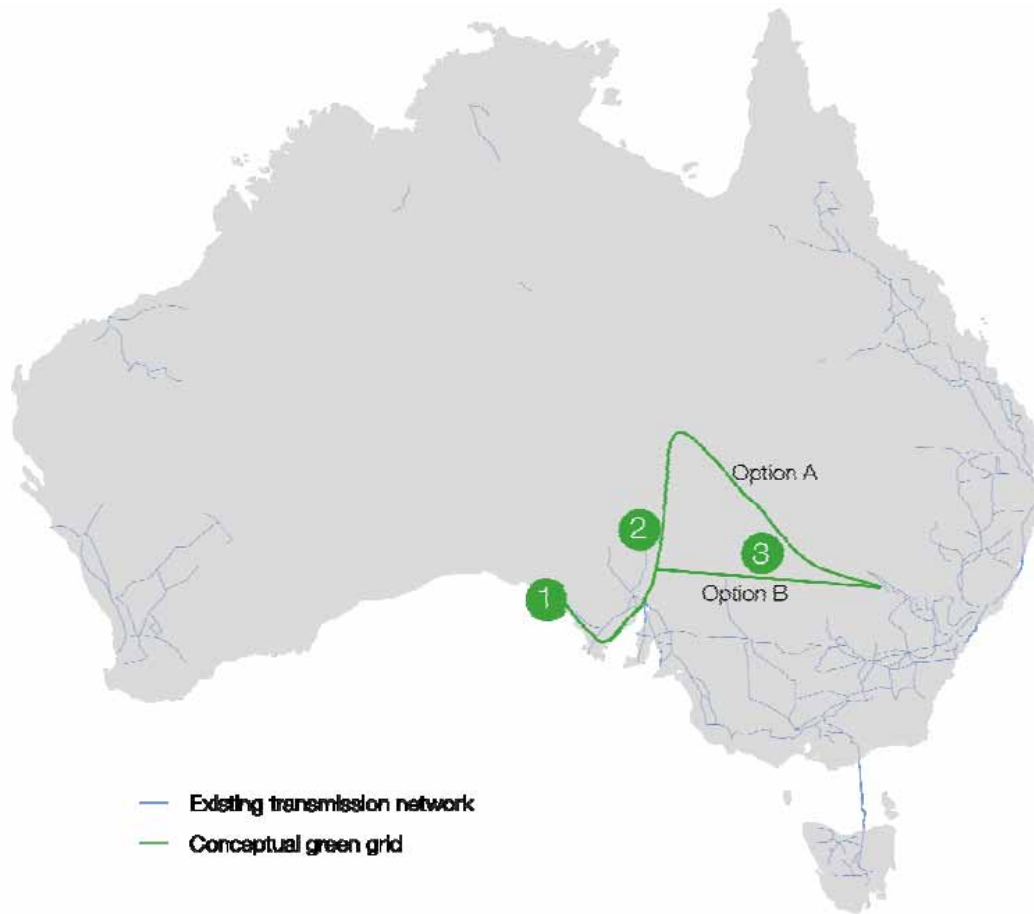












1. **Eyre Peninsula**
  - ▶ Australia's best wind resource
  - ▶ Up to 5000 MW
2. **Cooper Basin**
  - ▶ Geothermal and Solar Thermal
  - ▶ 1000 MW link
3. **Link to East Coast**
  - ▶ Link to NEM
  - ▶ Further 3000 MW link





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# Impact on Oil & Gas Industry





- ▶ New renewable energy sources are base load plants
- ▶ Can't rely on new build coal fired power plants with large reserve capacity
- ▶ Peaking sources
  - Hydro
  - Gas
- ▶ Hydro
  - Opportunities are rare
  - Suffering from reduced rainfall
- ▶ Gas
  - Numerous projects in each state
  - Both base load and peaking power plants being installed



- ▶ Competing government schemes
- ▶ MRET and ETS have different cost mechanisms
- ▶ Garnaut says that, perversely, this would increase **coal-fired** power stations as gas-fired power stations are crowded out
  
- ▶ Are we ready for a market where gas is increasingly used for peaking service?
  - Rapid demand nomination changes
  - Capacity to meet peaking service
  - Rule changes



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# Thank You Questions?

