**Submission to the Senate Select Committee on Fuel and Energy**

# The Future of Energy in Australia

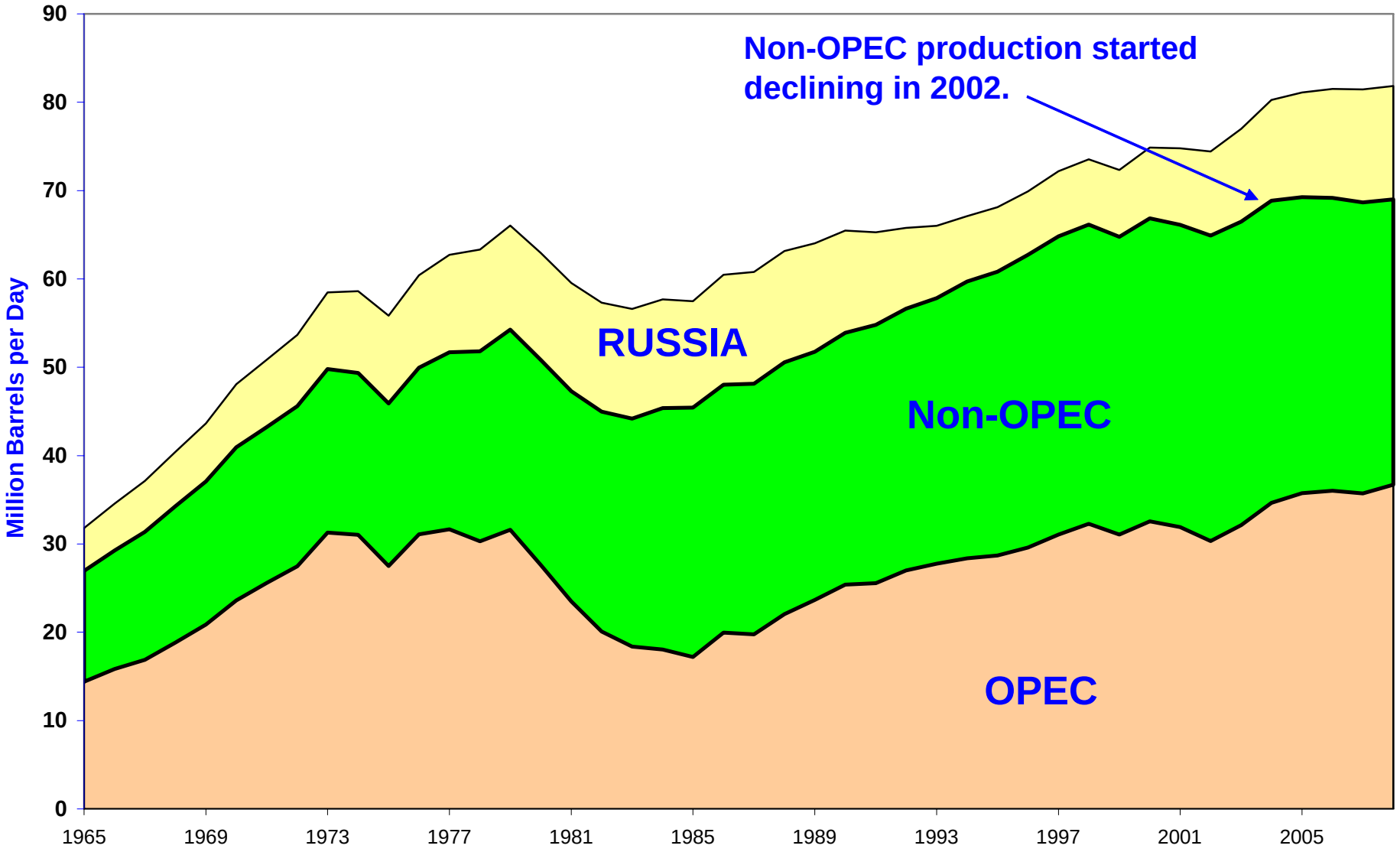
***David Archibald***

***19th June 2009***

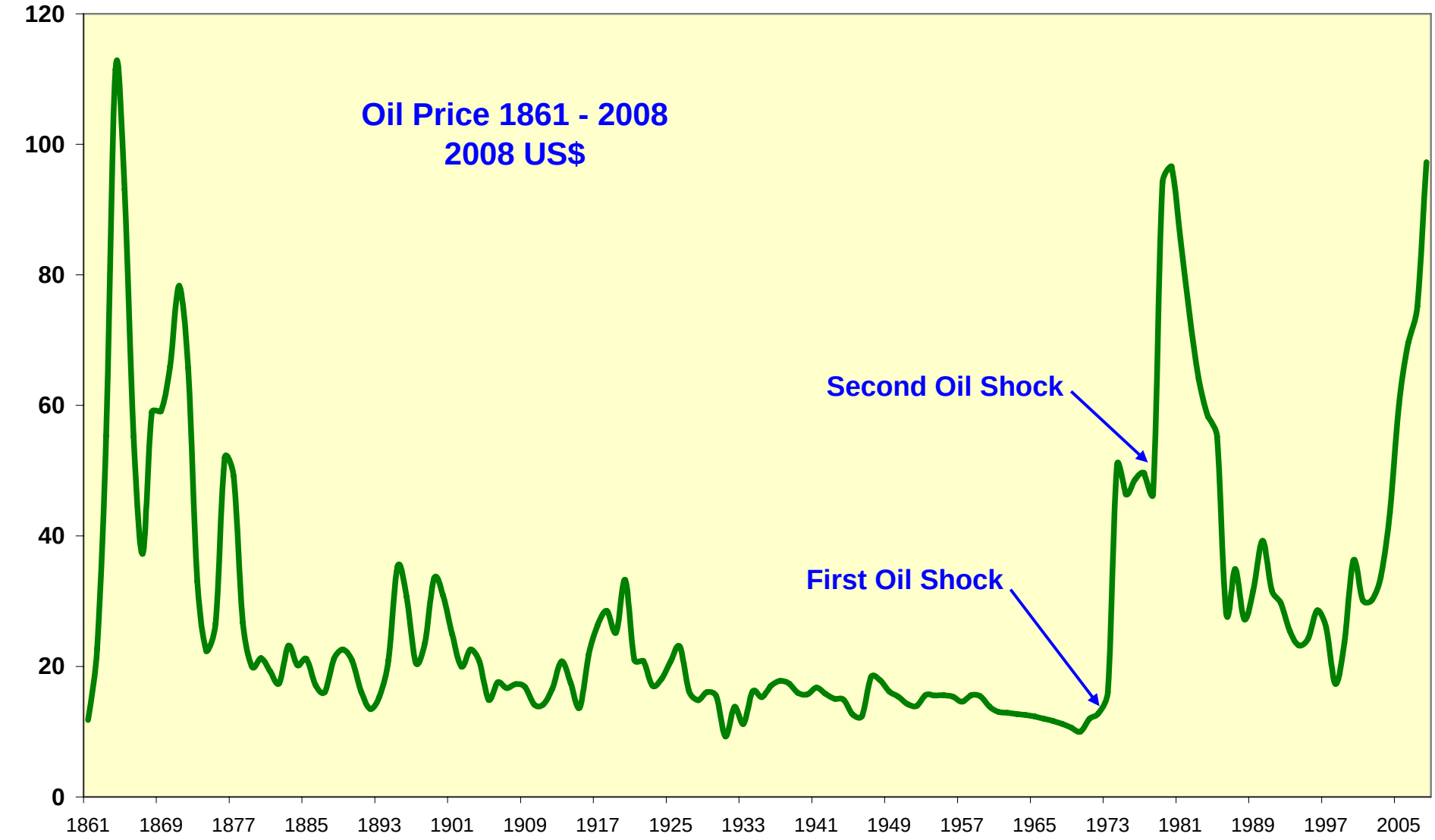
# Sections

- The Oil Price Driver
- Electric Power
- Liquid Fuels
- Convergence through Plug-in Hybrid

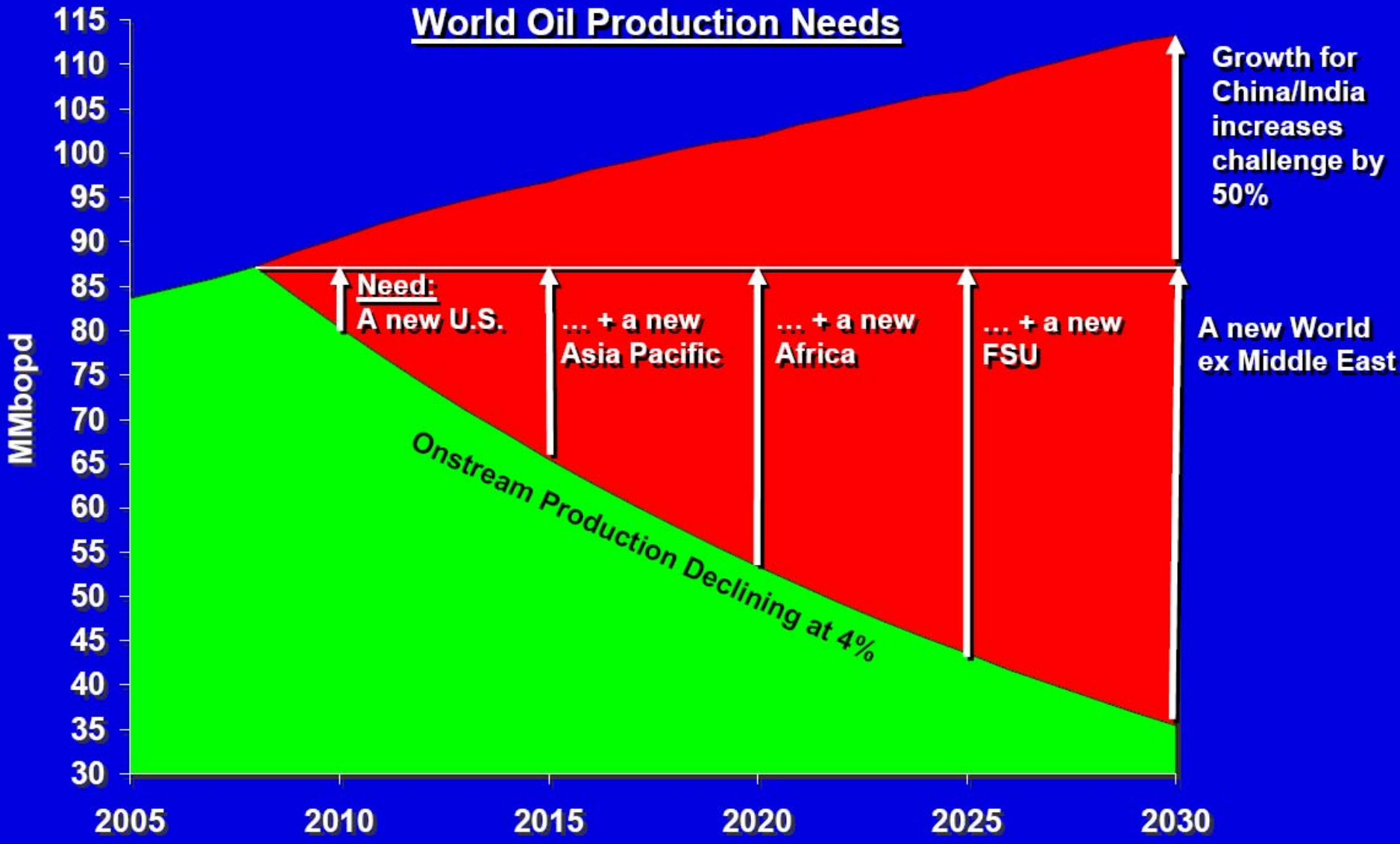
# World Oil Production 1965 - 2008



# Non-OPEC Production has fallen by 1.1% per annum since 2002 despite the oil price tripling.



# What will drive everything.




*Source: U.S. Department of Energy data, Perella Weinberg analysis.*

***Current demand will consume over half of world's proved oil reserves within 25 years***

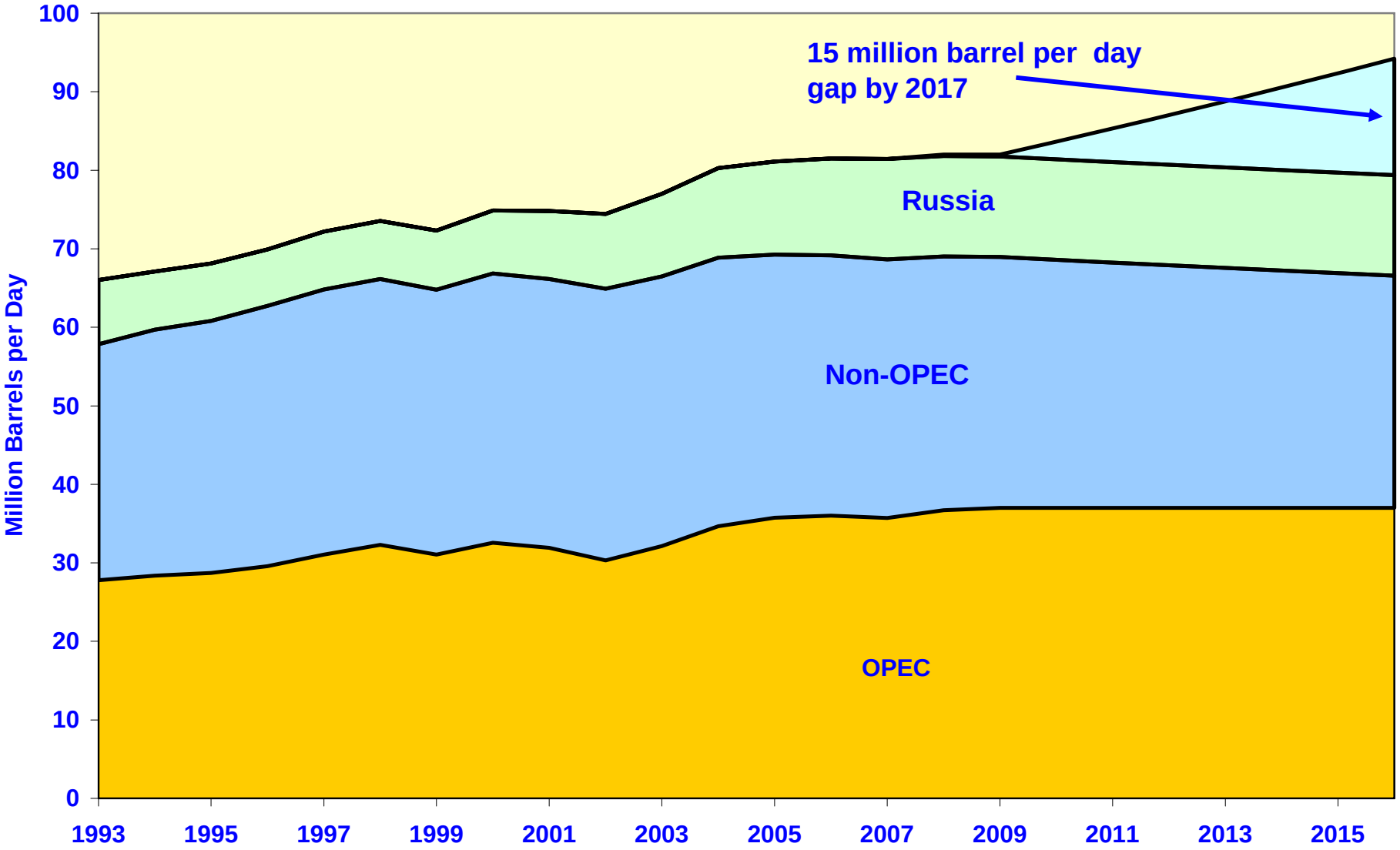
- **Current demand:** 85 MMbopd
- **Oil required next 25 years:**
  - No growth: 775 Bn barrels
  - 1.3% growth: 880 Bn barrels
  - 2.0% growth: 960 Bn barrels
- **World proved oil reserves:** 1,390 Bn barrels*
  - OPEC 935 Bn barrels*

* YE 2007 proved reserves including Canadian oil sands. Source: 2008 BP Statistical Review.

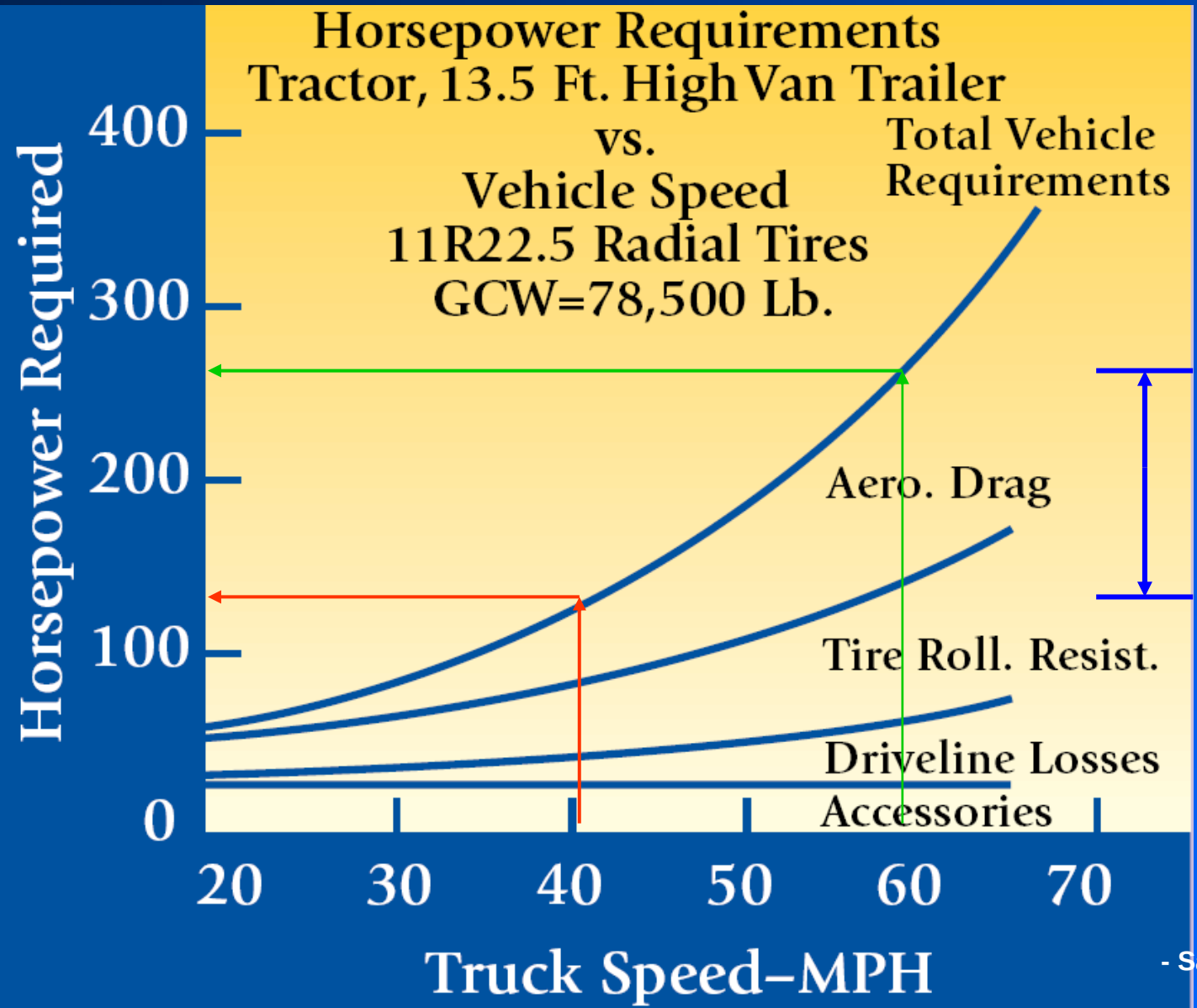
# Major hydrocarbon basins past peak production

| | Production Peak | Decline Since | 2007 MMboe/d |
|---|---|---|---|
| U.S. | 1972 | -25% | 15.7 |
| Netherlands | 1976 | -21% | 1.3 |
| Indonesia | 1997 | -22% | 2.0 |
| U.K. | 1999 | -38% | 2.8 |
| Colombia | 1999 | -26% | 0.7 |
| Australia | 2000 | -8% | 1.2 |
| Oman | 2001 | -7% | 1.1 |
| Norway | 2004 | -10% | 4.0 |
| Mexico | 2004 | -5% | 4.2 |

# The supply gap at 2% demand growth



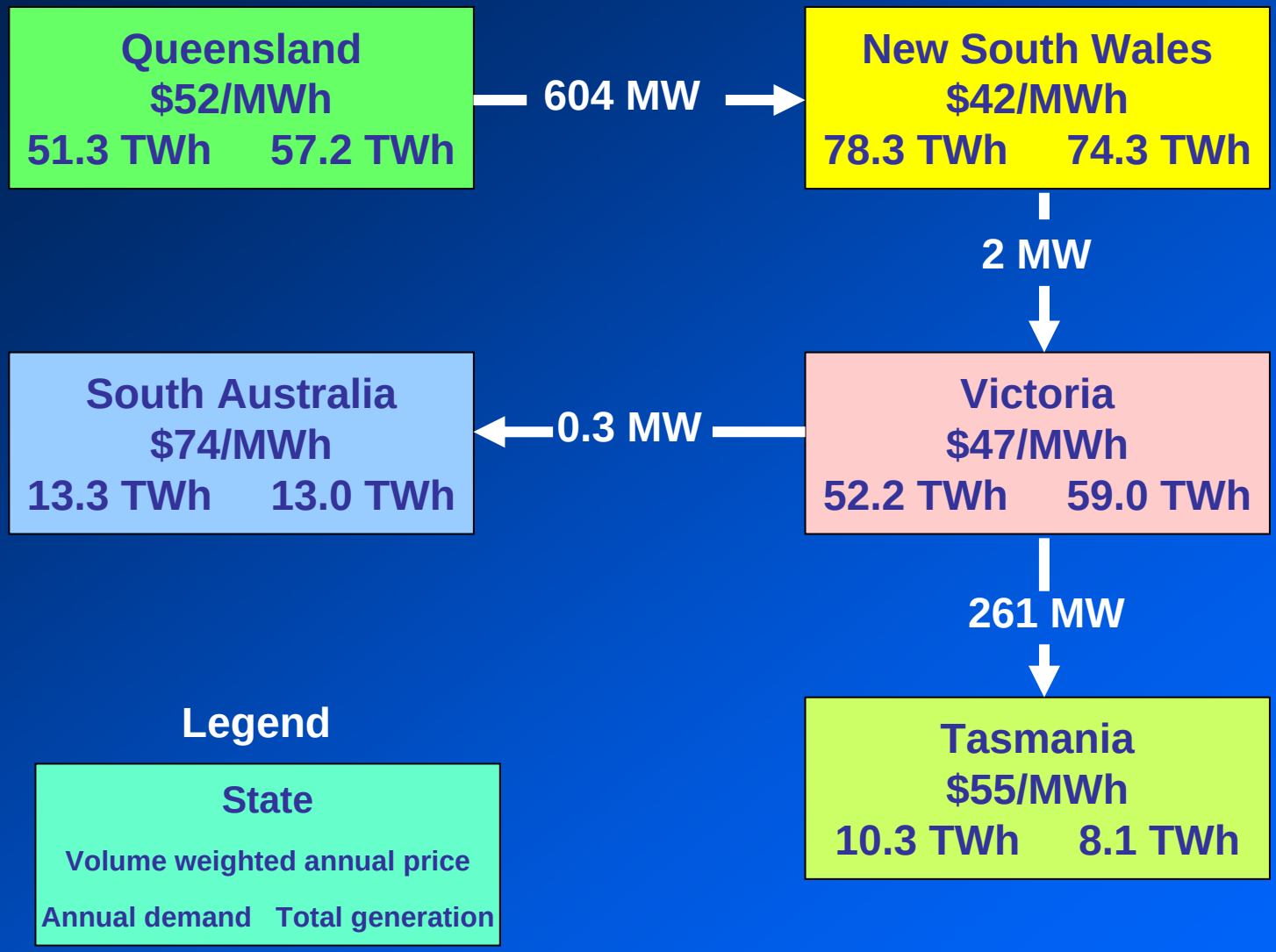
# The first response – lower speed



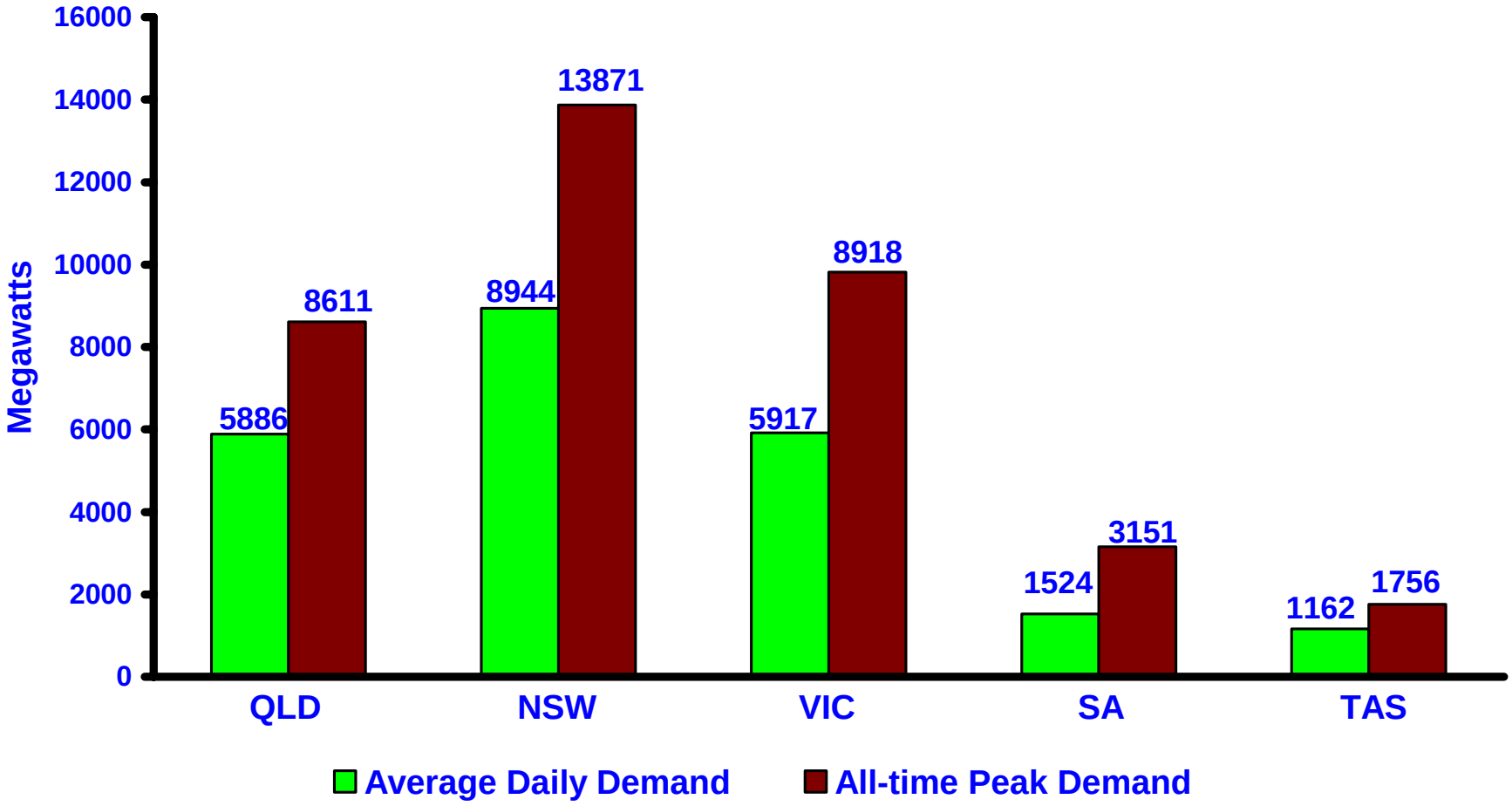

**50% decrease in fuel consumption for a 30% speed decrease**

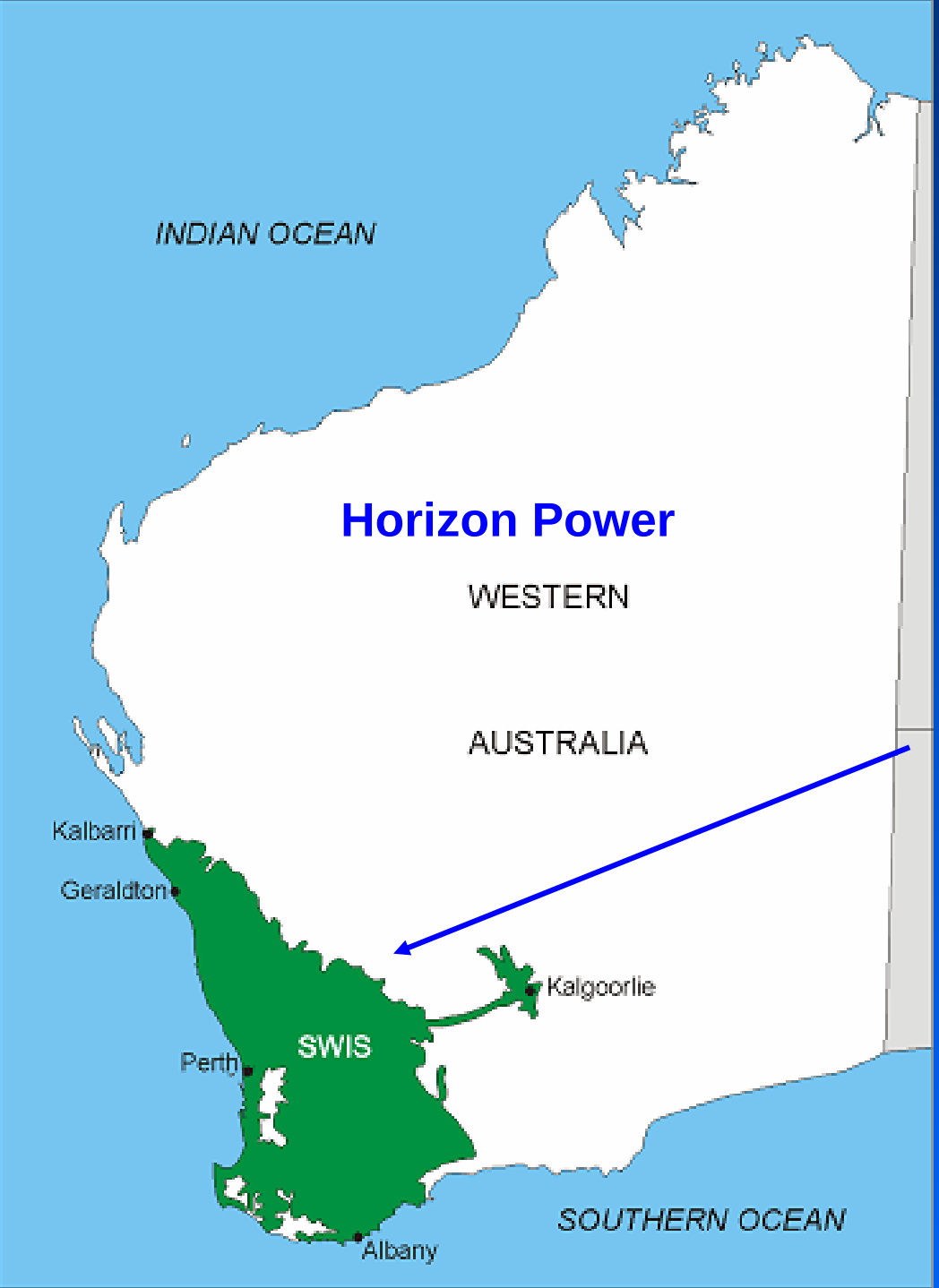
100,000 miles per annum
US$5/gallon
5 miles to the US gallon
- Saving US$50,000 per annum

# East Coast Power Market 2007 - 2008



# Average Daily Demand and All-Time Peak Demand






# South West Interconnected System

**Verve Energy - generation**

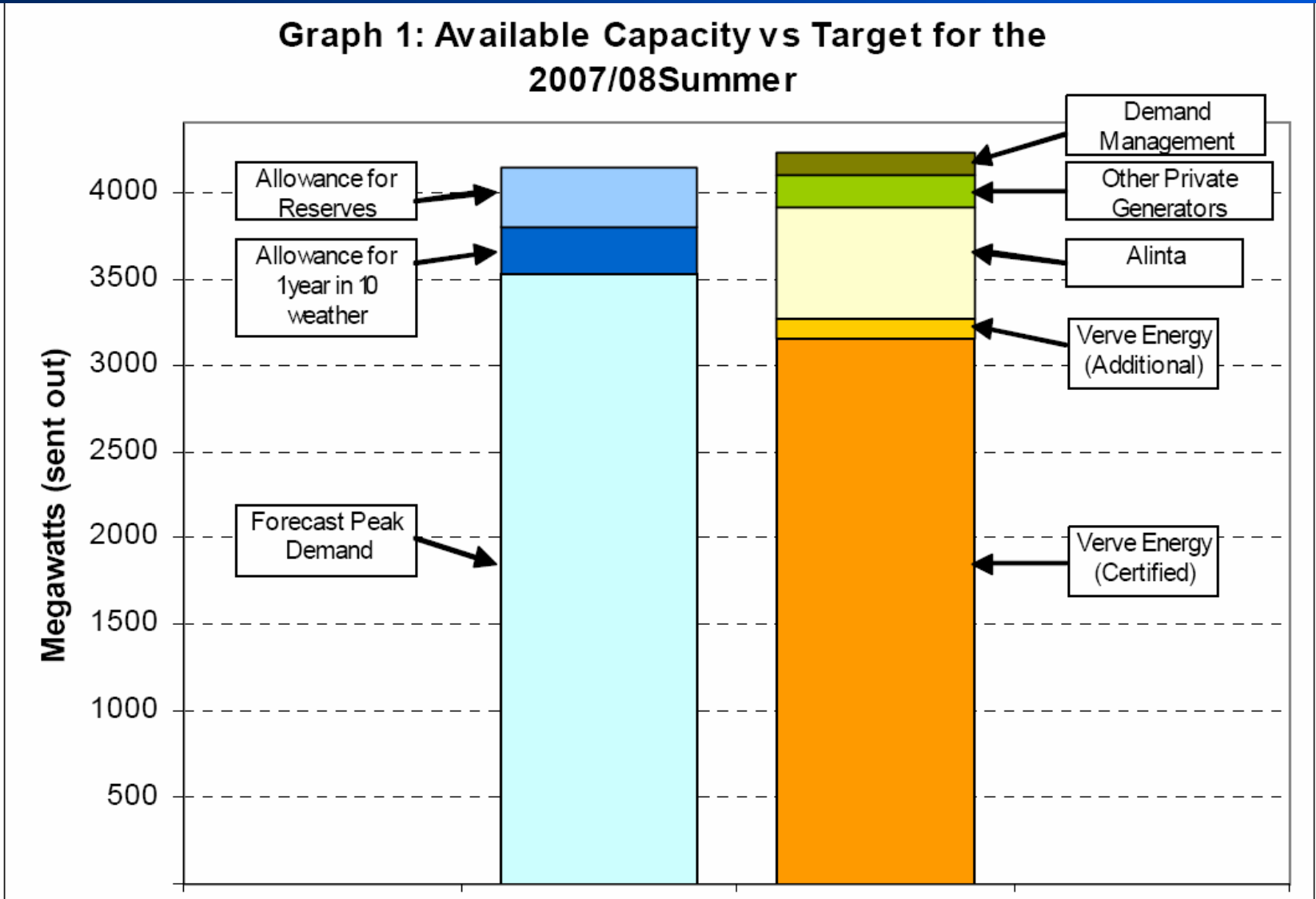
↓

**Western Power - distribution**

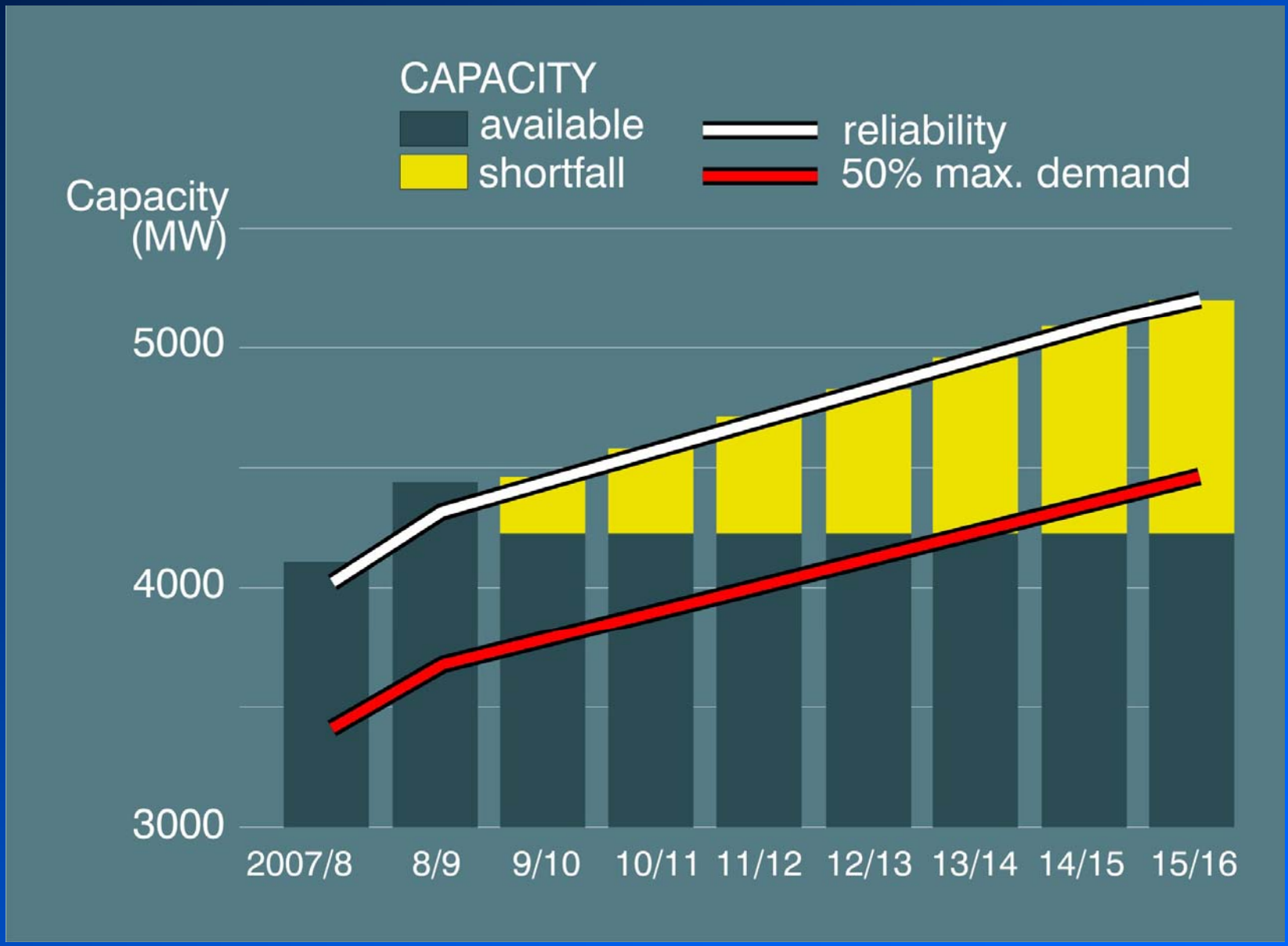
↓

**Synergy - retail**

# Western Australia Generation by Source



# SWIS Demand Growth to 2016

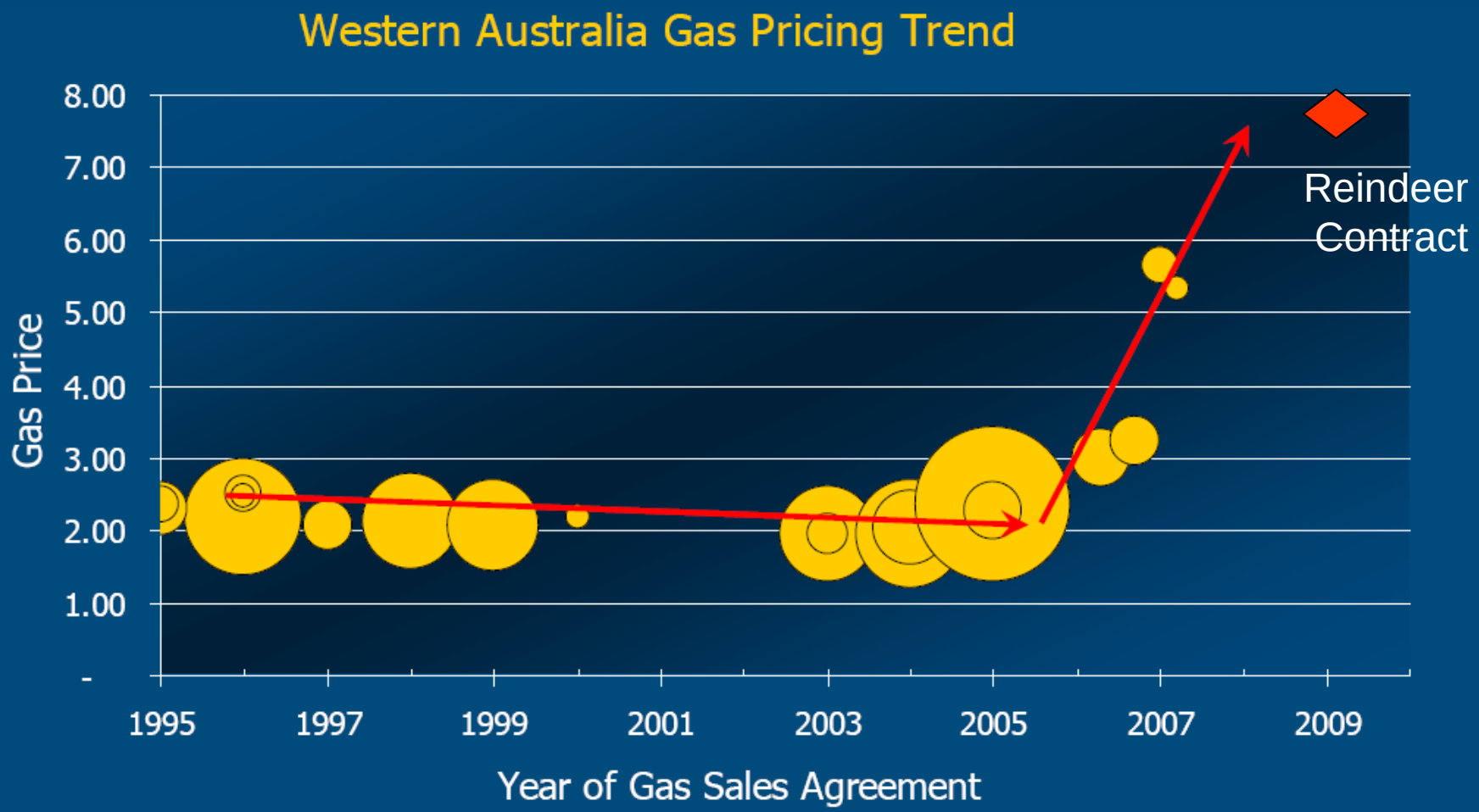



**Demand growth is expected to average 120 MW per annum.**

# The Gas Price Issue

- Gas has been cheap in WA for the last 20 years.
- Gas turbine power stations have been cheap to build.
- The long term, cheap gas contracts from the North West Shelf are running out in the next few years.
- Gas currently supplies 65% of WA electric power.
- Global warming as an issue has mesmerised the decision making process.

# Western Australian Experience




Step change in domestic gas prices realised notwithstanding huge reserves base

**From Santos presentation June, 2007 – Reindeer contract added**

# The Reindeer Contract

- Supply from 2011 at $7.80 per gj.
- From 2014 the price is indexed to the oil price.
- One third of reserves are committed to Sino Iron, the rest can go into the domestic market.
- Sino Iron only got seven years of supply for a 25 year plus project.

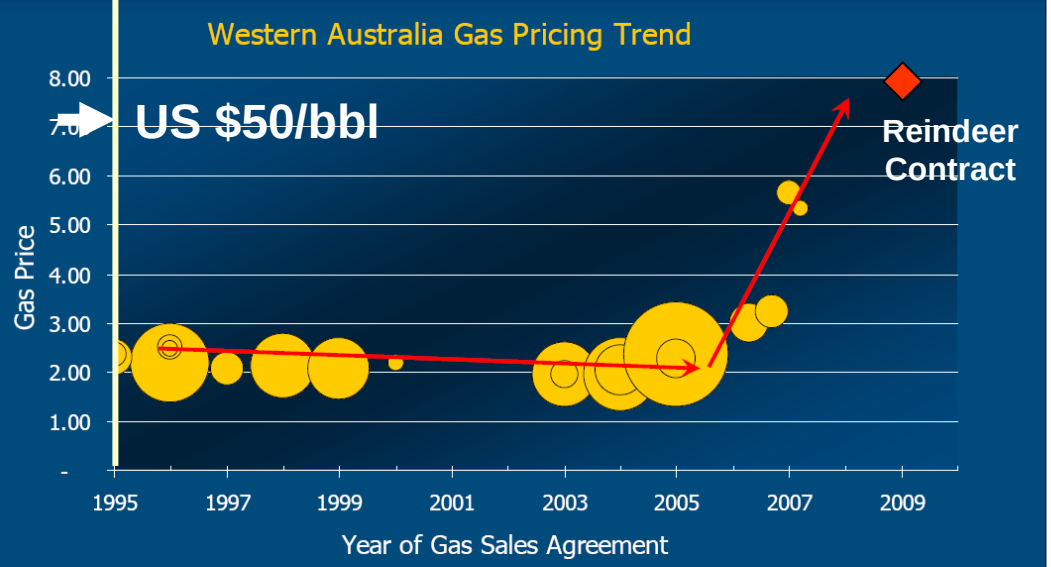
US $150/bbl

US $100/bbl

Likely mid-decade
Gas price
~ $20/gj

This price was achieved on an LNG contract in 2008.

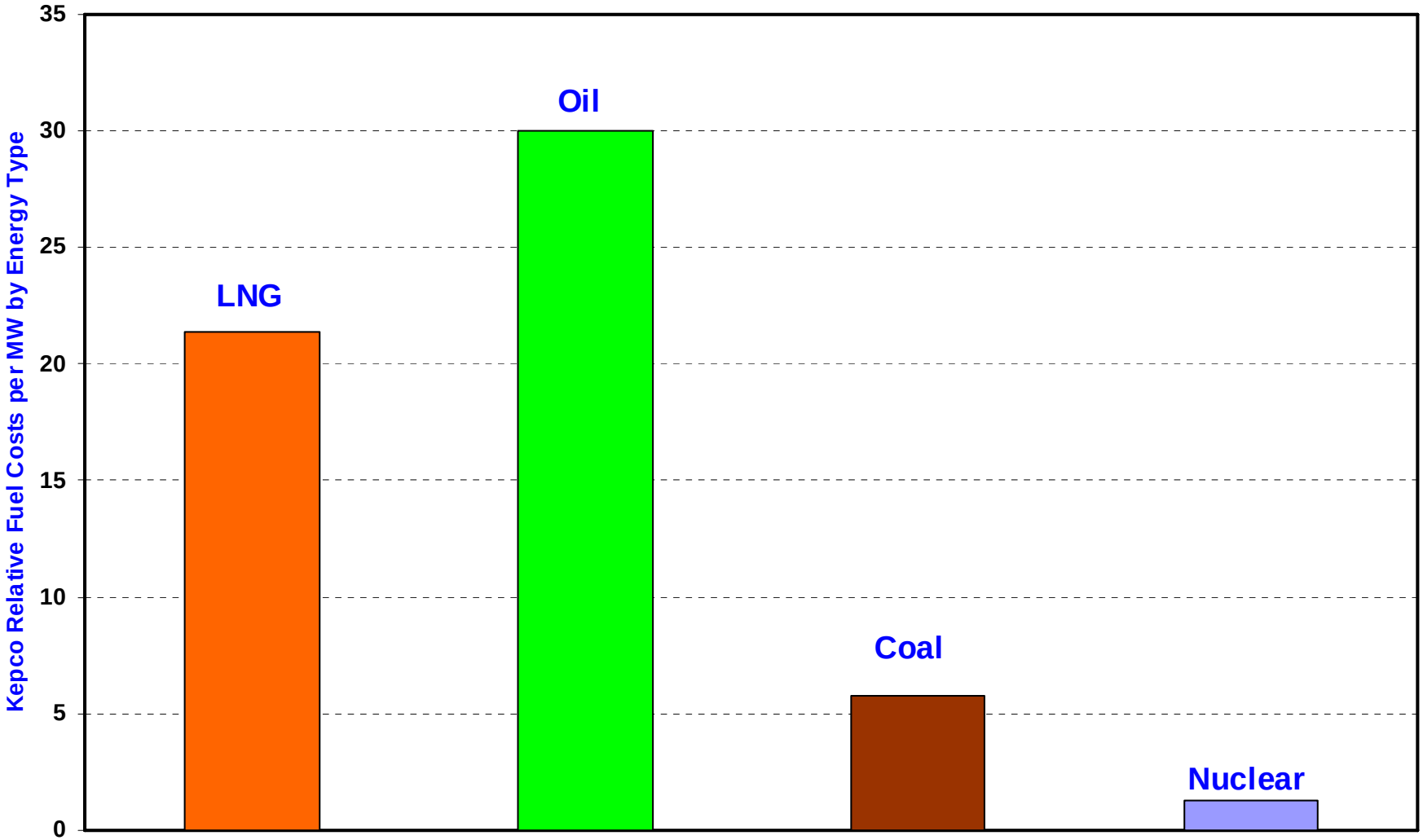
## Western Australian Experience




Step change in domestic gas prices realised notwithstanding huge reserves base

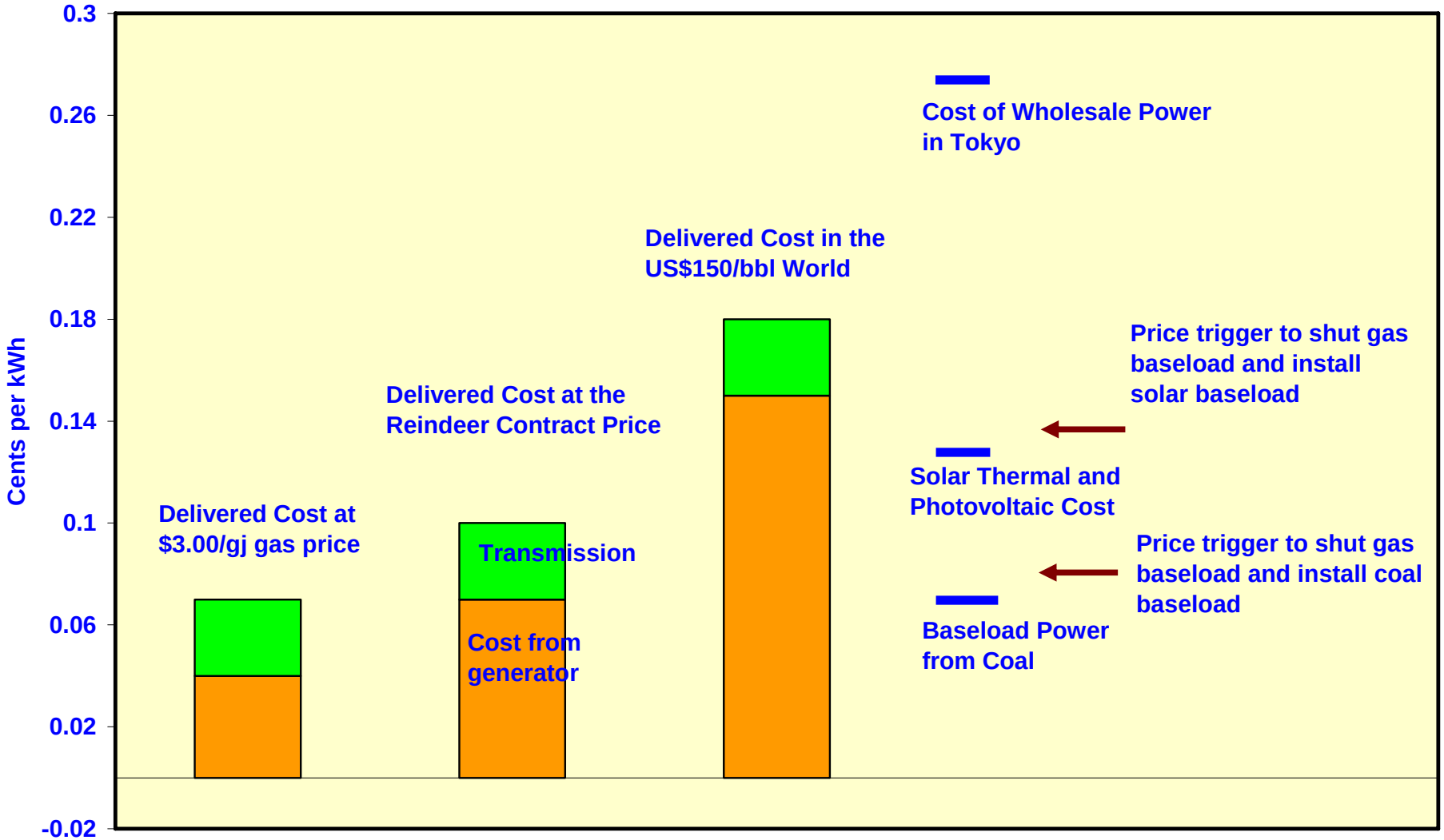
# A future that should be avoided.

## Korea Electric Power Corporation  January to September 2008

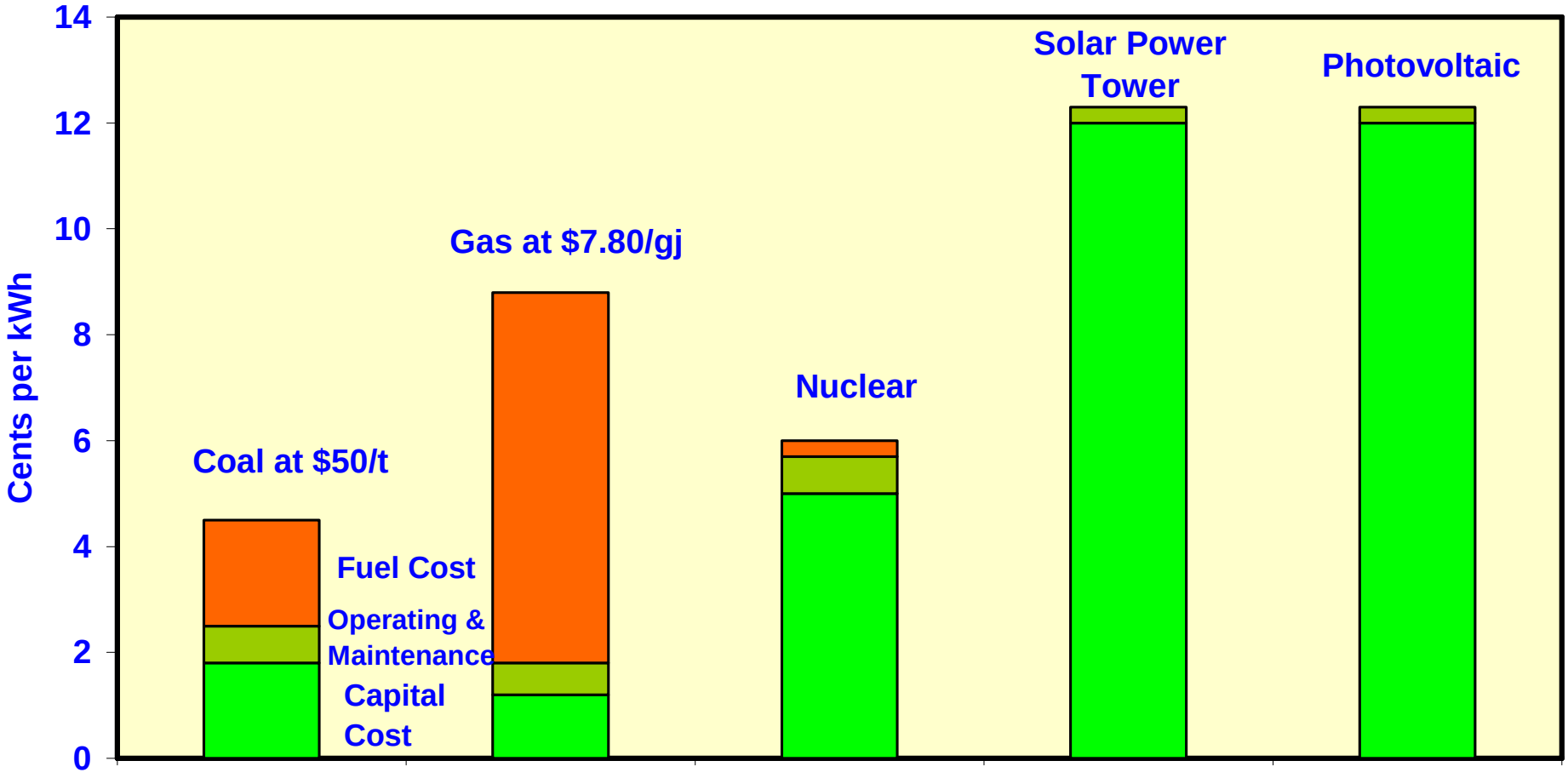



**LNG was 15% of production and 48% of fuel costs – 17x nuclear, 3x coal.**

# Power from gas relative to trigger points from coal and solar power



# Power Costs by Source

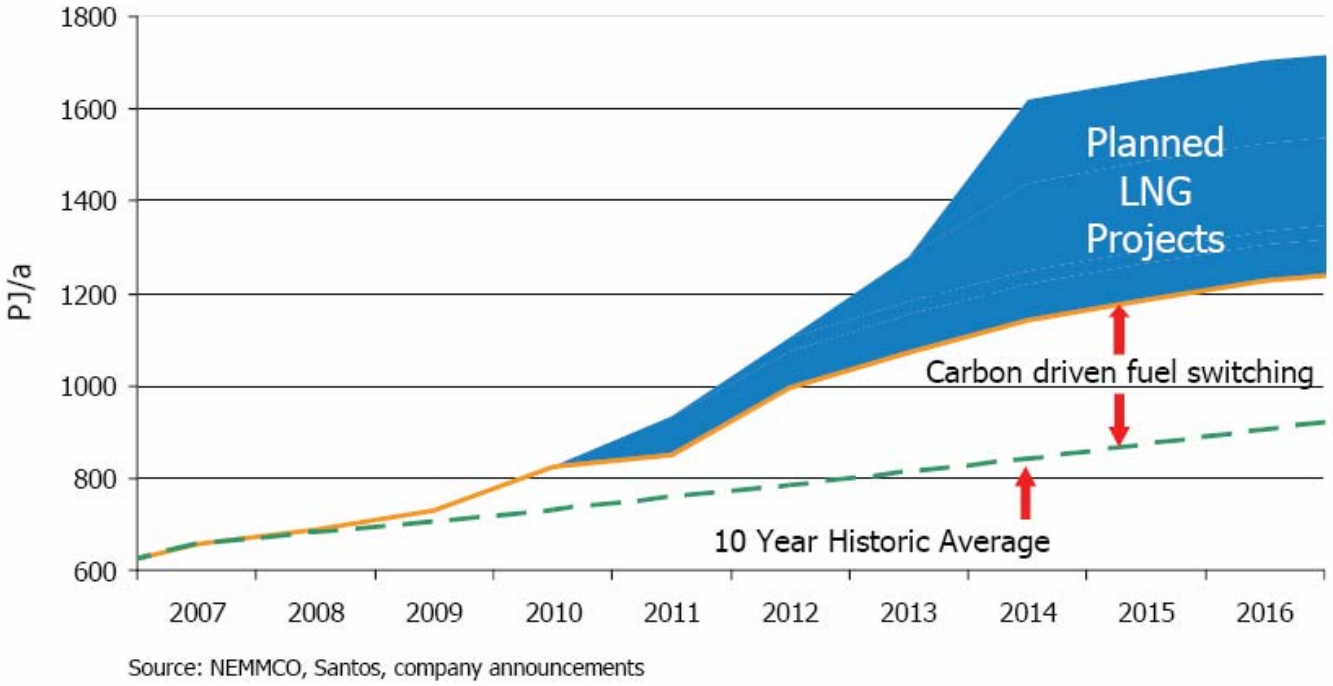



**Coal is cheaper than nuclear, and nuclear now comes in minimum 1000 MW units – a bit too lumpy for the east coast grid.**

# Looking forward to using the global warming scare to rip off east coast consumers.

## Demand for Eastern Australia gas

### Demand will more than double within 10 years...




Source: NEMMCO, Santos, company announcements

### ...driven by government carbon policy and LNG export

34

Santos

# There is a national capital strike on new coal-fired power generation.

THE WEST AUSTRALIAN FRIDAY, MARCH 20, 2009



Carbon trade hiatus limits new generation projects so utility plans to take Muja stations out of mothballs

## Verve eyes coal-fired revival

PETER KERR

Verve Energy wants to resurrect two 40-year-old coal-fired power plants in Collie to help secure WA's electricity supplies because uncertainty over the Federal Government's emissions trading scheme has caused funding for new power stations to dry up.

The $100 million plan would have State-owned Verve's 240MW Muja A and B power stations dragged out of mothballs permanently and retrofitted to reduce pollution by 2011.

Muja B was rushed back into production during last year's Varanus Island gas crisis, which cut about 30 per cent of WA's energy supplies, to ensure the State's lights stayed on during the outage.

It was due to be shut down again late this month when the peak summer power period ends.

Verve managing director Shirley In't Veld said yesterday the State remained vulnerable to another crisis because more than 60 per cent of its power was generated with gas from the North-West.

She said the plan would help increase the diversity of WA's electricity supply by adding an extra coal-fired power station at a time when it was unlikely new plants would be built because of uncertainty with the Rudd Government's ETS.

Of 129 new power stations being built in Australia, only one — Griffin Energy's Bluewaters plant in Collie — was coal-fired because banks were wary about extra costs the ETS would impose on coal-fired generators, Ms In't Veld said.

Due to start next year, the ETS will require industry to buy carbon credits to offset pollution.

But Verve's proposal, which would cost a fraction of the estimated $1 billion for a new plant, will attract controversy because of environmental issues and it will require the WA Government to waive the cap on the firm's generation capacity — currently 3000MW.

The cap was designed to reduce Verve's monopoly and encourage new investors into the market.

The new proposal would see Verve remain above its cap by about 240MW.

However, it will suit the Government's aim of preventing a repeat of the disruption caused by the Varanus Island explosion, which is the subject of an independent inquiry led by former Western Power executive Peter Oates.

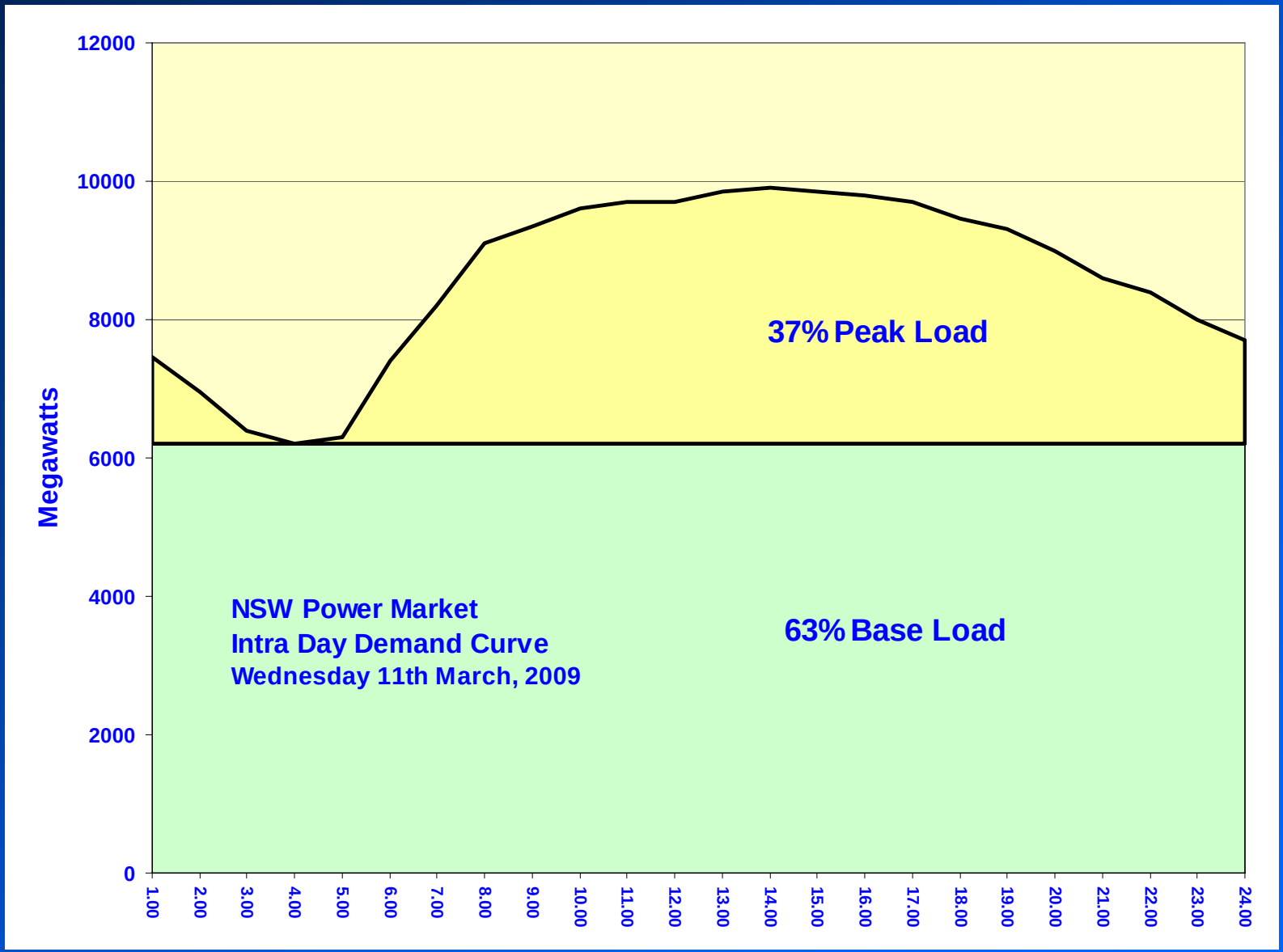
Ms In't Veld also urged the Government to continue lifting electricity prices to reflect the true cost of power, saying its decision to lift tariffs 25 per cent from July was expected to help the firm to a small profit in 2010-11 rather than a forecast loss of about $350 million this financial year.

Verve's losses are caused by a State Government requirement that it sell most of its power to Synergy at below cost to keep household power bills low.

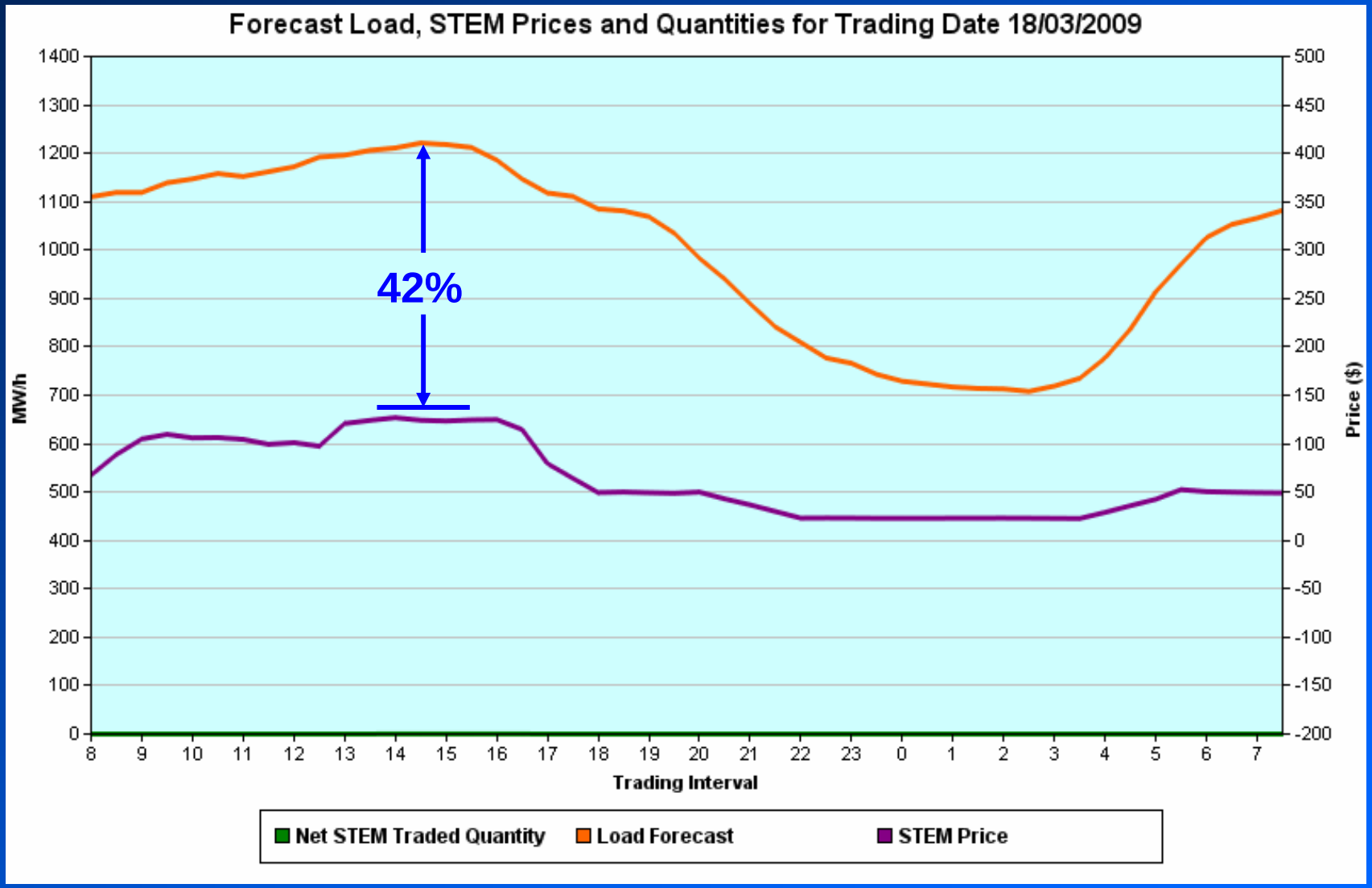
Energy Minster Peter Collier said he was aware of Verve's plan and would consider any proposal it presented to the Government.

**Only one of 129 new power stations being built in Australia is coal-fired.**

# What a Peak Load Curve looks like



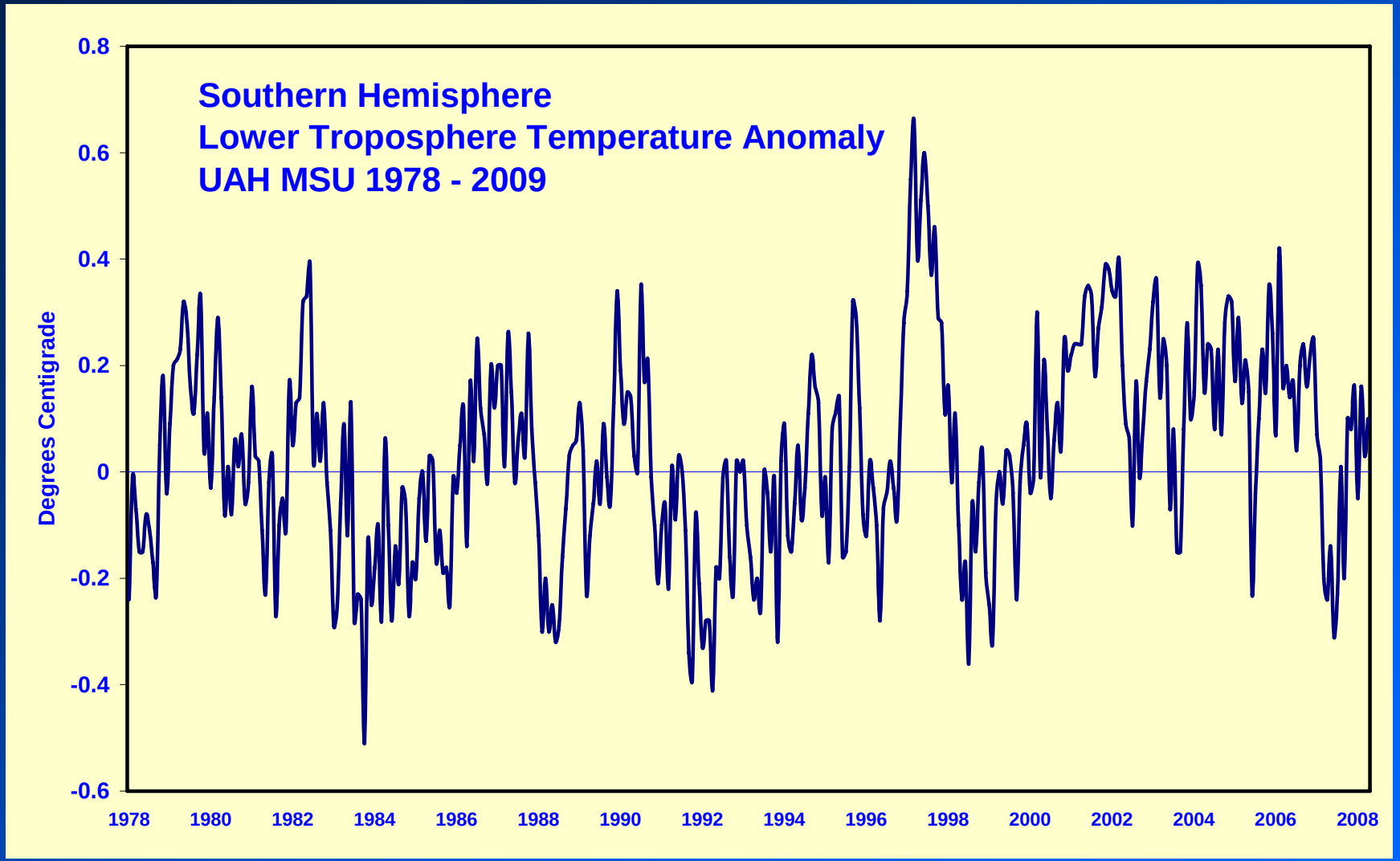
# The SWIS System Load Demand and Price Curves



# Renewable Energy Target Scheme

- Power generators will be required to provide 45,000 GWh of power from renewable sources by 2020 or pay a penalty of $0.065 per kWh.
- This is meant to be 20% of electric power production by 2020.
- For the east coast market, this is 2,520 MW more than planned capacity in 2014.
- At the cost of building coal-fired power stations, this is $5,000 million of investment that will be wasted.
- Solar power, both photovoltaic and power tower, is likely to be able to displace natural gas for peak power demand.
- For Western Australia, all the growth post 2014 has to be renewable to comply with the scheme.

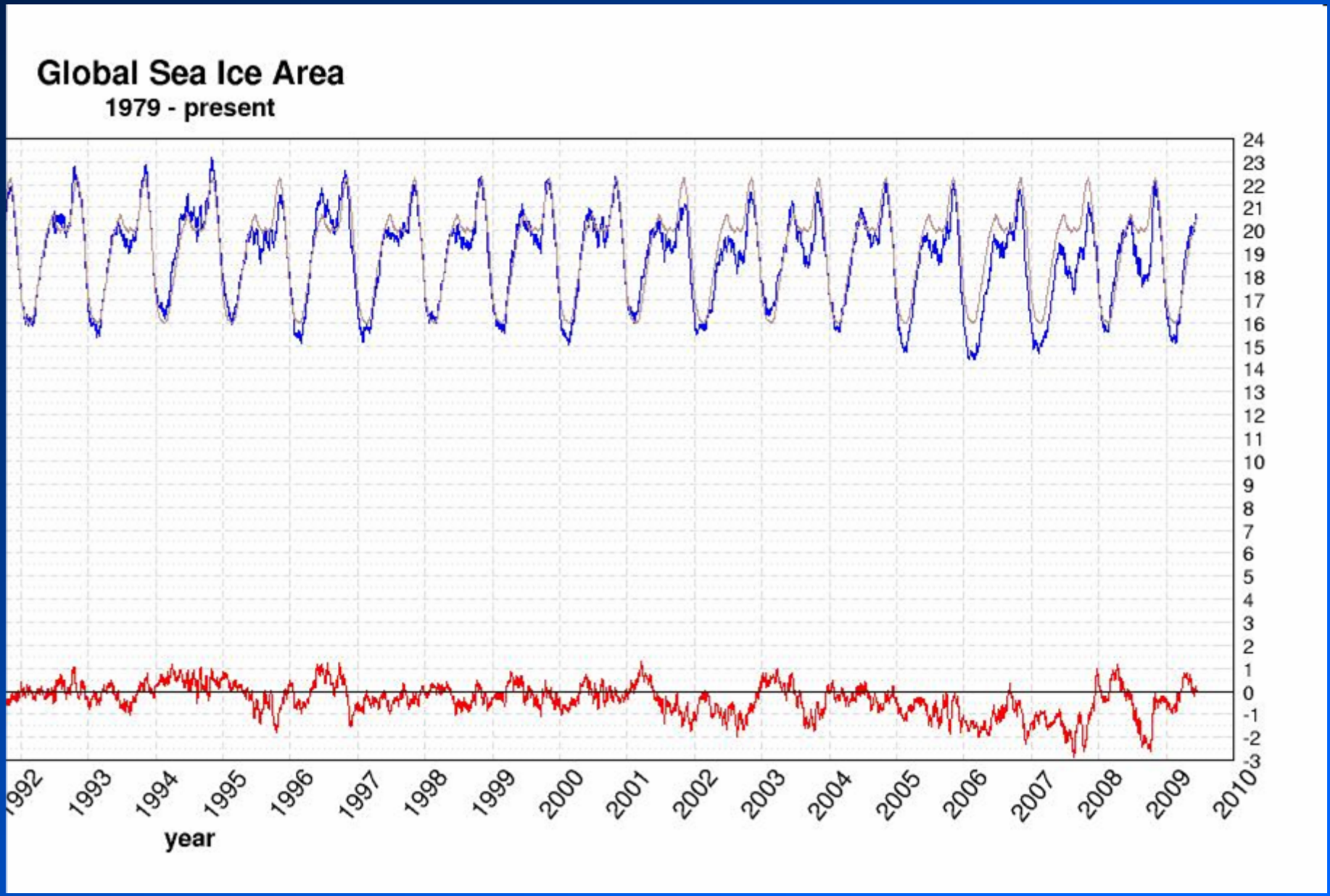
# Section 1: The Climate Record




**The 30 years of High Quality Satellite Data**

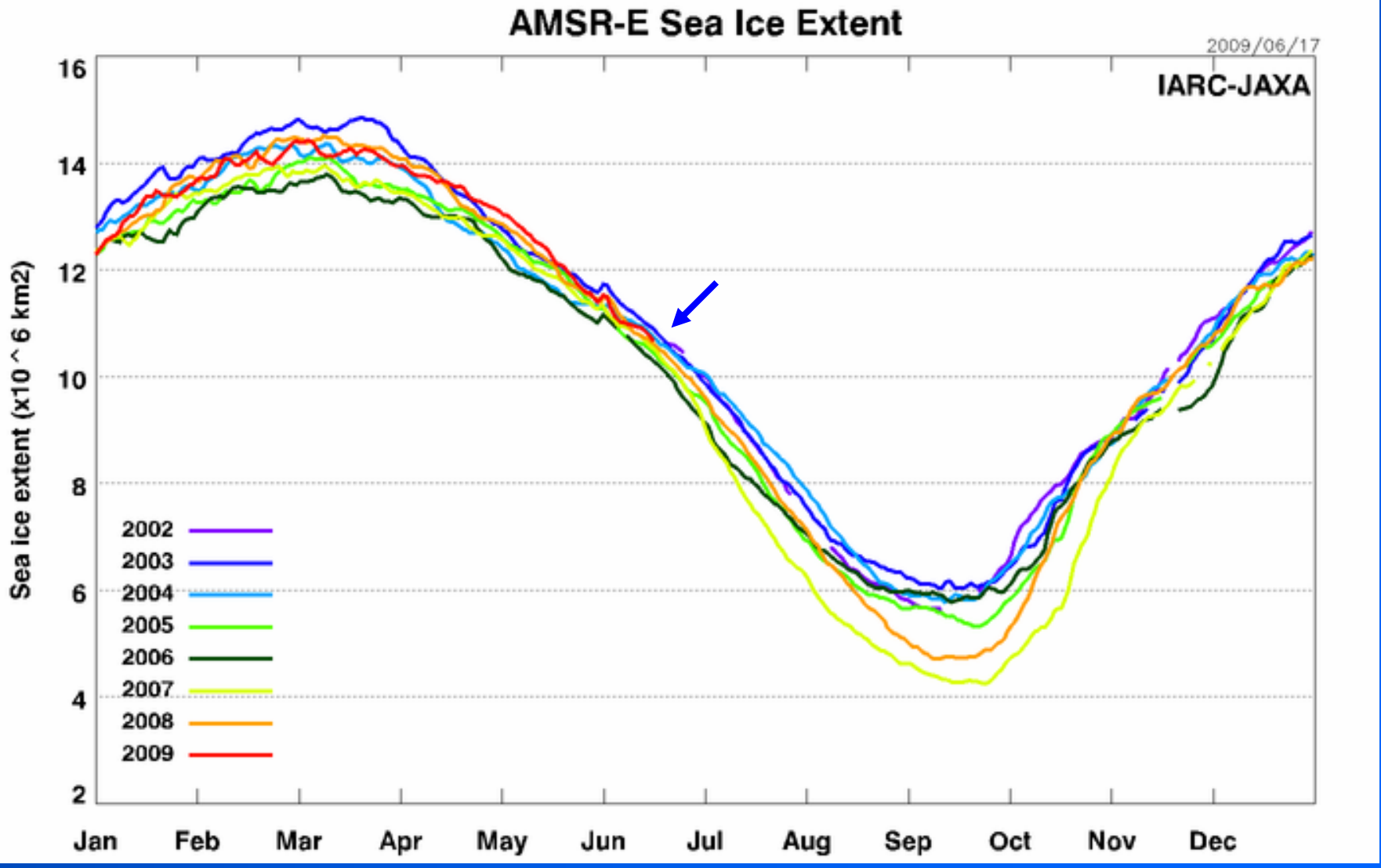
The Southern Hemisphere is the same temperature it was 30 years ago, the Northern Hemisphere has warmed slightly.

# Global Sea Ice Area is at the 1979 - 2000 average.




- As at 18th June 2009

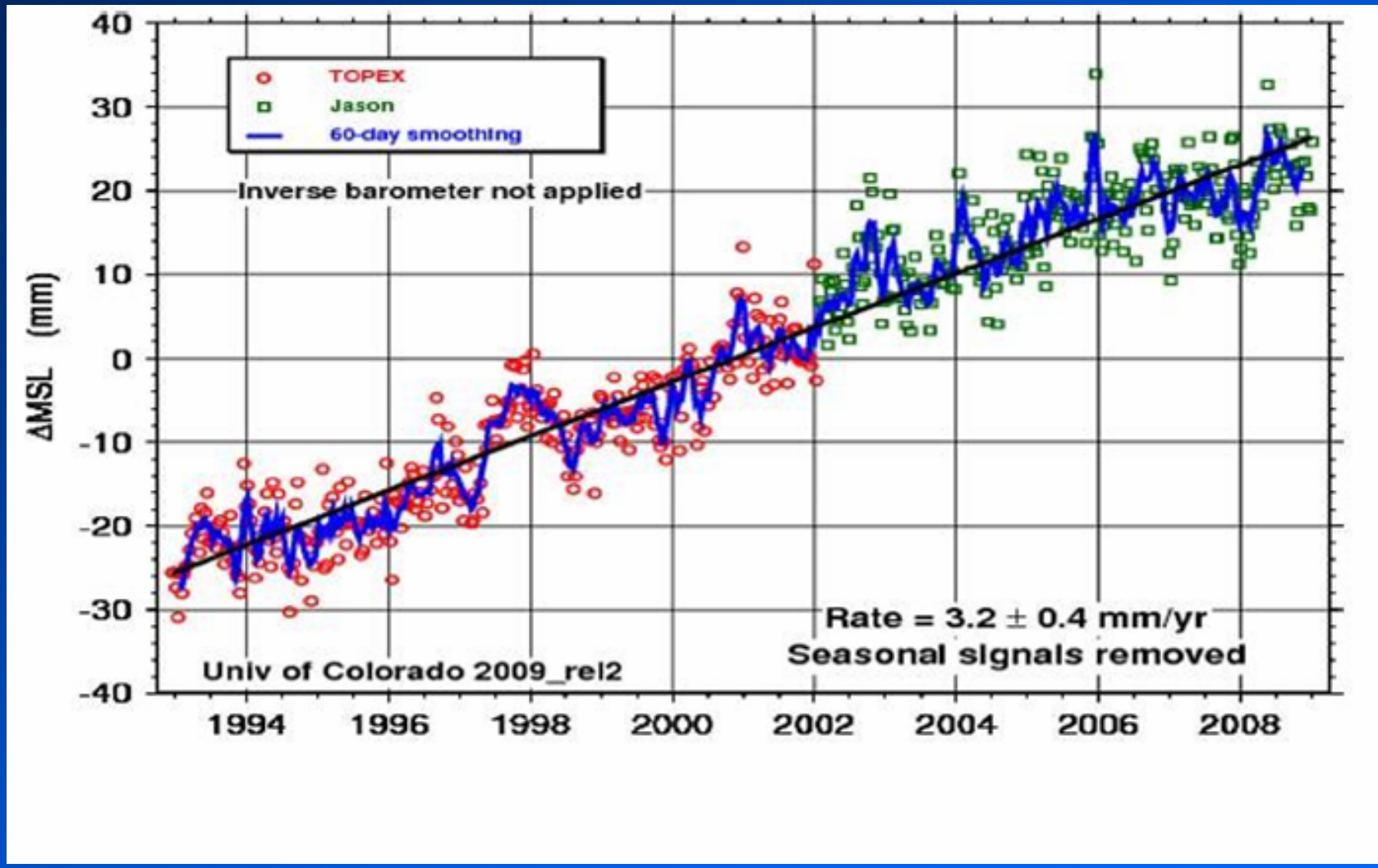
# Arctic sea ice extent is back in the pack.



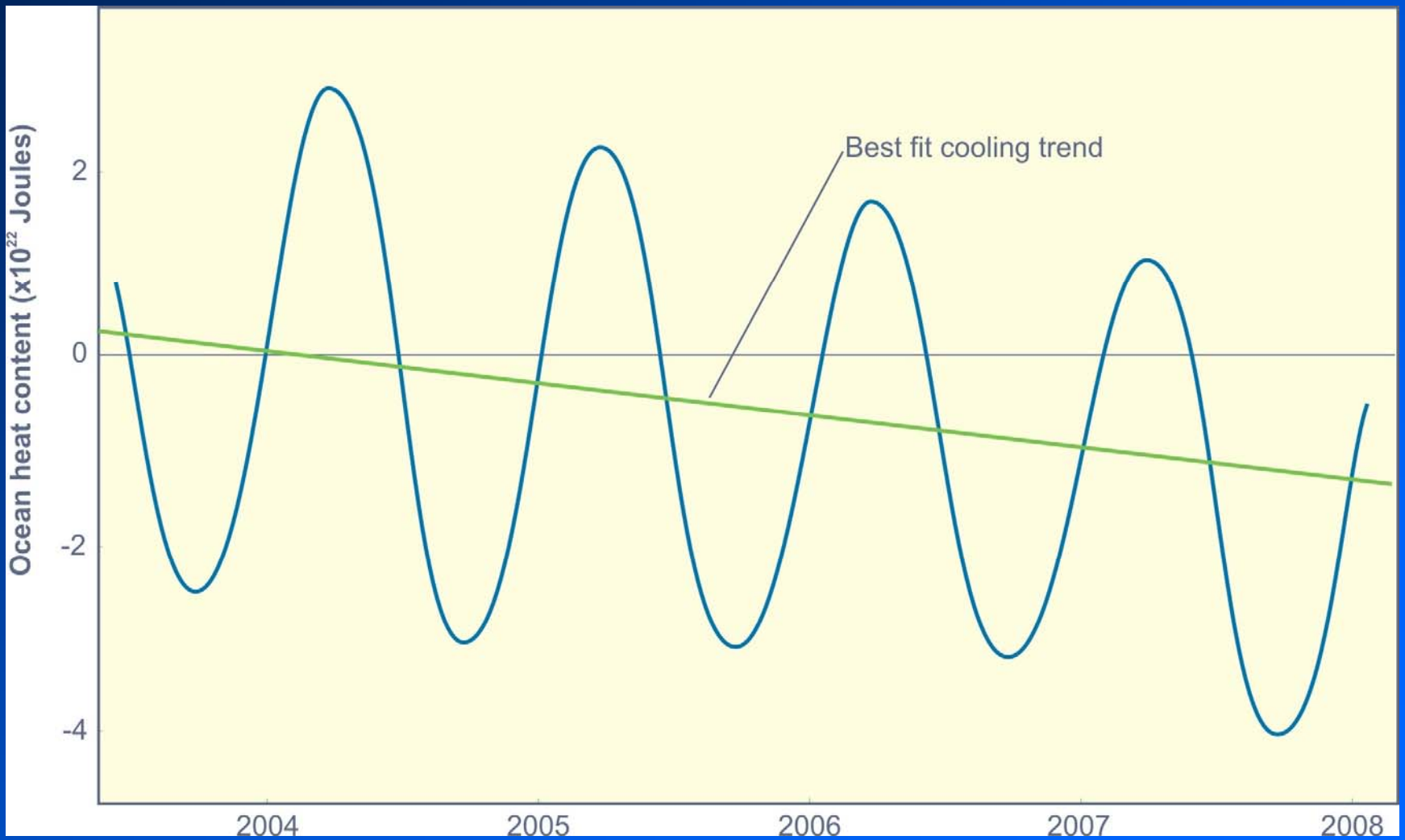

As at 17th June , 2009

# Discussion of the issue of sea level in the West Australian 13th May, 2009

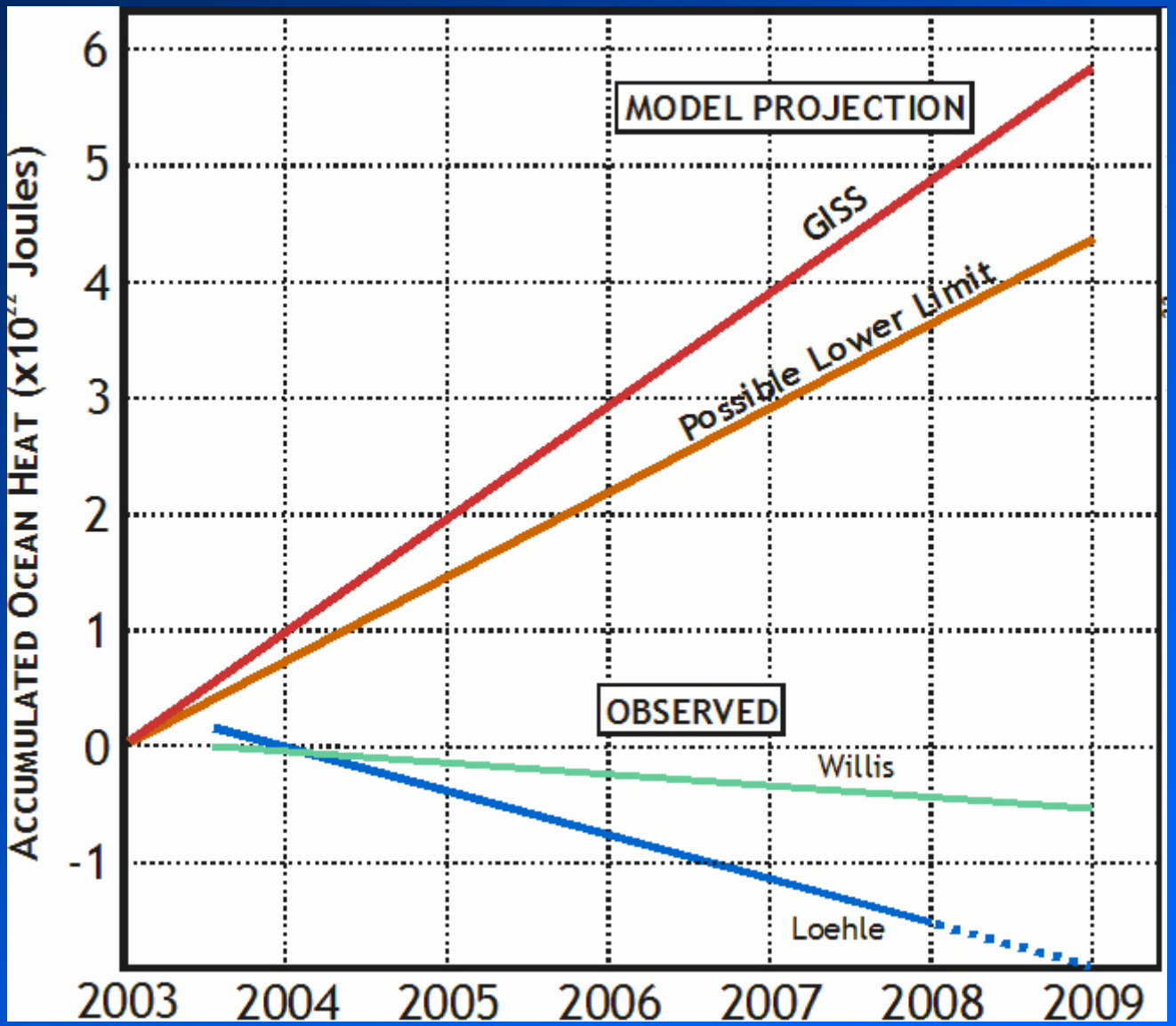
# Sea level has now been flat for four years.



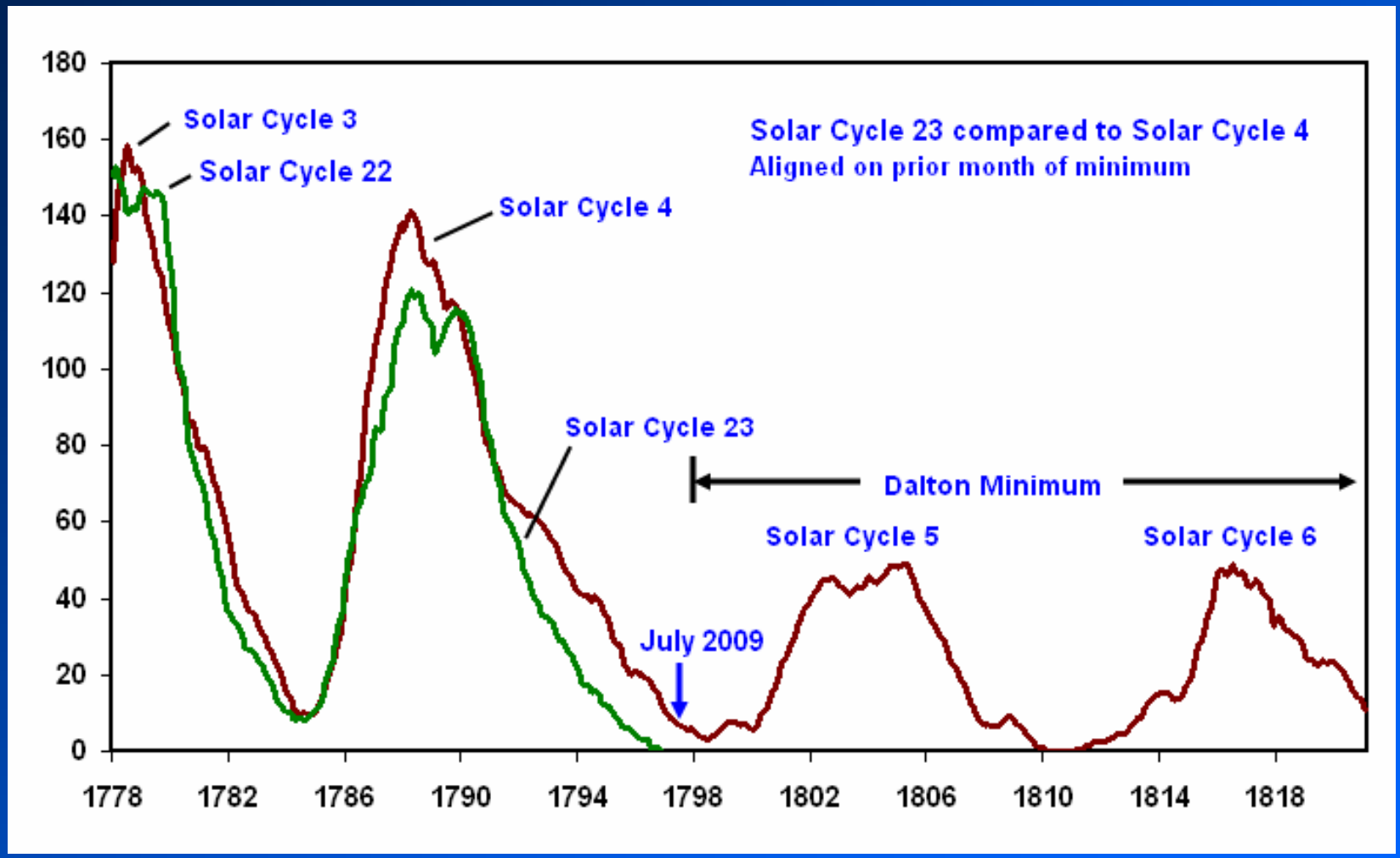
# The oceans started cooling in 2003.



# That ocean cooling proves the climate models wrong.

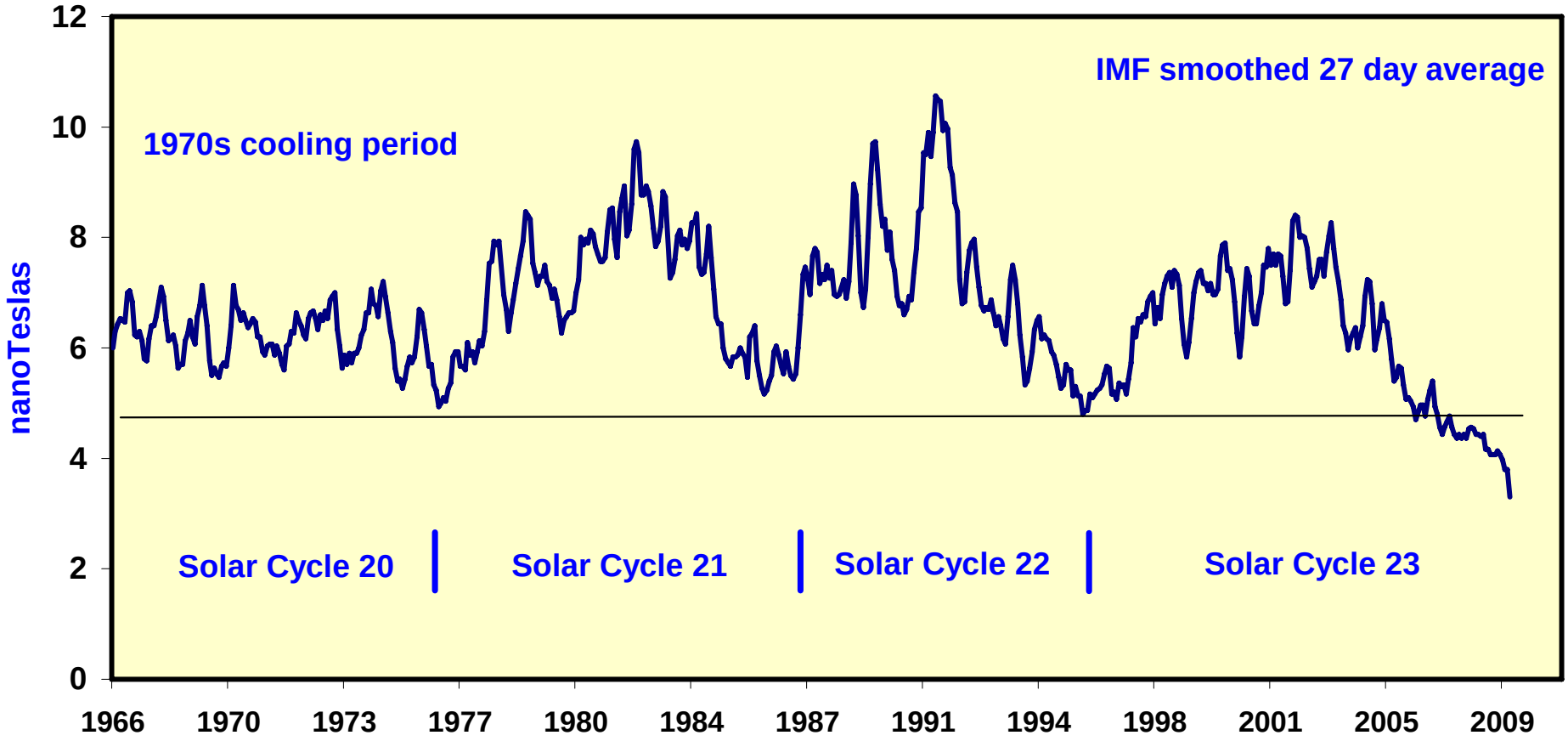


# Dalton Minimum Repeat?



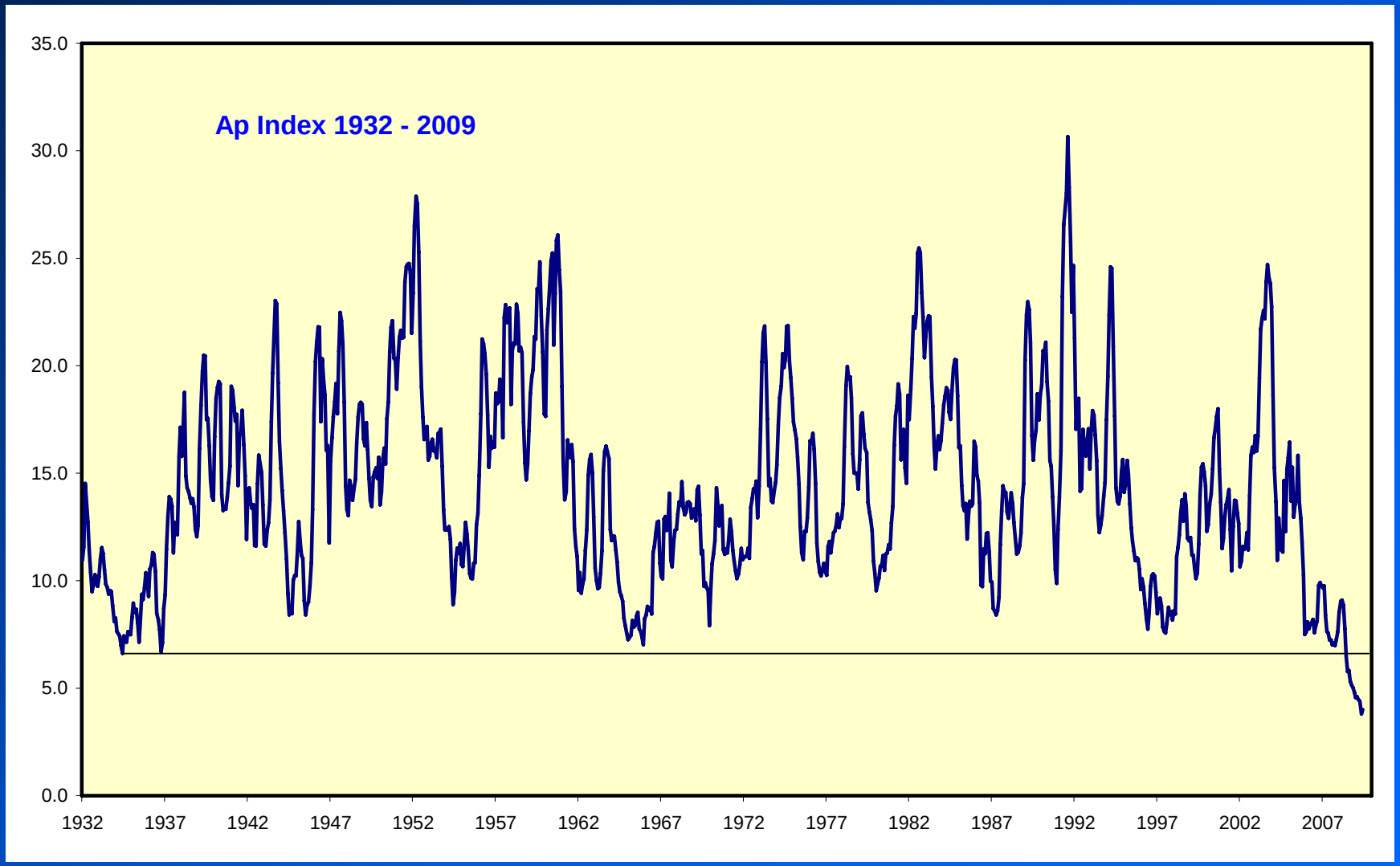

*A repeat of the Dalton Minimum is not precluded by the data to date. July 2009 equates to a 13 year long Solar Cycle 23.*

# Interplanetary Magnetic Field

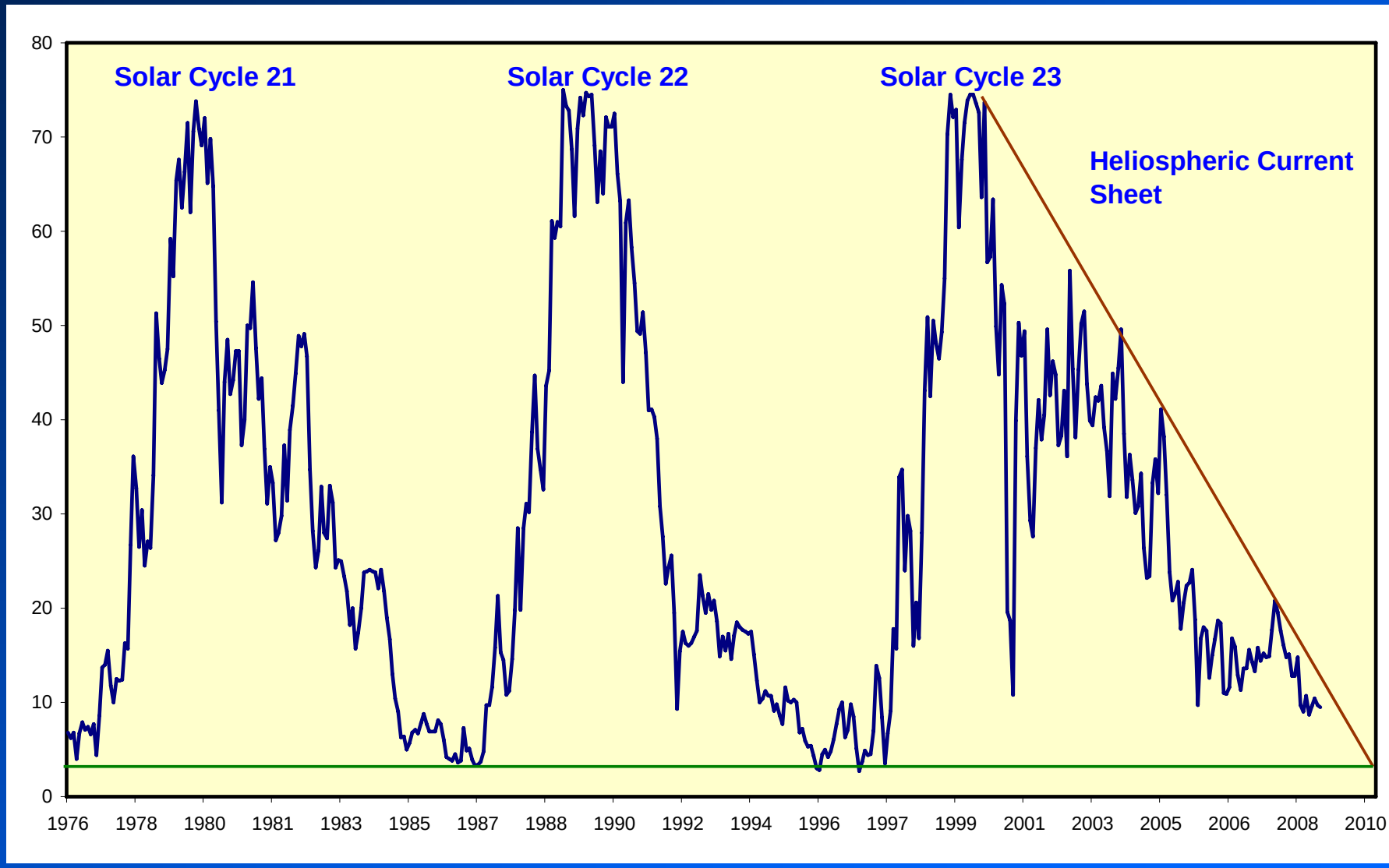



**Fell out of bed starting June 2008**

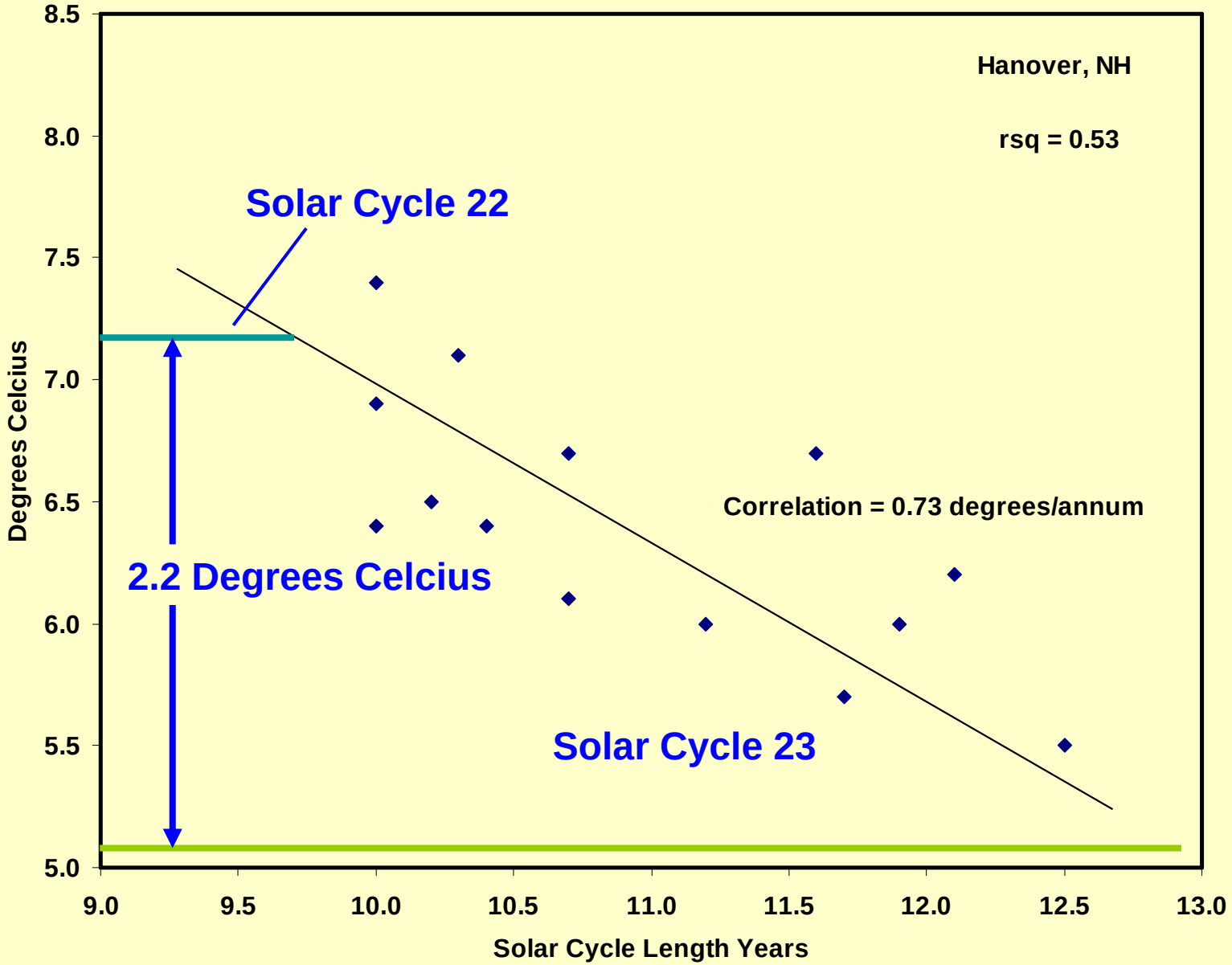
# The Ap Index has broken through its 70 year floor.



# The Heliospheric Current Sheet suggests another year to solar minimum.

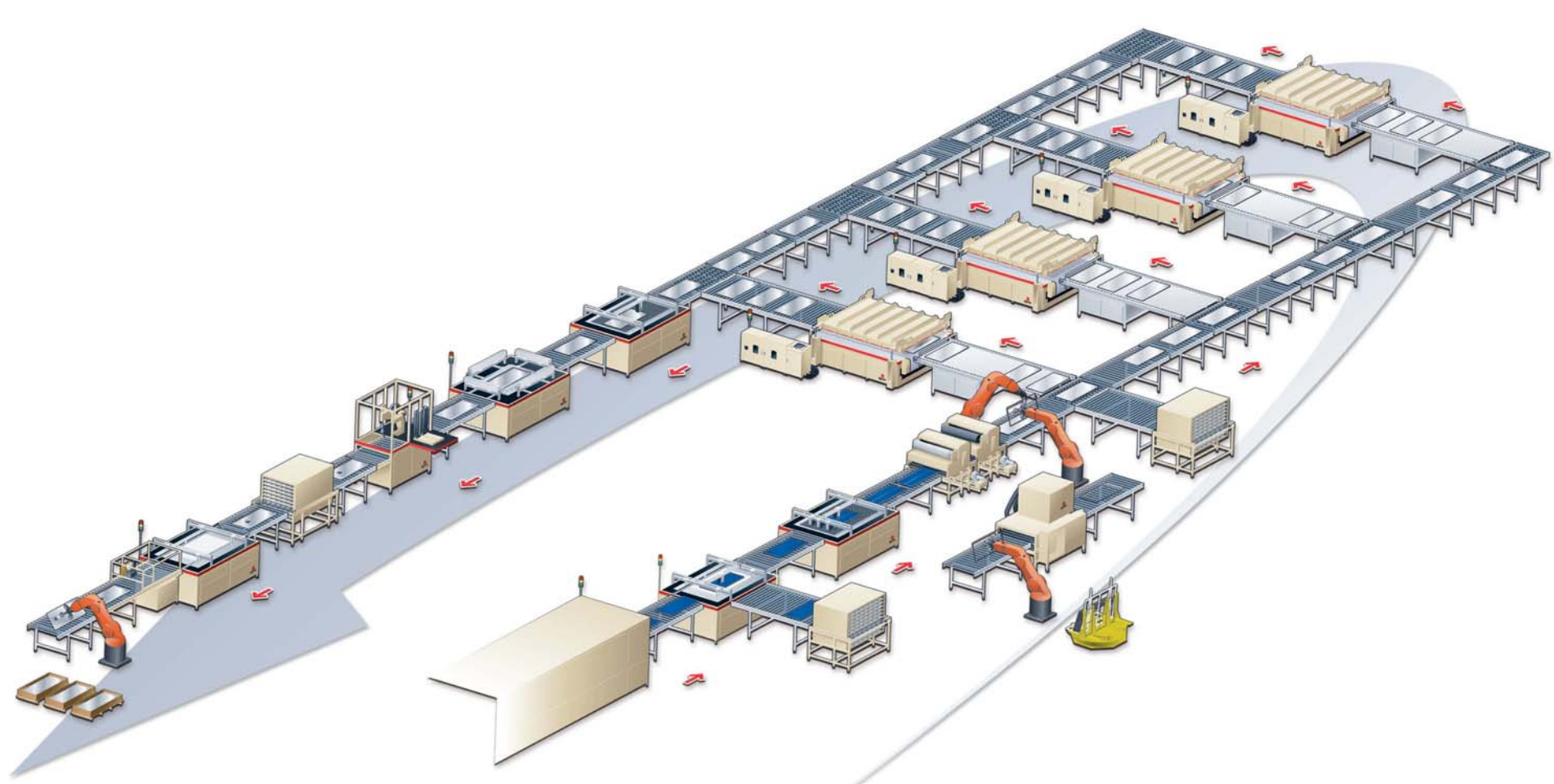


# Hanover, NH


Hanover, NH
rsq = 0.53
Solar Cycle 22
Correlation = 0.73 degrees/annum
2.2 Degrees Celcius
Solar Cycle 23
Degrees Celcius
Solar Cycle Length Years
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0

# An off-the-shelf 30 MW per annum thin film photovoltaic production line

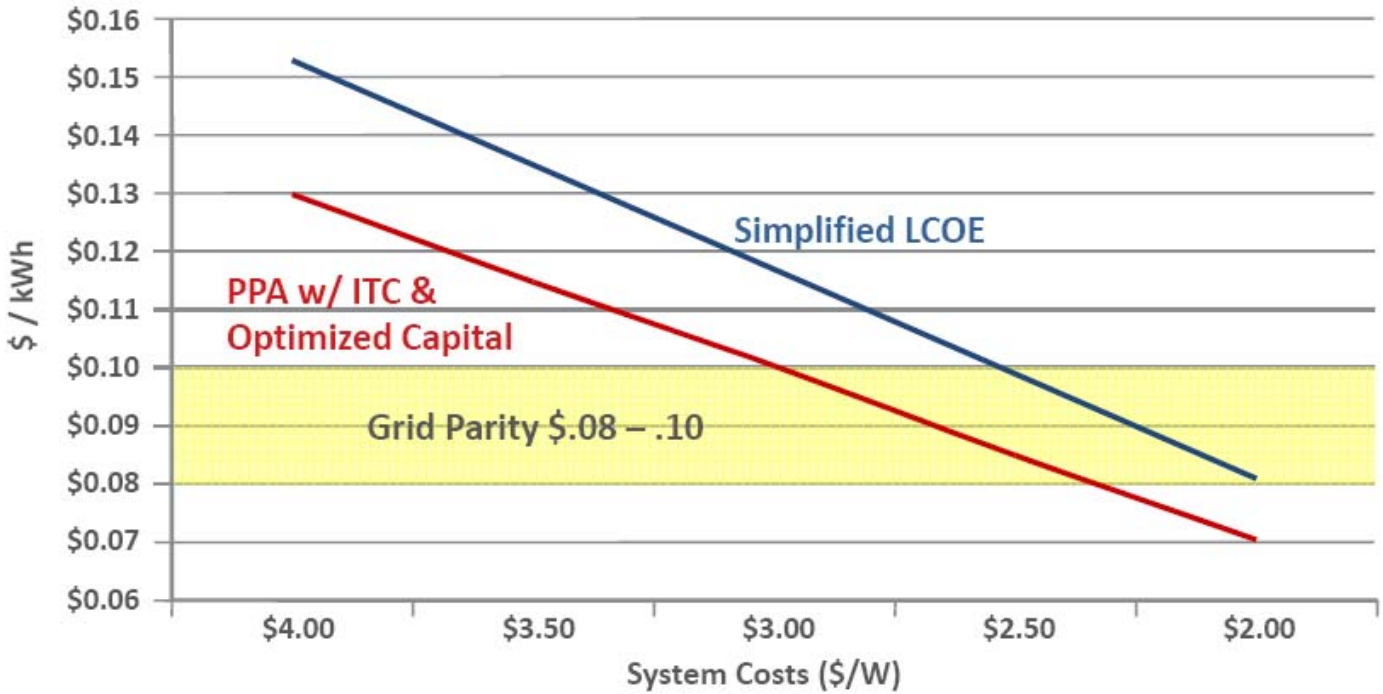
## -Not much more complicated than a fruit packing line



# A projection of grid parity at US$0.09/kWh within two years using thin film photovoltaic

## Roadmap to Grid Parity 2010-2012

Levelized Cost of Electricity (LCOE)




Note: Electricity price and O&M costs adjusted for 2.5% inflation escalator, Assumes 1,750 kw/h irradiance

# A Photovoltaic Success Story

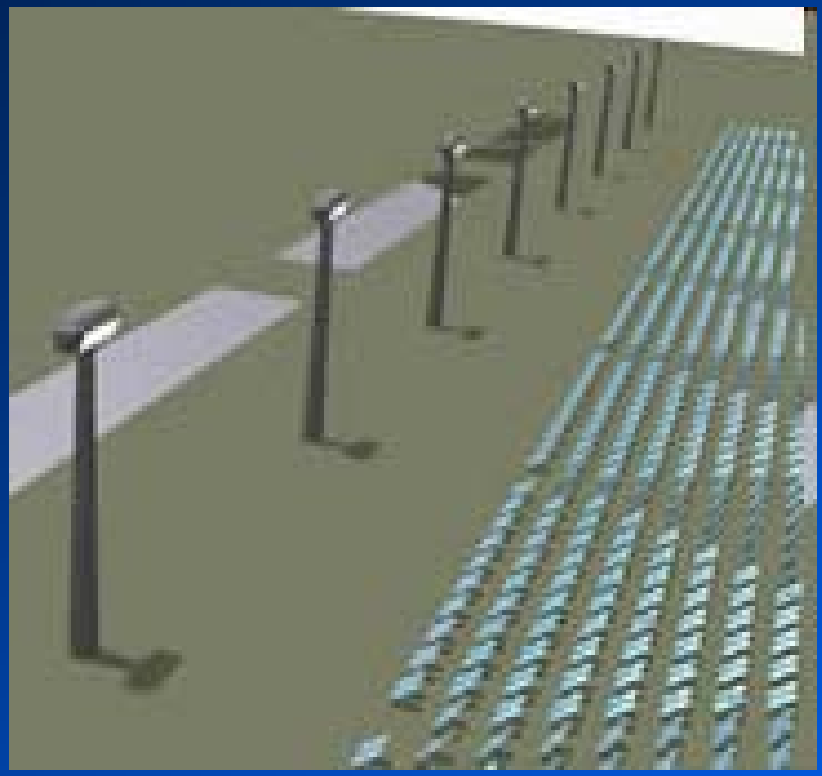
## First Solar Inc (NYSE: FSLR)

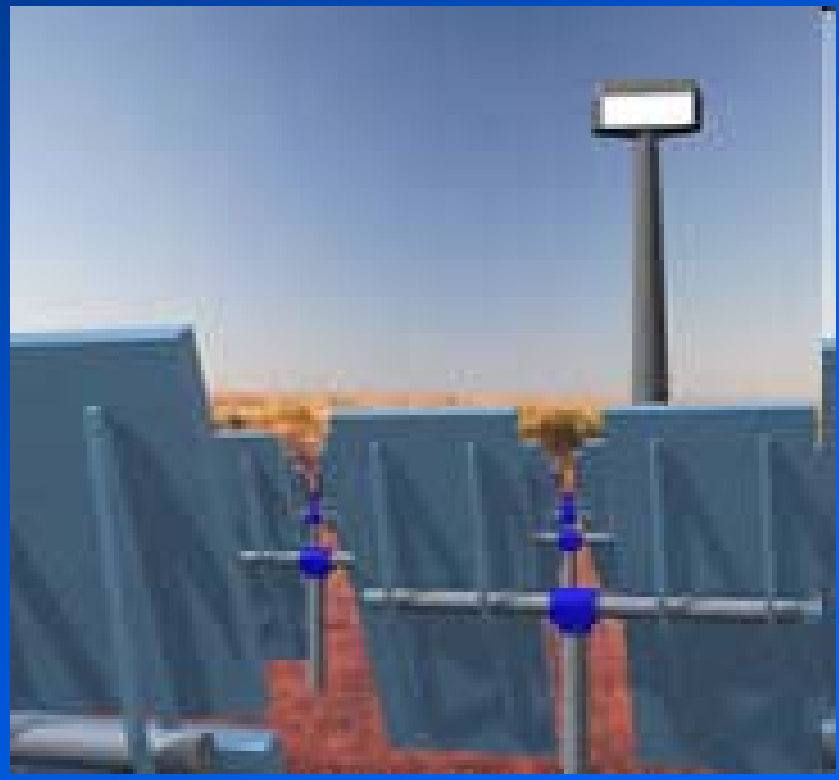
- US$171.28 share price
- US$14.5 billion market cap.
- PER  30.3x
- Total assets of US$2.1 billion, equity of $1.5 billion

- Launched commercial product in 2002
- Produced 25 MW in 2005
- Will have capacity of 1,136 MW in 2009

- Last quarterly average manufacturing cost of US$0.93 per watt

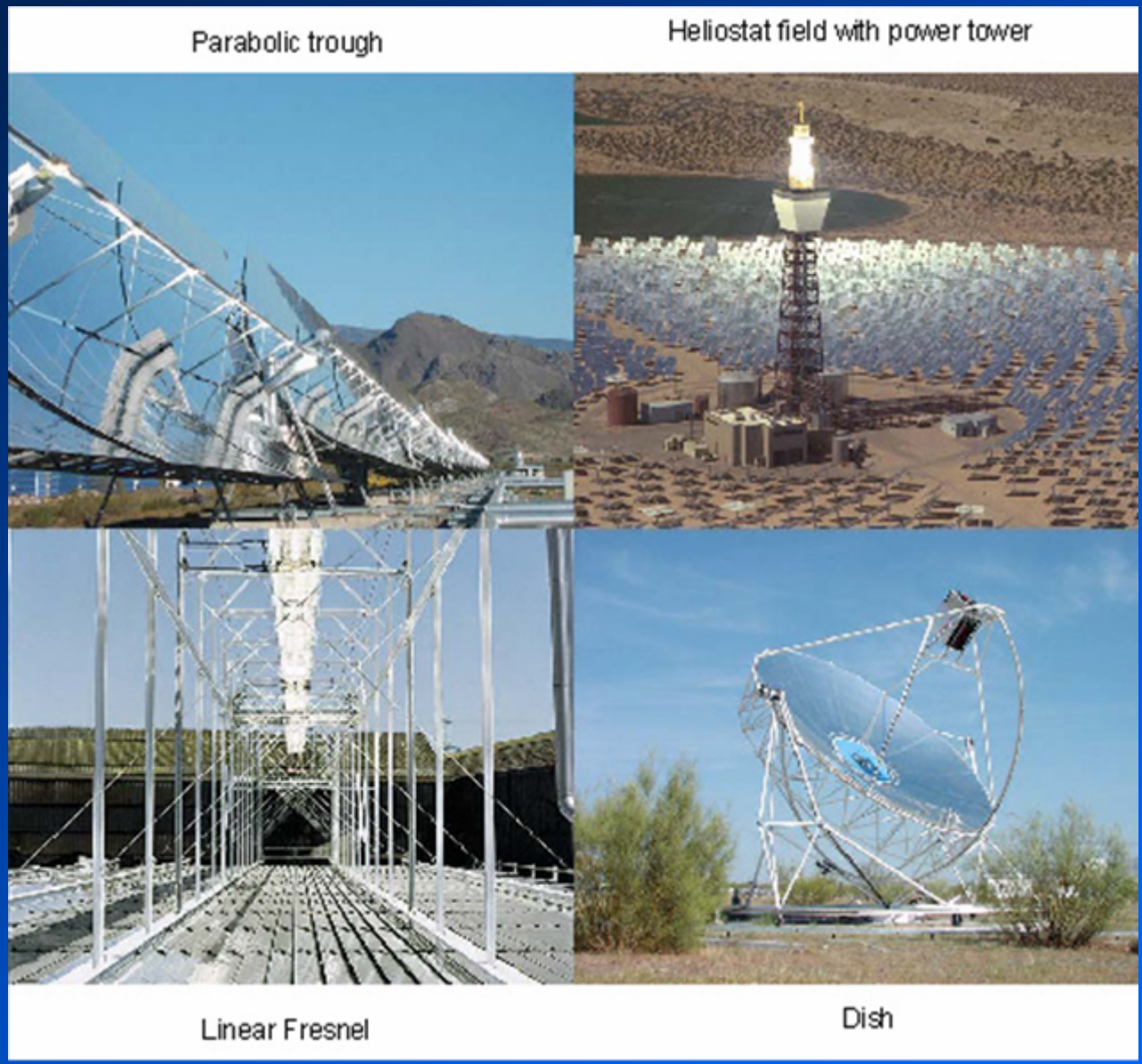
# Solar Systems – concentrated photovoltaic feed by heliostats





**154 MW to be installed in Mildura**
**First stage complete in 2010, full commissioning in 2013**
**Production of 270 MWh per annum**
**$1.55 per annual kWh capital cost**
**246 towers and 19,250 heliostats**

# Types of Solar Thermal Power



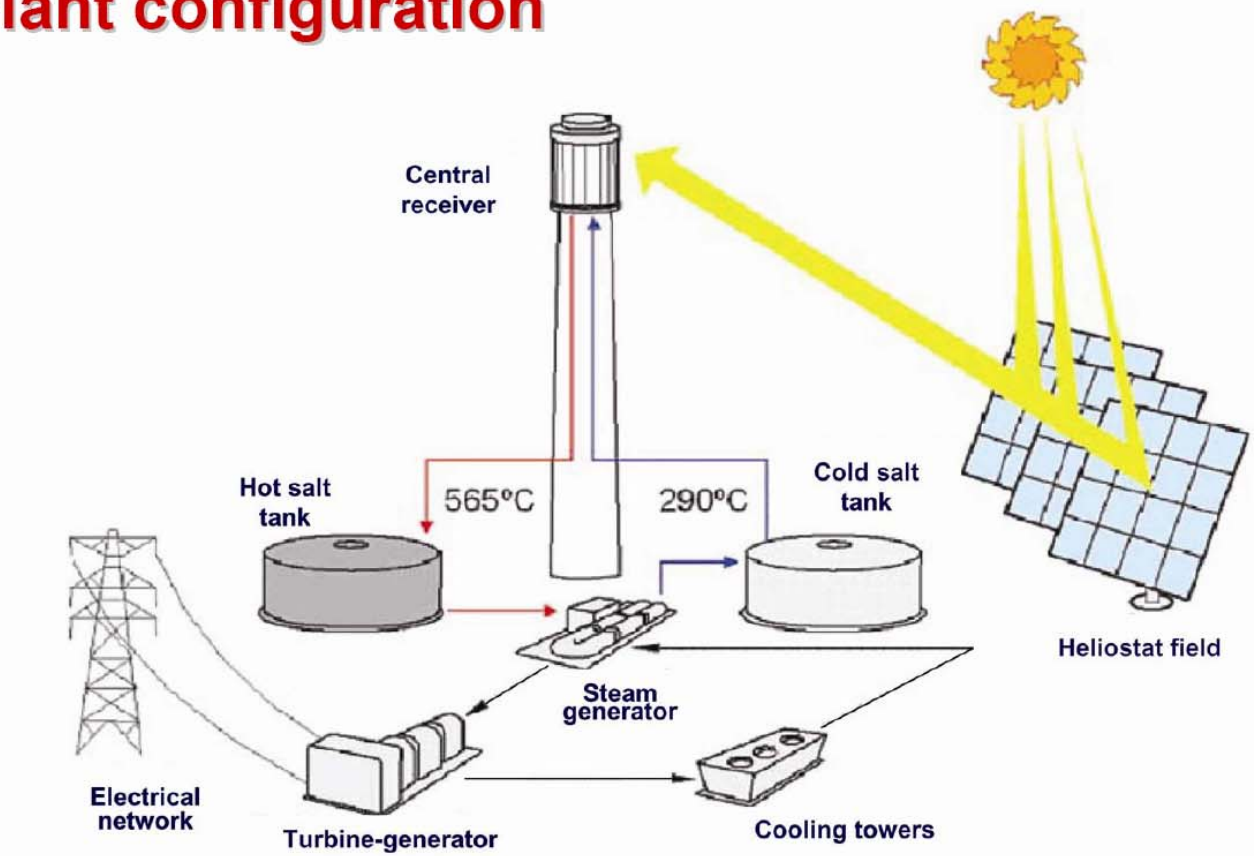

**Power Tower has lowest capital and operating costs.**

# Nevada Solar One – 64 MW Solar Trough Plant

**US$264 million capital cost, on line June 2007**
**134 million kWh per annum**
**Capital cost of US$1.99 per annual kWh**

# Power Tower using molten salt.

## Plant configuration

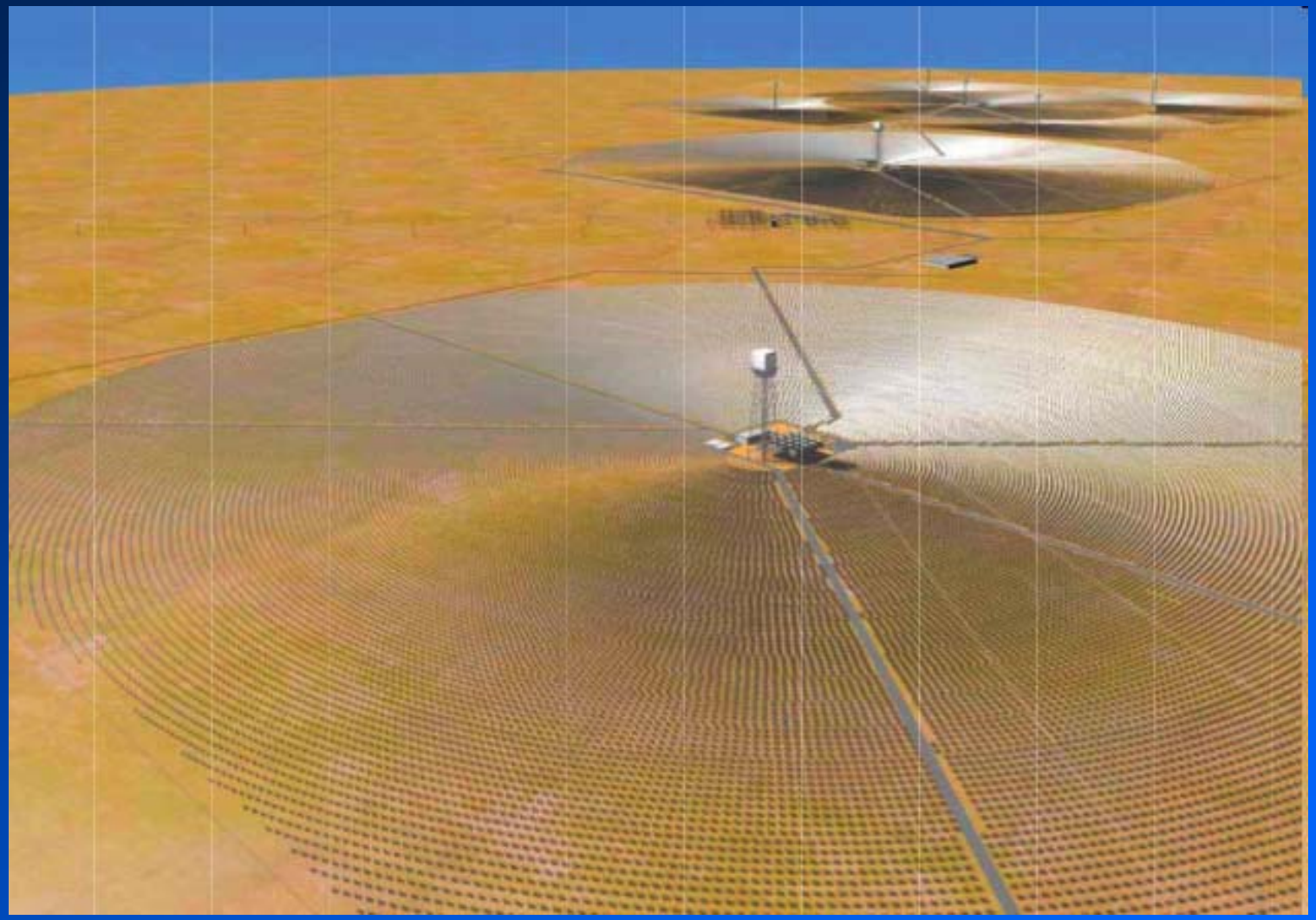



**Australia should become very good at heliostats.**

# eSolar's 5.8 MW demonstration facility in Lancaster, California

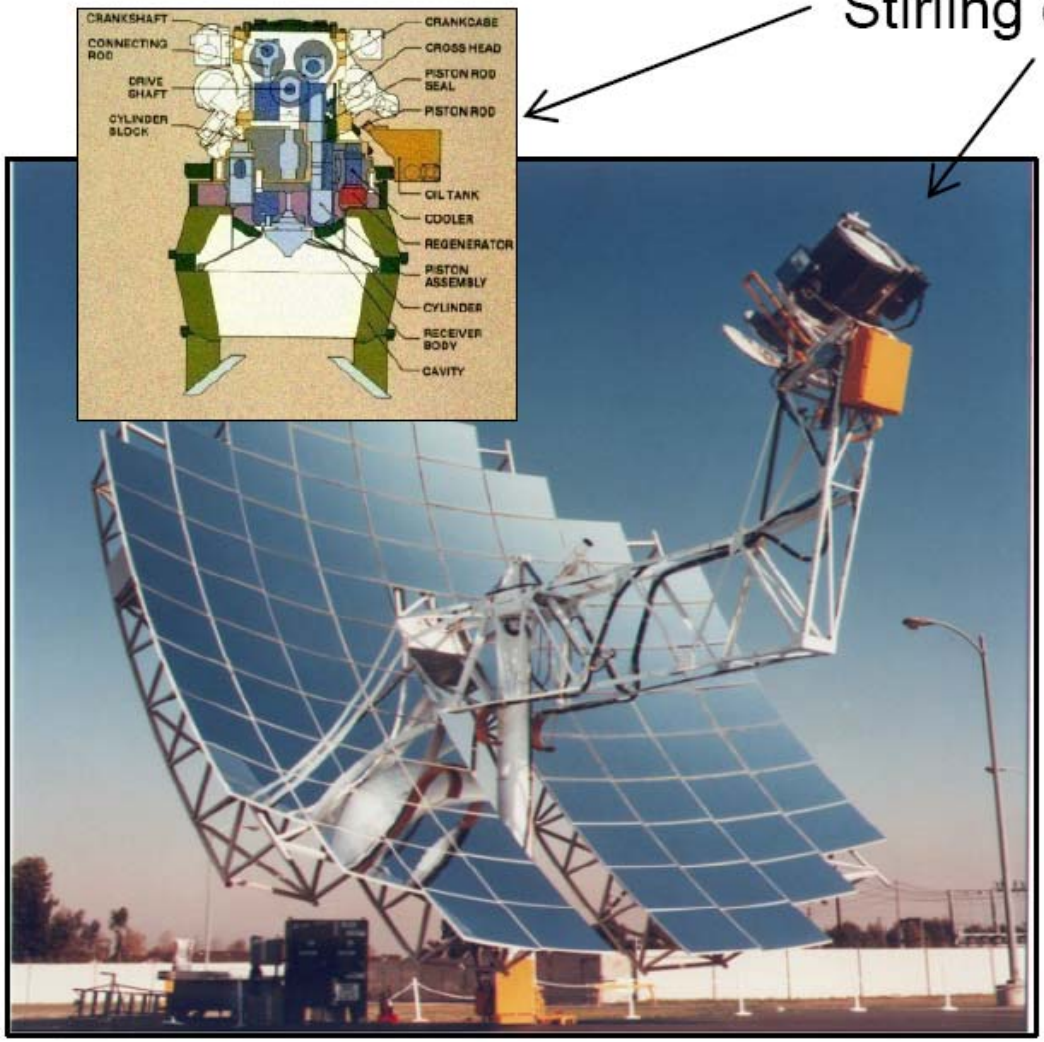
- the towers are 60 metres high.
- each tower has 7,200 mirrors.
- not necessarily the most efficient design.

# Ivanpah 400 MW System in the Mojave Desert



**Australia will benefit from the experience gained in the enormous experiments in power generation being undertaken in the deserts of California.**

# 750 MW on 2,500 hectares 160 km east of San Diego




Stirling Solar Dish

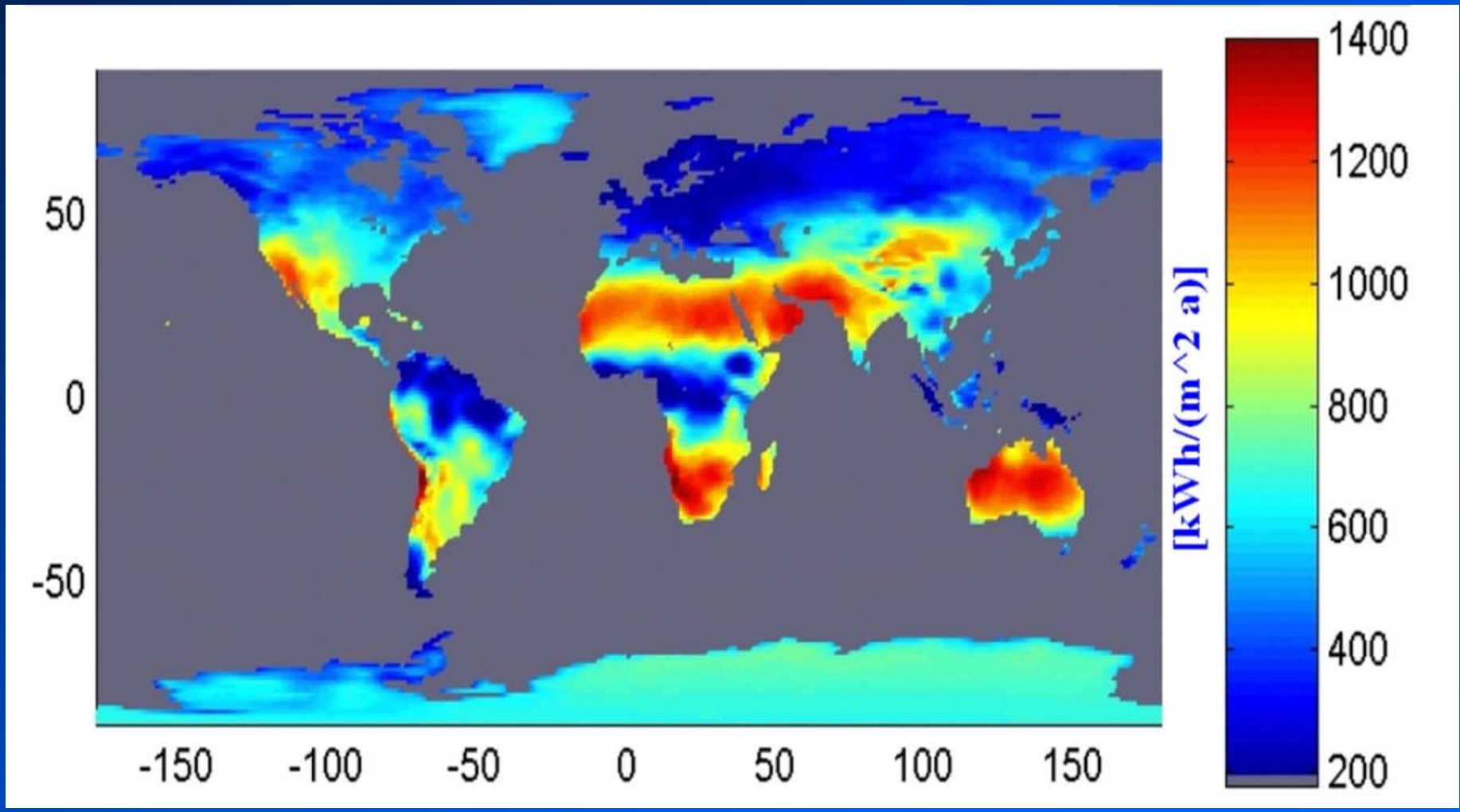
**30,000 of these**

**- each 11.6 m high**

**- producing 25 kW**

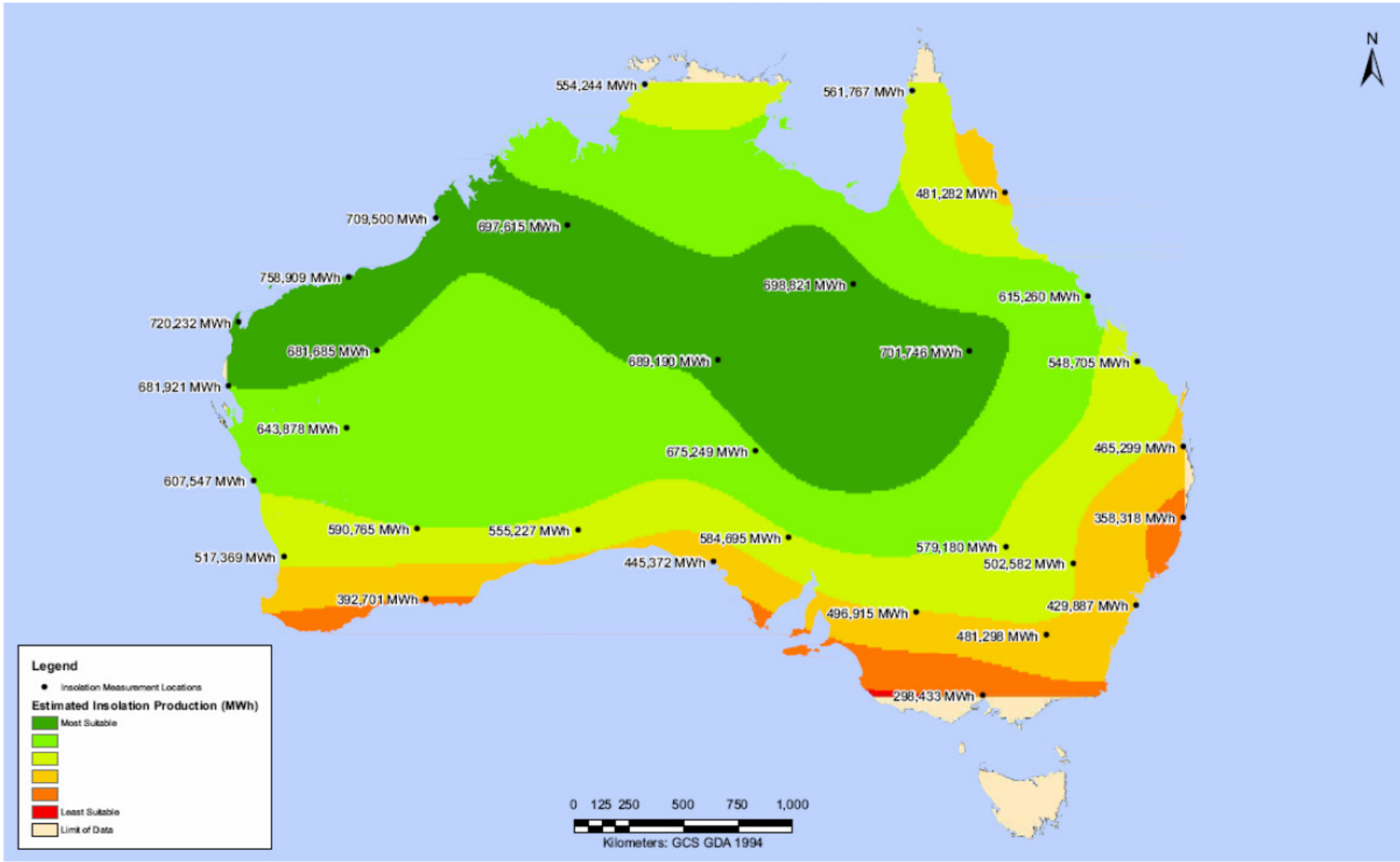
**- mechanically complicated**

# Most of Australia is good for solar power generation.



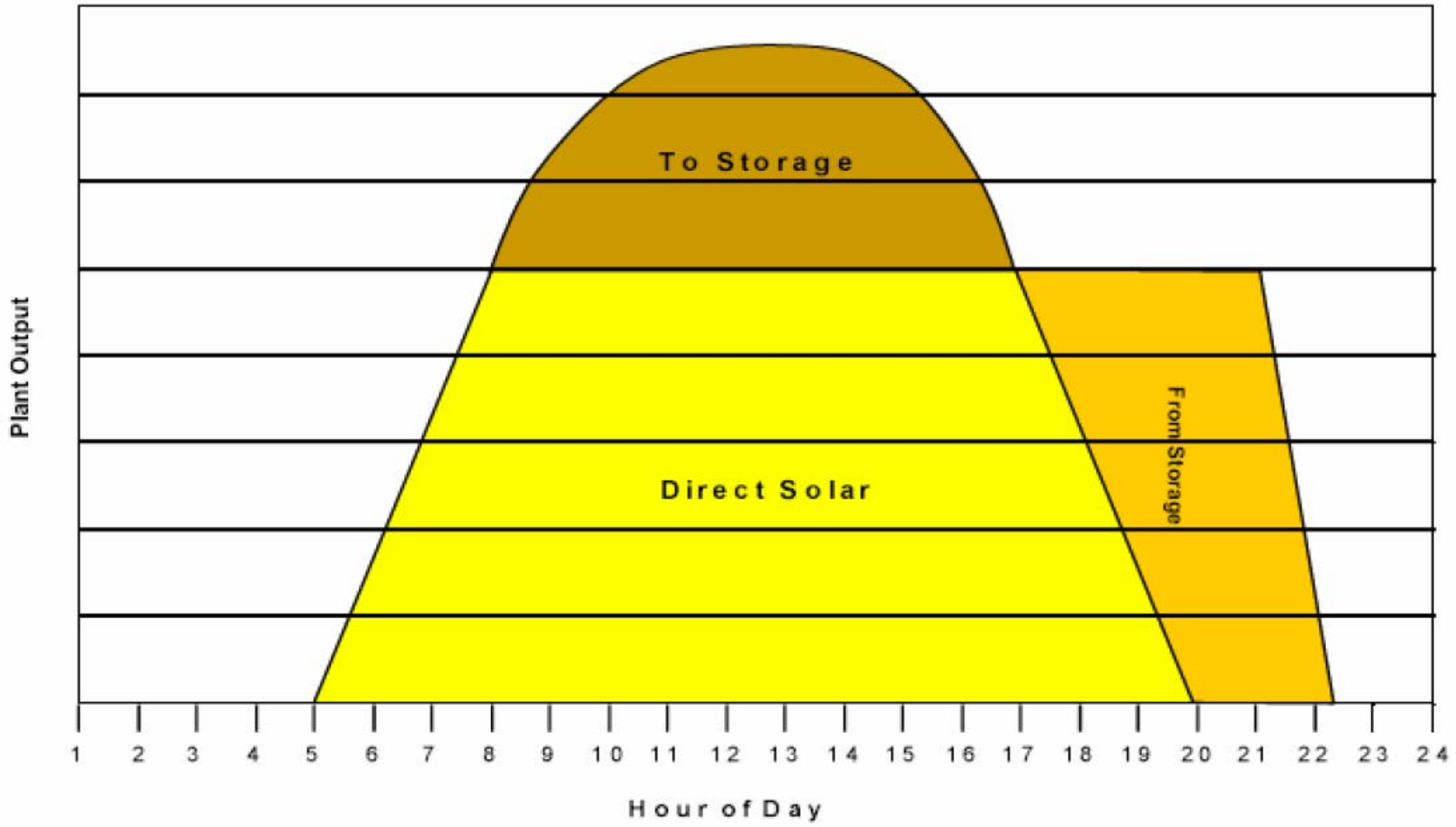

Kilowatt hours per square metre per annum

# Annual Power Generation from a 250 MW Solar Plant



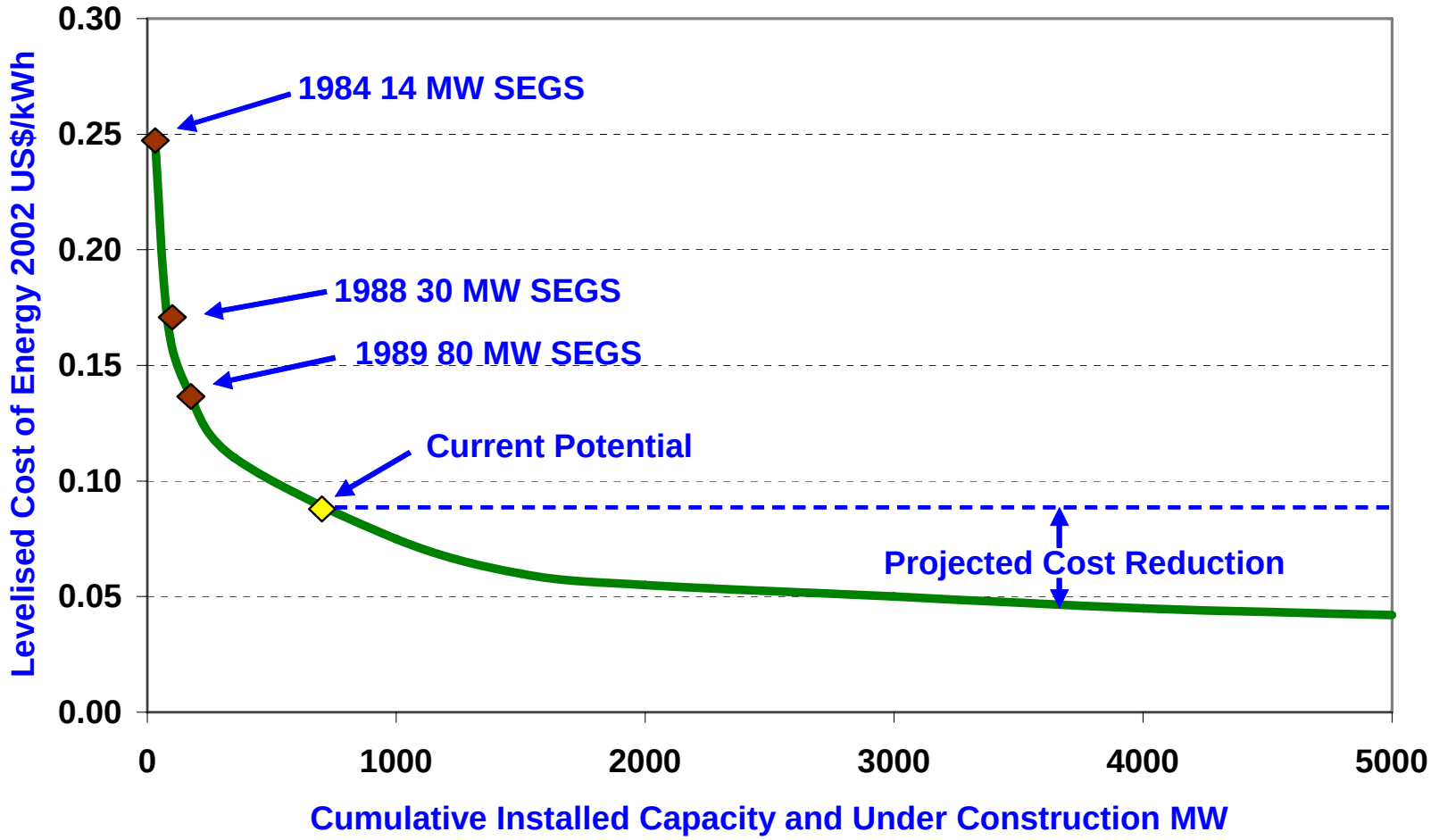

**Mildura would produce at 70% of a Central Queensland location.**

# Shifting generation to the demand profile



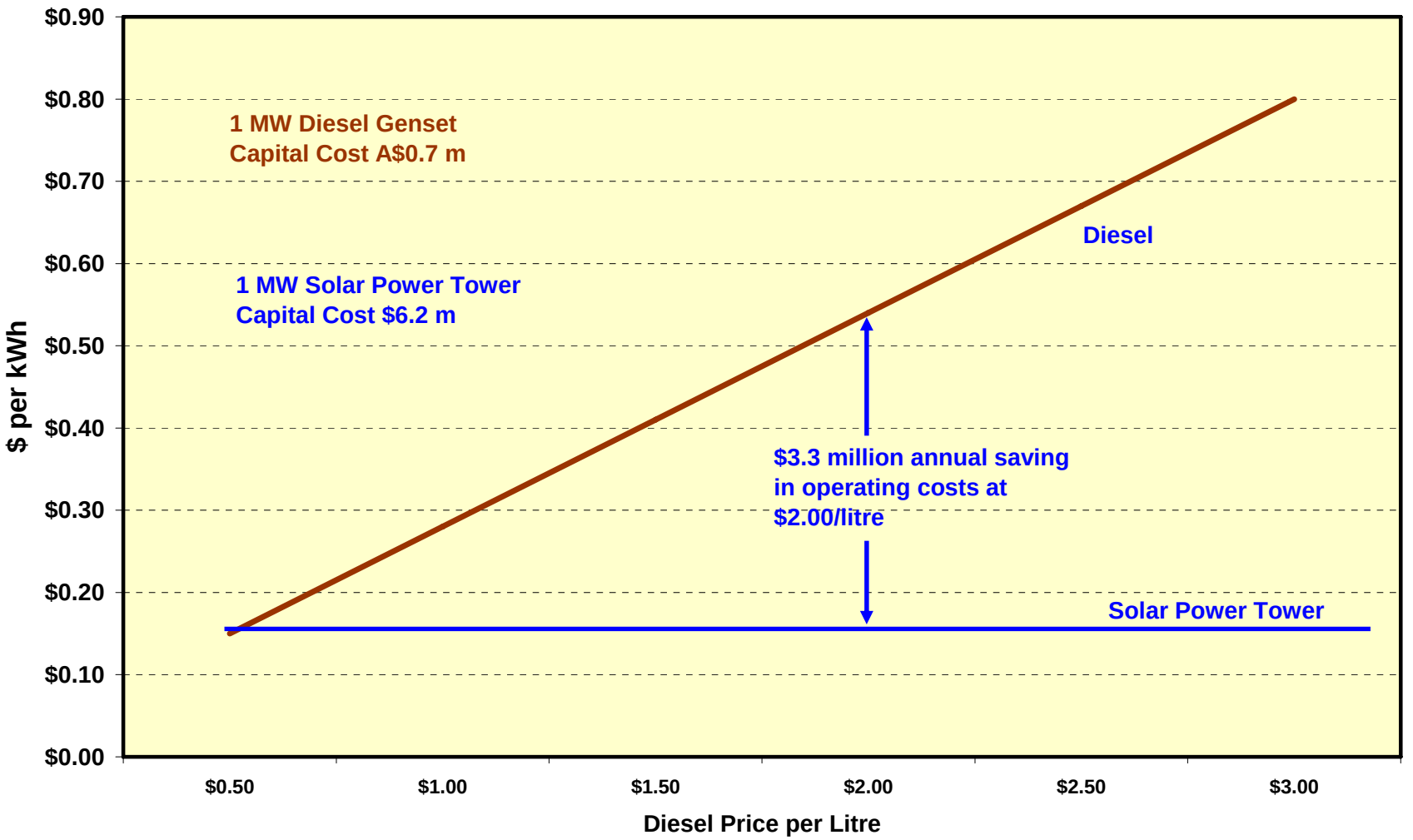

**This requires thermal storage by oil or molten salt.**

# A Projection from a 2007 US Department of Energy Report




**Economies of scale and technological advance have the potential to take the cost of solar thermal down to that of coal power.**

# Solar Power Tower may save Australia's off-grid operations in a high oil price world.




**Australia needs to get good at building cost-effective heliostats.**

# Wind power is idiotic.

- **Based on data from the wind farms in the SWIS, Western Power estimates that for current levels of almost 200 MW of wind capacity, around 60 MW of gas turbine capacity would be required for load following purposes.**

- **Load following is generally achieved by maintaining additional gas turbines in reserve to provide sufficient fast response capability to accommodate the positive and negative changes in wind generator production.**

- **Given the spasmodic operational requirements of the load following plant, it runs at very low efficiency and hence high cost, compared to more regular use.**

# Carbon capture is idiotic.

| Source | Projected Increase in Cost of Electricity from Addition of CCS |
|---|---|
| Duke Energy Indiana[10] | 68% |
| MIT Future of Coal Report[11] | 61% |
| Edison Electric Institute[12] | 75% |
| National Energy Technology Laboratory[13] | 81% |

**The cost of power would go up 80%**
**-putting a lot of people out of work**
**- we would burn through our coal reserves 80% faster.**

# Geothermal? Why bother?

- Hotspots are remote from demand centres – large transmission build cost if nothing else.
- The hotspots are barely lukewarm at best.
- Solar thermal can get to temperatures of 390° (oil) to 550° (molten salt) with just mirrors.
- Turbines at these temperatures will be much more efficient than ones at 120°.

# Photovoltaic required to power an air conditioning unit

- 1,500 watt air conditioning unit
- Operating at 10 hours per day
- 15 kWh
- PV modules rated at 75 watts with an area of 0.72 sq metres and 12% efficiency
- 7 watts per day per watt of rated capacity
- 29 modules required – 2,143 watts rated
- $2.50 per watt installed in a paddock
- $5,400 cost of PV system installed in a paddock or $11,000 installed on roof

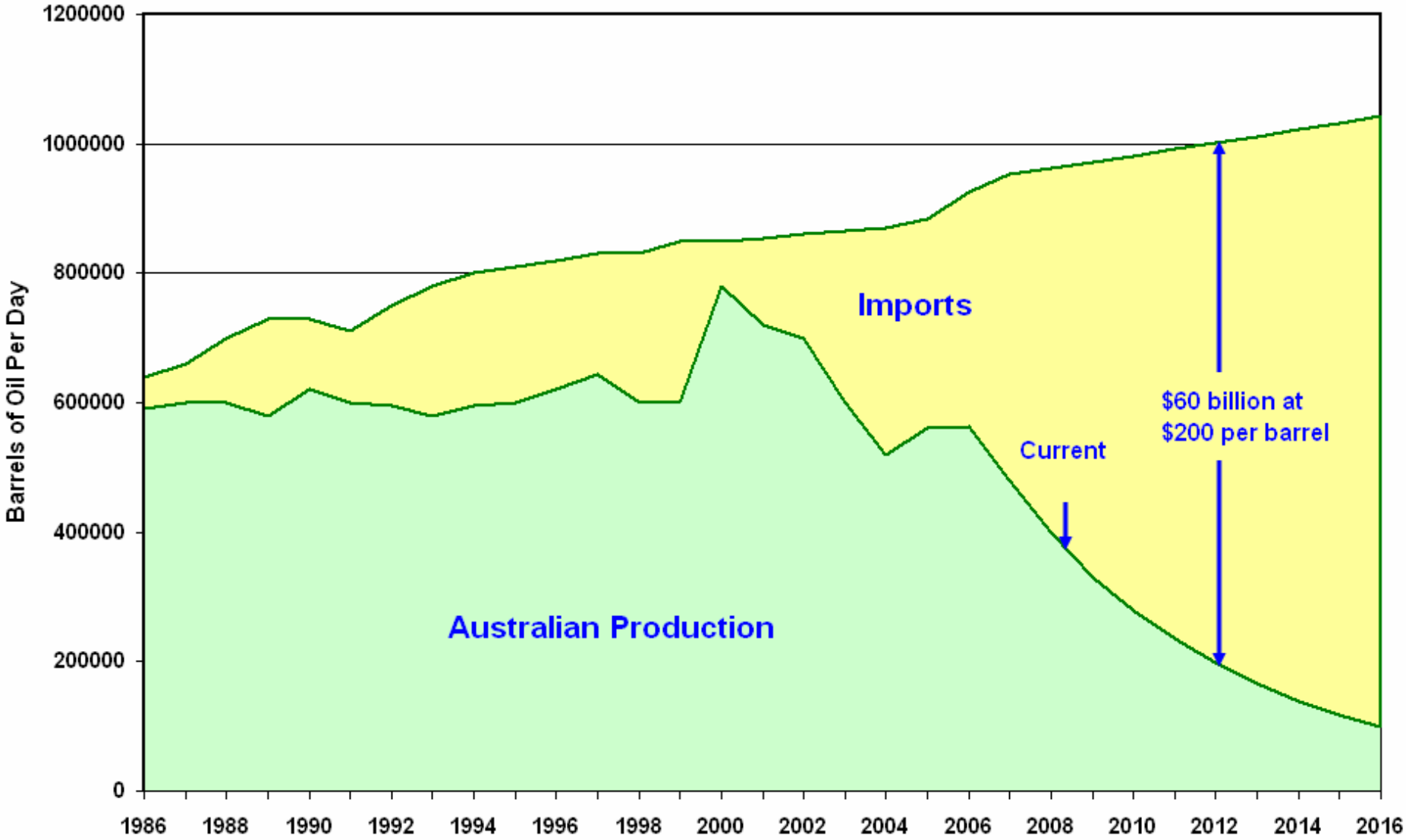
# Cost of PV for a home

- 6,000 kWh average annual consumption in Perth (Florida is 14,000 kWh)
- 16.4 kWh per day
- 23 sq metres of PV
- $6,000 greenfield capital cost
- $450,000 current median Perth house price
- 1.3% PV system cost as percentage of total house cost

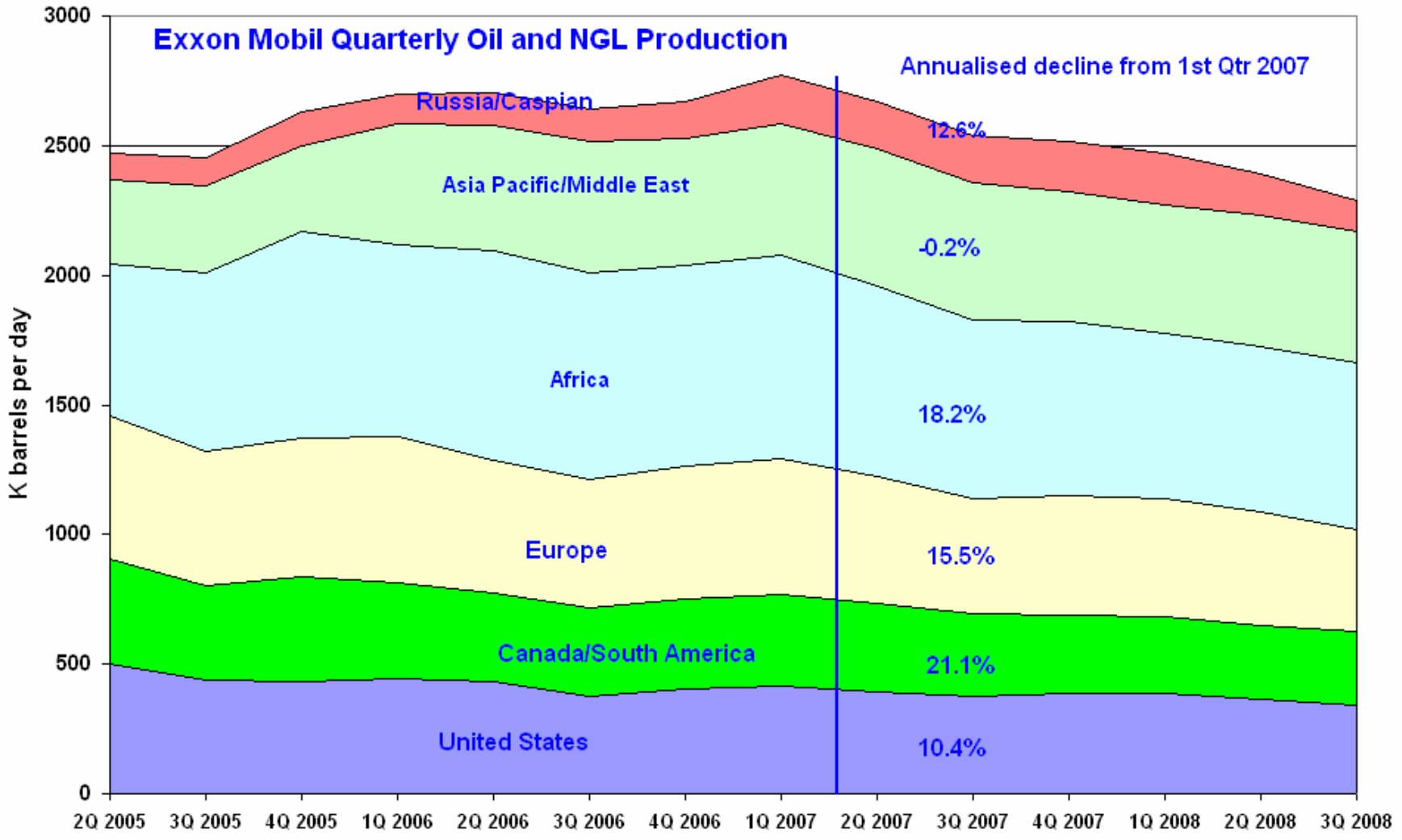
# Potential optimum solution

- Increase coal base-load capacity.
- Plan to say goodbye to gas base-load generation.
- Install thin film photovoltaic for daily peak demand, beginning with the far ends of the distribution system.
- Solar power tower with hot oil or molten salt storage for the demand shoulders.
- Some gas turbine capacity retained for backup.
- Solar power tower may save Australia’s off-grid mines in a high oil price world.

# The Enormous Oil Trade Deficit Coming

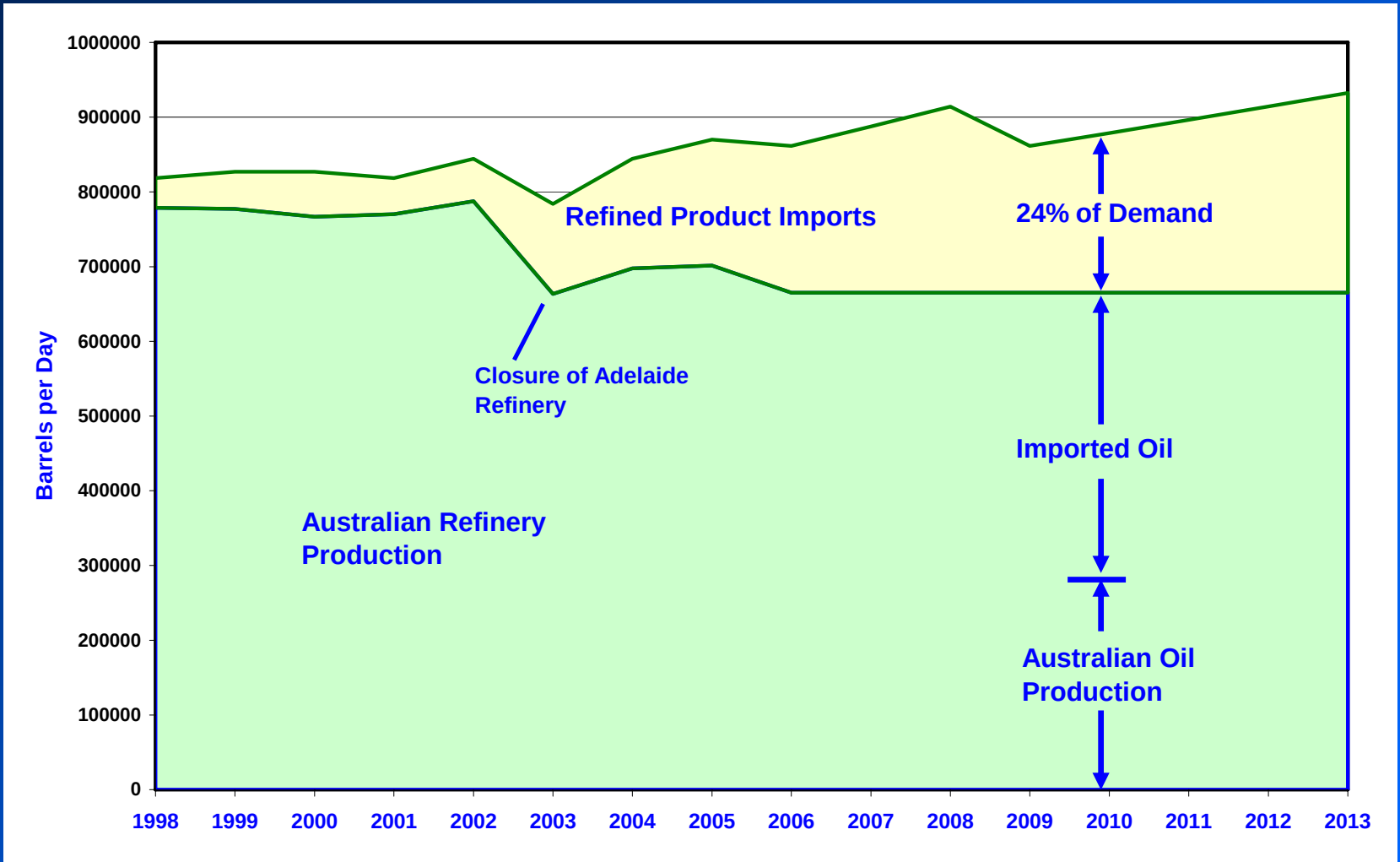


# Rapid Exxon Mobil Production Decline

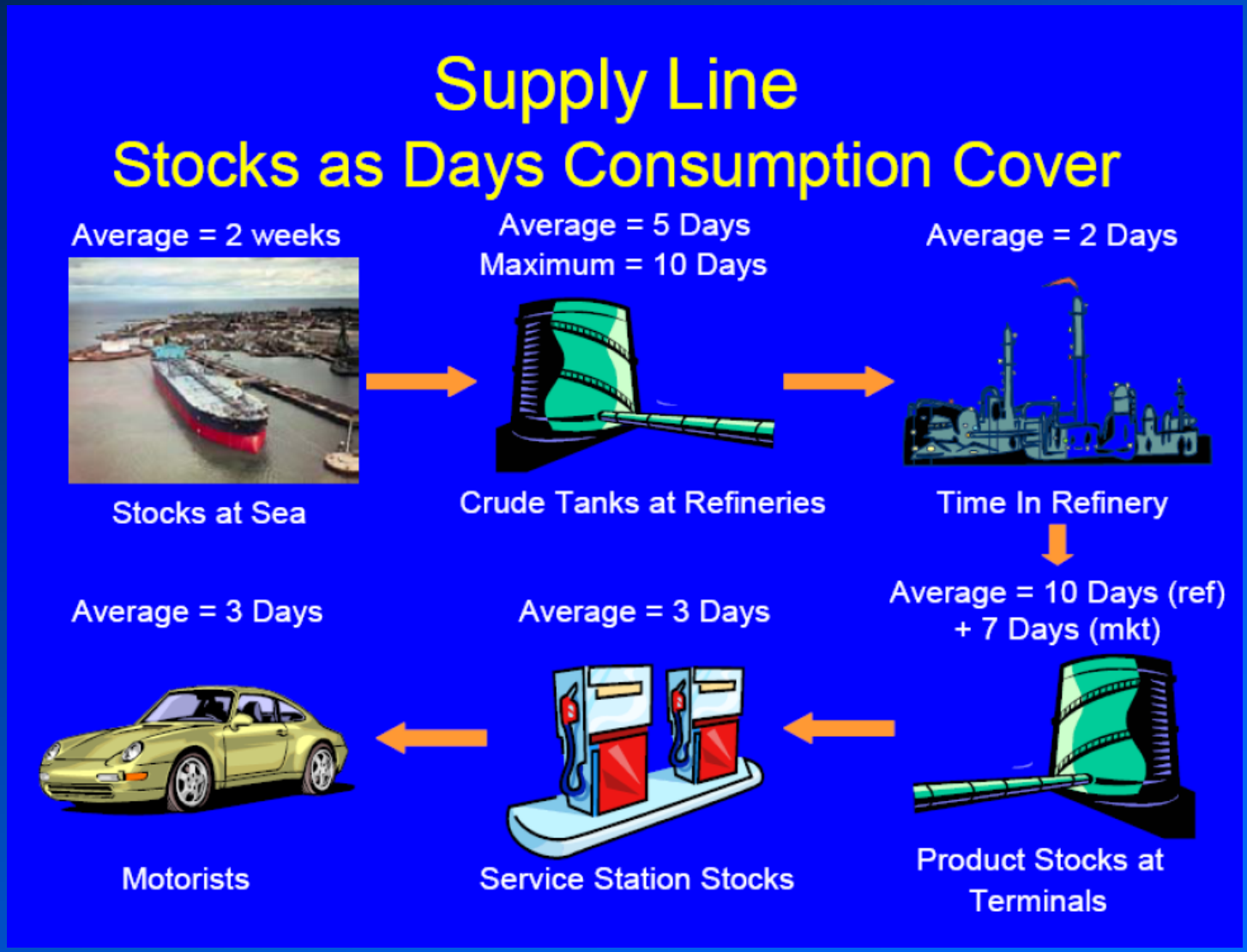



**Production does not respond to price – the majors can't produce any more.**

# A very rude awakening is coming for Australia.



# We are living on a hair trigger in terms of stock cover.



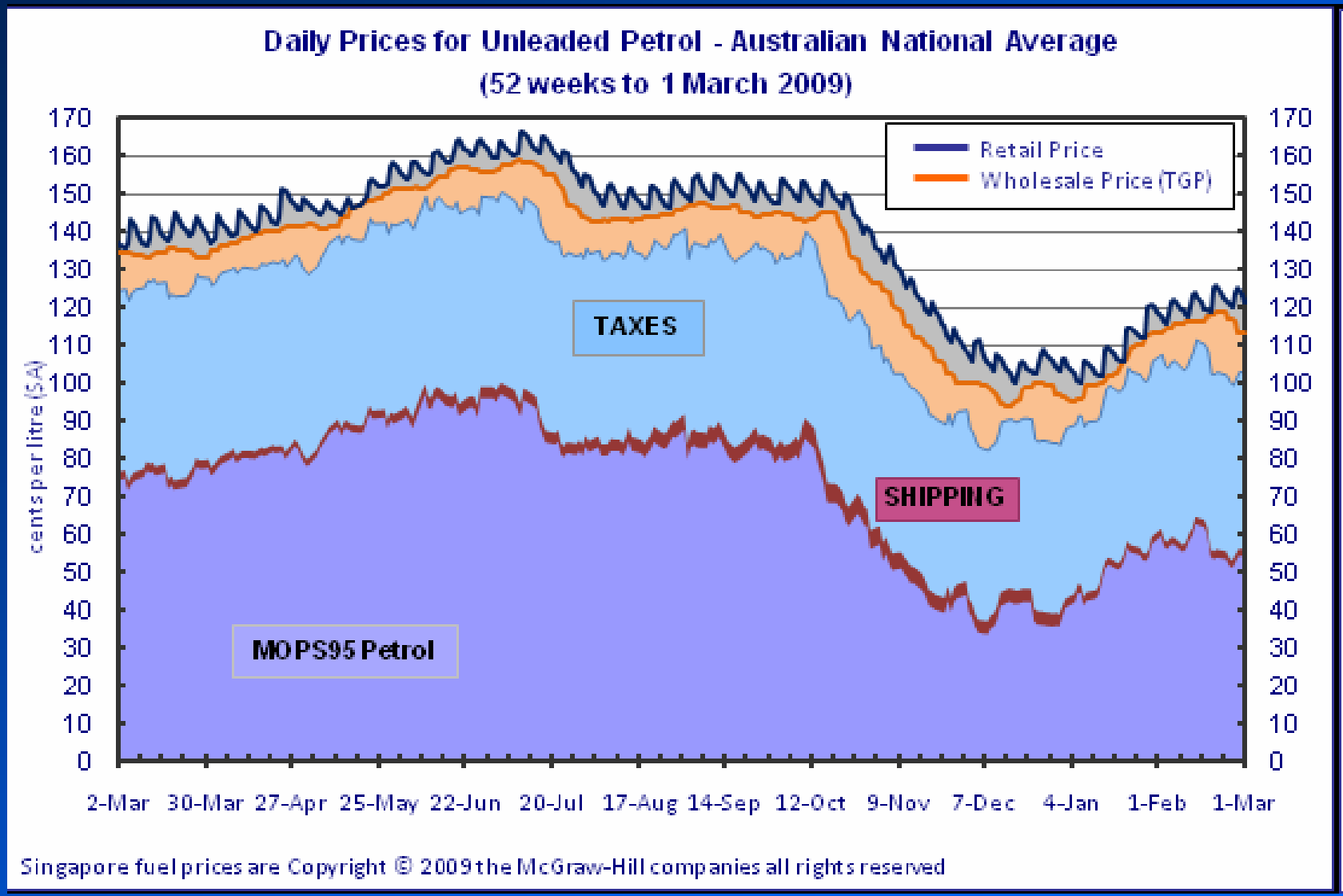

**Source: Australian Institute of Petroleum**

# Twin Problems

1. After four decades of being largely self sufficient in liquid fuels, Australia is now becoming highly exposed to potential supply disruption, with potentially catastrophic consequences for the economy and national security.

2. The trade deficit is going to balloon out.

# Cost Makeup of Australian Petrol



# Solution: Coal to Liquids

- The breakeven price for CTL projects is about $50 per barrel.

- Modelling of a 50,000 bopd plant has the following results at US$100/bbl:

| | |
|---|---|
| Capital Cost: | $4,200 million |
| NPV at 10% discount rate: | $8,850 million |
| IRR: | 25% |

- US$100/bbl is A$0.77 per litre pre taxes.

# CTL is no more expensive than deep water oil

**Coal to Liquids has operating costs and capital costs per barrel, over the life of the project, are similar to that of current deepwater oil and LNG projects around the world:**

| Country | Project | Project Type | Startup | Capex $ billion | Recoverable m bbls | Capex/ boe |
|---|---|---|---|---|---|---|
| Canada | Fort Hills Project | Tar sands | 2011 | $30.2 | 4,700 | $6.40 |
| Angola | Pazflor | Deepwater oil | 2011 | $9.4 | 750 | $12.50 |
| Norway | Snohvit Area | Deepwater LNG | 2007 | $9.1 | 1,302 | $7.00 |
| Nigeria | OPL 222 | Deepwater Oil | 2011 | $5.4 | 620 | $8.70 |
| US | Wyoming CTL | 50,000 bopd CTL | 2013 | $4.20 | 665 | $6.32 |

# The Virtues of Coal to Liquids

1. CTL will make Australia impervious to oil supply disruptions.

2. CTL will stop an enormous blow out in the trade deficit.

3. The capital cost per annual barrel of capacity at about A$300/barrel will be less than twice the oil price.

4. Backing out 800,000 BOPD of imports by 2012 at US$200/barrel will result in $17 billion of company tax being paid.

# Binary Outcome

**Either:**

**Australia continues as is with potential for enormous economic disruption from supply squeezes and a ballooning trade deficit.**

**Or:**

**Australia installs CTL capacity, insulates itself from supply disruptions and generates a large amount of company tax in the process.**

# Indonesian CTL Projects

- Sasol has announced an intention to build an 80,000 BOPD CTL plant in Indonesia using lignite.
- Ultimately they expect to produce 1,000,000 barrels per day.
- At that level, they would produce 20 times as much CO2 as the La Trobe Valley power stations.
- Why is Australia denying itself liquid fuel supply security when our neighbours are going hell for leather?

# Australian CTL Potential

- **The La Trobe Valley has 30 billion tonnes of brown coal – this could make 30 billion barrels of diesel and refinery feedstock.**
- **We have billions of tonnes of lignite in a belt stretching from Esperance in WA to east of Adelaide.**
- **Distributed diesel production would contribute to fuel supply security.**
- **The Fischer-Tropsch process can operate at very high ash levels.**

# Convergence through plug-in hybrid

- GM Volt will have a lithium ion battery giving 64 km range
- Also a 1.4 litre petrol engine with 53 kW generator – no mechanical connection to the wheels
- 111 kW (150 hp) electric motor
- 100 litre battery volume, 170 kg weight – will drop with ongoing battery development
- Top speed of 190 kmph
- 45 litre fuel tank
- 3 hour charge time at 240 volt
- The battery will lose 25% of its storage potential over 10 years
- Financially attractive at $1.25 per litre
- Reduce petrol consumption 90% on a typical driving pattern

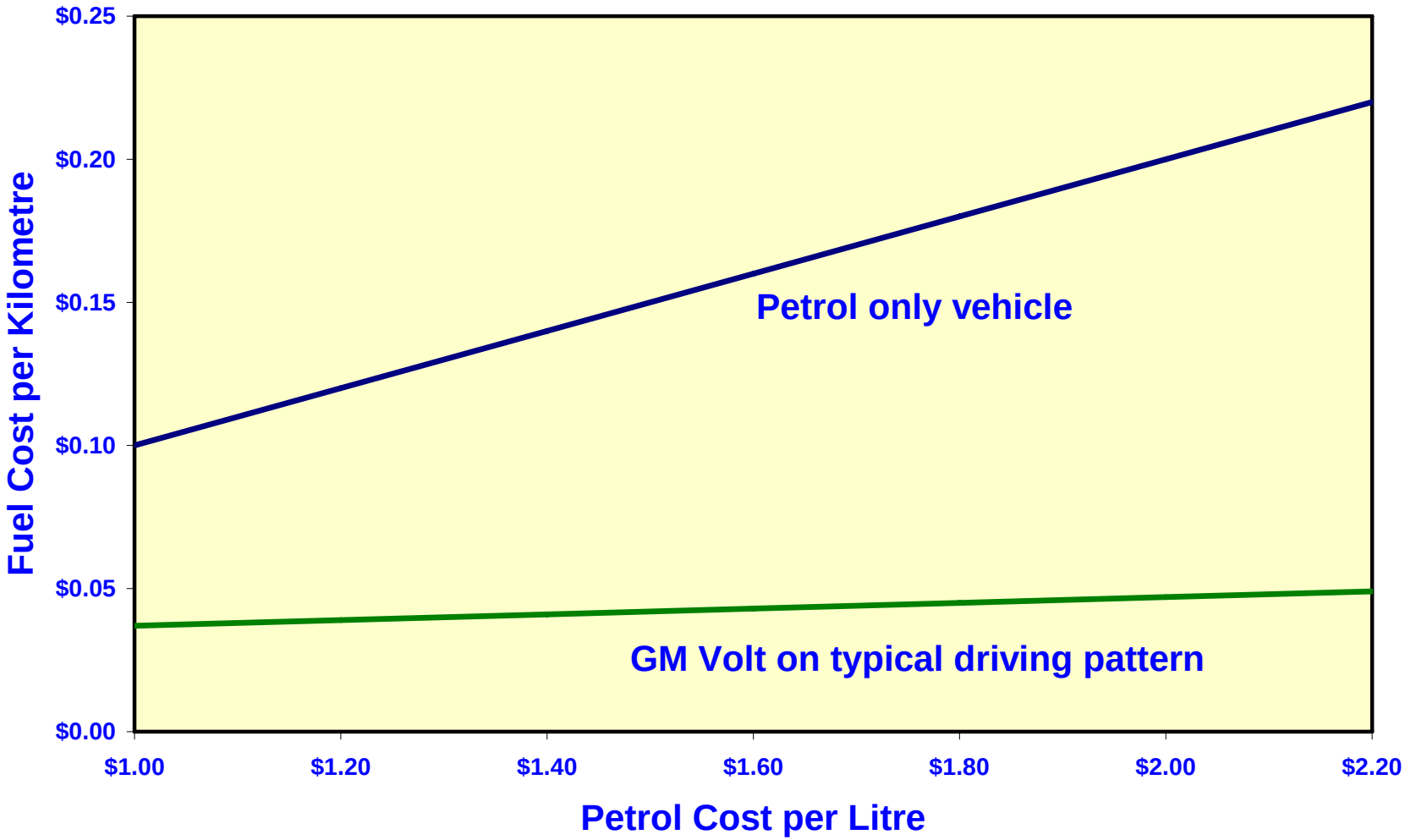
# Photograph of GM Volt


**When high oil prices return, the electric car drivers will be the only ones accelerating hard and enjoying themselves.**

# Comparative Costs

- At $0.20 per kWh, electric motoring will cost $0.03 per km as opposed to $0.12 per km with $1.20 petrol
- 20,000 km per annum equates to 8.0 kWh per day
- Recharging a car doing 55 km per day will be about half the cost of running an air conditioner for 10 hours per day
- A photovoltaic system to provide the charge would cost $3,000 – approximately 10% of the vehicle cost
- Half a million vehicles would require another 500 MW of generating capacity

# Per Kilometre Comparative Fuel Cost



# Is there enough lithium?

- The GM Volt has a 16 kWh battery.
- Lithium carbonate consumption is 0.6 kg per kWh, therefore 10 kg per GM Volt.
- Cost per battery is US$70 for lithium carbonate.
- This is less than 2% of the battery cost.
- Estimated world recoverable reserves of lithium carbonate are 150 million tonnes – enough for 1.5 billion vehicles.
- There is a 1,000 km belt of playa lakes from Bolivia through Chile and Argentina.

# Summary

- Gas will get priced out of the power market.
- Australia should build more coal base-load power and introduce solar peaking.
- Decisions need to be made in the next two years to avoid high power costs next decade.
- The carbon tax needs to be abandoned so that we can install CTL capacity.
- Lithium batteries combined with CTL fuels promise an eternity of low cost motoring.