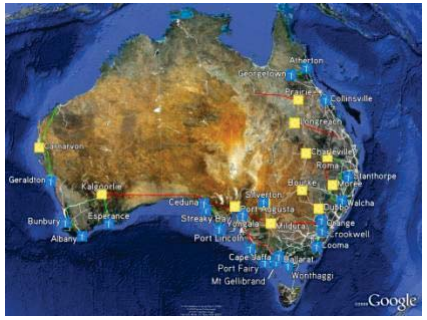


Zero Carbon Australia Stationary Energy Plan

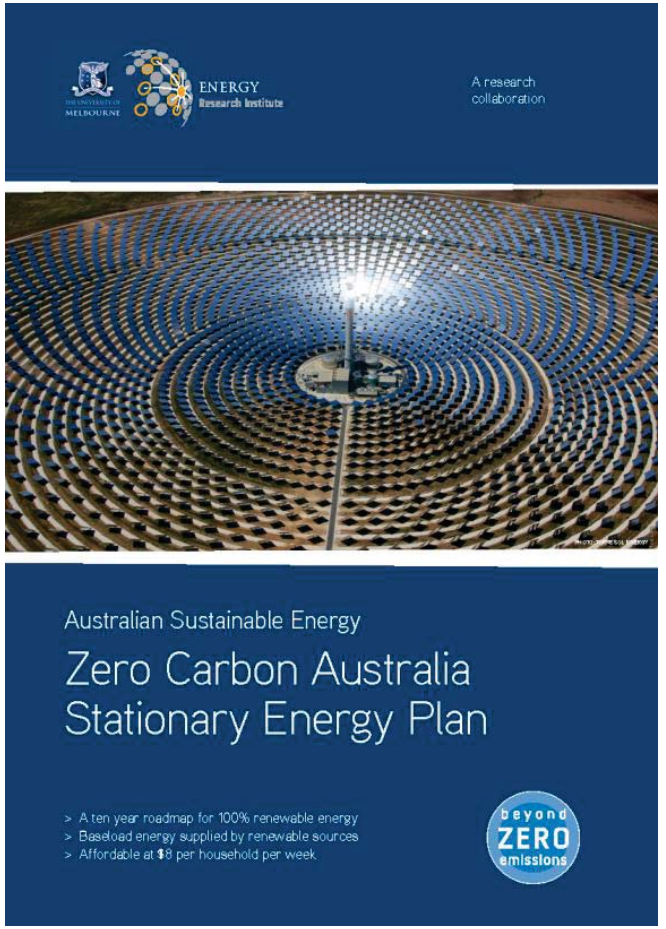
A plan to repower Australia with 100% renewable energy in 10 years

beyond ZERO emissions

Major questions

- Need?
- Technology?
- Reliability?
- Resources?
- Jobs?
- Economics?

- Social and Political Will?
- What can I do?

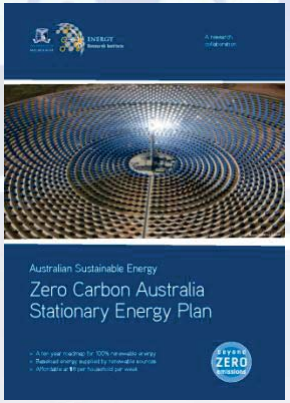


Science based - Solutions focused

(BZE)

Research & Communications
Completely independent
Probono contributions
Staff coordinators
Run on your donations

Zero Carbon Australia Stationary Energy Plan Contributors



THE UNIVERSITY OF MELBOURNE

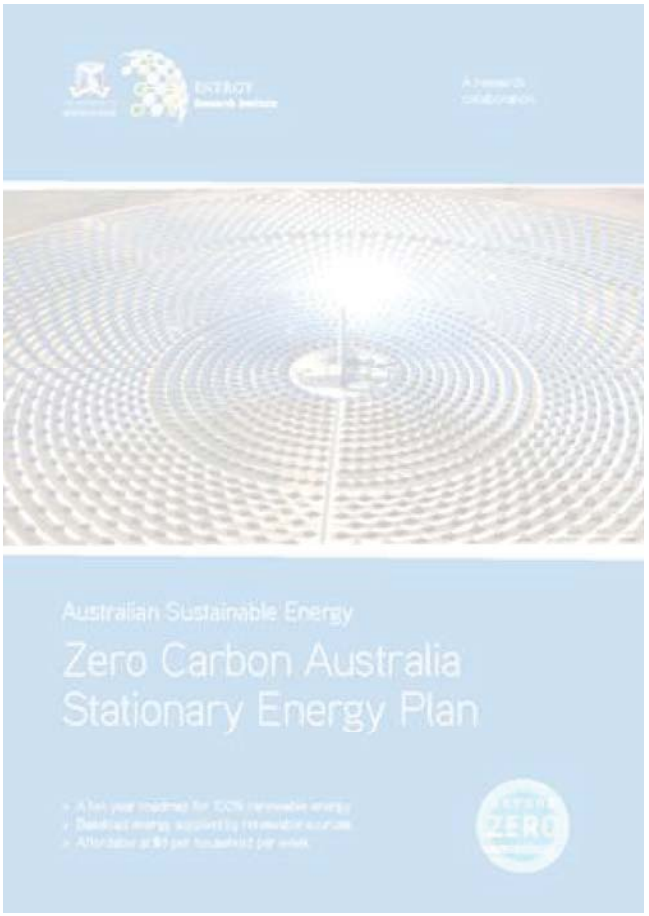
ENERGY Research Institute

beyond ZERO emissions

Zero Carbon Australia Plan (ZCA) - Guiding Principles

- **Blueprint for a Zero Carbon Australia in 10 years**
- Fully accept latest climate science evidence
- Specifies only Commercial-Off-The-Shelf technology
- Maintain or enhance Australia's:
  - Energy Supply security and reliability
  - Food and water security
  - Standard of living

ZCA Stationary Energy Plan



- Stationary Energy = Electricity from power stations
- A detailed, fully costed, resourced model of
- One way to
- **Repower Australia with 100% renewable energy in 10 years**

Endorsements

ENERGY
Research Institute

As the IEA has shown in its research, solar energy is now a serious global player for providing the world's energy. Australia has one of the world's best solar energy resource, especially suited for concentrating solar thermal power plants, which can dispatch electricity when it is needed. The Zero Carbon Australia Plan is based on up-to-date and sound information and provides quality insights on how a country well-endowed in renewable resources

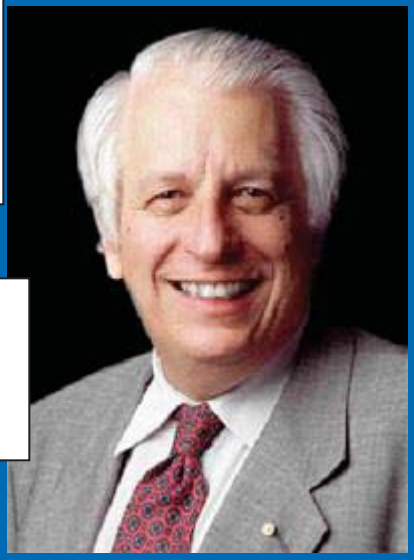
ROBIN BATTERHAM
KERNOT PROFESSOR OF ENGINEERING, UNIVERSITY OF MELBOURNE
PRESIDENT, AUSTRALIAN ACADEMY OF TECHNOLOGICAL SCIENCES AND ENGINEERING
FORMERLY CHIEF SCIENTIST OF AUSTRALIA

The Zero Carbon Australia 2020 plan shows that it is technically feasibl affordable to replace all fossil fuel electricity with 100% renewable ener given the willpower and commitment to do so. This is a cutting-edge sci based plan that should be read by every energy decision maker and poli in Australia.

MARK Z. JAC
PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING
PROFESSOR BY COURTESY OF ENERGY RESOURCES ENGINEERING
DIRECTOR, ATMOSPHERE/ENERGY PROGRAM
STANFORD UNIVERSITY, USA

iea International Energy Agency

General Peter Gration
Former Chief of Defence



Sir Gustav Nossal

Former Australian Chief Scientist
Robin Batterham

Want to feel good?
Then go overseas!

Germany

Denmark

Japan

Finland

China

India

Developing world

Confused about the language?

Low Carbon, “Clean” ENERGY

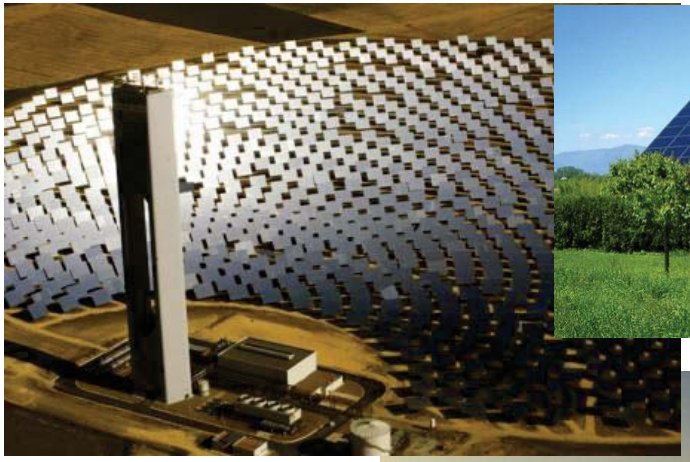
or

Zero Carbon, “Renewable” ENERGY

Two paradigms, Two pathways

Low Carbon

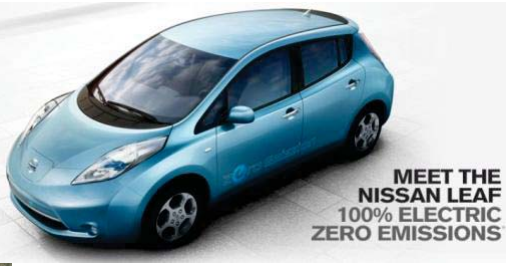
- Zero Carbon



Two paradigms, Two pathways

Low Carbon

• Zero Carbon

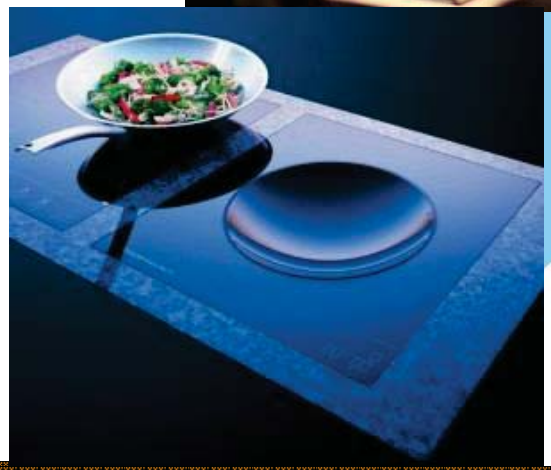


Two paradigms, Two pathways

Low Carbon

Noxious Gas Stove Emissions Worsen Asthma Symptoms In Young Children
ScienceDaily (Oct. 13, 2008) — Johns Hopkins scientists report that high levels of a noxious gas from stoves can be added to the list of indoor pollutants that aggravate asthma symptoms of inner-city children, especially preschoolers.

• Zero Carbon

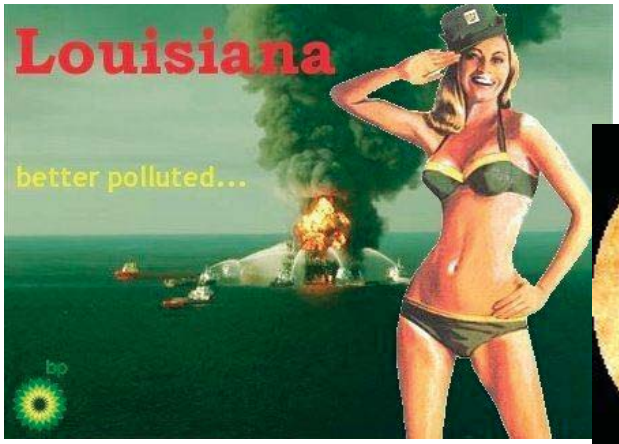


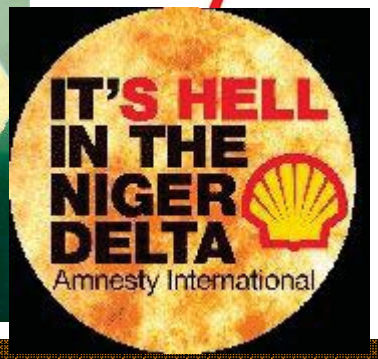
Two paradigms, Two pathways

Low Carbon

thebpplan

shrinking the environment





Zero Carbon

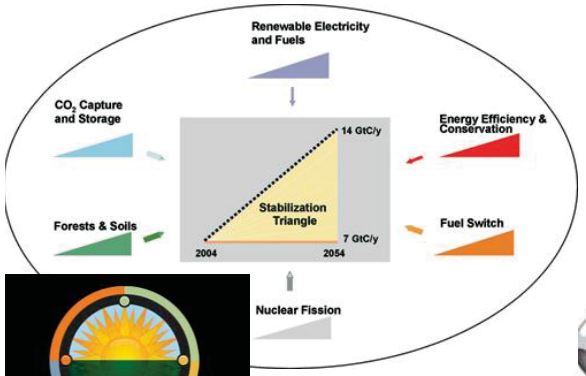
UNSW
THE UNIVERSITY OF NEW SOUTH WALES
SYDNEY • AUSTRALIA

SUNTECH

ENERCON
ENERGY FOR THE WORLD

Two paradigms, Two pathways

Low Carbon



BP

Ford

CMI
Carbon Mitigation Initiative

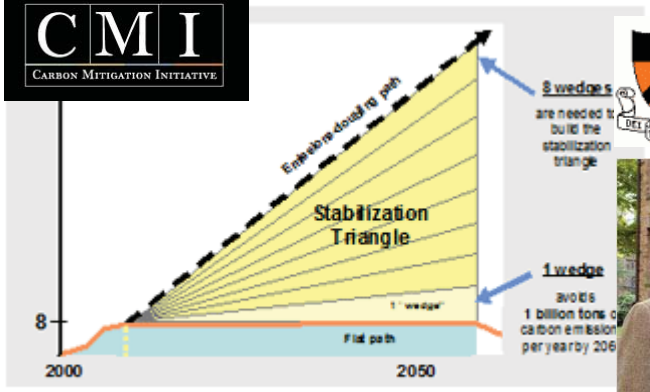


Figure 2

Princeton University

- Zero Carbon

beyond ZERO emissions

Tri-generation
Wrong Way Go Back

1. Introducing NOX into the Sydney air-shed goes against 100 years of cleaning up city air
2. Coal Seam Gas – signal for extraction devastating farmland
3. Biogas excuse – debunked – 250km radius Sydney all available feedstock – competes with industrial process /transport needs / nutrient stripping


elyplanetimages.com

Santos and GLNG

Santos 30% /Petronas 27.5%/ Total 27.5%/ Kogas 15%

3 LNG processing plants "trains" Curtis Island -10mtpa

2650 wells- **first train only**

Total wells 10,000?

Cover 24,065 sq km

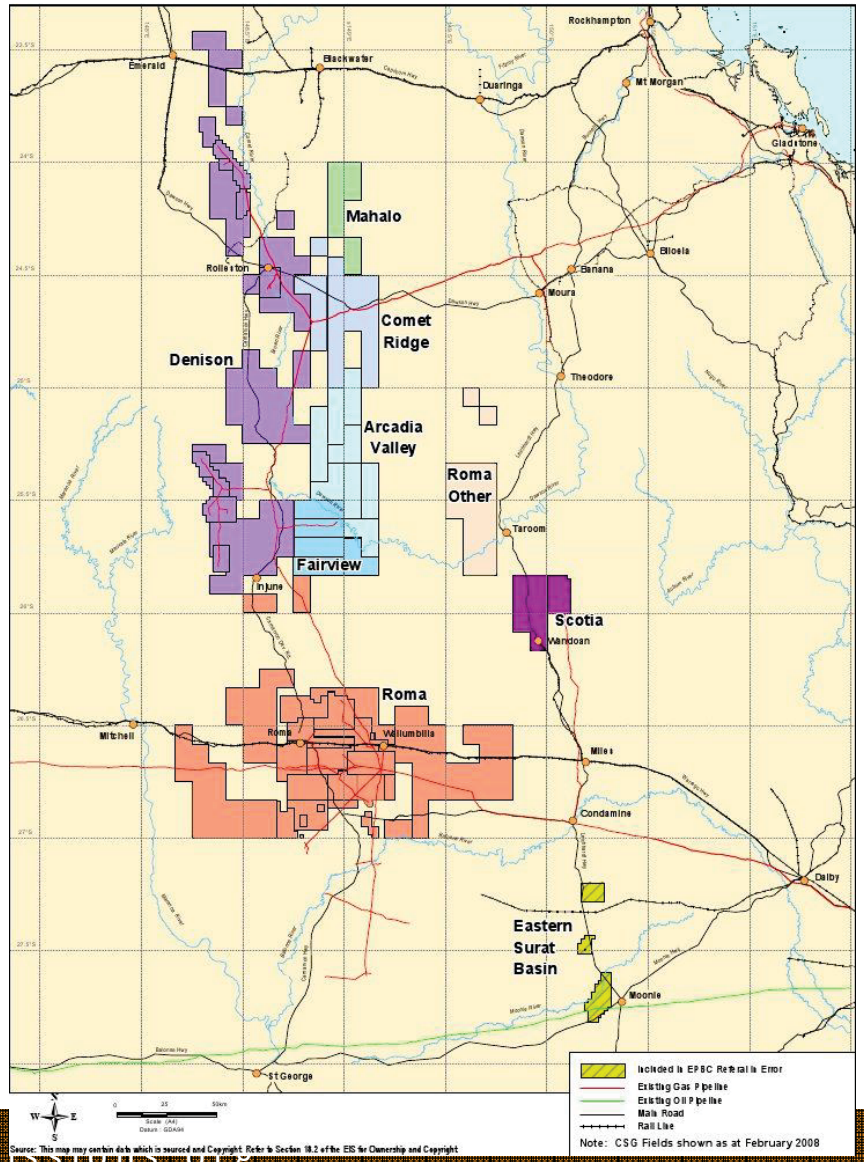
450 compressor stations

Water treatment facilities

20400 km access roads

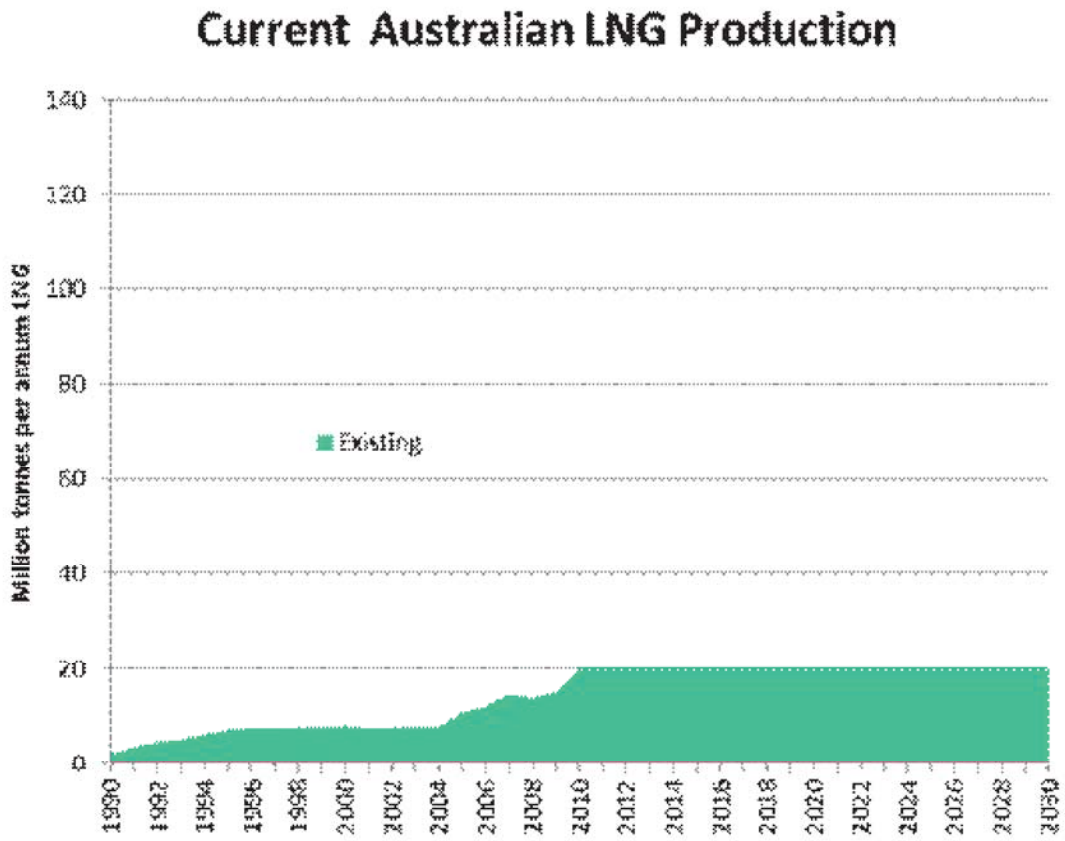
6000 km water and gas pipes

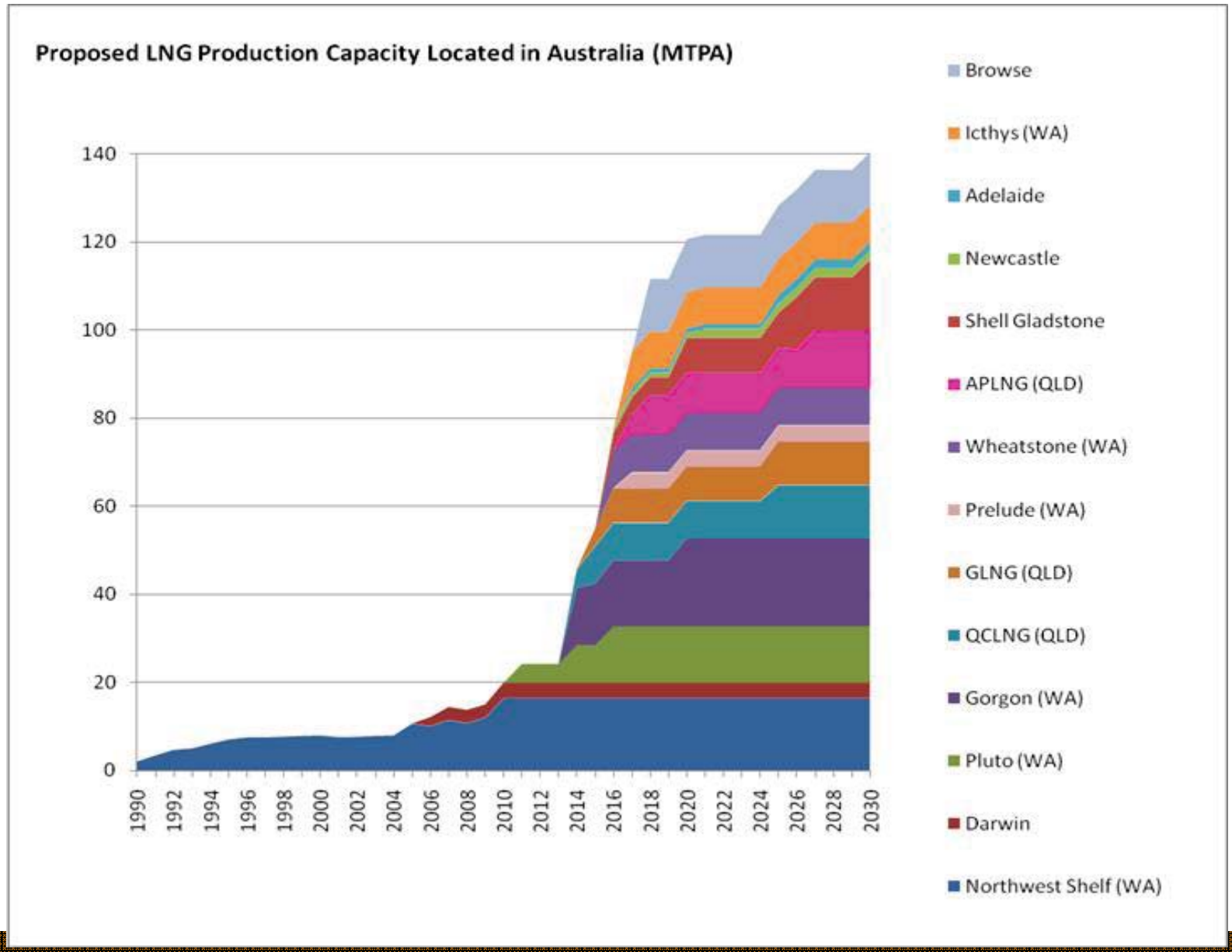
435 KM major pipeline to Curtis Is



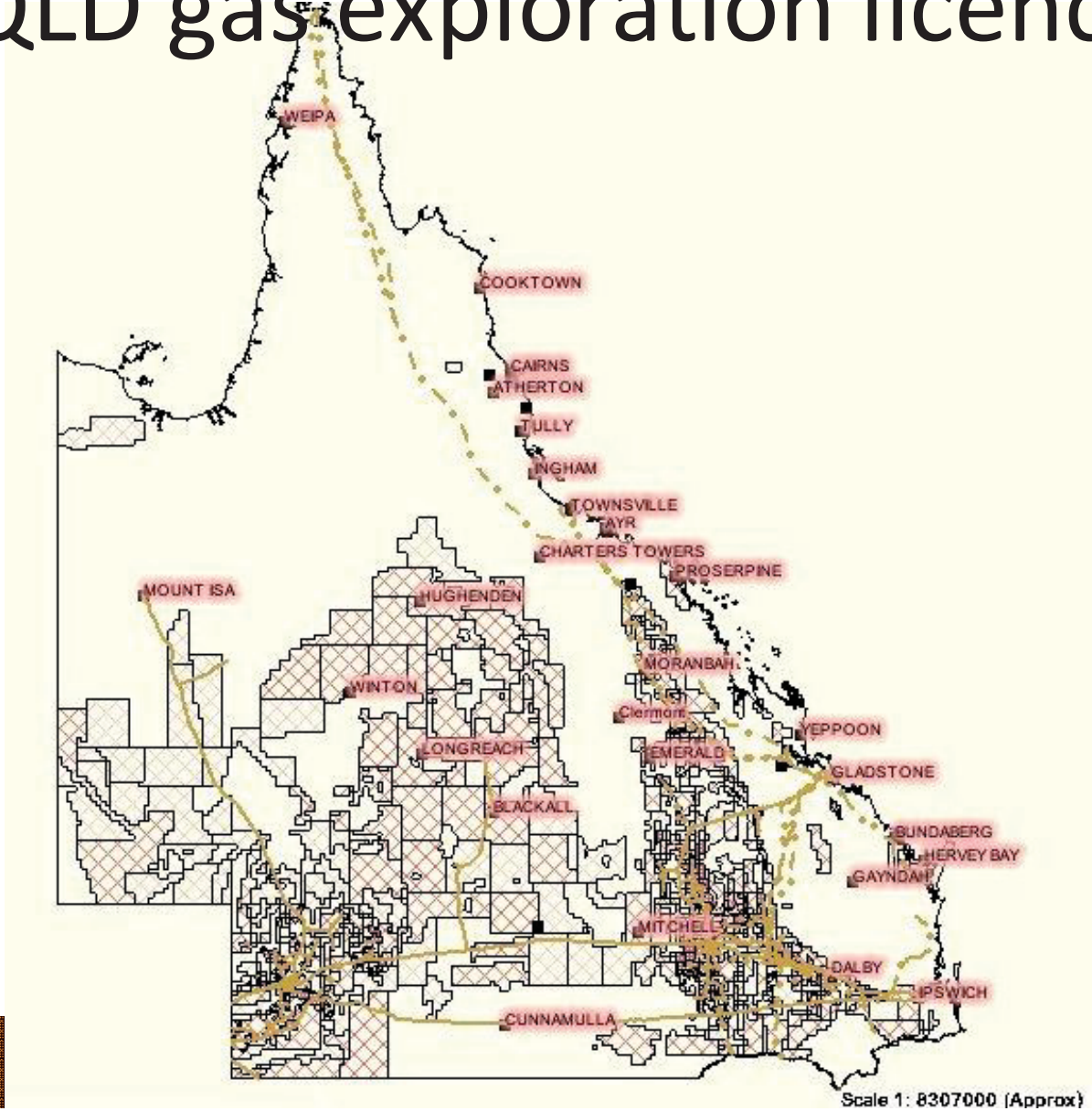
Current LNG production in Australia

North West Shelf and Darwin LNG



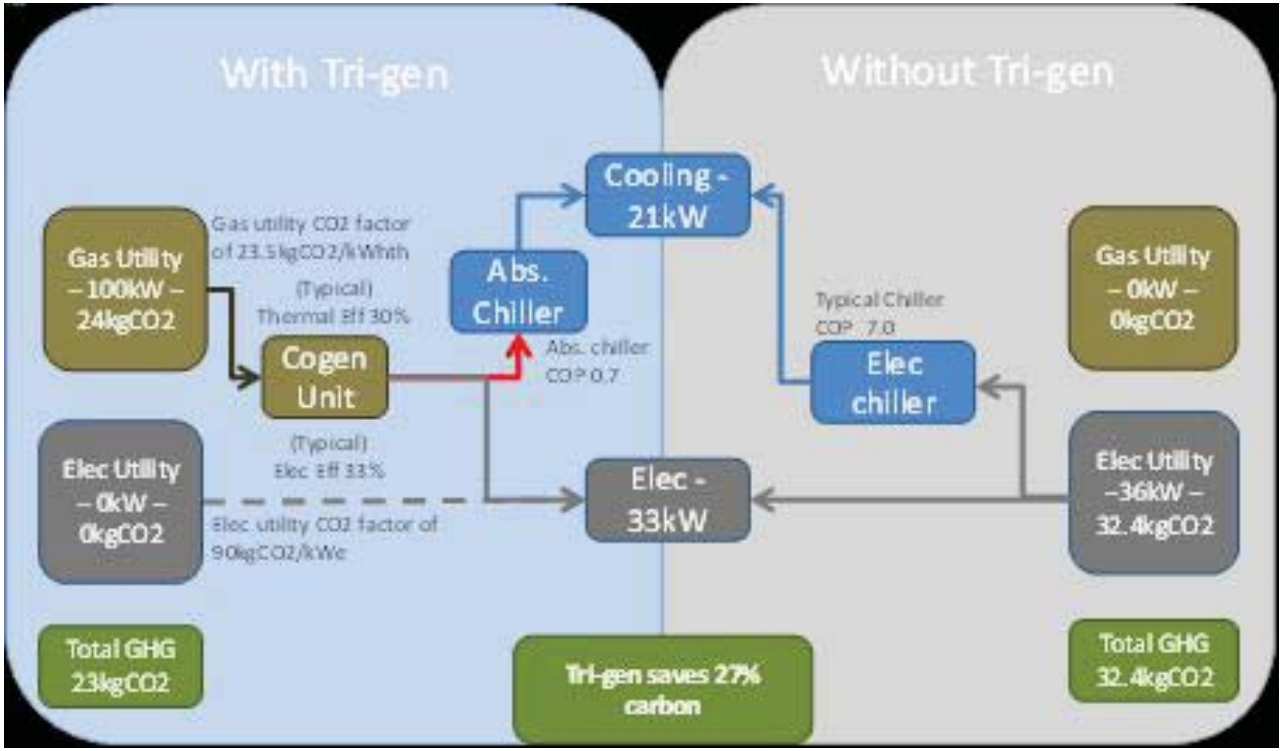

Proposed LNG Production Capacity Located in Australia (MTPA)
140
120
100
80
60
40
20
0
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
2024
2026
2028
2030
Browse
Icthys (WA)
Adelaide
Newcastle
Shell Gladstone
APLNG (QLD)
Wheatstone (WA)
Prelude (WA)
GLNG (QLD)
QCLNG (QLD)
Gorgon (WA)
Pluto (WA)
Darwin
Northwest Shelf (WA)

QLD gas exploration licences



Tri-gen Try Again!

4. CSG wells leaking at 15% of total field yield at Wyoming Powder River Basin US DoE
5. Unconventional wells Denver Co leaking at a rate upto 7% of total field yield NOAA
6. Gas is dirtier than coal in peaker/CCGT/trigen
7. Tri-gen cooling C.O.P 70% efficient VS Japanese VRF HVAC with C.O.P 410% electric
8. Cogeneration Is centralised

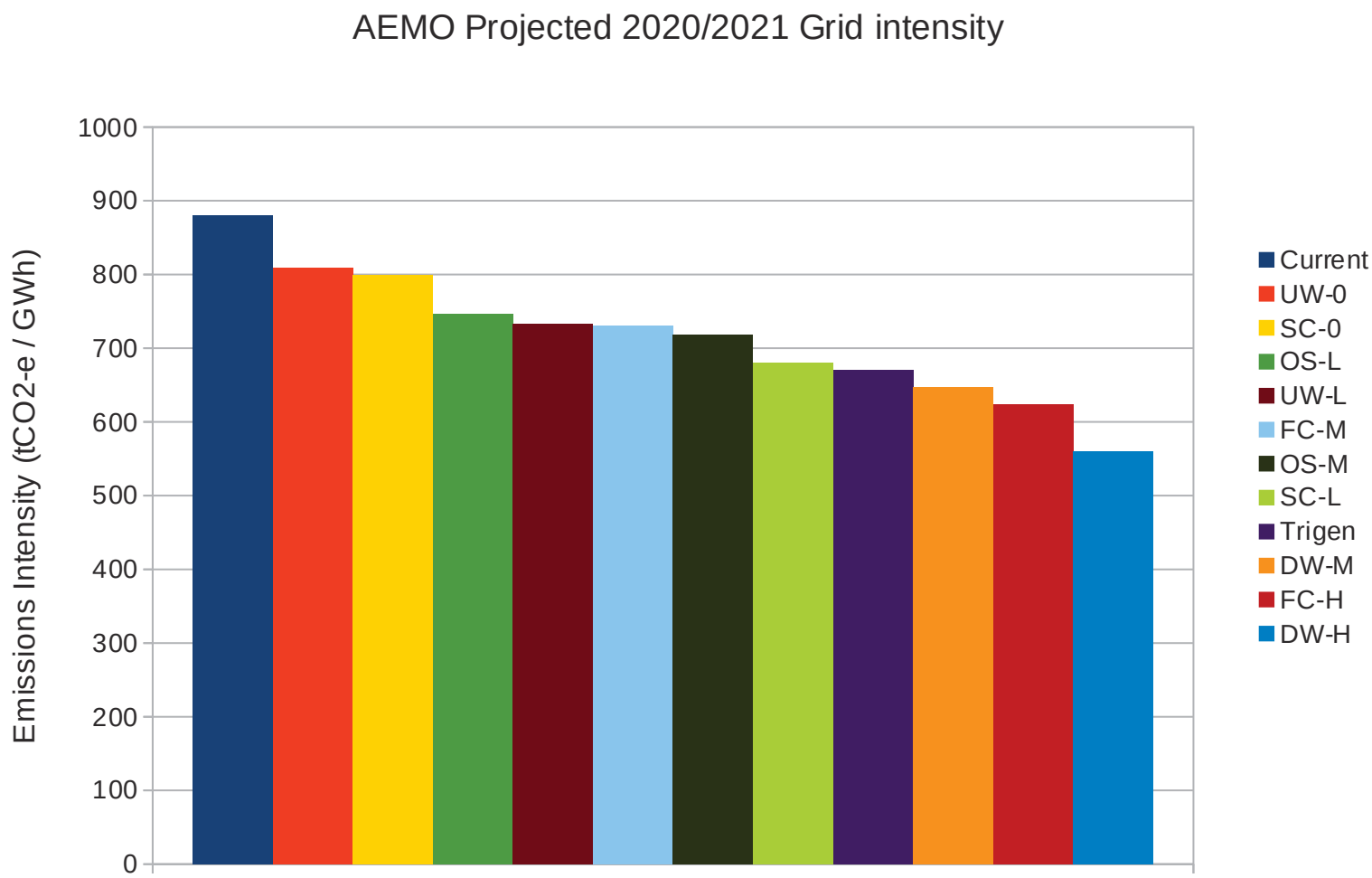


Emissions intensity of an standard trigen unit is – 0.67kgCO2/kWh

CCGT plant – 0.45kgCO2/kWh

Calculating GHG emissions intensity trigeneration plant in Australia

$$\frac{Elec\ GHG_e\left(kgCO_2e/kWh\right)}{Gas\ GHG_e\left(kgCO_2e/kWh\right)} > \left(\eta_{trigen\ ,elec} + \frac{\eta_{trigen\ ,thermal} \times COP_{Absorption\ \ Chiller}}{COP_{Electric\ ,Chiller}}\right)^{-1}$$

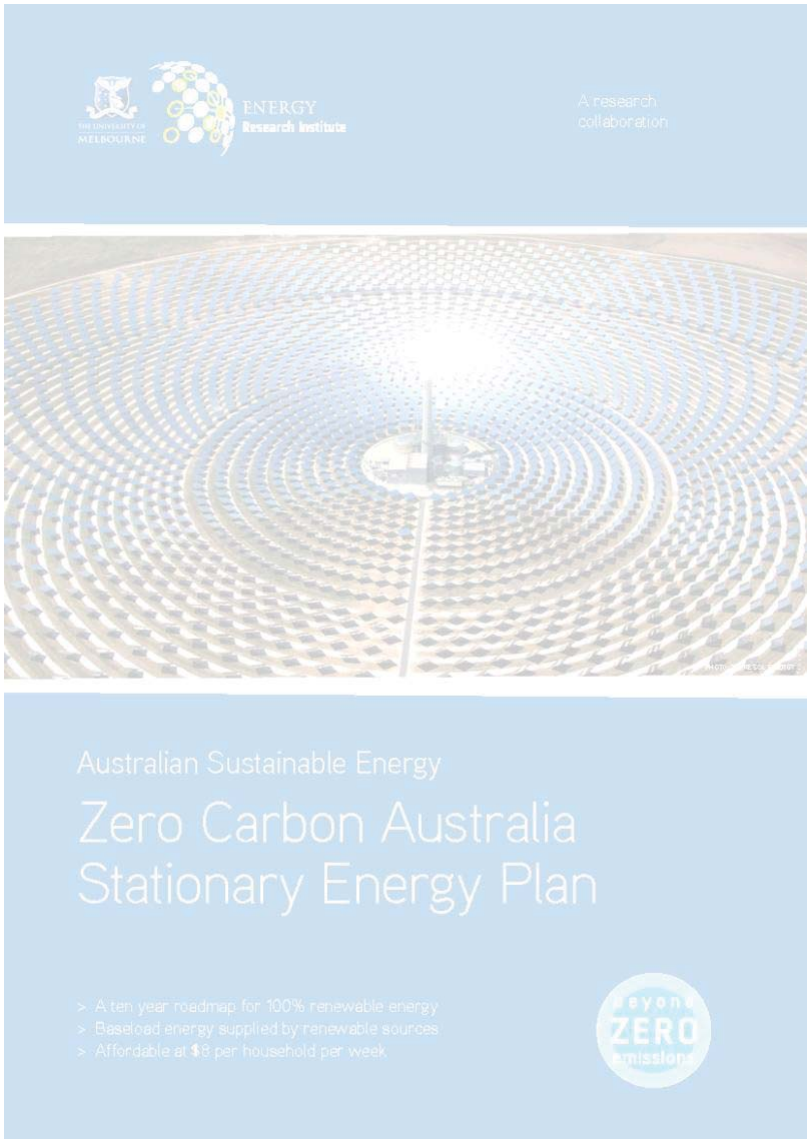


What happens if we decarbonise faster?


2
Buildings


3
Transport


4
Land Use


ENERGY
Research Institute
A research collaboration
Australian Sustainable Energy
Zero Carbon Australia
Stationary Energy Plan
> A ten year roadmap for 100% renewable energy
> Baseload energy supplied by renewable sources
> Affordable at $8 per household per week
beyond ZERO emissions

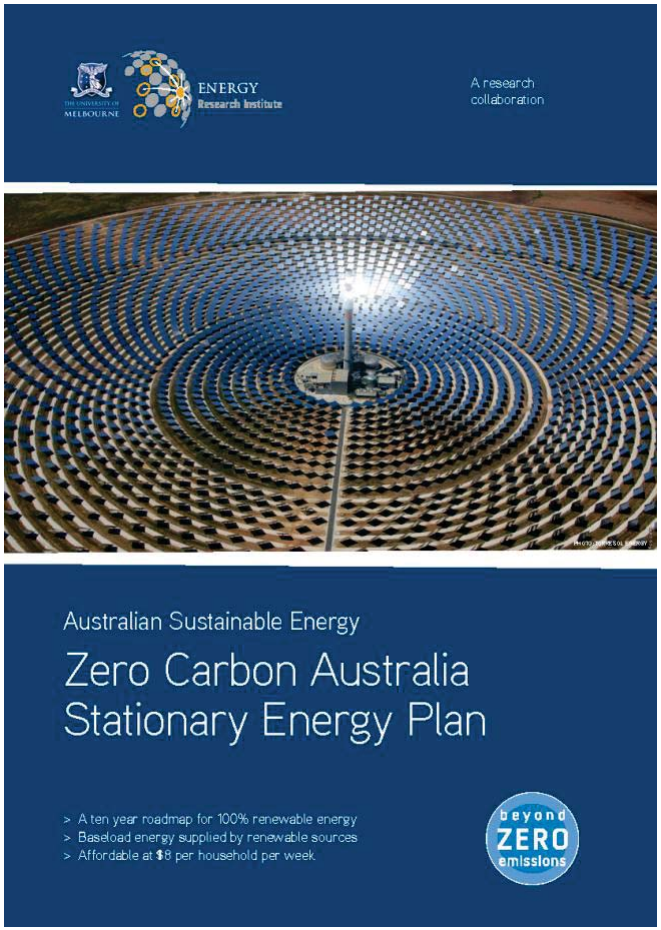

5
Industrial
Processes

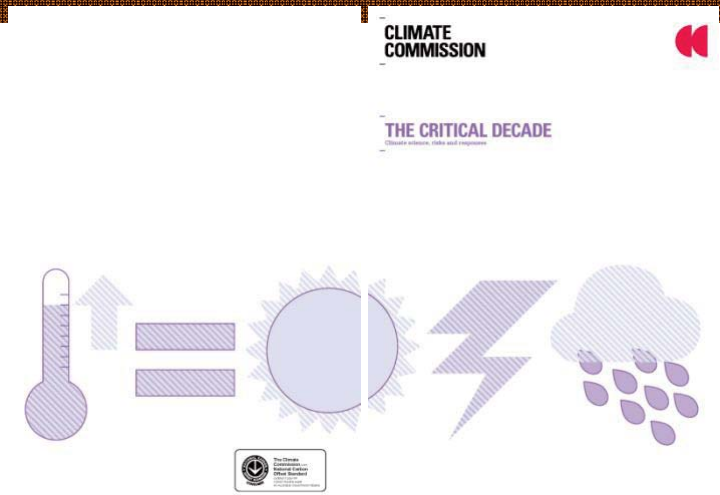

6
Renewable
Energy
Superpower

Major Questions

- Need? **- Part One**
- Technology?
- Reliability?
- Resources?
- Jobs?
- Economics?

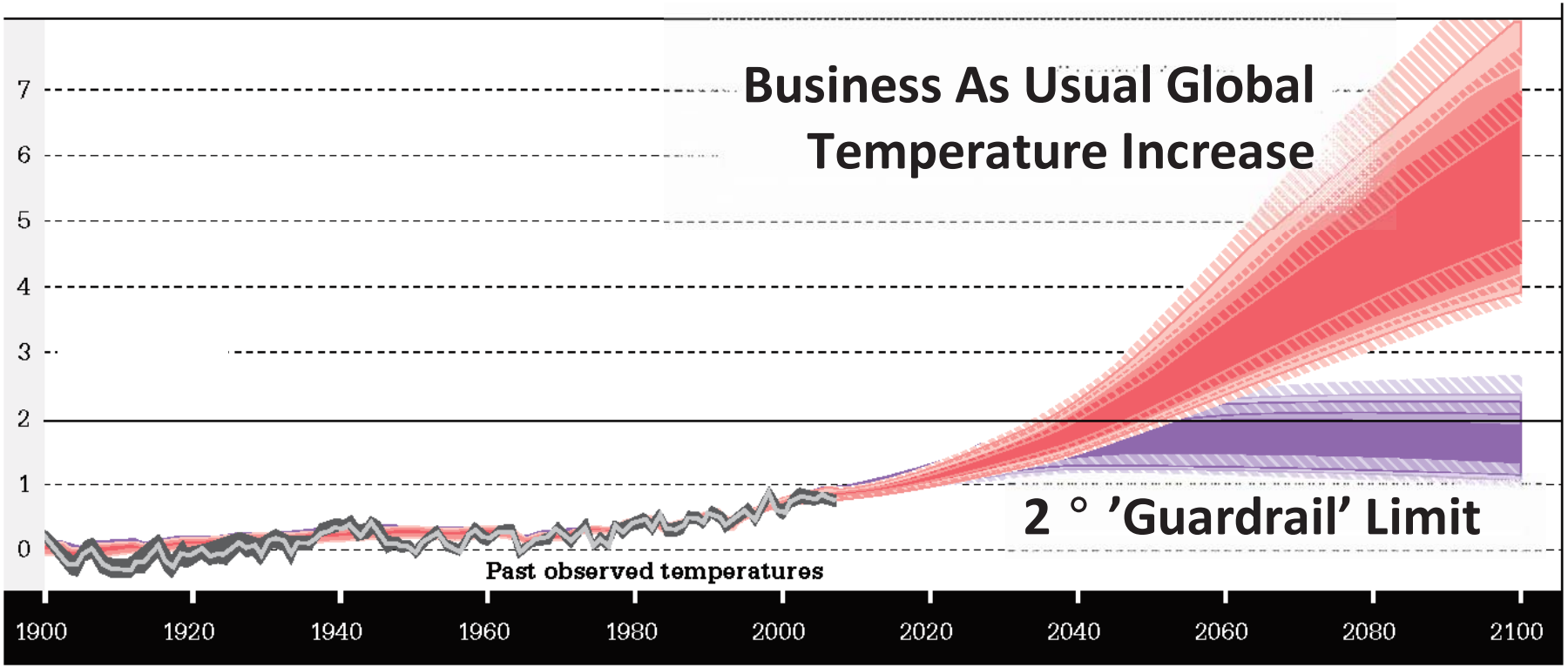
- Social and Political Will?
- What can I do?





- 2 ° Celcius Global warming ‘guardrail’ for a safe climate
- To have 75% chance of staying below this -
  - global emissions from now

    must be less than 1 Trillion tonnes

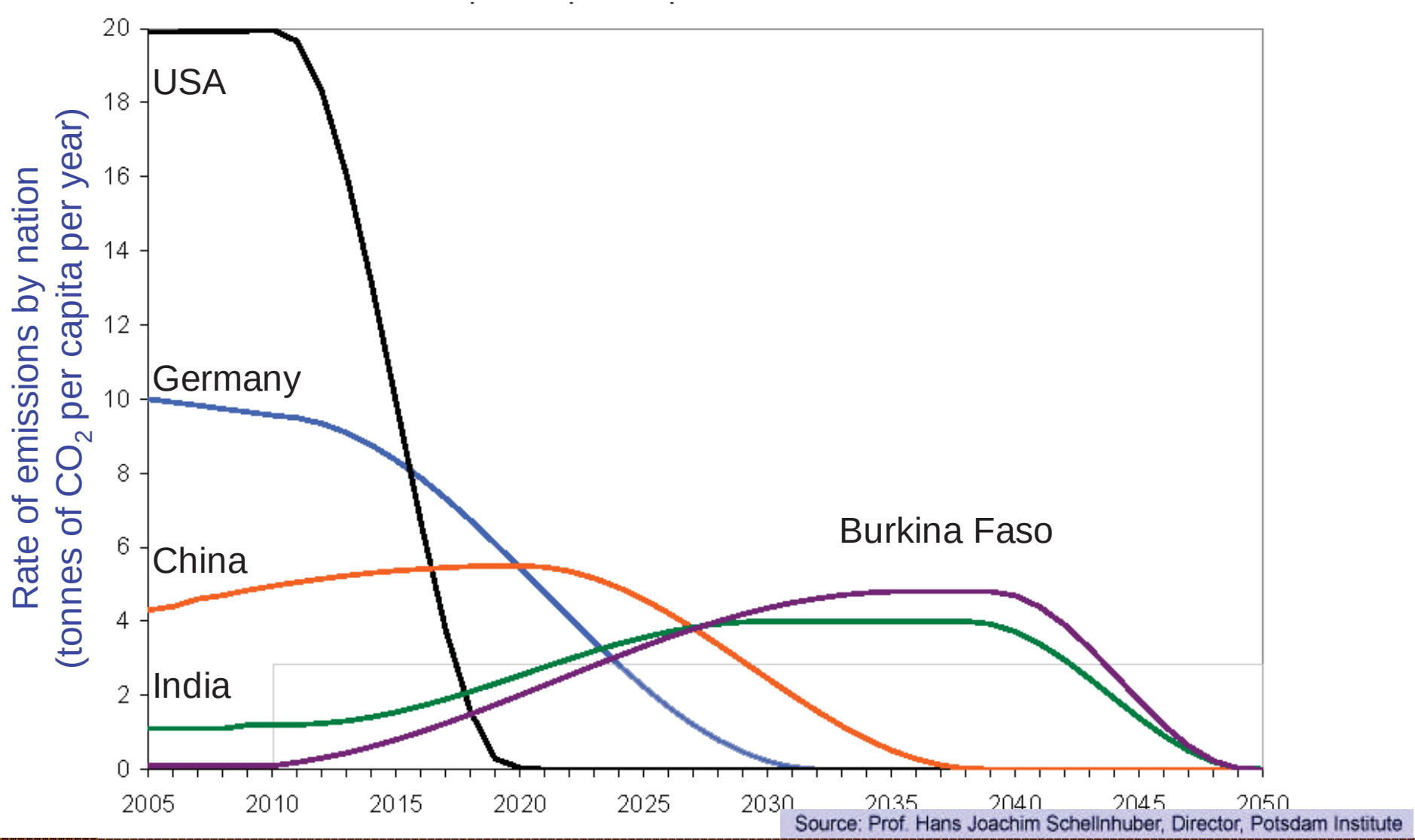


"The difference between

2 ° & 4 °

is human civilisation"

Per Capita Global Carbon Budget 2010-2050

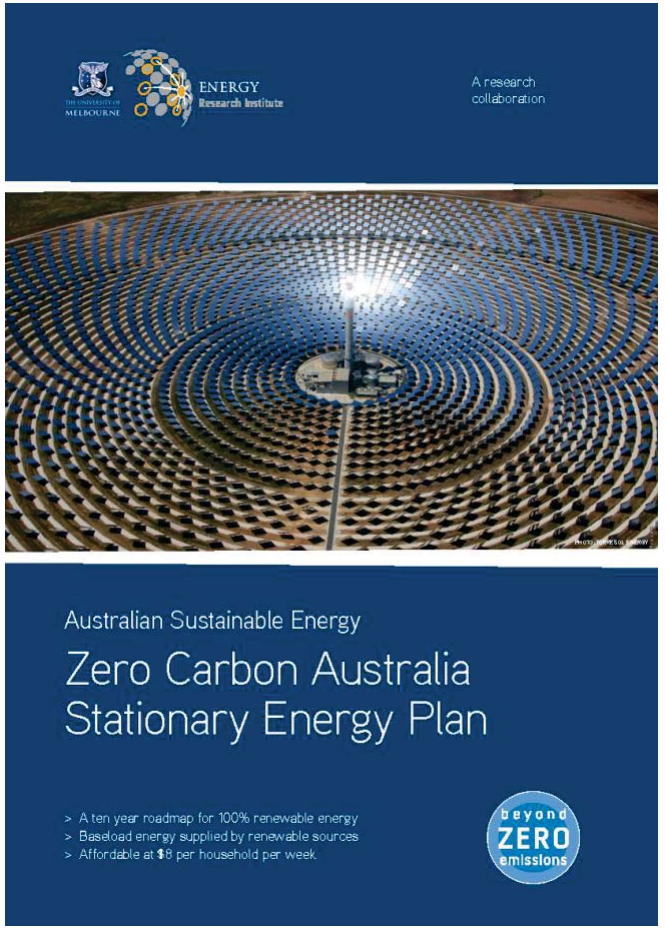


Source: Prof. Hans Joachim Schellnhuber, Director, Potsdam Institute

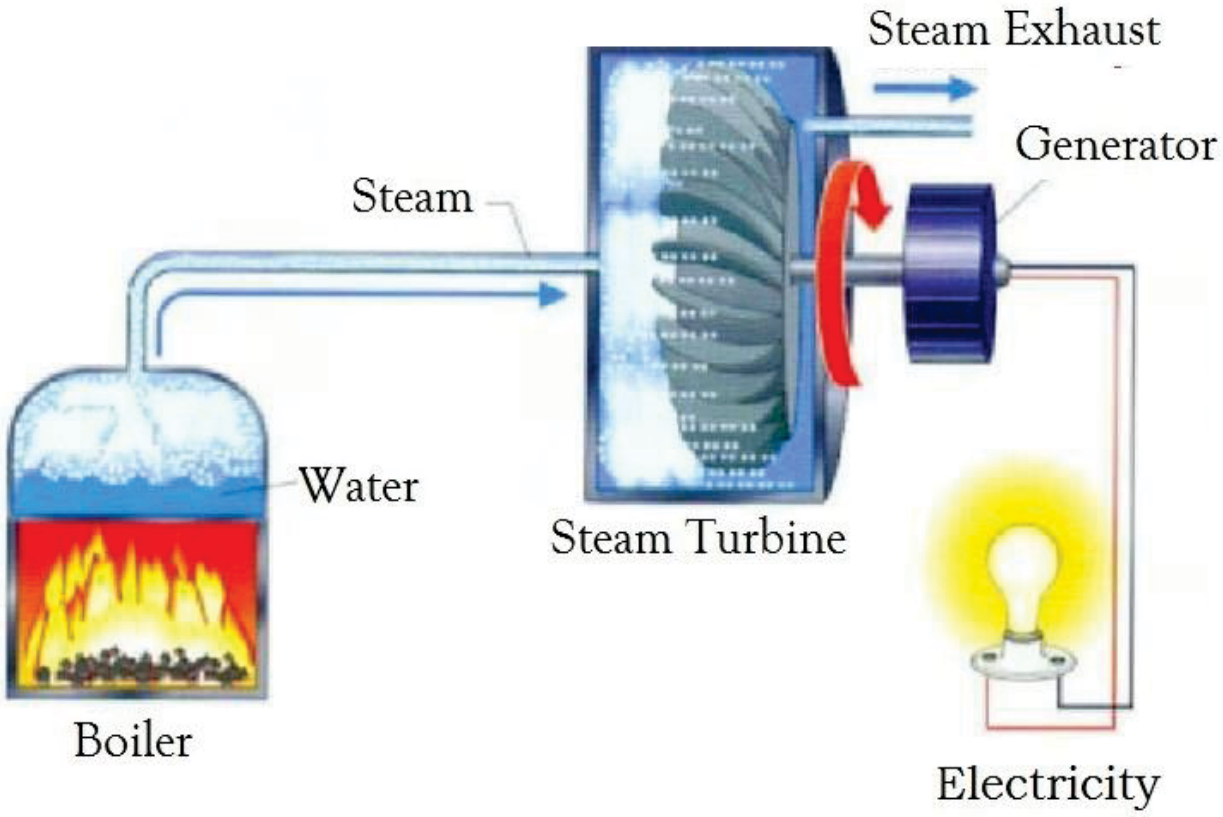
Major Questions

- Need ✓
- Technology? **- Part Two**
- Reliability?
- Resources?
- Jobs?
- Economics?

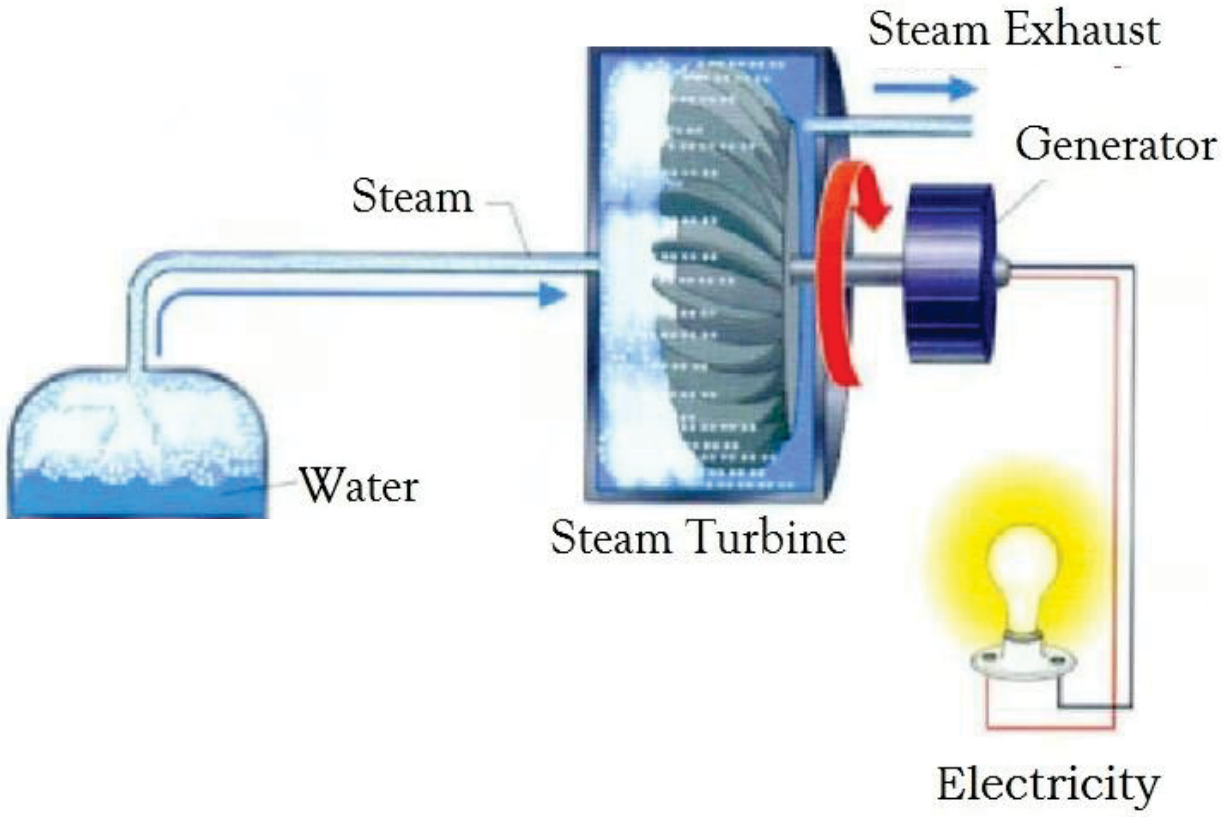
- Social and Political Will?
- What can I do?



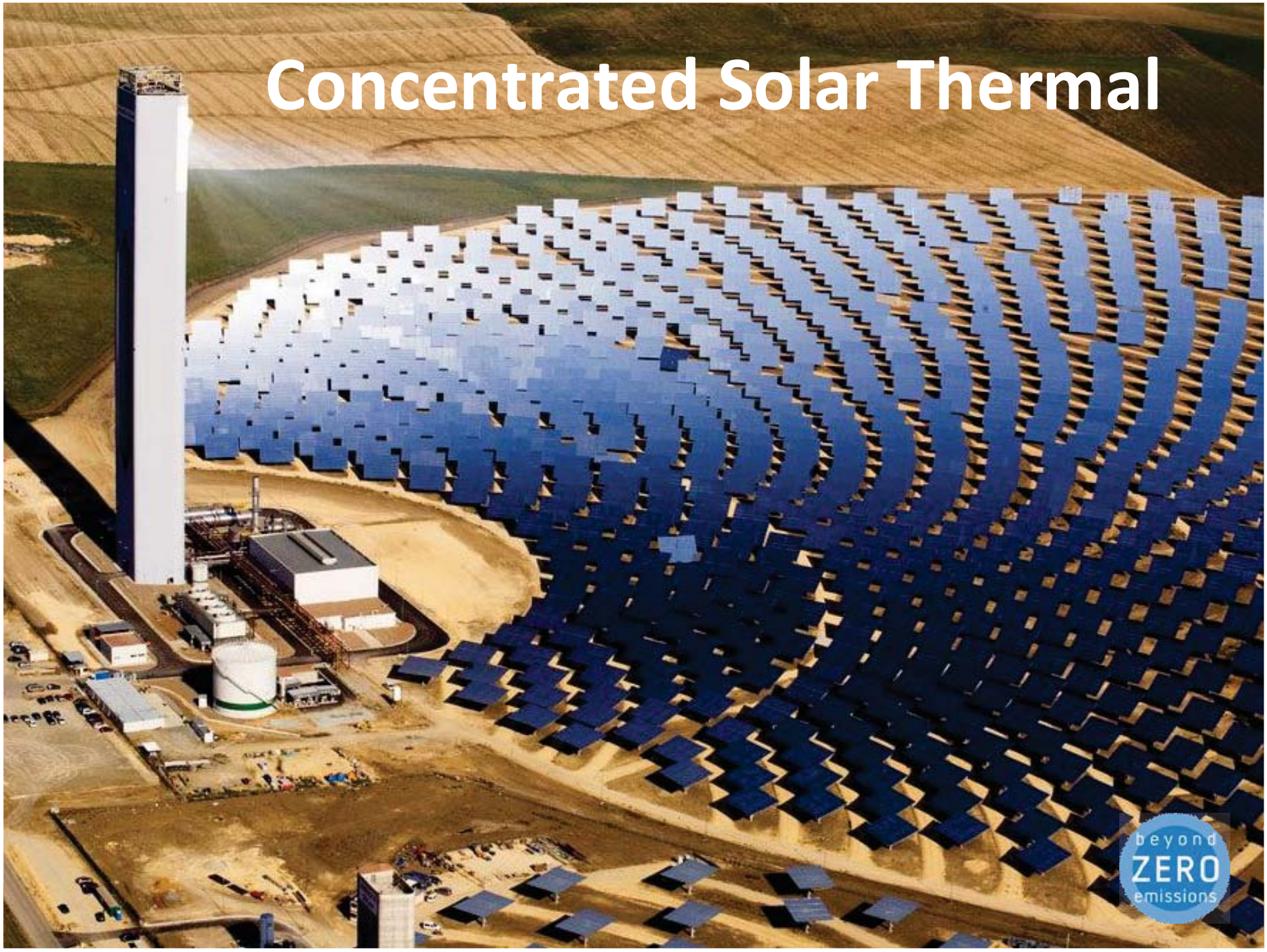
Traditional Power Generation



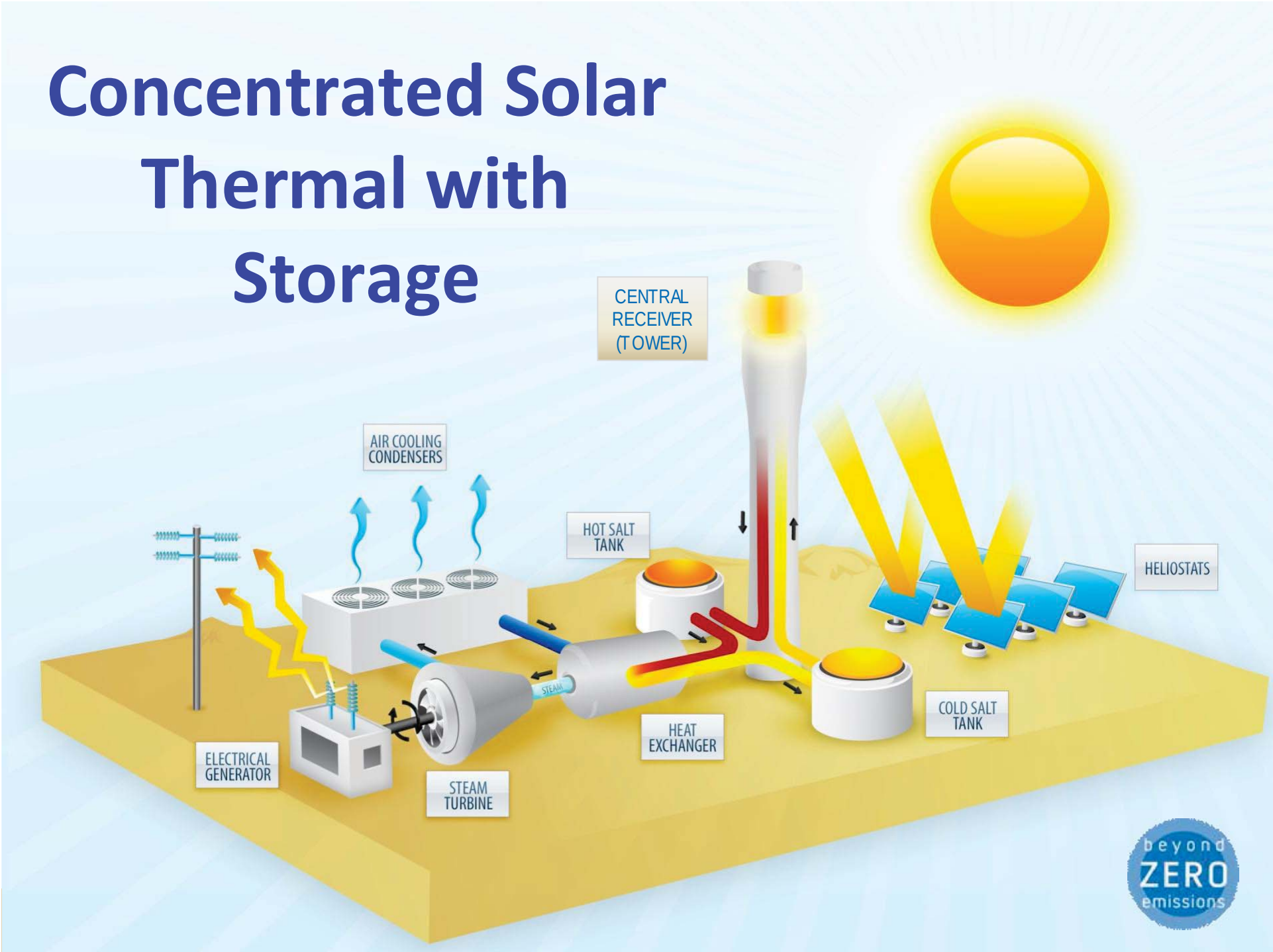
Traditional Power Generation



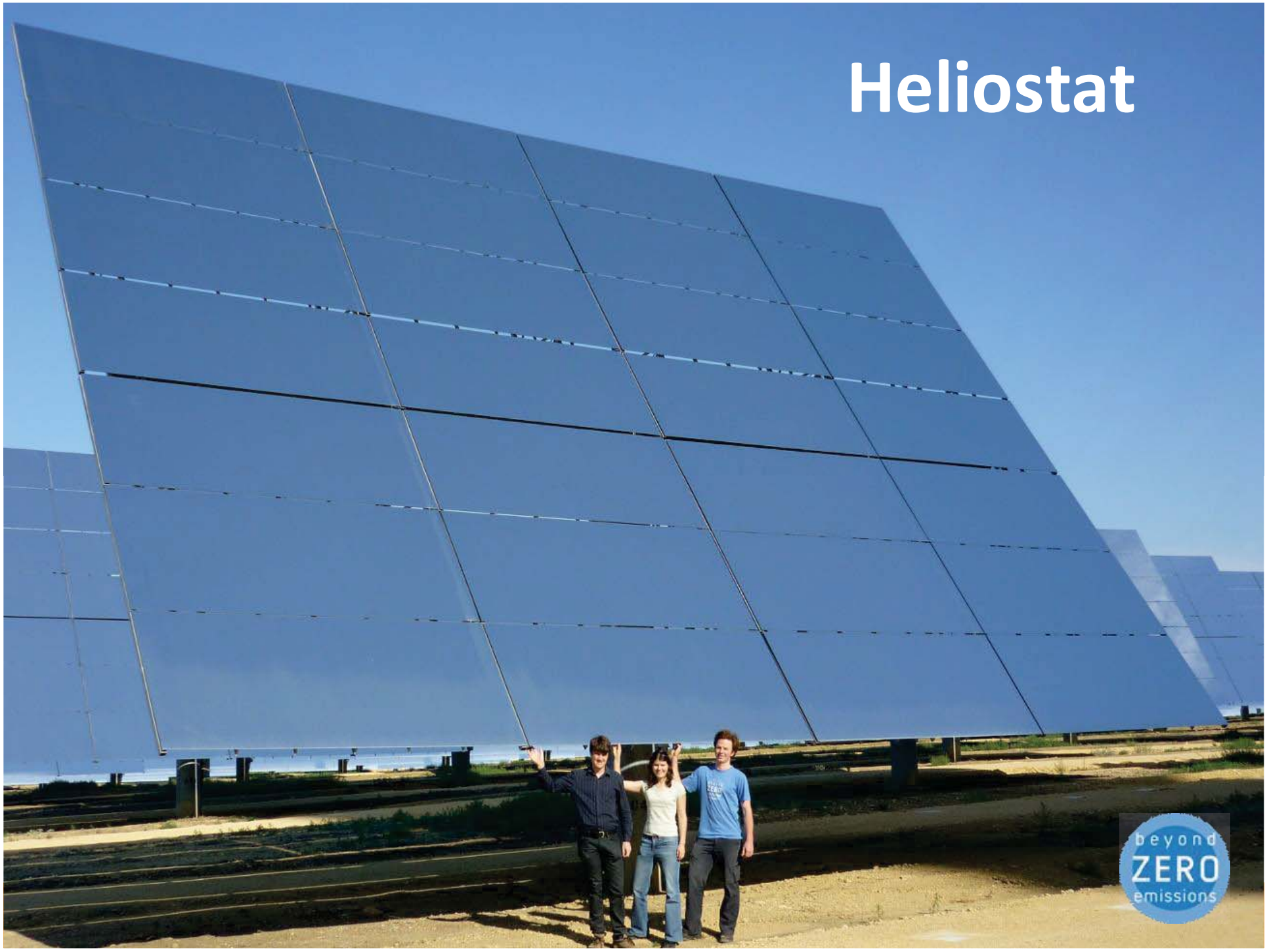
Concentrated Solar Thermal



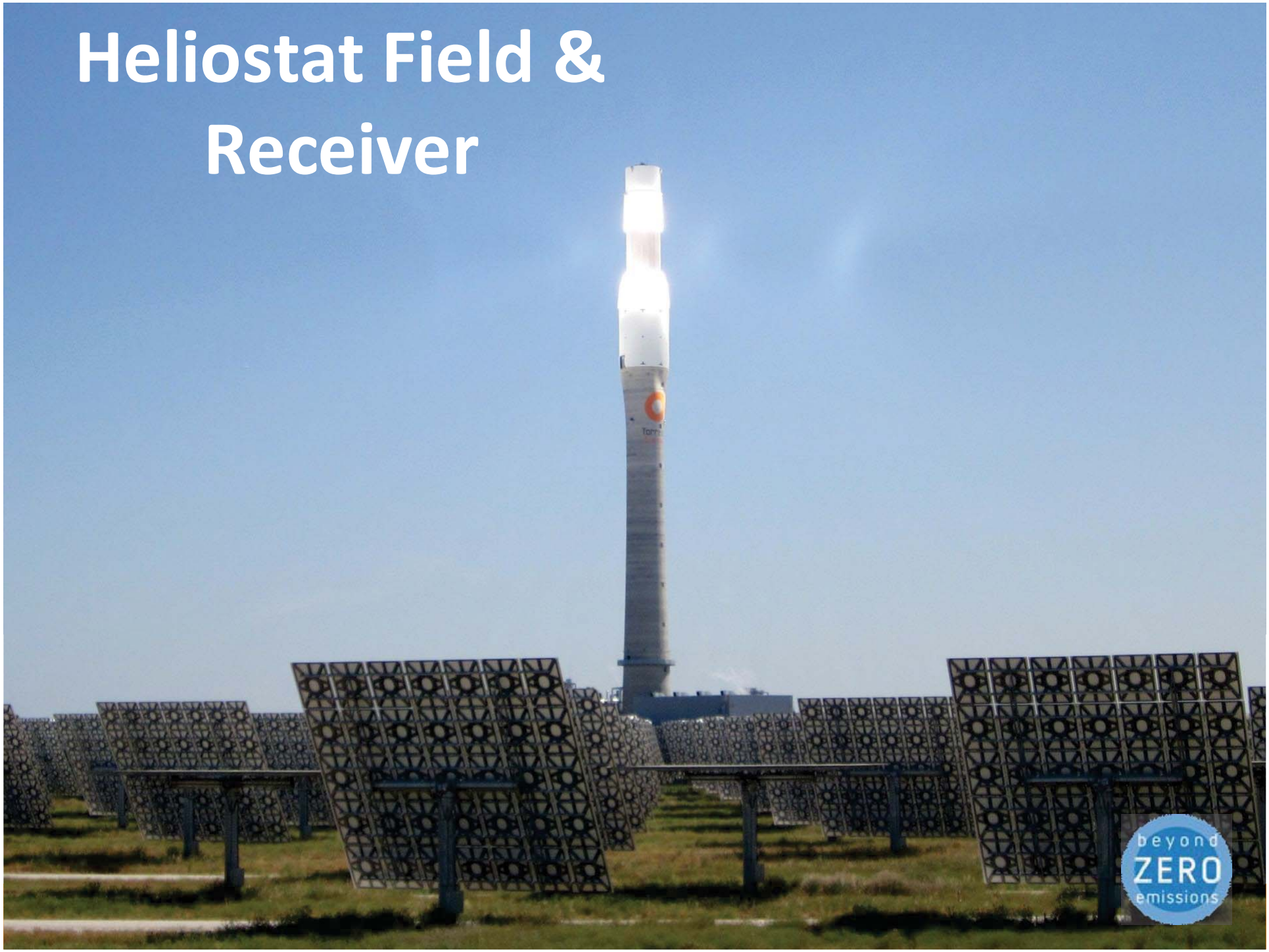
Concentrated Solar Thermal with Storage



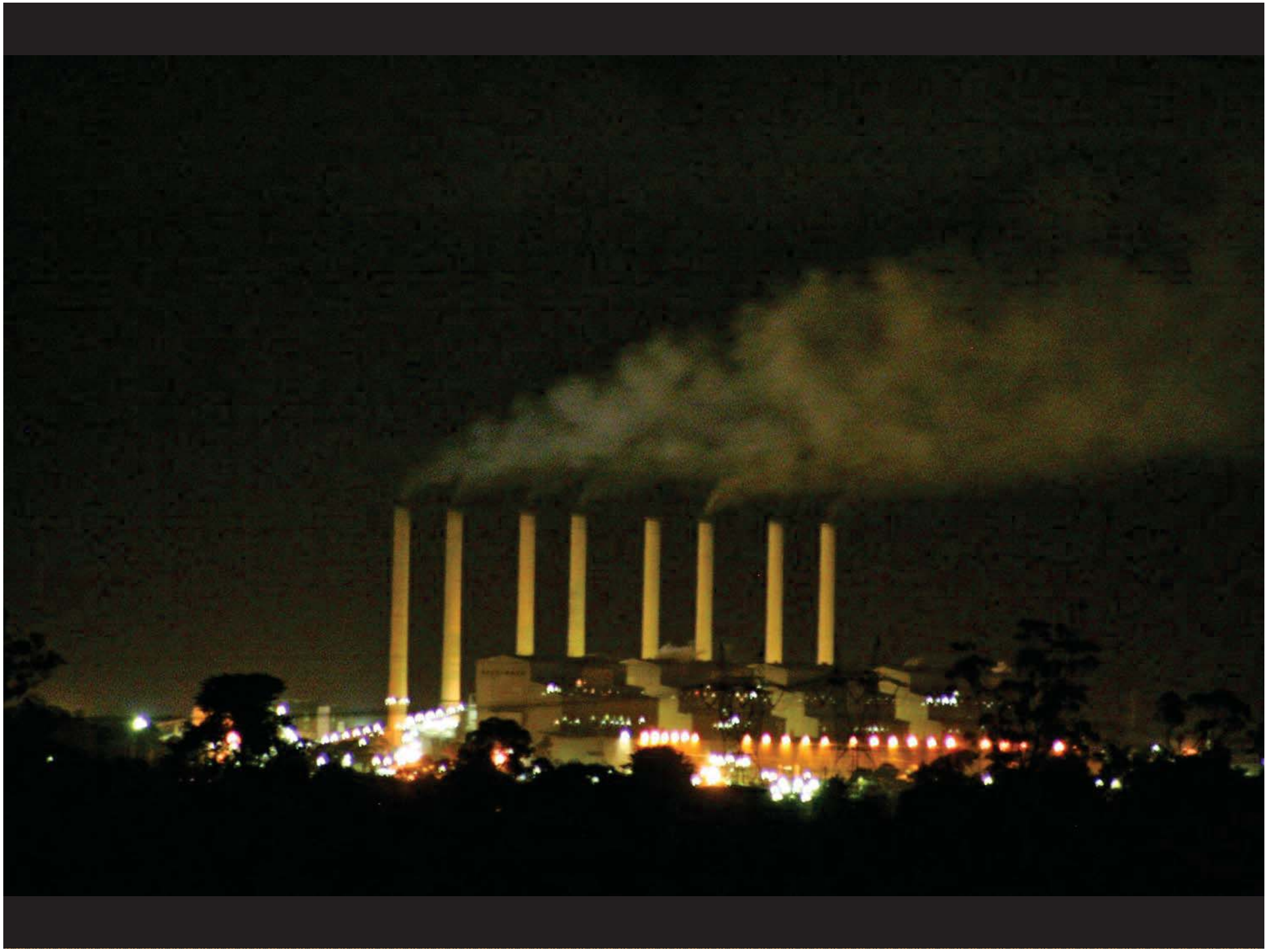
Heliostat



Heliostat Field & Receiver



View from the receiver

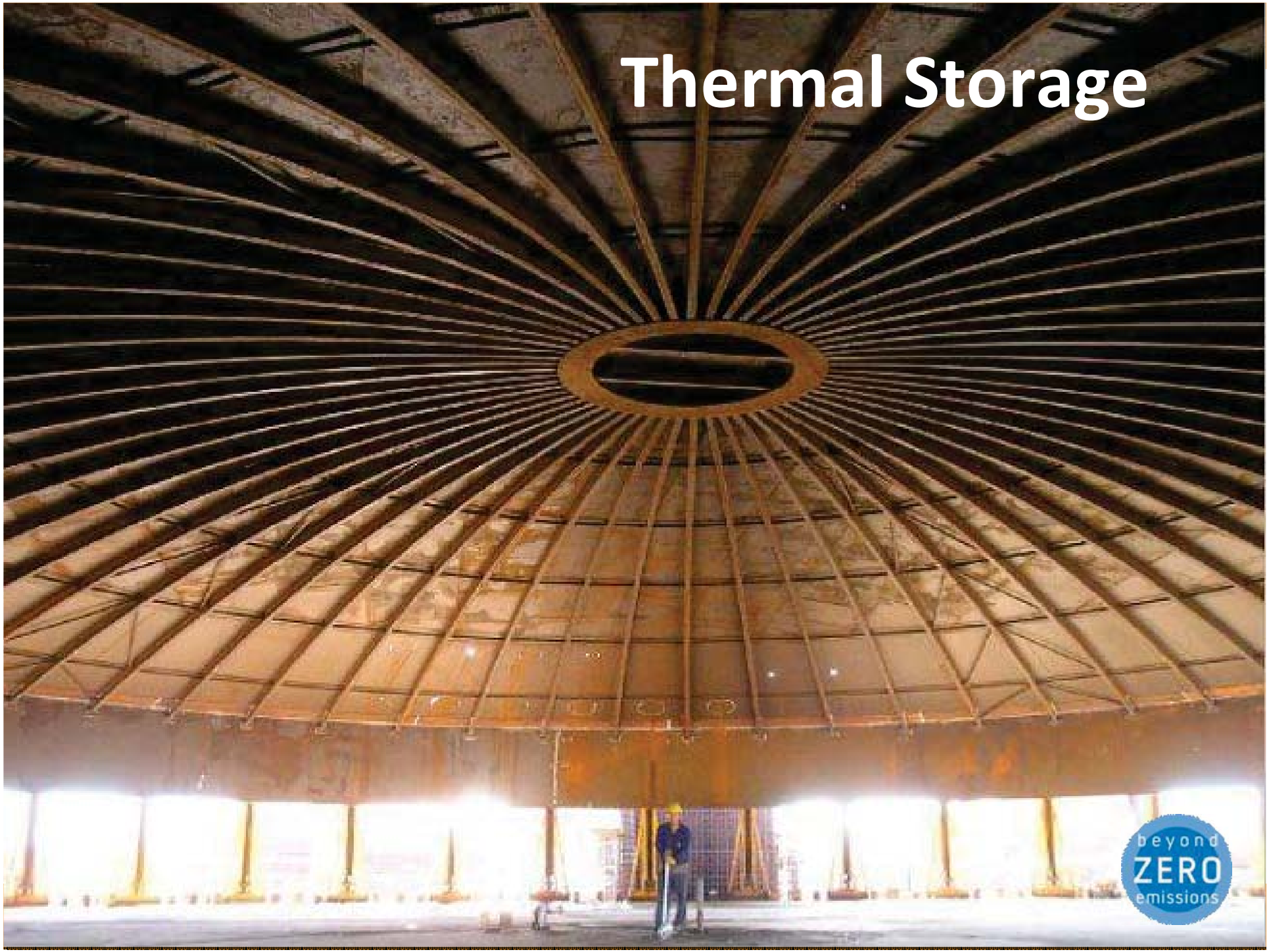



CENTRAL RECEIVER (TOWER)
565ºC
HOT SALT TANK
565ºC
HELIOSTATS
290ºC
COLD SALT TANK
HEAT EXCHANGER
beyond ZERO emissions


‘Un-Molten’
Salt
beyond
ZERO
emissions

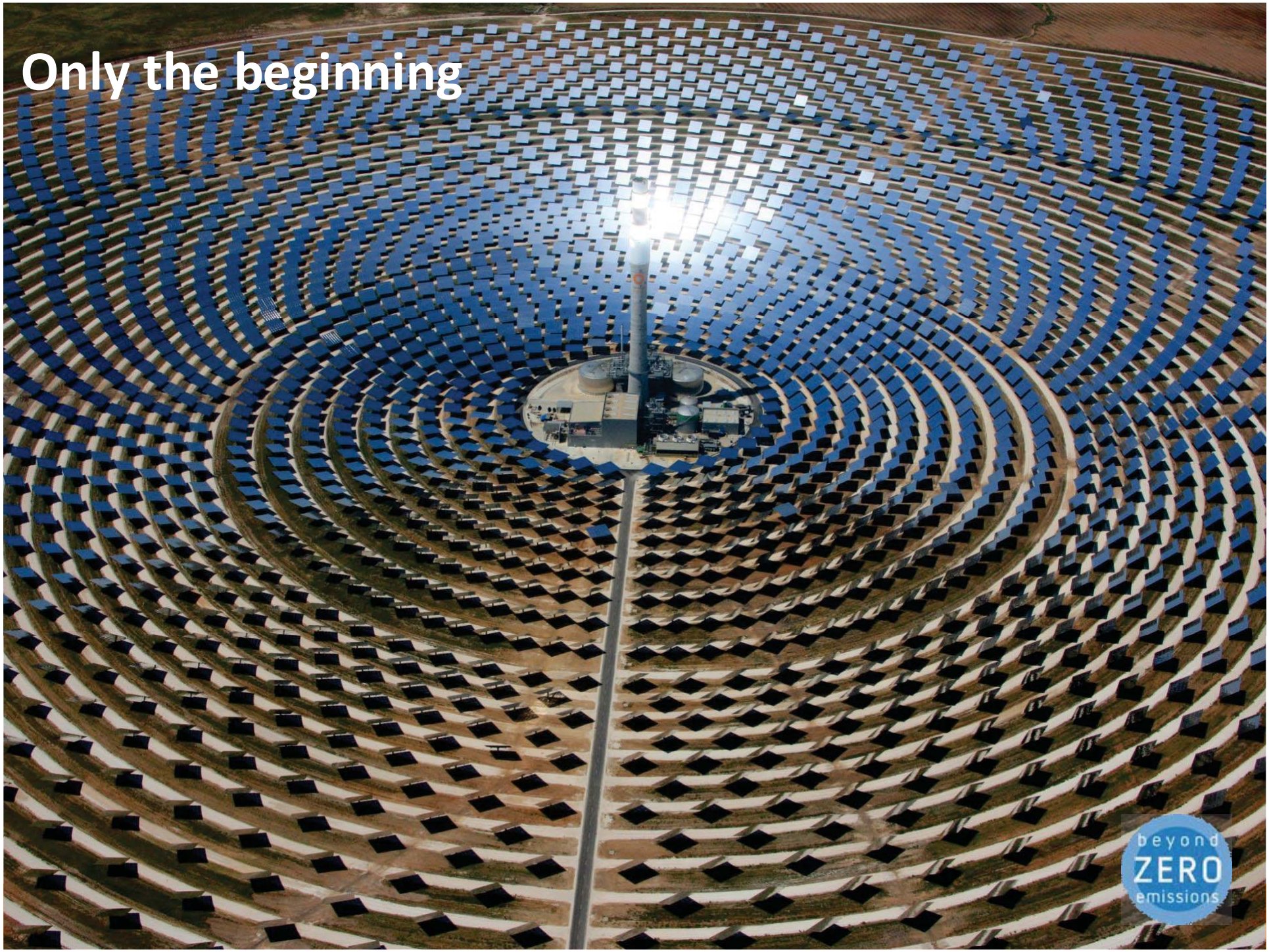
Thermal Storage

Thermal Storage




Spain 2011
Torresol Gemasolar
20MW. 15h storage
beyond
ZERO
emissions

Only the beginning

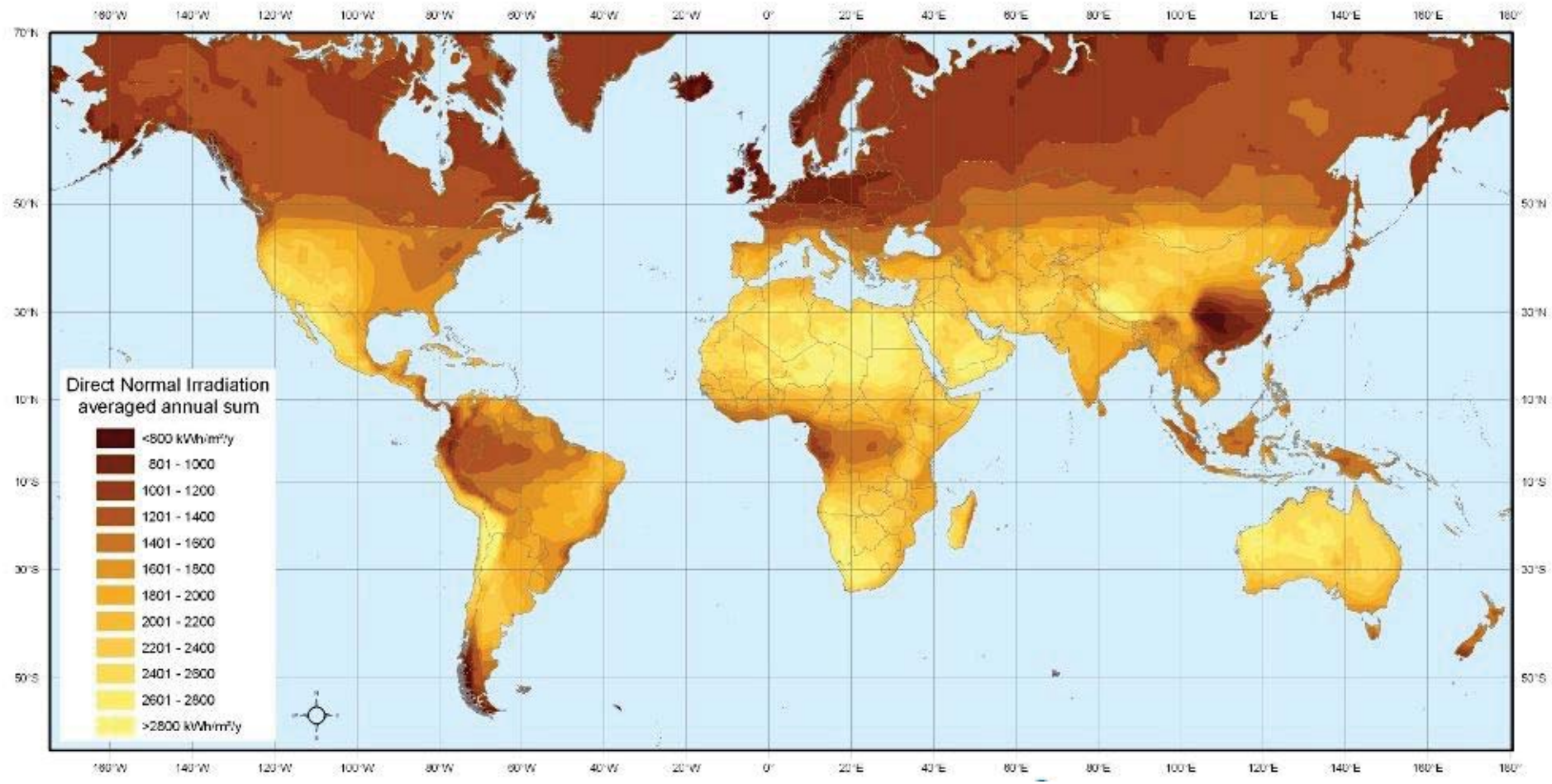



USA - Nevada 2013
Solar Reserve Tonopah
110MW
25-40%
saving
beyond
ZERO
emissions

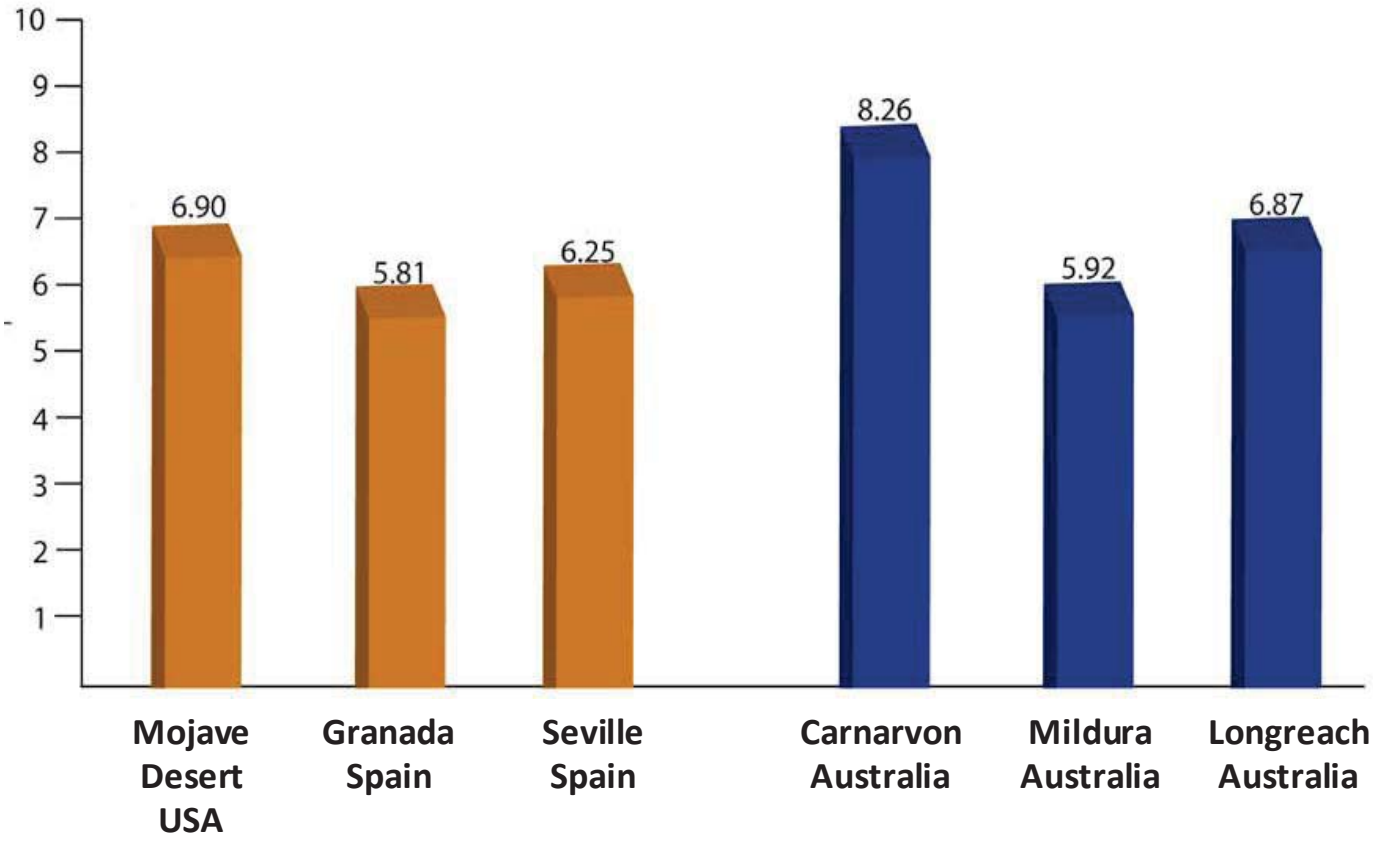
World Solar Thermal growth

- Globally 17.54GW under development
  - USA – 8.67GW
  - Spain – 4.46GW
  - China – 2.5GW

Australia – Best Solar Resource in the World



Solar irradiation (Megawatt-hours per square metre per day)



More Bang for our Buck!

30 Years

1m² mirror

OR

20 tonnes of coal


beyond
ZERO
emissions

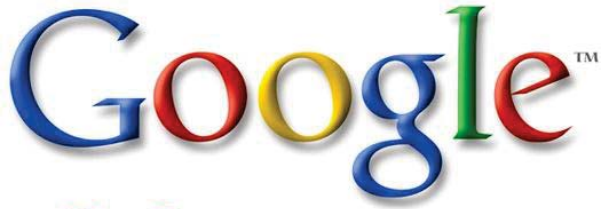
World Wind Power growth

- Global investment increased 30% p.a. in last decade
- China 200,000 MW by 2020, 1,000,000MW 2050
- Denmark 50% by 2020
  - 20% in 2010
- Sweden 1100 Enercon Turbine Farm


30 years
507,000
tonnes
CO_2 saved

Who is backing this?

- Built by biggest engineering and construction companies in the world
- Investment flowing from smart, forward thinking companies



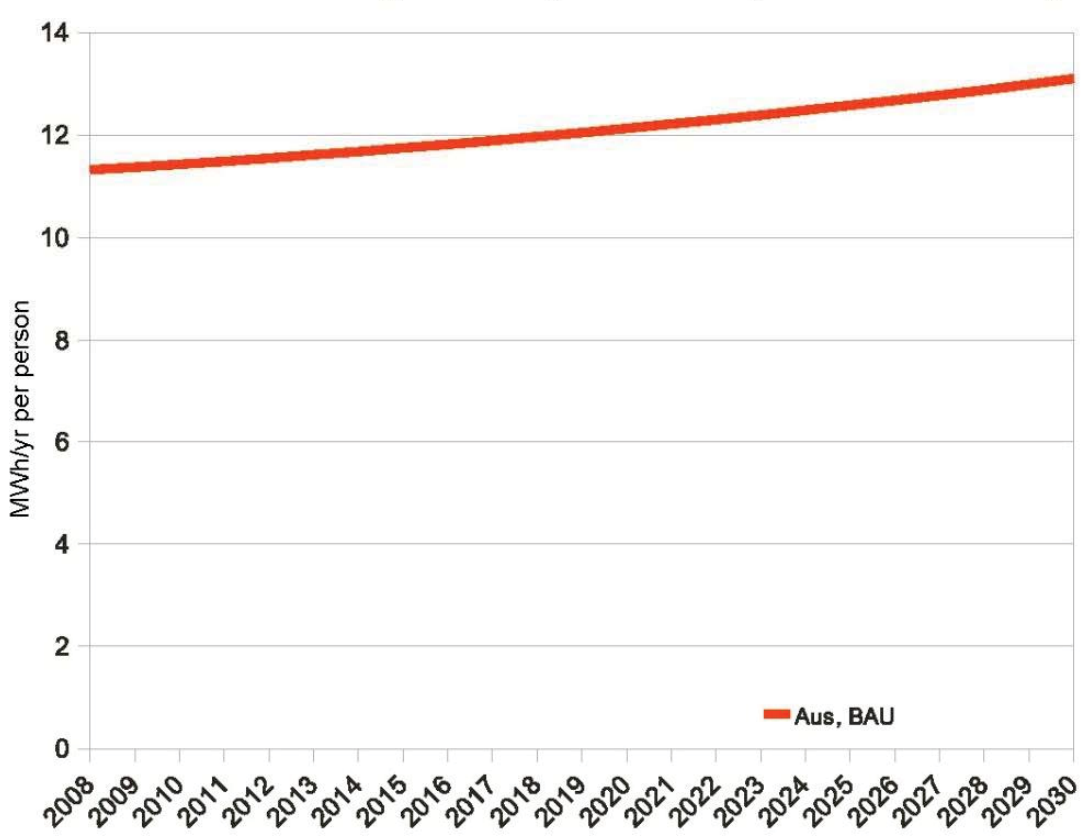
Zero Carbon Australia Total Electricity Energy Demand

- 325 TWh/year in 2020

(Up from 230 TWh/year in 2010)

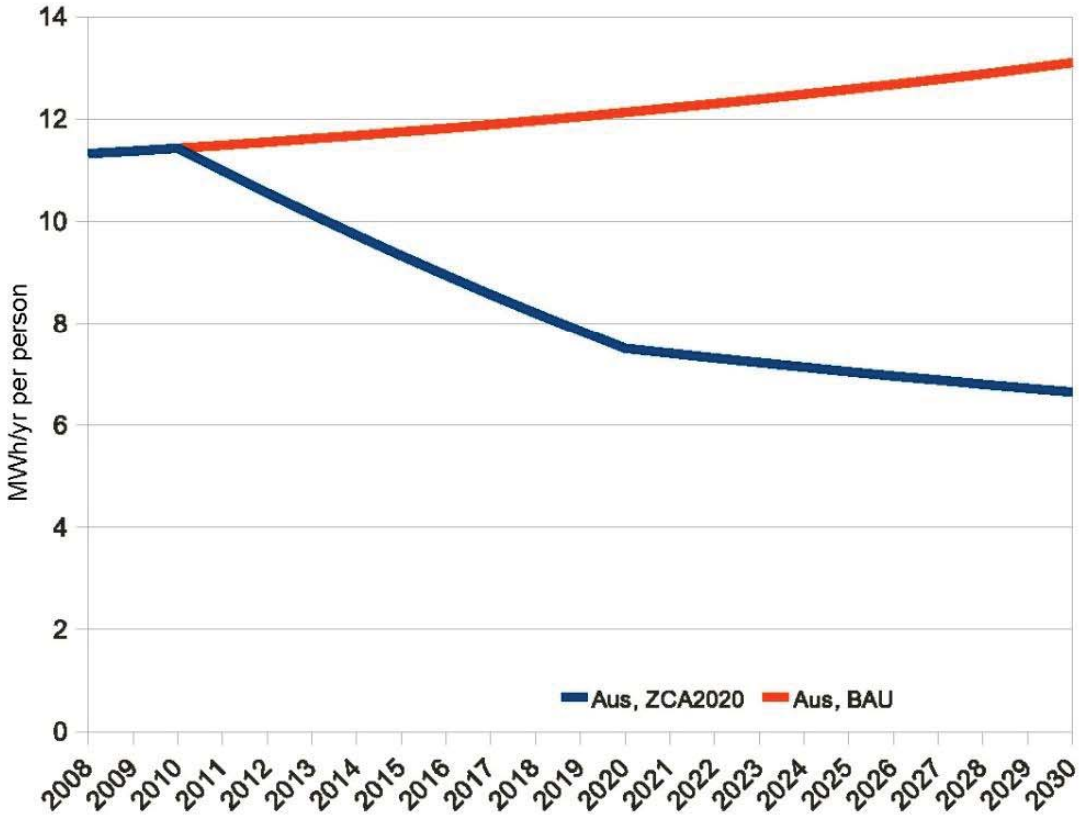
Business as usual Electricity Use

MW hours per person per year (2010 – 2030)



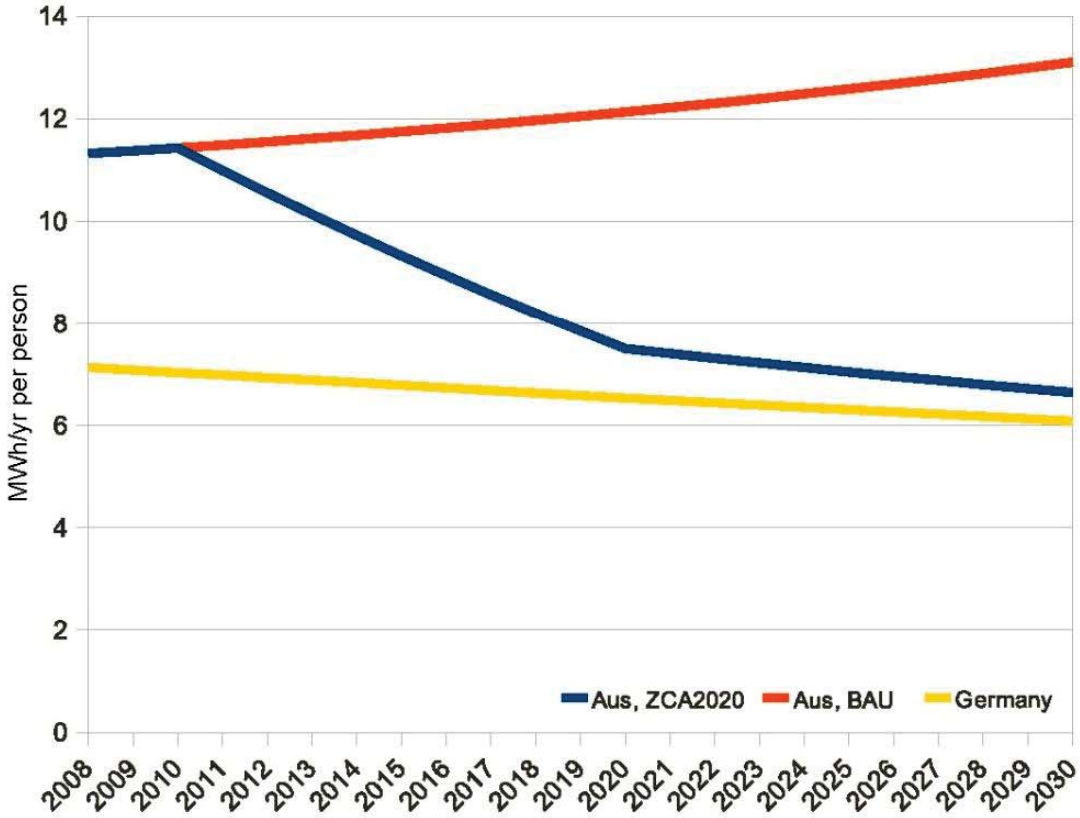
Zero Carbon Australia Electricity Use

MW hours per person per year (2010 – 2030)

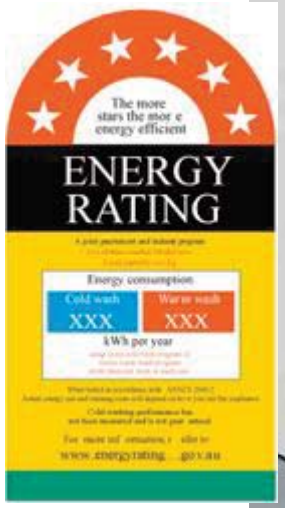


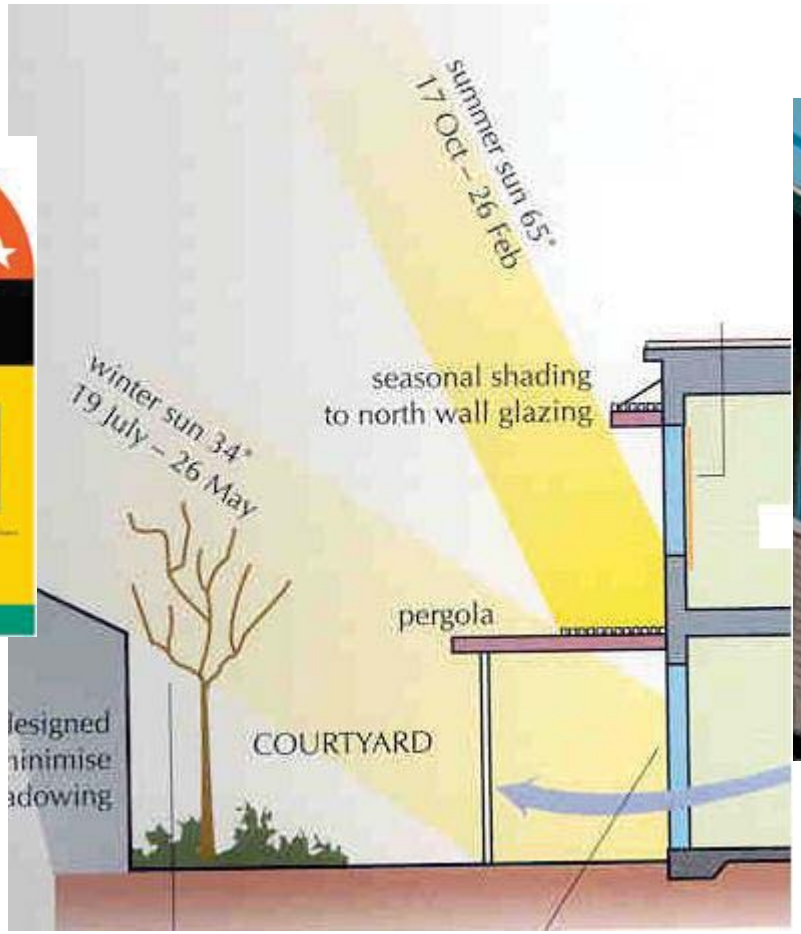
German Electricity Use

MW hours per person per year (2010 – 2030)



Efficiency Opportunities

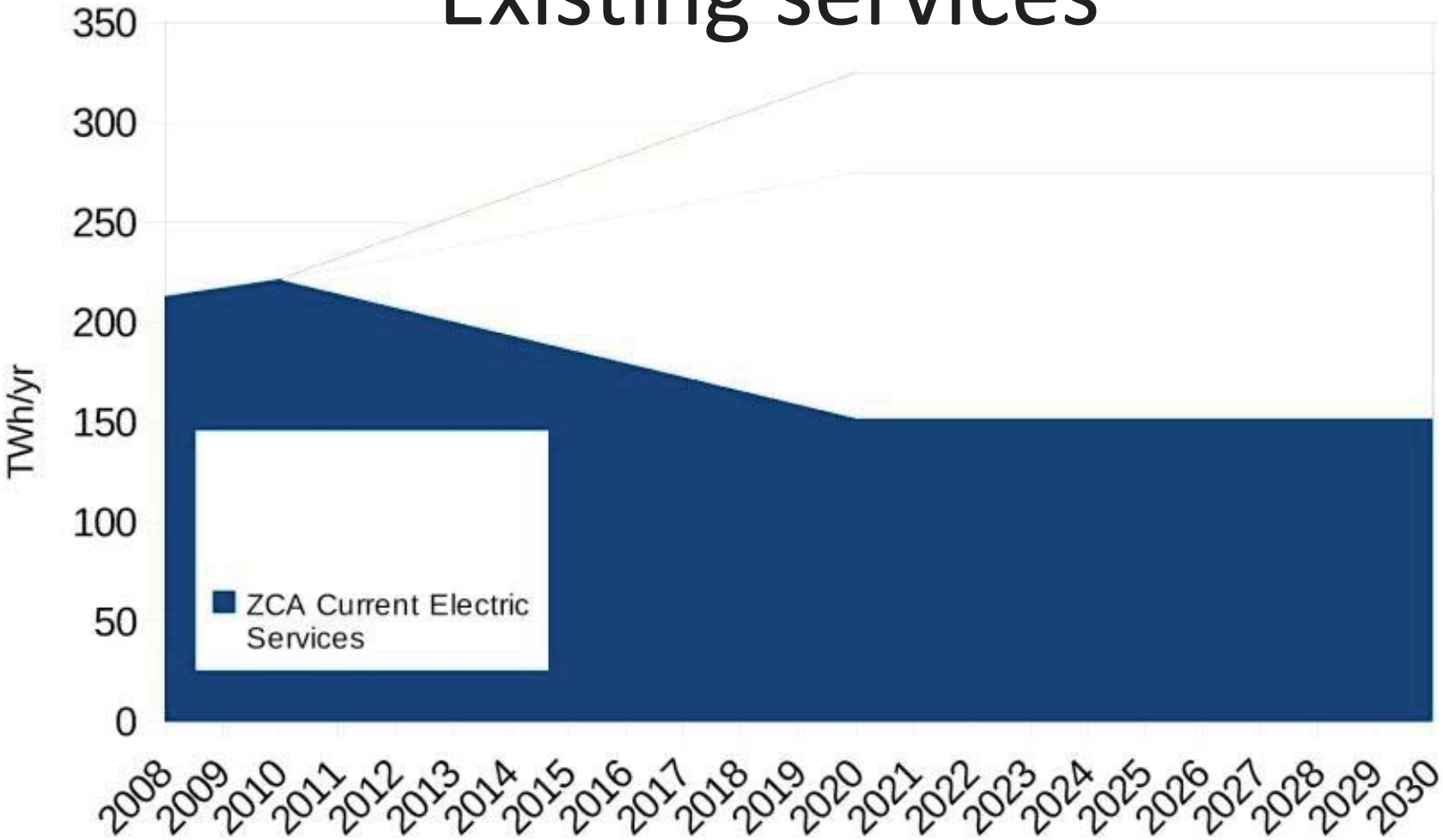




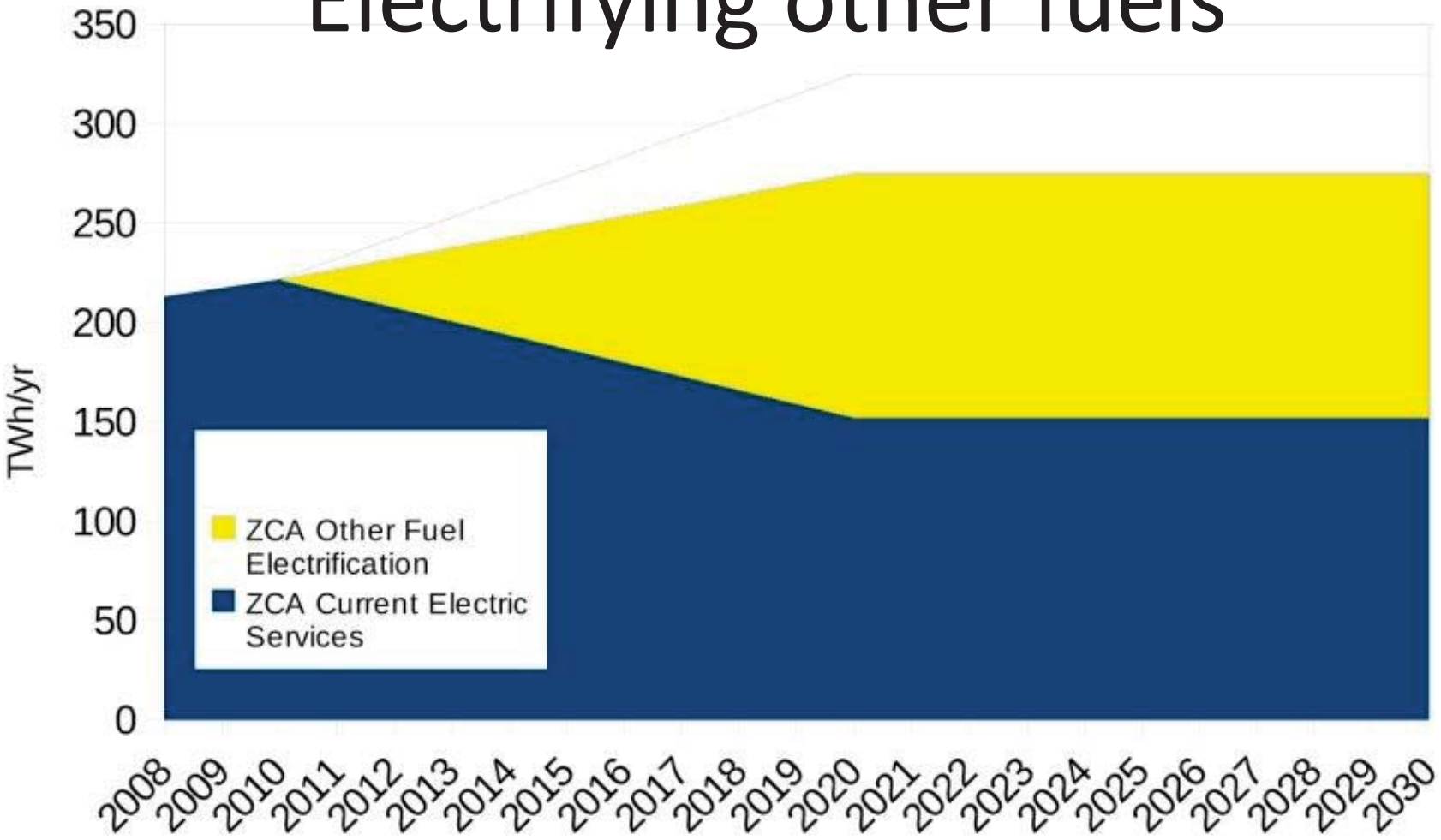
The Empire State Building retrofit

- Cost $20 million
- 38% reduction in energy use
- Save $4.4 million per year

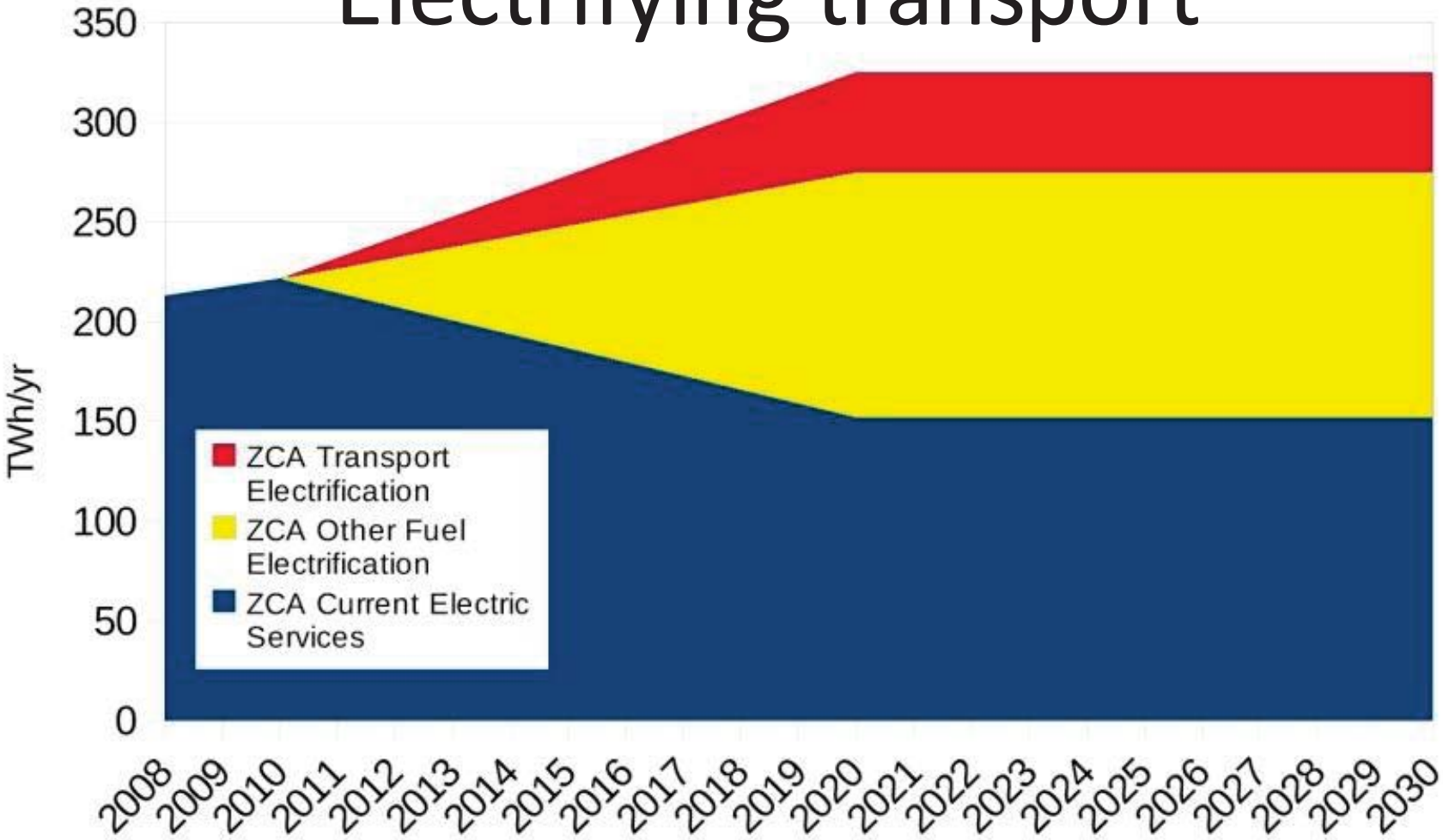
ZCA Total Energy Demand
Existing services



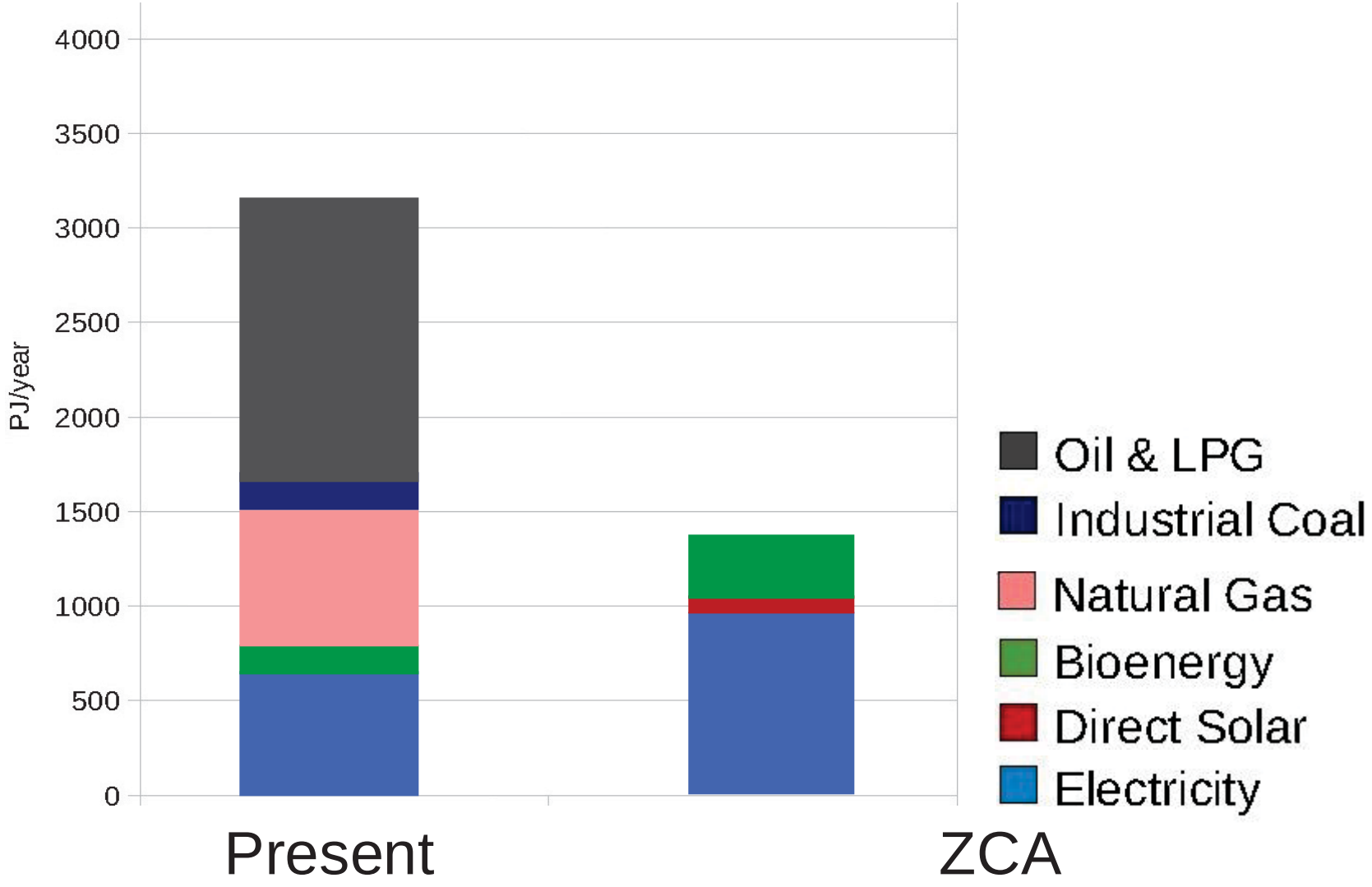
ZCA Total Energy Demand Electrifying other fuels



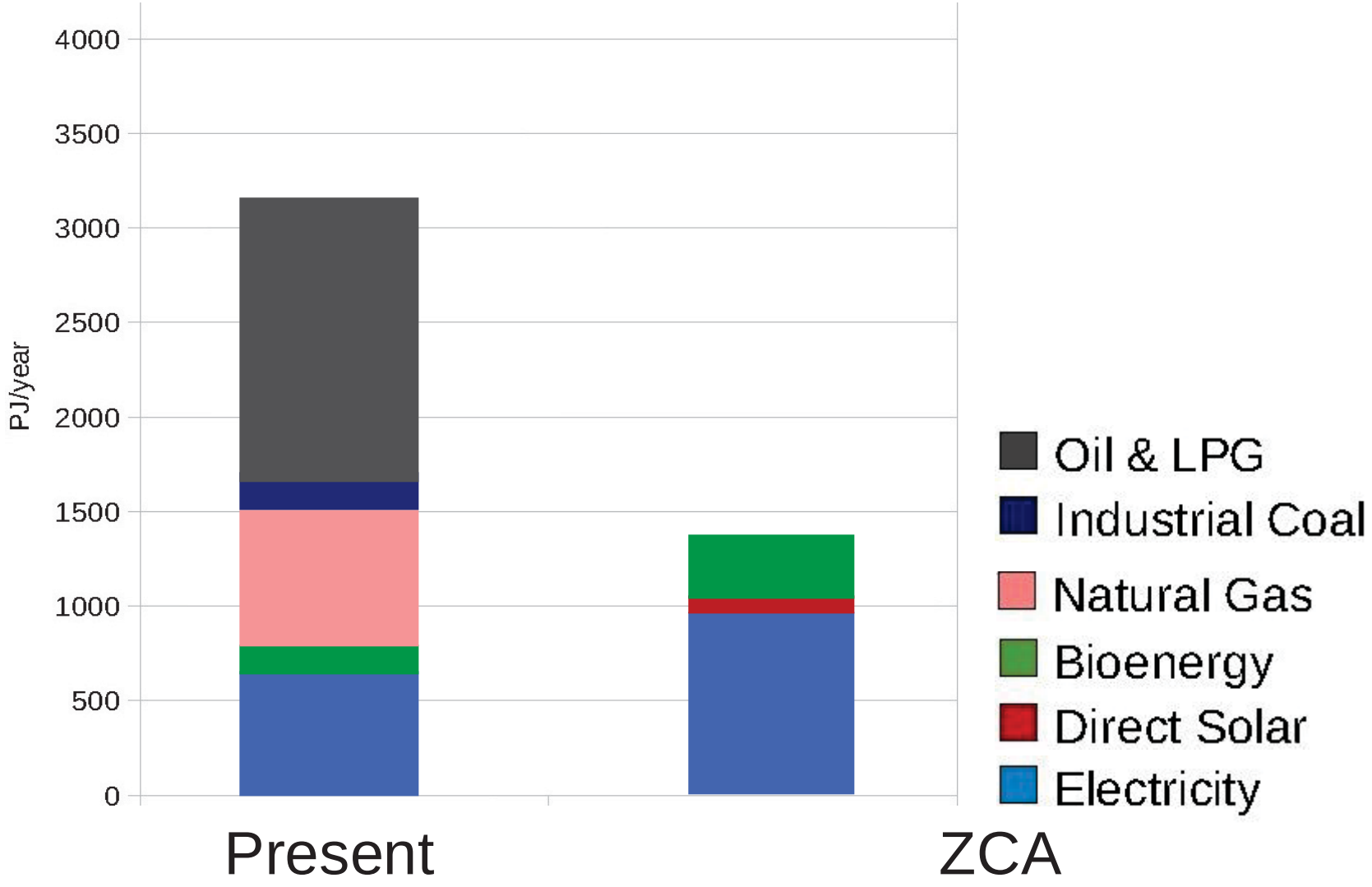
ZCA Total Energy Demand Electrifying transport



Australian End-Use Energy



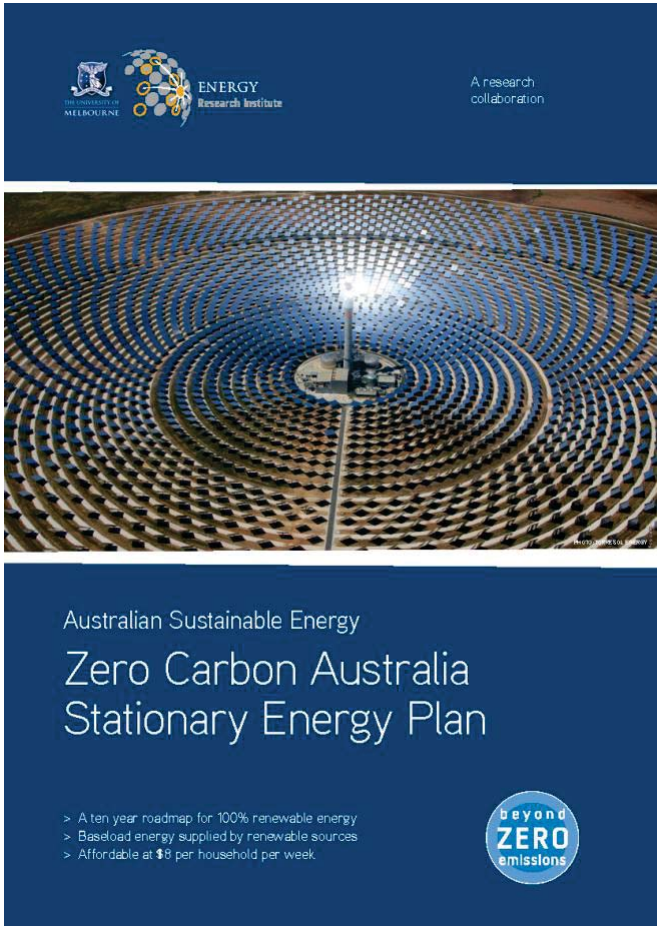
Australian End-Use Energy



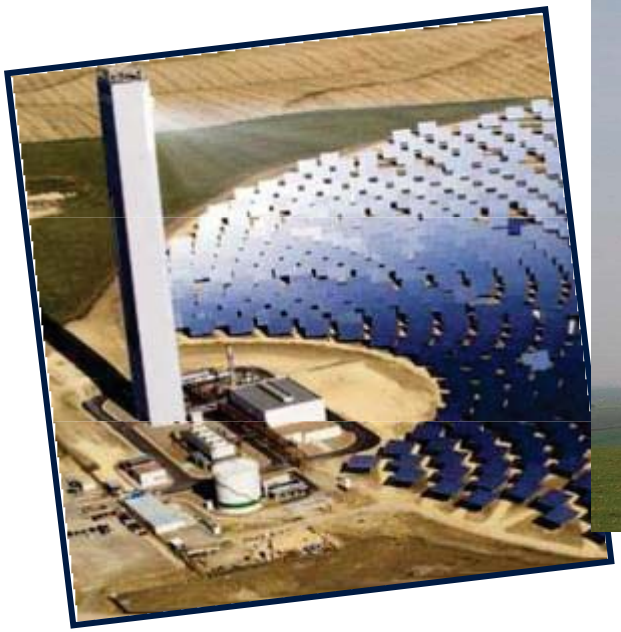
Major Questions

- Need ✓
- Technology? **- Part Three & Five**
- Reliability?
- Resources?
- Jobs?
- Economics?

- Social and Political Will?
- What can I do?



100% Renewable Energy for Australia - three main components



Concentrated solar thermal power

Wind power

Upgraded electricity grid

Concentrated solar thermal power

220MW

× 17 = 1

3700MW

Solar region

× 12 = 60% of Australia's Stationary Energy delivered by Solar Thermal with storage

Kalgoorlie Launch

ABC Goldfields ▸ visit another location

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17 March, 2011 1:41PM AWST

Bold plan to power Kalgoorlie from the sun

By Emma Wynne

Thirty people gathered this week in Kalgoorlie-Boulder to hear about a radical plan to convert all of Australia's power generation to renewable sources within the next ten years.

It's the brain child of *Beyond Zero Emissions* (BZE), a not-for-profit think tank based in Melbourne.

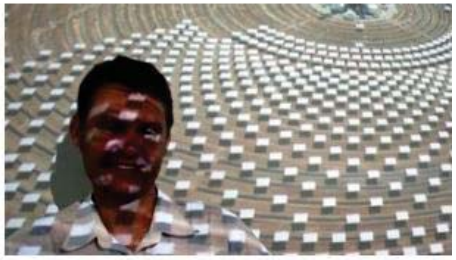
The idea centres on an upgrade to the national energy grid, and an energy supply based on existing wind and hydro-electric sources, as well as a network of solar-thermal power stations in regional areas.

BZE has identified the Goldfields as a prime location for a solar-thermal power station, a number of which have already been constructed in Spain.

Detailed plans are outlined in a document called the *Zero Carbon Australia Stationary Energy Plan*.

BZE are now taking their plan around Australia and working on a revised version, based on community feedback.

Related Photos



Mark Ogge, communications director of Beyond Zero Emissions, which a picture of a solar thermal power station in Spain (Emma Wynne - ABC Goldfields)

Roma & Charleville

WESTERN TIMES

SOLAR OPPORTUNITY

WESTERN Queensland has been touted as one of the best locations in the country for the expansion of Australia's solar industry.

A report by climate change group, Beyond Zero Emissions, found Charleville, along with Roma and Longreach, was an ideal site to establish a solar thermal power plant.

The Zero Carbon Australia 2020 Stationary Energy Plan outlines a technically feasible and economically attractive way for Australia to transition to 100% renewable energy within 10 years.

The proposed sites were chosen based on three criteria: their relatively high solar incidence and daily sunlight hours, low winter to summer solar resource ratios and proximity to load centres to connect the solar plants to existing population centres.

Charleville scored equal highest for its high level of solar incidence.

Beyond Zero Emissions strategic

SOLAR: The Gemasolar plant in Spain. A similar plant has been proposed in Charleville. INSET: Tony Windsor and Ross Garnaut on a recent tour of the Spanish site. Photo: Contributed

Ford
P: 4654 1477 50-56 Alfred St, Charleville

with solar power.

"Solar is more expensive to establish than baseload coal-fired power stations so consumers will pay more," he said.

"We have to look at opportunities to reduce carbon emissions and I think we'll get to the situation where solar is competitive, but we haven't been able to get the price lower than it is."

Mr Ogge said despite the initial building costs, solar energy was still the best option for consumers.

"They cost more at start, but solar plants allow us to lock in electricity prices," he said.

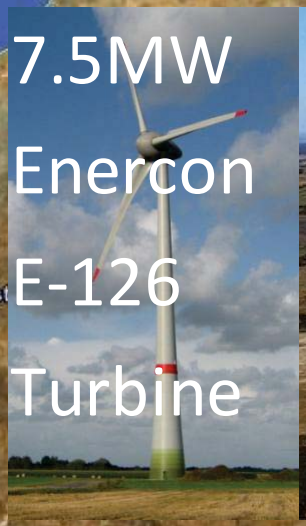
"There's no further cost for the fuel resource throughout their lifetime.

"We can keep doing what we're doing now, but when the gas industry takes off local gas prices will be linked to international prices.

"It's $12 per gigajoule (GJ) world wide at the moment and it's only $3 per GJ in Australia.

Repower Port Augusta

Wind power



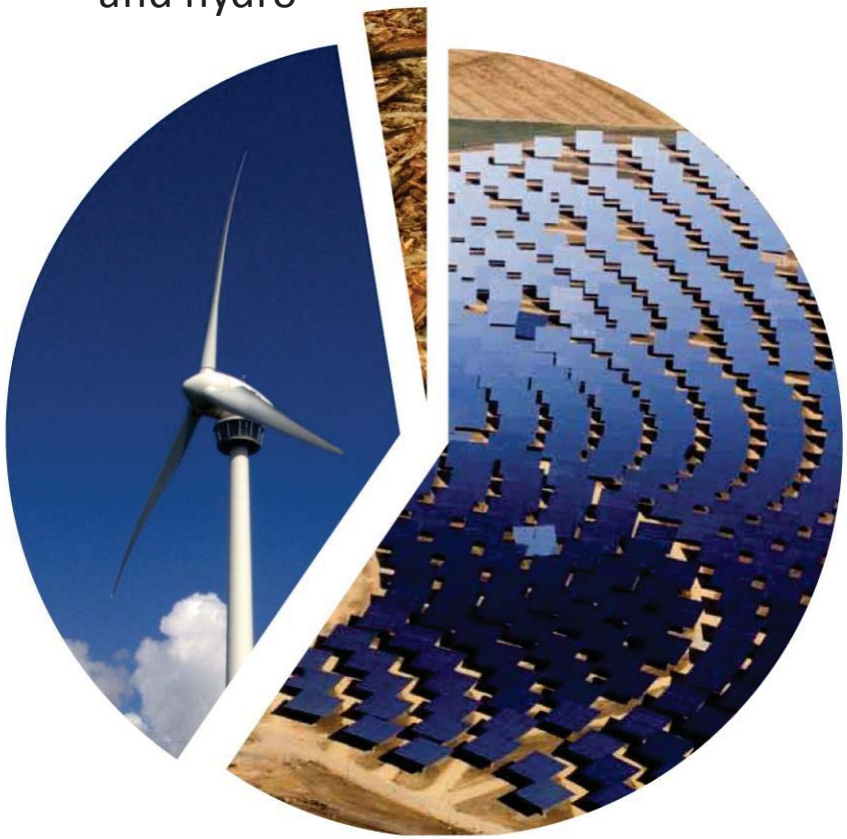
7.5MW
Enercon
E-126
Turbine

× 330 = 1
2500MW
Wind region

× 23 = 40% of Australia's Stationary Energy delivered by Wind

100% Renewable Stationary Energy

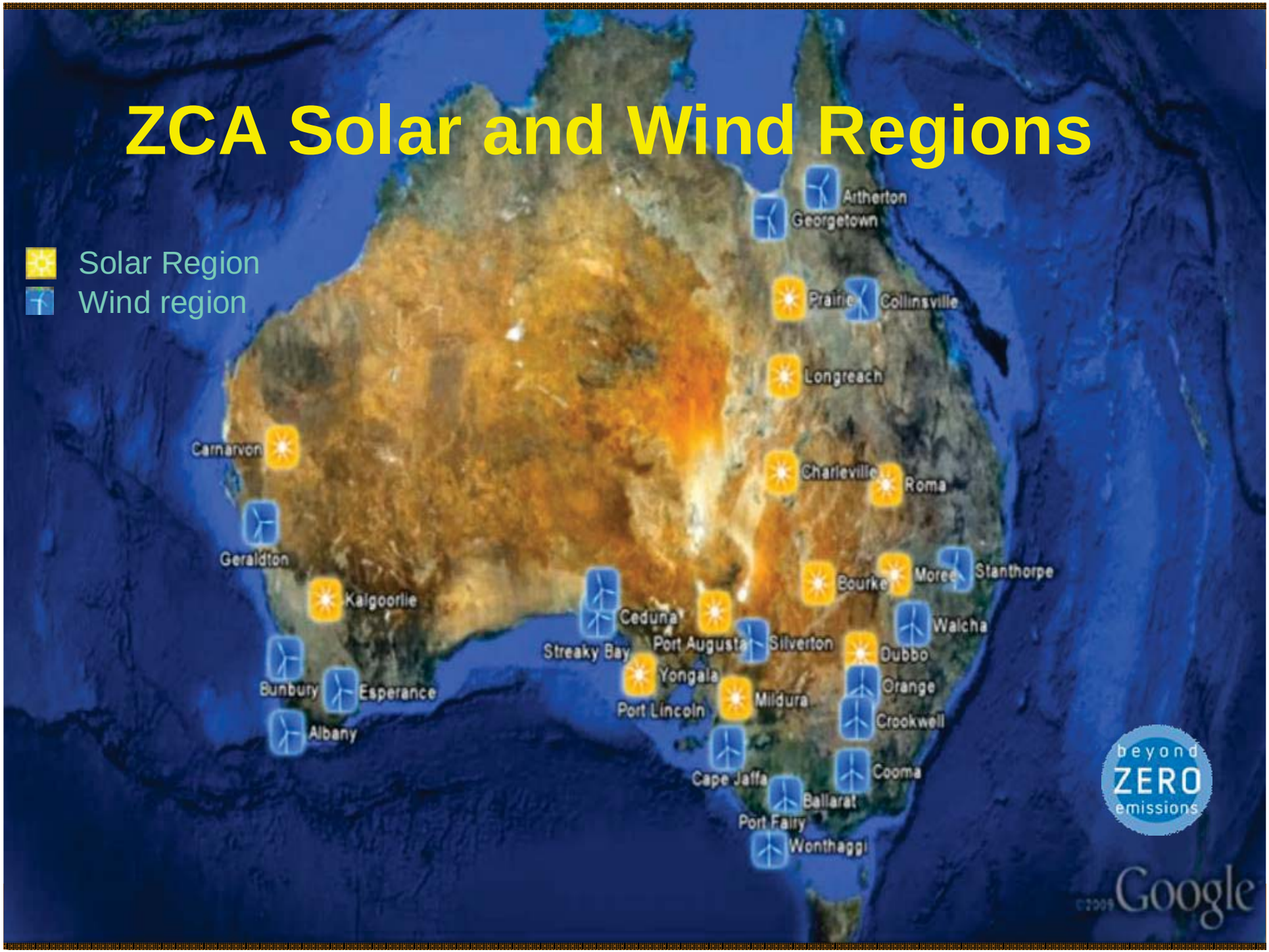
Backup with bio-mass
and hydro



Concentrated Solar
Thermal with storage

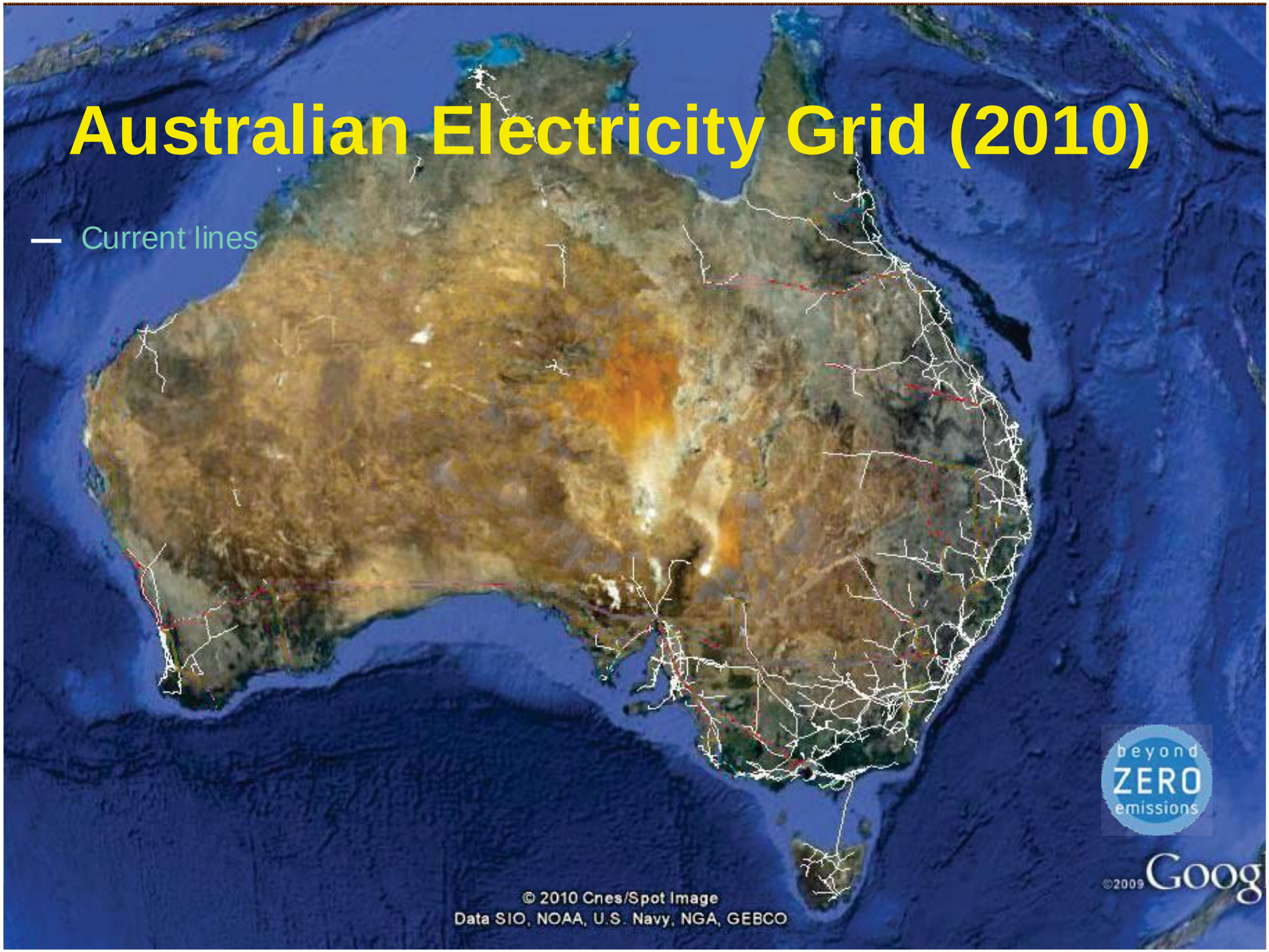
Large scale wind
farms

ZCA Solar and Wind Regions

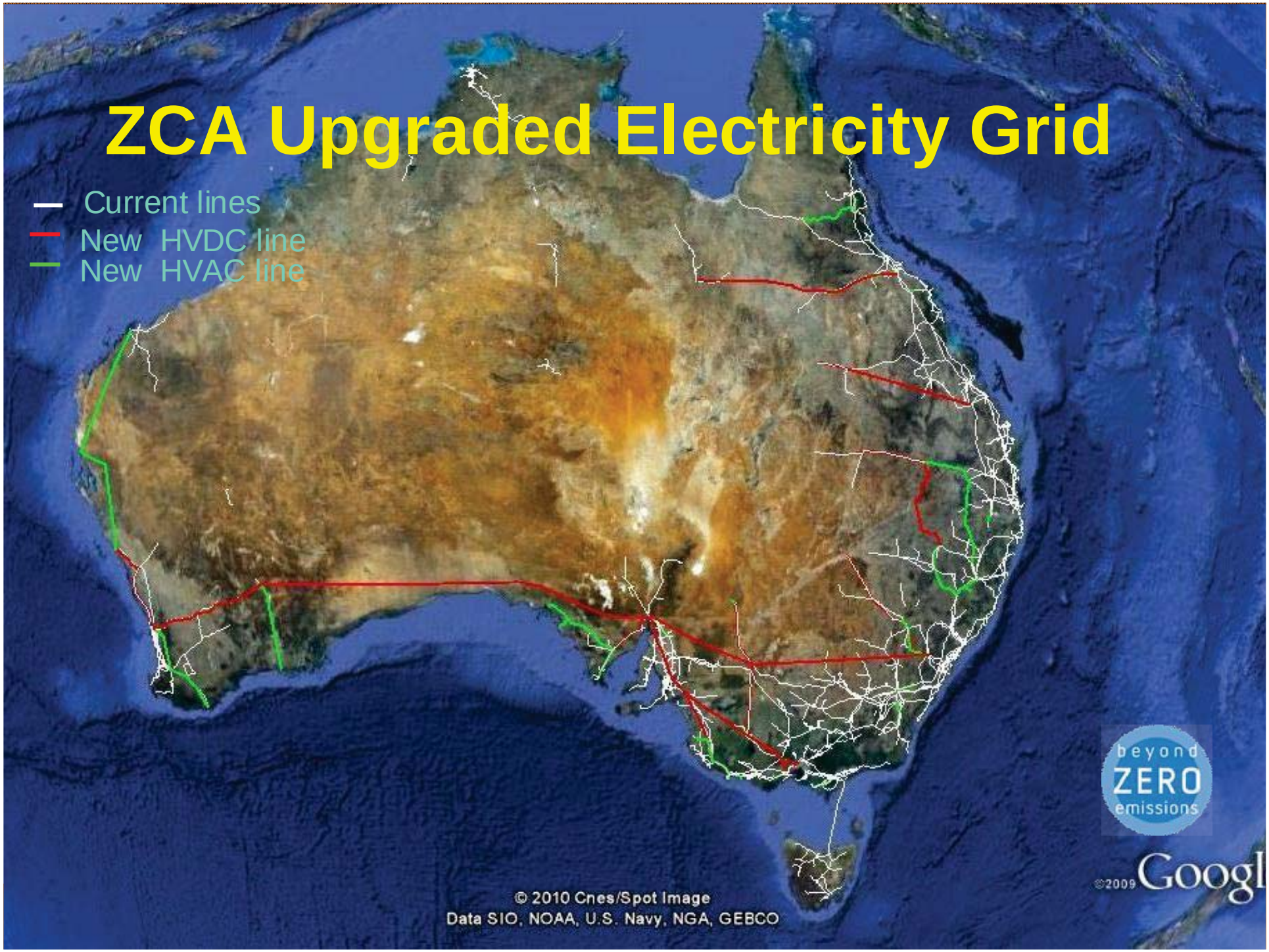


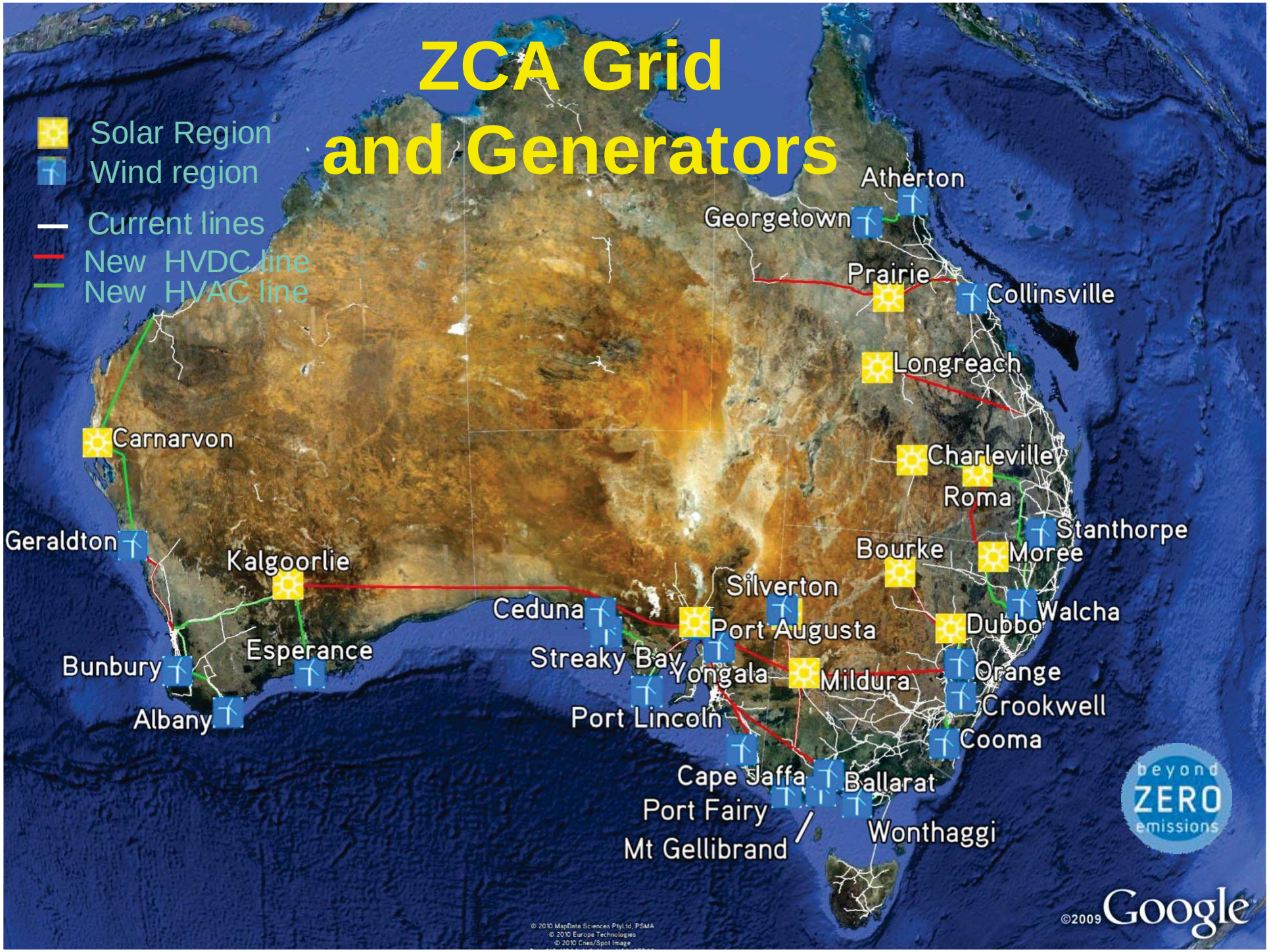
Australian Electricity Grid (2010)

— Current lines



ZCA Upgraded Electricity Grid




ZCA Grid
and Generators
Solar Region
Wind region
Current lines
New HVDC line
New HVAC line
Atherton
Georgetown
Prairie
Collinsville
Longreach
Carnarvon
Charleville
Roma
Stanthorpe
Geraldton
Kalgoorlie
Bourke
Moree
Silverton
Ceduna
Walcha
Port Augusta
Dubbo
Esperance
Streaky Bay
Yongala
Mildura
Orange
Bunbury
Crookwell
Albany
Port Lincoln
Cooma
Cape Jaffa
Ballarat
Port Fairy
Wonthaggi
Mt Gellibrand
beyond ZERO emissions
©2009 Google

Leading engineering consultancy review of grid

"The review finds that the transmission scenario proposed is technically feasible in terms of capacity and reliability. In addition, the proposed transmission uses mature technology with proven capability around the world."

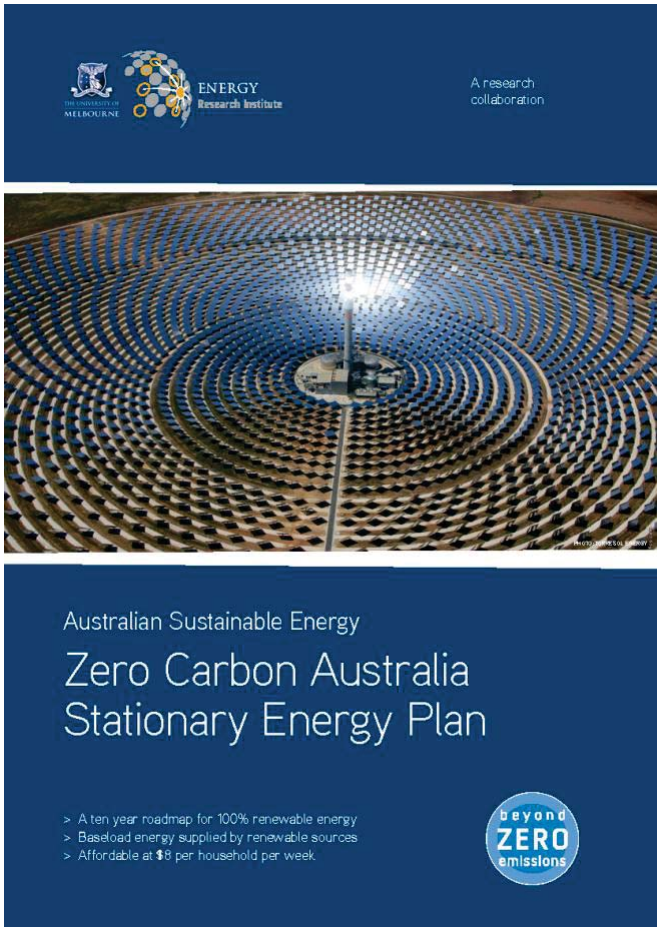
SINCLAIR KNIGHT MERZ

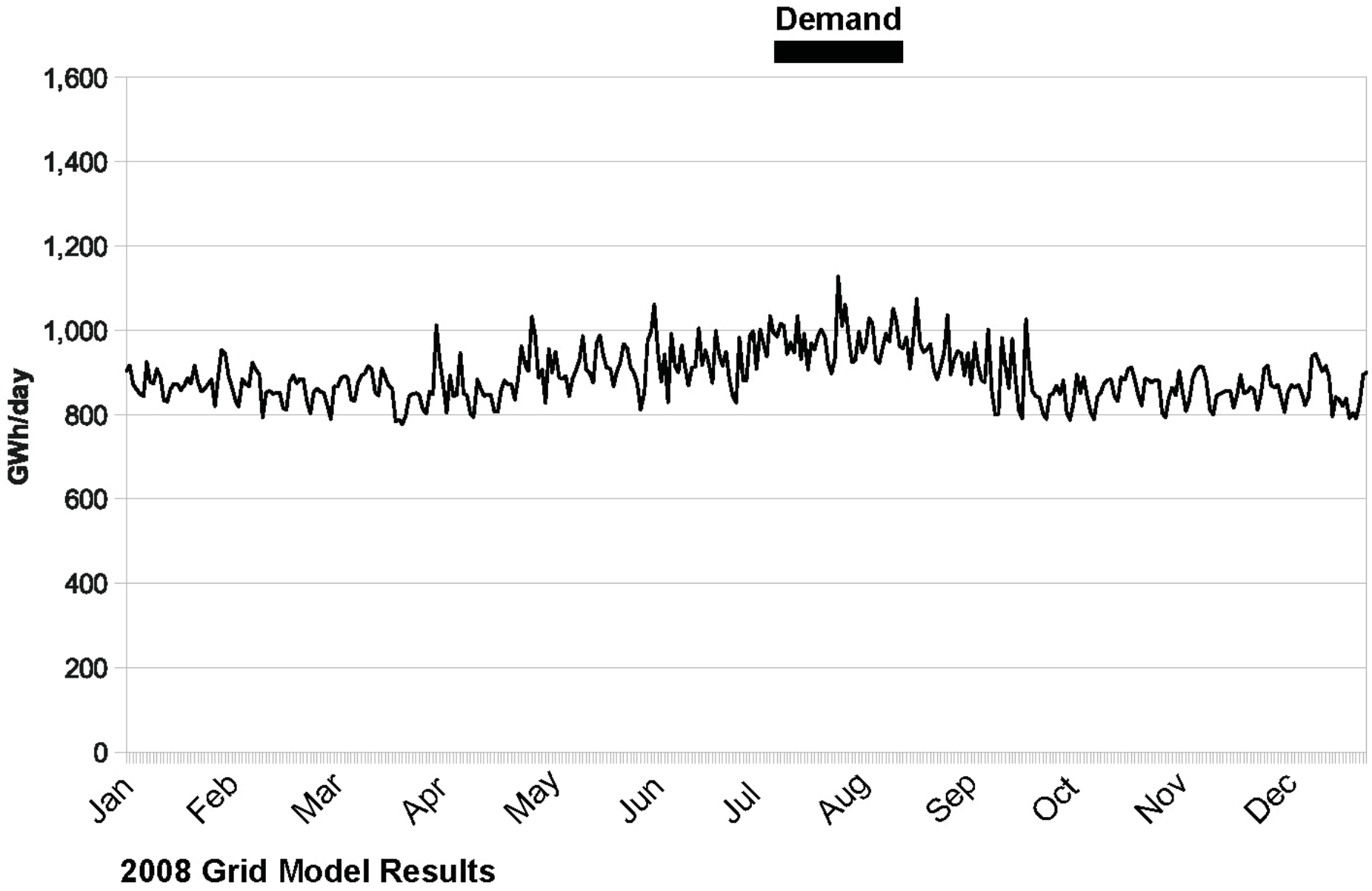
SKM

Major Questions

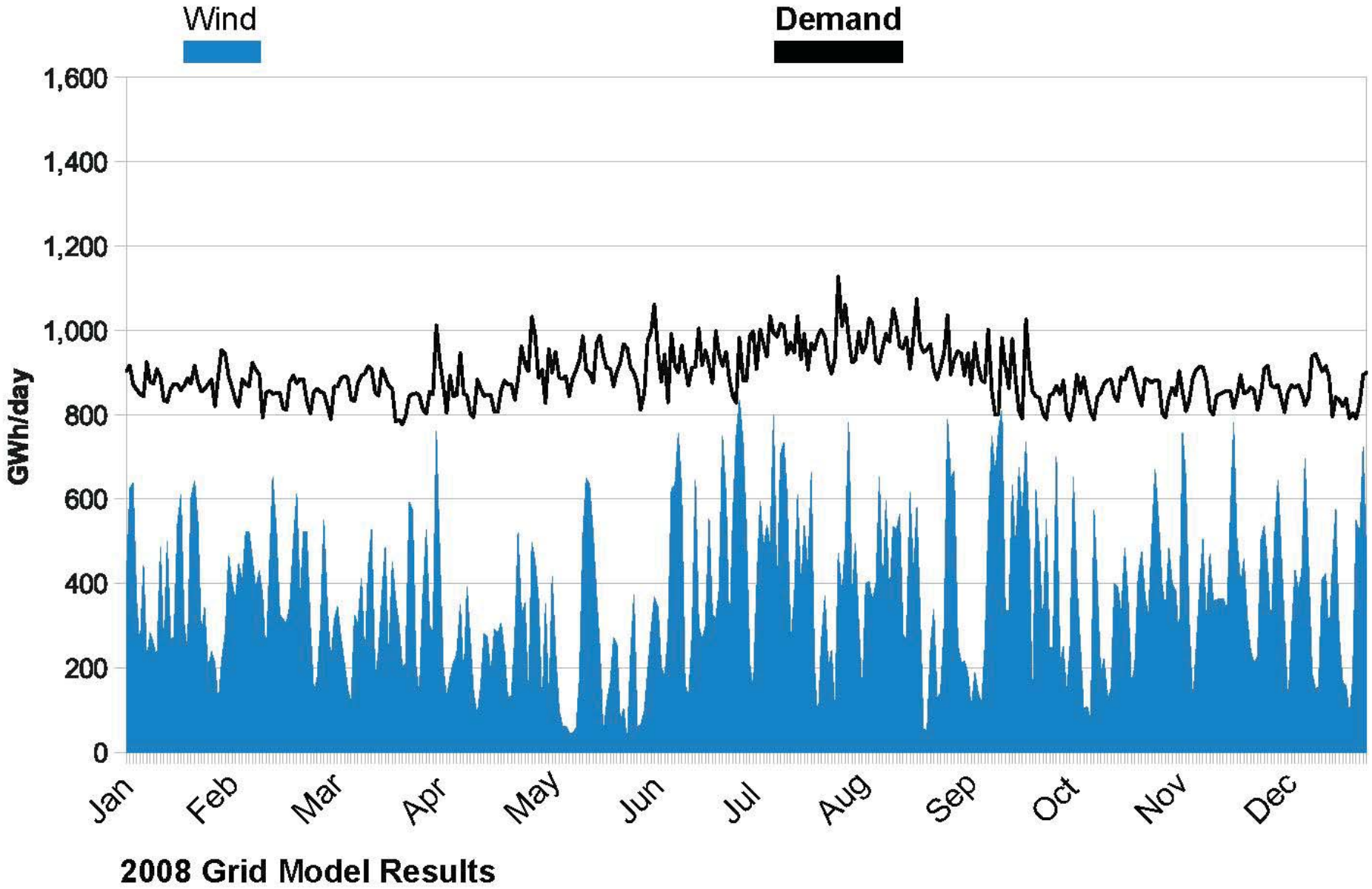
- Need ✓
- Technology ✓
- Reliability? **- Part Four**
- Resources?
- Jobs?
- Economics?

- Social and Political Will?
- What can I do?

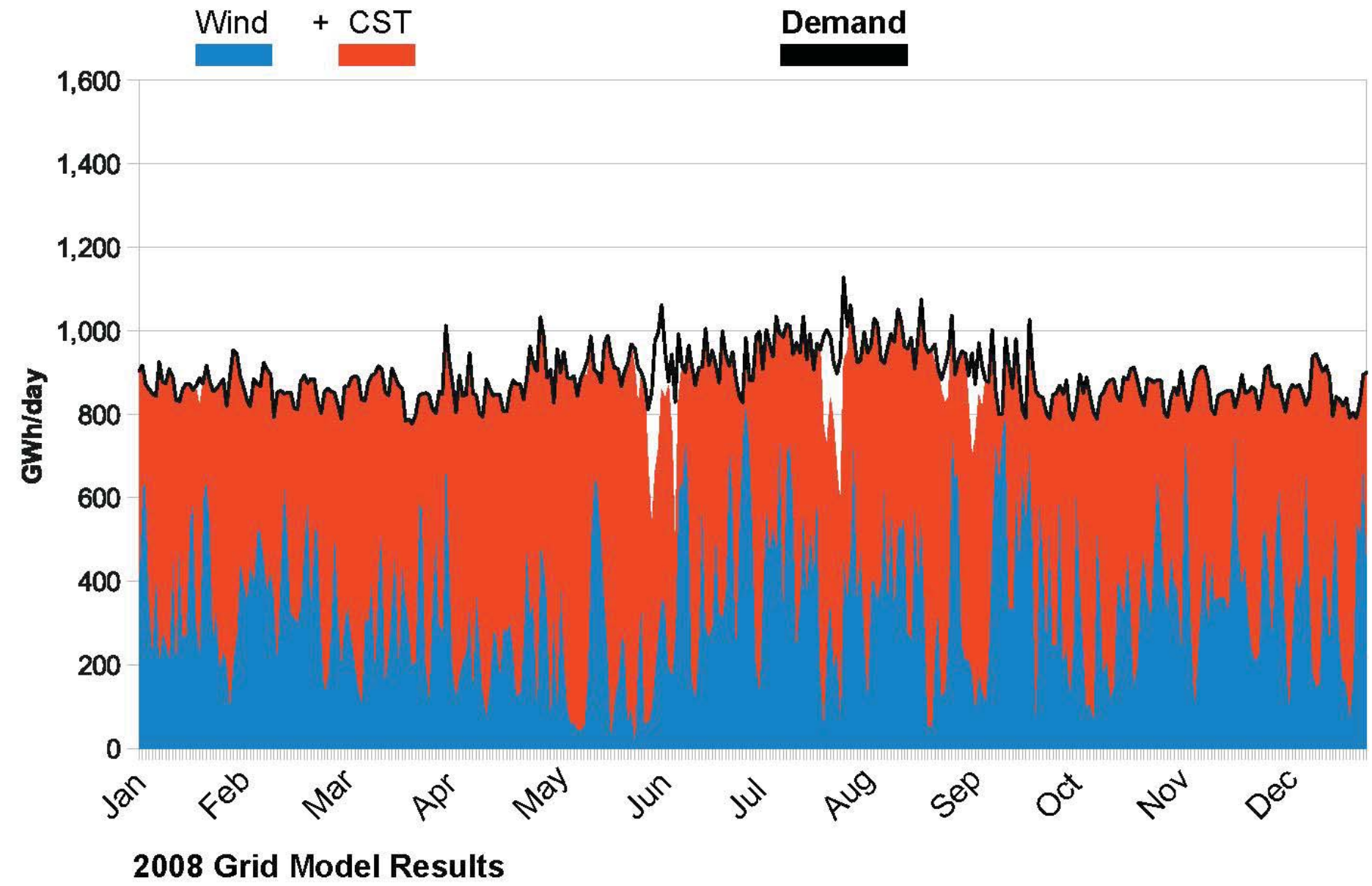




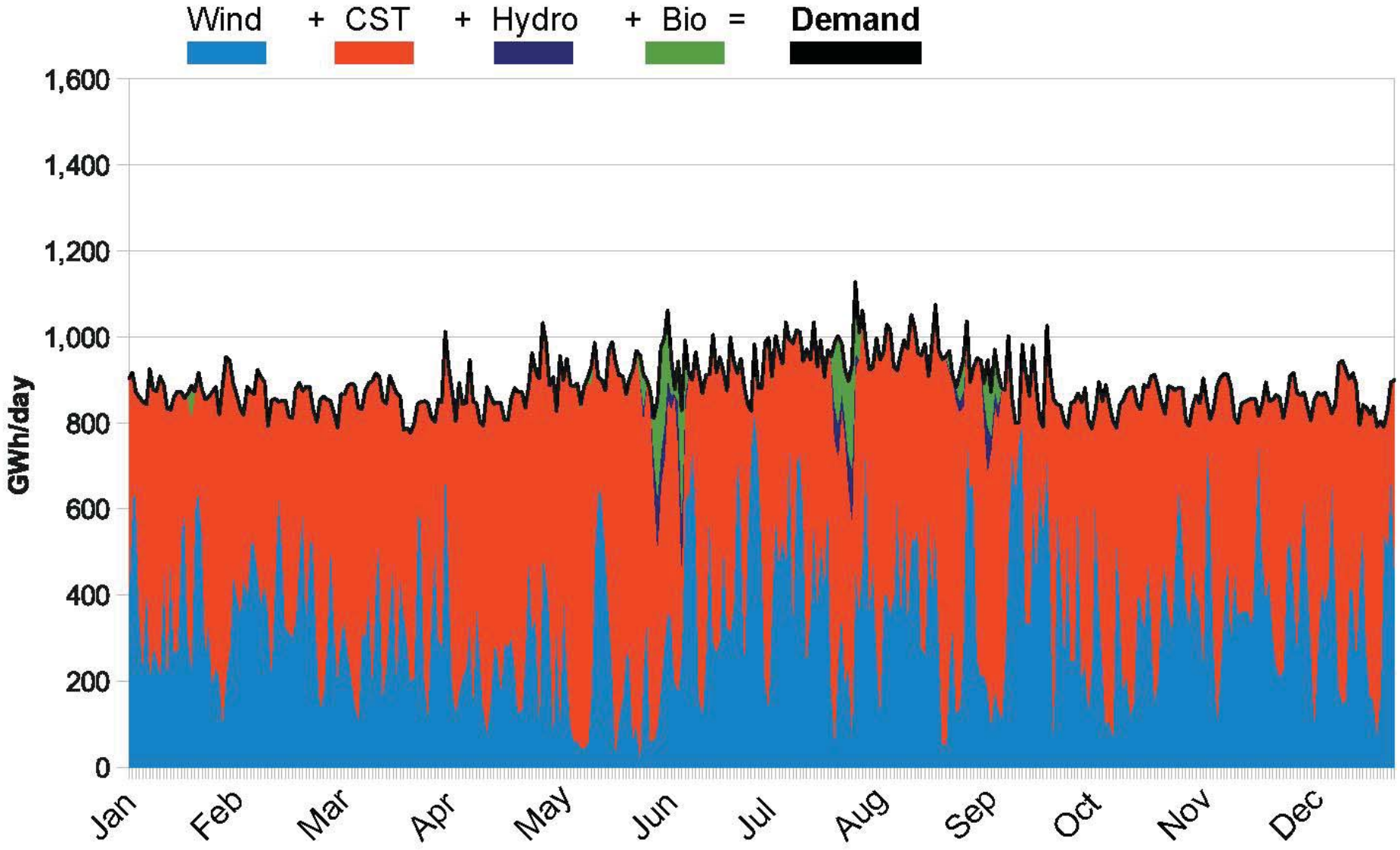
2008 Grid Model Results



2008 Grid Model Results



2008 Grid Model Results

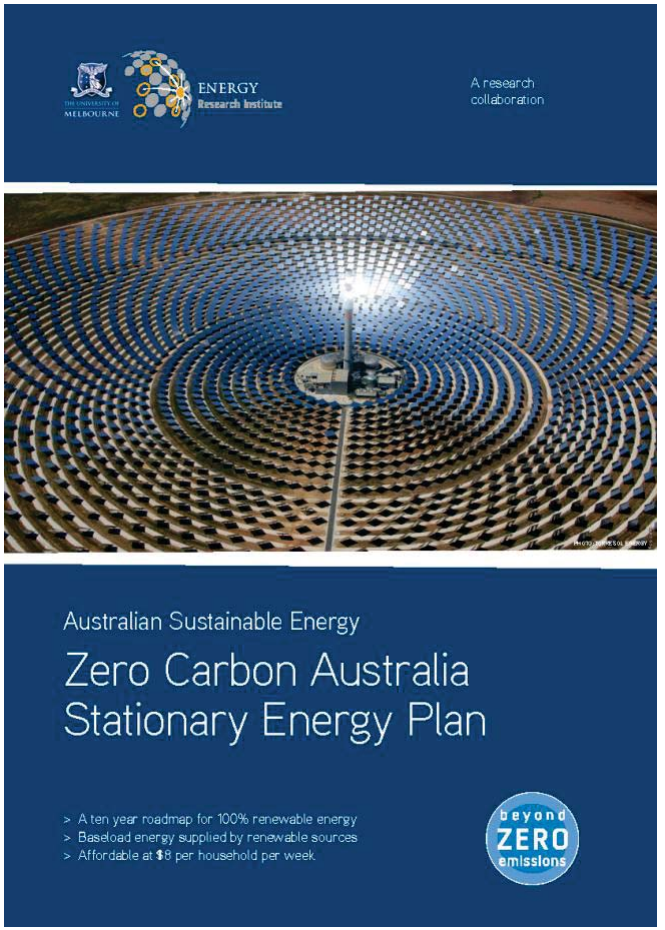


2008 Grid Model Results

Major Questions

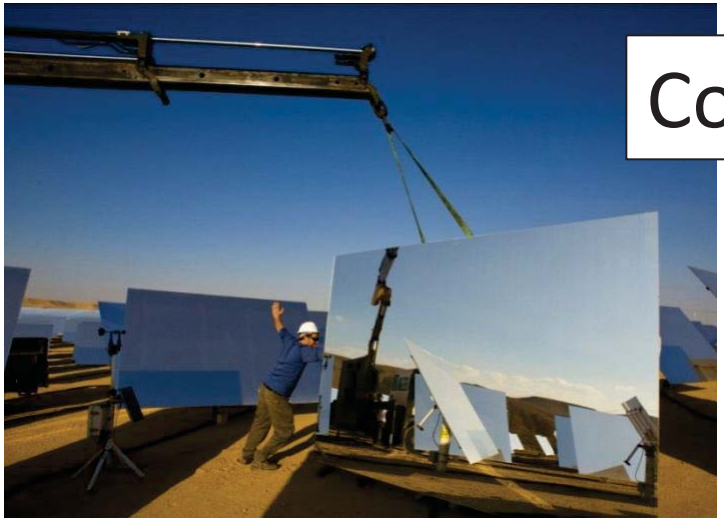
- Need ✓
- Technology ✓
- Reliability ✓
- Resources? } **Part Six**
- Jobs? } **Part Six**
- Economics? } **Part Six**

- Social and Political Will?
- What can I do?



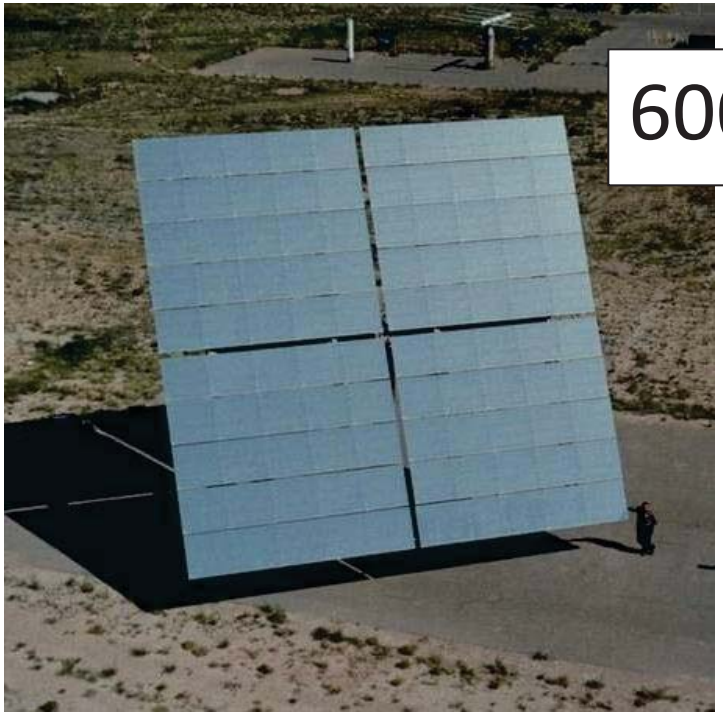
Getting the job done in 10 years

Manufacturing

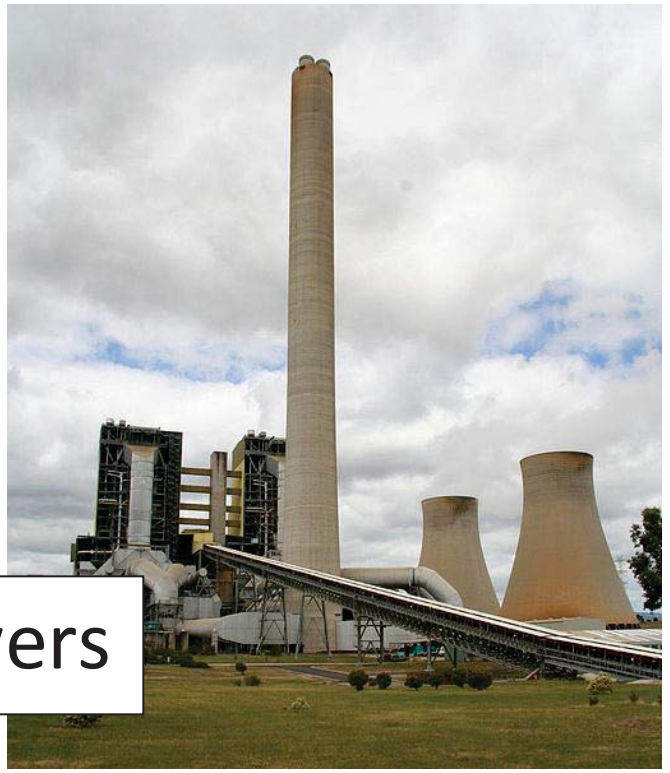


Construction

Peak Concentrated Solar ‘roll-out’



600,000 Heliostats



30 concrete towers

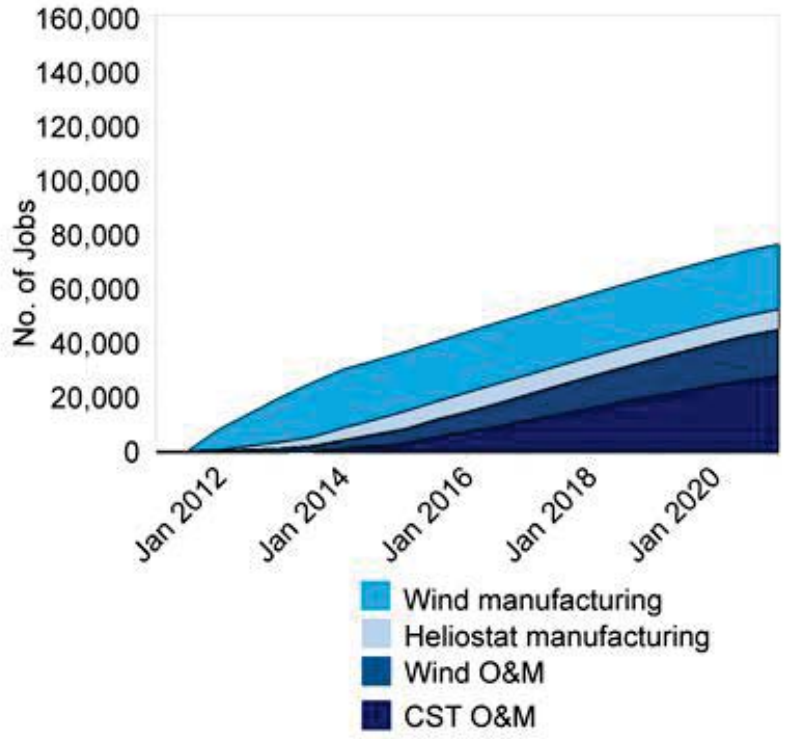
Enercon Viana Do Costelo Wind Turbine blade and tower factories Portugal
250 towers per year 400 Jobs



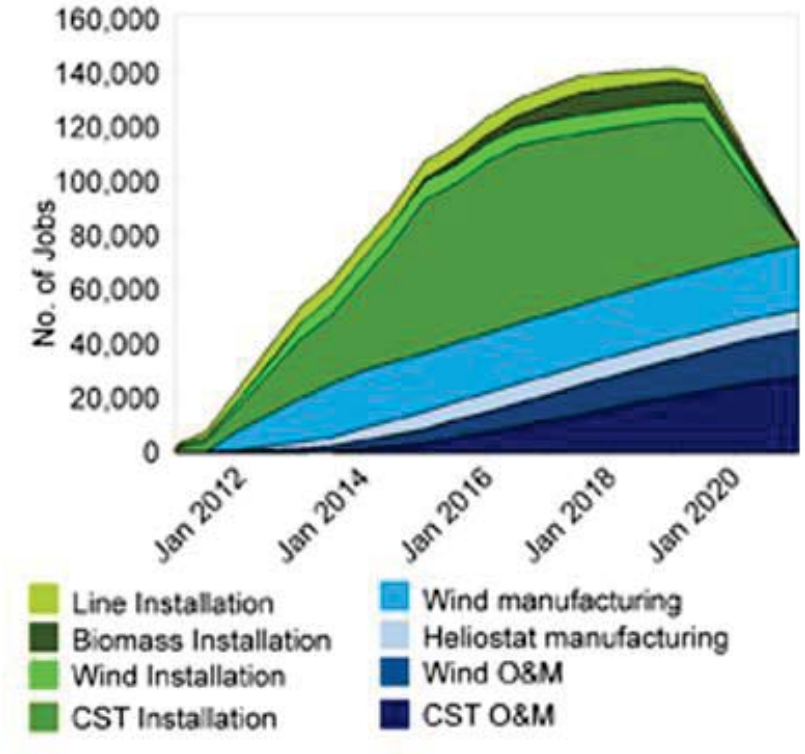


ZCA 10 year Resource Requirements

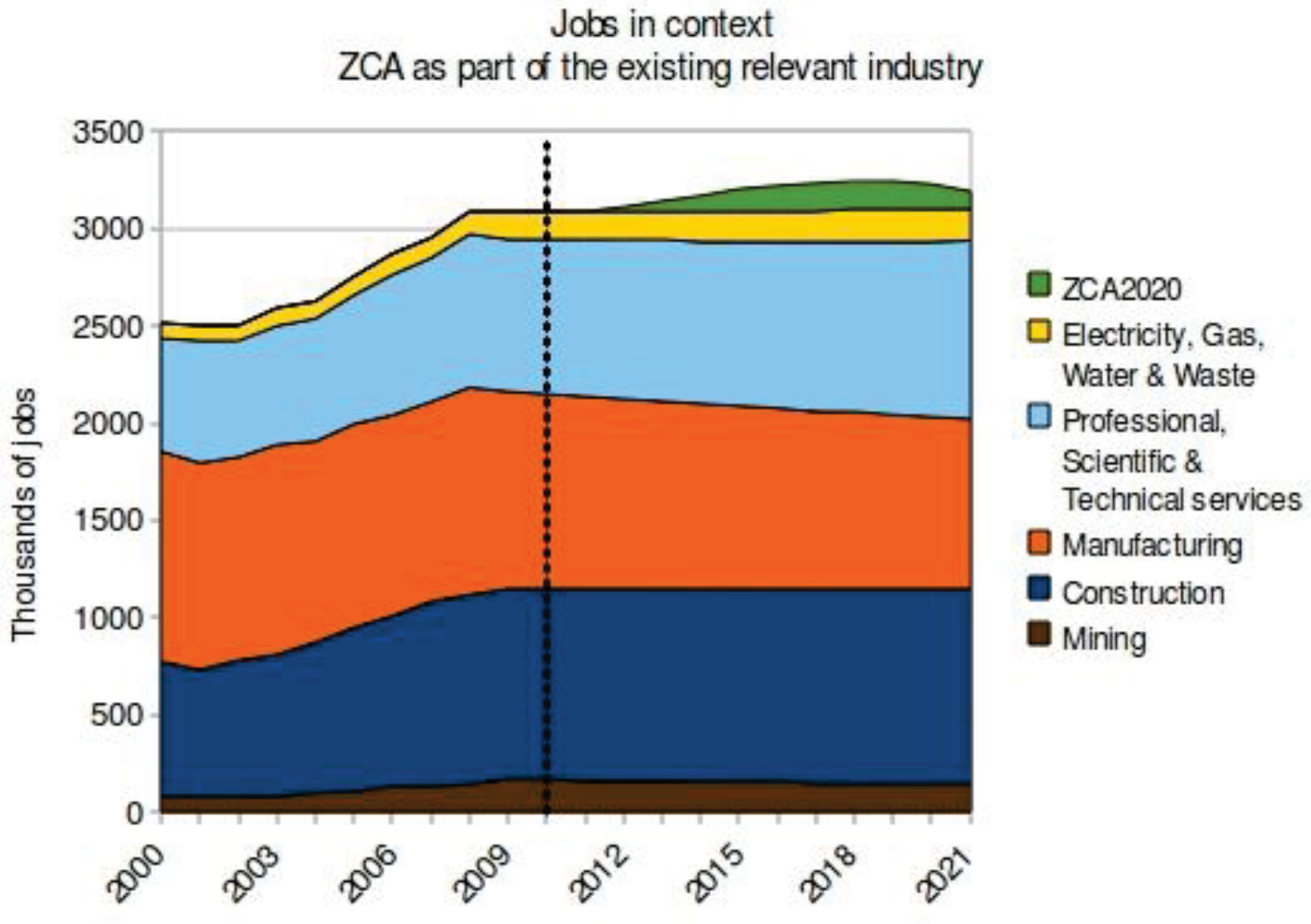
Labour Requirements



Labour Requirements



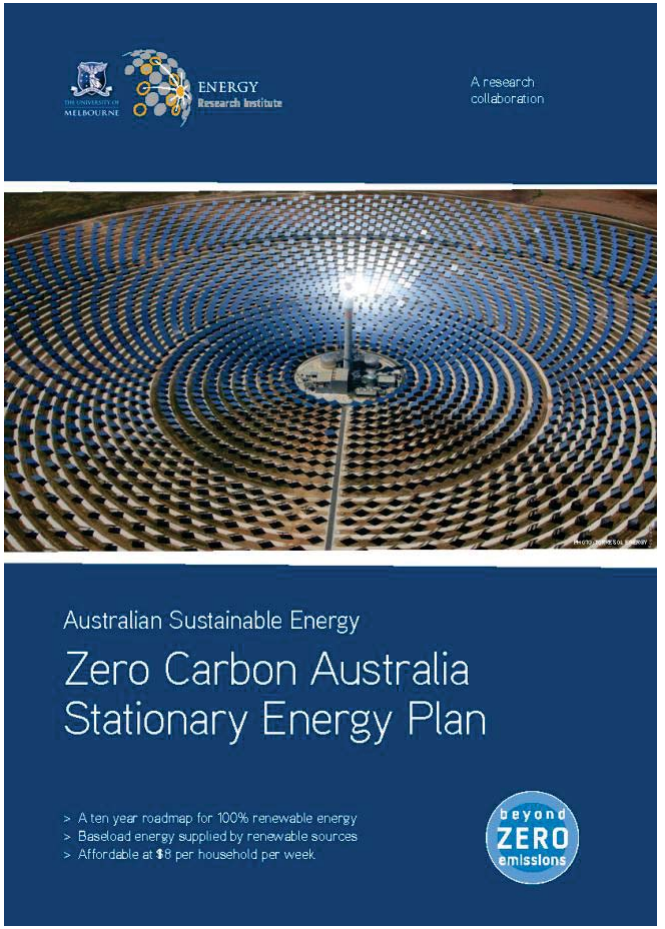
Achievability: Jobs In Context



Major Questions

- Need ✓
- Technology ✓
- Reliability ✓
- Resources ✓
- Jobs ✓
- Economics? **- Part Seven**

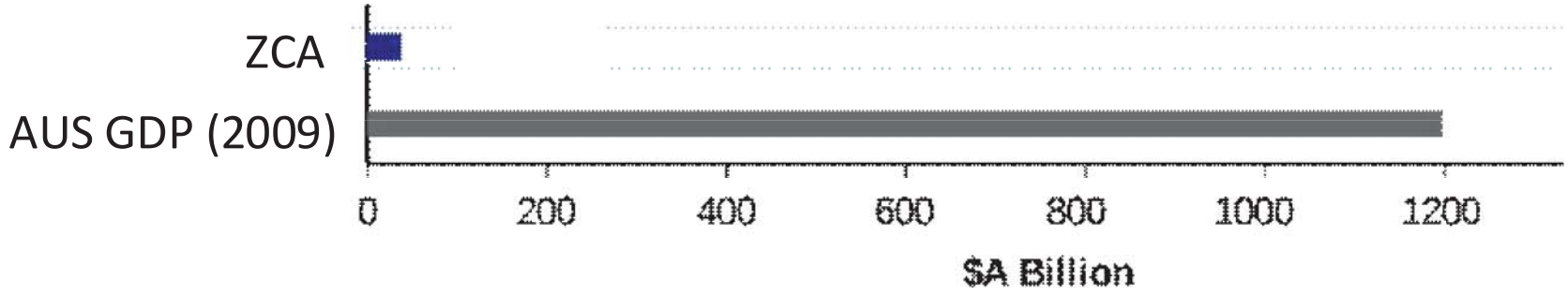
- Social and Political Will?
- What can I do?



Investment: 3% of GDP for 10 years

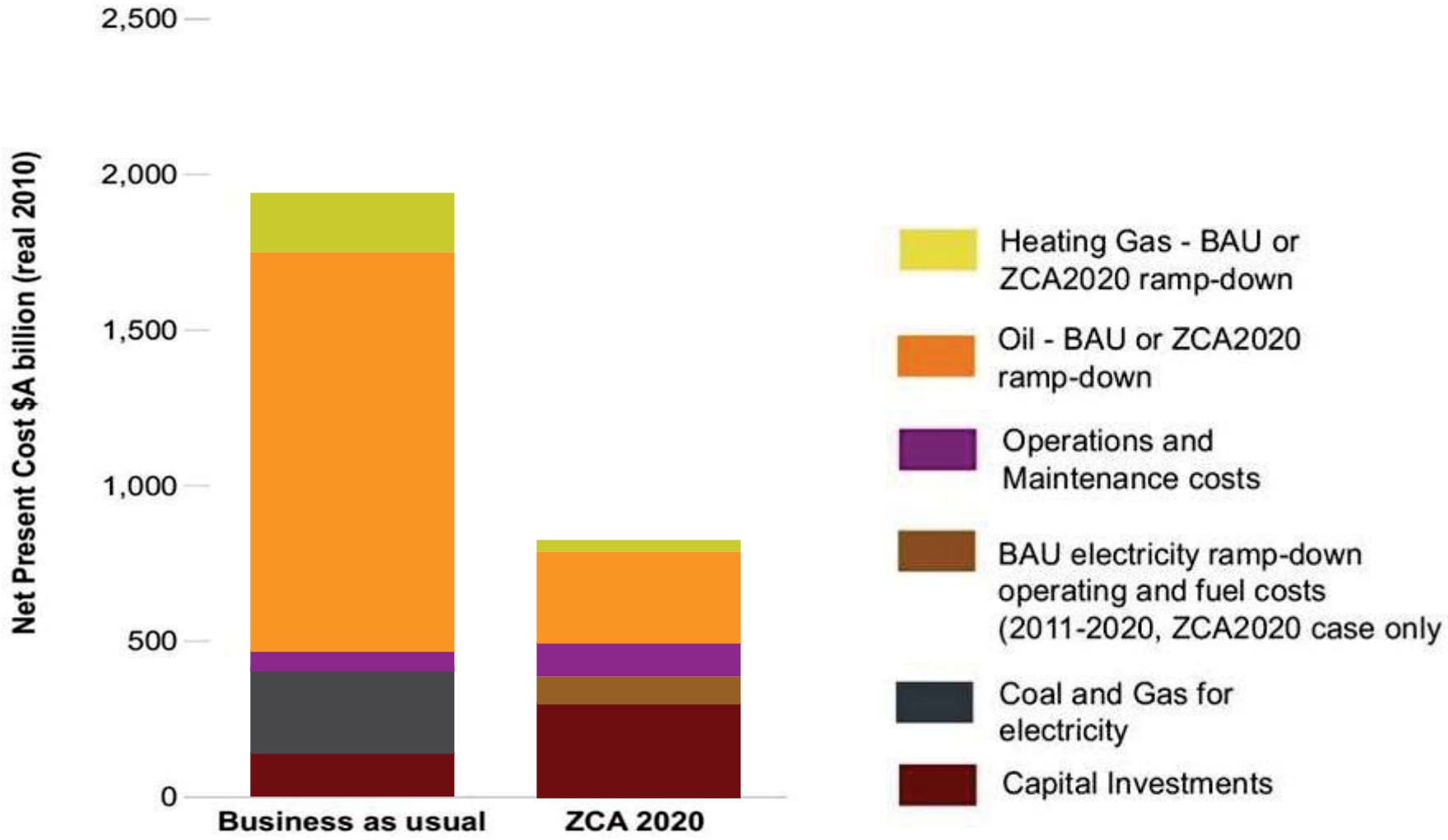
Component	$AU,Bn
CST	$175
Backup Heaters	$8
Bioenergy supply	$6
Wind	$72
Transmission	$92
TOTAL	**$353**
Off-grid CST + Backup	$17
TOTAL + Offgrid	**$370**

ZCA per year and Australia's GDP



- ZCA – $37Bn for 10 years
- Australian Gambling 2009 – $20Bn
- Australian Insurance 2009 – $38Bn

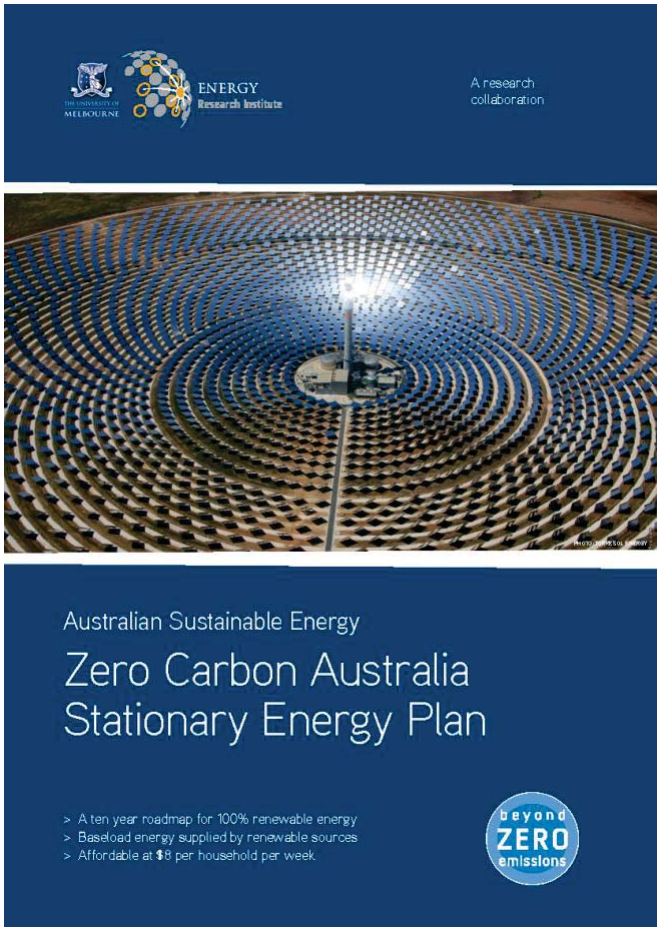
30 year Cost to Economy – all energy



Major Questions

- Need ✓
- Technology ✓
- Reliability ✓
- Resources ✓
- Jobs ✓
- Economics ✓

- Social and Political Will?
- What can I do?



Social & Political Will?


What can I do?
Donate
Contribute
beyond
ZERO
emissions