The Future of Energy in Australia

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20th July 2009
Sections

• The Oil Price Driver
• Electric Power
• Liquid Fuels
• Convergence through Plug-in Hybrid
Non-OPEC production started declining in 2002.
Non-OPEC Production has fallen by 1.1% per annum since 2002 despite the oil price tripling.
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*

Major hydrocarbon basins past peak production

<table>
<thead>
<tr>
<th>Region</th>
<th>Production Peak</th>
<th>Decline Since</th>
<th>2007 MMboe/d</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.</td>
<td>1972</td>
<td>-25%</td>
<td>15.7</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1976</td>
<td>-21%</td>
<td>1.3</td>
</tr>
<tr>
<td>Indonesia</td>
<td>1997</td>
<td>-22%</td>
<td>2.0</td>
</tr>
<tr>
<td>U.K.</td>
<td>1999</td>
<td>-38%</td>
<td>2.8</td>
</tr>
<tr>
<td>Colombia</td>
<td>1999</td>
<td>-26%</td>
<td>0.7</td>
</tr>
<tr>
<td>Australia</td>
<td>2000</td>
<td>-8%</td>
<td>1.2</td>
</tr>
<tr>
<td>Oman</td>
<td>2001</td>
<td>-7%</td>
<td>1.1</td>
</tr>
<tr>
<td>Norway</td>
<td>2004</td>
<td>-10%</td>
<td>4.0</td>
</tr>
<tr>
<td>Mexico</td>
<td>2004</td>
<td>-5%</td>
<td>4.2</td>
</tr>
</tbody>
</table>
The supply gap at 2% demand growth

15 million barrel per day gap by 2017
The first response – lower speed

Horsepower Requirements
Tractor, 13.5 Ft. High Van Trailer
vs.
Vehicle Speed
11R22.5 Radial Tires
GCW=78,500 Lb.

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
The east coast power market is now run by the Australian Energy Market Operator (AEMO)
Average Daily Demand and All-Time Peak Demand

QLD: Average Daily Demand - 5886, All-time Peak Demand - 8611
NSW: Average Daily Demand - 8944, All-time Peak Demand - 13871
VIC: Average Daily Demand - 5917, All-time Peak Demand - 8918
SA: Average Daily Demand - 1524, All-time Peak Demand - 3151
TAS: Average Daily Demand - 1162, All-time Peak Demand - 1756
South West Interconnected System

- Verve Energy - generation
- Western Power - distribution
- Synergy - retail
Western Australia Generation by Source

Graph 1: Available Capacity vs Target for the 2007/08 Summer
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

Western Australia Gas Pricing Trend

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 – equivalent to US$50/bbl.
- 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.
Reindeer Contract

- US $150/bbl
- US $100/bbl
- US $50/bbl

Likely mid-decade
Gas price
~ $20/gj

This price was achieved on an LNG contract in 2008.

Western Australian Experience

Western Australia Gas Pricing Trend

- US $50/bbl

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

Delivered Cost in the US$150/bbl World

Delivered Cost at the Reindeer Contract Price

Delivered Cost at $3.00/gj gas price

Transmission

Cost from generator

Baseload Power from Coal

Solar Thermal and Photovoltaic Cost

Price trigger to shut gas baseload and install solar baseload

Price trigger to shut gas baseload and install coal baseload

Cost of Wholesale Power in Tokyo
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...

...driven by government carbon policy and LNG export
There is a national capital strike on new coal-fired power generation.

Only one of 129 new power stations being built in Australia is coal-fired.
What a Peak Load Curve looks like

NSW Power Market
Intra Day Demand Curve
Wednesday 11th March, 2009

37% Peak Load
63% Base Load
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.
Atmospheric Temperature hasn’t changed yet.

The 30 years of High Quality Satellite Data
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.
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

1970s cooling period

Fell out of bed starting June 2008
The Ap Index has broken through its 70 year floor.
Hanover, NH

rsq = 0.53

Correlation = 0.73 degrees/annum

Solar Cycle 22

2.2 Degrees Celsius

Solar Cycle 23
Carbon Dioxide is tuckered out as a greenhouse gas.

Plant growth shuts down

Level during Ice Ages

Pre-industrial level

Level in 2009

Atmospheric Carbon Dioxide in ppm

Degrees Celsius

20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420
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
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 the 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
Effect of the June, 1991 eruption of Mt Pinatubo on the solar thermal power plants in California

California has had 300 MW of solar troughs since the mid-1980s. Solar power peak capacity factor dropped 25%. World temperature dropped by 0.5° C.
Power Tower using molten salt.

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

30,000 of these
- each 11.6 m high
- producing 25 kW
- mechanically complicated
Most of Australia is good for solar power generation.
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.

- 1 MW Diesel Genset
  Capital Cost A$0.7 m

- 1 MW Solar Power Tower
  Capital Cost $6.2 m

$3.3 million annual saving in operating costs at $2.00/litre
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.
Extra Idiotic: Build a wind farm where there is no wind.

- Silverton wind farm approved by NSW Govt. on 3rd June 2009.
- 596 turbines
- 1000 MW rated
- $2,000 million capital cost
Carbon capture is idiotic.

<table>
<thead>
<tr>
<th>Source</th>
<th>Projected Increase in Cost of Electricity from Addition of CCS</th>
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</thead>
<tbody>
<tr>
<td>Duke Energy Indiana¹⁰</td>
<td>68%</td>
</tr>
<tr>
<td>MIT Future of Coal Report¹¹</td>
<td>61%</td>
</tr>
<tr>
<td>Edison Electric Institute¹²</td>
<td>75%</td>
</tr>
<tr>
<td>National Energy Technology Laboratory¹³</td>
<td>81%</td>
</tr>
</tbody>
</table>

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

The chart shows the trend of oil production and imports over the years from 1986 to 2016. The graph indicates a significant increase in oil imports, with a peak exceeding $60 billion at a price of $200 per barrel. In contrast, Australian production has decreased significantly, reaching a point where it is no longer sufficient to meet domestic demands.
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.
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:

<table>
<thead>
<tr>
<th>Country</th>
<th>Project</th>
<th>Project Type</th>
<th>Startup</th>
<th>Capex $ billion</th>
<th>Recoverable m bbls</th>
<th>Capex/boe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>Fort Hills Project</td>
<td>Tar sands</td>
<td>2011</td>
<td>$30.2</td>
<td>4,700</td>
<td>$6.40</td>
</tr>
<tr>
<td>Angola</td>
<td>Pazflor</td>
<td>Deepwater oil</td>
<td>2011</td>
<td>$9.4</td>
<td>750</td>
<td>$12.50</td>
</tr>
<tr>
<td>Norway</td>
<td>Snohvit Area</td>
<td>Deepwater LNG</td>
<td>2007</td>
<td>$9.1</td>
<td>1,302</td>
<td>$7.00</td>
</tr>
<tr>
<td>Nigeria</td>
<td>OPL 222</td>
<td>Deepwater Oil</td>
<td>2011</td>
<td>$5.4</td>
<td>620</td>
<td>$8.70</td>
</tr>
<tr>
<td>US</td>
<td>Wyoming CTL</td>
<td>50,000 bopd CTL</td>
<td>2013</td>
<td>$4.20</td>
<td>665</td>
<td>$6.32</td>
</tr>
</tbody>
</table>
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 Latrobe Valley power stations.

- Why is Australia denying itself liquid fuel supply security when our neighbours are going hell for leather?
Australian CTL Potential

• The Latrobe 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.
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Capital Intensity per Motorist

- US$80,000 per barrel of daily Fischer-Tropsch production is A$274 per barrel of annual production.
- A car doing 20,000 km per annum at 10 km per litre would consume 2,000 litres, which is 12.6 barrels.
- The capital cost of that would be $3,452.
- For a car costing $25,000, that would be 14% of the capital cost of the car.
- The Fischer-Tropsch plant will last a lot longer than the car.
Coal Liquefaction

• The world’s first commercial coal liquefaction plant built in Inner Mongolia by China’s Shenhua Group.
• 9 million barrels per annum for US$1.4 billion.
• Commissioned in December 2008.
• Capital intensity of US$155 per annual barrel.
• Shenhua has plans to increase capacity to 81 million barrels per annum.
Capital Cost of the CTL Solution

• Liquefaction is more complicated than Fischer-Tropsch but more efficient.

• Shenhua’s US$155 per annual barrel is $193 per annual barrel at A$/US$0.80 exchange rate.

• Daily consumption of 1.0 million barrels is 365 million annual barrels.

• $70.5 billion or $3,202 per capita to provide all our liquid fuel requirements by CTL.

• Not significant relative to the $300 billion debt that the Federal Government is taking us to.
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.
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

- Petrol only vehicle
- GM Volt on typical driving pattern
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 15 billion vehicles.
- There is a 1,000 km belt of playa lakes from Bolivia through Chile and Argentina.
Lithium batteries from electric cars will get a second life.

- The GM Volt will run its battery down to 30% charge before the petrol motor kicks in.
- 25% battery performance decline expected over 10 years.
- The battery doesn’t contain enough lithium to be worth scrapping.
- Used car batteries could be used to store photovoltaic-derived power.
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.