Gas: part of the solution/problem to climate change?

The G7 countries have committed to decarbonisation of the global economy this century

The global gas industry has argued that natural gas can contribute to this objective in ways that coal cannot.

Yet, to have 50% probability to stay below 2 degrees, the majority of proven and probable fossil fuel reserves are unburnable

Can clean burning gas be part of the solution but as a fossil fuel also be part of the problem?
The world is committed to addressing climate change

Global energy-related CO₂ emissions (Gt)

- Global: limit the maximum global average temperature increase to no more than 2 degrees Celsius
- EU: at least 40% domestic reduction in emissions by 2030
- USA: reduce CO₂ emissions by 26%-28% below 2005 levels in 2025 and "to make best efforts to reduce emissions by 28%.
- China: achieve the peaking of CO₂ emissions around 2030 and "to make best efforts to peak early"

Source: IEA WEO 2014; Asian Development Bank TA
Changing the demand outlook for fossil fuels

If governments continue their current energy and climate policies, and implement the ones they have proposed, the energy path is one that is consistent with a global temperature increase of about 4 degrees Celsius.

We have less than half our carbon budget remaining and are set to exhaust it by 2040

Source: IEA World Energy Outlook 2014
Gas: part of the solution

World Gas Conference:

• Natural gas emits half as much CO₂ as coal. For example, US CO₂ emissions have fallen sharply via shale gas

• Energy companies have accepted that reducing CO₂ emissions is now firmly established on political and corporate agendas across the world

• Gas emits 90% fewer air pollutants than coal - important in a world where there are seven million deaths linked to pollution every year.

• Gas is the most environmentally-friendly fossil fuel to act as a back up when variable solar and wind power cannot satisfy demand.

• Gas can be used to power vehicles with much lower emissions than oil-based petrol or diesel.
Gas: part of the solution

Importance to Australia:

• In 2013-14, Australia exported 24.1 million tonnes of liquefied natural gas
• Australia was the third largest LNG exporter
• LNG export earnings were $16 billion
• Additional 62 million tonnes of LNG capacity will make Australia the largest exporter
Gas: part of the problem

• Natural gas remains a fossil fuel that emits harmful CO$_2$. And lots of it.

• If all the coal power stations in the world were turned off and replaced with modern gas-fired plants, total global CO$_2$ emissions would fall by about five billion tonnes a year to 25 billion tonnes. But emissions need to fall to about five billion tonnes for the climate to stabilise (IEA)

• The extraction of unconventional gas (shale gas and coal seam gas) adds significant emissions to those produced when gas is burned, and has major risks for water supplies.

• At some point in the next 20-30 years, gas use will have to start falling to avoid dangerous climate change. CCS remains unproven and expensive.

• Rather than rely on gas, governments should invest in large-scale energy storage systems and in renewable energy that is not variable, such as tidal and geothermal.
Growing demand for LNG

- LNG supply grows by 48 Bcf/d by 2035
- Australia (16 Bcf/d) will contribute around a third of that increase

Australian LNG nameplate capacity

Source: Accenture, 2015, World Gas Conference, June 2015
Australia’s gas resources by major basins

Source: BREE, GA (2014); EIA World Shale Gas Resources (2013), World Gas Conference, June 2015
Overview

- Australia on verge of an unprecedented transition to be world’s leading LNG producer
- Growth enabled by resources, innovation, policy settings and proximity to Asia
- A focus on sustaining competitive advantages and securing next wave of investment

ACHIEVING NET ZERO EMISSIONS: THE ROLE OF GAS

GRATTAN POLICY PITCH EVENT

21 July 2015

Anna Skarbek,
CEO ClimateWorks Australia
There is a finite “carbon budget” to avoid exceeding 2°C rise.
Australia’s share has been calculated by the Climate Change Authority.

**Figure 1: Recommended Emissions Reduction Goals**

- **Historical emissions**
- **Emissions (Mt CO₂-e)**
  - 700
  - 600
  - 500
  - 400
  - 300
  - 200
  - 100
  - 0

- **National emissions budget**
  - 2013-2020: 4,193 Mt CO₂-e
  - 2013-2050: 10,100 Mt CO₂-e

- **Targets**
  - -19% by 2020
  - -40 to -60% by 2030

Our research shows that Australia can reach zero net emissions by 2050, while our economy continues to grow, in a 2°C scenario.

**Our economy grows by 150% by 2050**
Real GDP

![Graph showing Real GDP growth from 2012 to 2050]

**Annual rate of change**
+2.4%

**Australia can reach zero net emissions by 2050**
Emissions, MtCO₂e

![Graph showing emissions reduction from 1990 to 2050]

---

www.climateworksaustralia.org
This is achieved through four “pillars” of transformation, focused on energy emissions and sequestration

**Ambitious Energy Efficiency**
in all sectors leads to a halving of the energy intensity of the economy.

**Low Carbon Electricity**
Low carbon electricity is supplied by renewable energy or a mix of renewable energy and either CCS or nuclear power at similar costs.

**Electrification and Fuel Switching**
from fossil fuels to bioenergy, and from coal and oil to gas reduces emissions from transport, industry and buildings.

**Non-Energy Emissions**
are reduced through process improvements and CCS in industry, while a profitable shift from livestock grazing to carbon forestry offsets any remaining emissions.
While use of gas in buildings would decrease to near zero, an equivalent demand would come from shift from oil to gas in road freight.
Gas use in mining and manufacturing remains at similar levels, a result of industry growth being offset by efficiency and fuel switch.
Nationally, primary use of gas would decrease but final use would increase slightly, with a shift of demand from buildings to transport.

Gas use by sector, PJ

Source: Pathways To Deep Decarbonisation In 2050: How Australia Can Prosper In A Low Carbon World - ClimateWorks Australia and ANU
Renewables becomes the dominant electricity source as Australia’s electricity grid can be almost completely decarbonised – three scenarios at similar costs
Past developments also show that technological step change is achievable within the required time frame

- In 1933 the world was still emerging from the great depression but by 1969...

- Today, solar panels cost less than 10% of their 1980 cost and half their cost in 1998

- 20 years ago very few people had an email address

- 7 years ago very few people had a smartphone
FOR FURTHER INFORMATION:

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P: +613 9902 0741
E: anna.skarbek@climateworksaustralia.org
W: http://www.climateworksaustralia.org/


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Transport Fuels from Australia's Gas Resources
Advancing Australia's Energy Security

UNSW Press Book – December 2014

Institutional Lead Authors

• Dr Mark Thomson – Australian Strategic Policy Institute
• Professor Dianne Wiley, Professor Sandra Kentish – CO2CRC
• Dr Paul Graham, Dr Nick Burke, Dr Justine Lacey – CSIRO
• Mr Barry Goldstein, Mr Nick Panagopoulos – SA Govt
• Drs Clinton Foster, Marita Bradshaw, Andrew Stacey – GA
• Mr Tony Wood – Grattan Institute and Clinton Foundation
• Dr Susan Pond AM – United States Studies Centre
• Professor Robert Clark AO – UNSW

Grattan Institute & State Library of Victoria, Tuesday 21 July 2015
Policy Pitch – Natural gas: part of the problem or part of the solution?
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 1</td>
<td>Strategic overview</td>
</tr>
<tr>
<td>Chapter 2</td>
<td>Australia's oil and gas resources and infrastructure</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>The outlook for gas in the transport fuels market</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>LNG for Australian articulated trucks</td>
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<td>Chapter 5</td>
<td>The economics of GTL</td>
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<td>Chapter 6</td>
<td>Strategic considerations</td>
</tr>
<tr>
<td>Chapter 7</td>
<td>GTL and LNG transport fuel technologies</td>
</tr>
<tr>
<td>Chapter 8</td>
<td>Well to wheels environmental considerations</td>
</tr>
<tr>
<td>Chapter 9</td>
<td>Earning a social licence for alternative transport fuels</td>
</tr>
<tr>
<td>Chapter 10</td>
<td>Regulatory issues</td>
</tr>
</tbody>
</table>
AUSTRALIA: OIL REQUIREMENT BY INDUSTRY SECTOR

Source: ABS, UBS, AMP Capital Investors
AUSTRALIA: OIL CONSUMPTION BY TRANSPORT SECTOR, 2009

- Road Transport: 26.7%
- Rail Transport: 12%
- Air Transport: 4%
- Water Transport: 2.3%
- Non-Transport: 55%

ARTICULATED TRUCKS: ROAD FREIGHT SHARE BY BROAD COMMODITY CLASS, 2007

- Food and live animals: 19.2%
- Crude materials, inedible, except fuels: 21.7%
- Manufactured goods: 9.0%
- Mineral fuels, lubricants and related materials: 21.7%
- Other (e.g., tools of trade, beverages): 28.4%

AUSTRALIA: ROAD TRANSPORT VEHICLE STATISTICS, 2012

<table>
<thead>
<tr>
<th>All Vehicles</th>
<th>Number (M)</th>
<th>Total km per year (B)</th>
<th>Freight Vehicle Average km per year (1,000)</th>
<th>Litres of Fuel per year (B)</th>
<th>Freight Vehicle Average Fuel Consumption (L/100 km)</th>
<th>Freight Tonne-km per year (B)</th>
<th>Vehicle Average Load (t)</th>
<th>POTENTIAL FUTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger</td>
<td>12.68</td>
<td>167.5</td>
<td>18.5 (85% petrol)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freight</td>
<td>3.12</td>
<td>60.5</td>
<td>12.5 (see below)</td>
<td>18.5 (50% diesel) (43% petrol)</td>
<td>1.2</td>
<td>194</td>
<td></td>
<td>LNG/CNG</td>
</tr>
<tr>
<td>Other</td>
<td>0.8</td>
<td>4.5</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>16.6</td>
<td>232.5</td>
<td>32</td>
<td></td>
<td></td>
<td>194</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Light Commercial
  - Number: 2.58
  - Total km per year: 43.7
  - Freight Vehicle Average km per year: 16.9
  - Litres of Fuel per year: 5.5 (50% diesel) (43% petrol)
  - Freight Vehicle Average Fuel Consumption: 12.6
  - Freight Tonne-km per year: 7.76
  - Vehicle Average Load: 0.4
  - POTENTIAL FUTURE: CNG

- Rigid Truck
  - Number: 0.44
  - Total km per year: 9.3
  - Freight Vehicle Average km per year: 20.8
  - Litres of Fuel per year: 2.65 (diesel)
  - Freight Vehicle Average Fuel Consumption: 28.7
  - Freight Tonne-km per year: 35.3
  - Vehicle Average Load: 5.6
  - POTENTIAL FUTURE: LNG

- Articulated Truck
  - Number: 0.087
  - Total km per year: 7.4
  - Freight Vehicle Average km per year: 83.0
  - Litres of Fuel per year: 4.26 (diesel)
  - Freight Vehicle Average Fuel Consumption: 57.7
  - Freight Tonne-km per year: 151
  - Vehicle Average Load: 24.8
  - POTENTIAL FUTURE: LNG

Retabulated from:
Survey of Motor Vehicle Use, Australia 2012, ABS

- 4.3 BL/a diesel - 7 BL/a LNG (x1.62) - 3 Mt/a LNG
- 3 Mt/a LNG requires ~ 0.15 Tcf/a gas
- 0.15 Tcf/a gas requires ~ 300 shale gas wells (at average 1.5 mcf/d)
ASSIGNED INTER-REGIONAL ROAD FREIGHT, 2005

ROAD FREIGHT IN AUSTRALIA, 2007: INTERSTATE, CAPITAL CITY, REST-OF-STATE

(Billions Tonne-Km)

<table>
<thead>
<tr>
<th>Australia</th>
<th>Capital City</th>
<th>Interstate</th>
<th>From</th>
<th>To</th>
<th>Through</th>
<th>Rest-of-State</th>
</tr>
</thead>
<tbody>
<tr>
<td>182.5</td>
<td>Sydney</td>
<td>NSW</td>
<td>13.72</td>
<td>12.24</td>
<td>7.13</td>
<td>16.33</td>
</tr>
<tr>
<td></td>
<td>Melbourne</td>
<td>VIC</td>
<td>7.31</td>
<td>7.57</td>
<td>0.62</td>
<td>12.67</td>
</tr>
<tr>
<td></td>
<td>Brisbane</td>
<td>QLD</td>
<td>2.61</td>
<td>2.59</td>
<td>-</td>
<td>20.84</td>
</tr>
<tr>
<td></td>
<td>Perth</td>
<td>WA</td>
<td>1.99</td>
<td>1.28</td>
<td>-</td>
<td>20.61</td>
</tr>
<tr>
<td></td>
<td>Adelaide</td>
<td>SA</td>
<td>2.81</td>
<td>3.00</td>
<td>0.86</td>
<td>5.03</td>
</tr>
<tr>
<td></td>
<td>Hobart</td>
<td>TAS</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3.03</td>
</tr>
<tr>
<td></td>
<td>Darwin</td>
<td>NT</td>
<td>0.31</td>
<td>0.64</td>
<td>-</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>Canberra</td>
<td>ACT</td>
<td>0.01</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38.4</strong></td>
<td><strong>64.7</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>79.3</strong></td>
</tr>
</tbody>
</table>

Articulated truck percentage

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>78%</td>
<td>49%</td>
<td>-100%</td>
<td></td>
<td></td>
<td>88%</td>
<td></td>
</tr>
</tbody>
</table>


80% of Australian road freight is transported over distances of < 100km
MICRO LNG SUPPLY CHAIN: LOGGING TRUCKS, TASMANIA

LNG Plant

LNG Refuelling Station

LNG Dispenser

Truck LNG Tank

Source: RARE Consulting - LNG for Trucking in Tasmania, ANGVA 2011 Conference
## US Heavy Duty Vehicle Lifecycle GHG Emission Reductions – LNG/CNG VS Diesel

<table>
<thead>
<tr>
<th>Vehicle/Fuel</th>
<th>Baseline Vehicle/Fuel</th>
<th>WTT</th>
<th>TTW</th>
<th>WTW</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDV LNG (NA NG)</td>
<td>Heavy Duty Truck Ultra-low-sulfur Diesel</td>
<td>22-57%</td>
<td>20%</td>
<td>21-28%</td>
</tr>
<tr>
<td>HDV CNG (NA NG)</td>
<td>Heavy Duty Truck Ultra-low-sulfur Diesel</td>
<td>53%</td>
<td>22%</td>
<td>29%</td>
</tr>
</tbody>
</table>

HDV – Heavy Duty Vehicle  
TTW – Tank to Wheels  
NA NG – North American Natural Gas  
WTT – Well to Tank  

## Australian Tail Pipe Emission Requirements: Diesel/NG Heavy Duty Vehicles

<table>
<thead>
<tr>
<th>Standard</th>
<th>Date Introduced</th>
<th>Emission Limits (g/kWh)</th>
<th>Emissions Test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>CO</td>
<td>NMHC</td>
</tr>
</tbody>
</table>
| ADR 80/3   | Jan 2010 – Jan 2011 | 1.5 | 0.46 | 2.0 | 0.02 | ESC  
|            |                 | 4.0 | 0.55 | 2.0 | 0.03 | ETC |

ADR – Australian Design Rule  
NMHC – Non-Methane Hydrocarbon  
ESC – Euro Stationary Cycle  
PM – Particulate Matter  
ETC – Euro Transient Cycle
# US: Sensitivity of Payback Periods to Assumptions

<table>
<thead>
<tr>
<th>Interest Rate</th>
<th>Fuel Price Differential ($ per gallon)</th>
<th>Vehicle Cost Differential ($35,000)</th>
<th>$70,000</th>
<th>$100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fuel Economy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>5.6 mpg</td>
<td>5.1 mpg</td>
<td>4.6 mpg</td>
</tr>
<tr>
<td>0.05</td>
<td>$1.50</td>
<td>1.62</td>
<td>1.82</td>
<td>2.14</td>
</tr>
<tr>
<td></td>
<td>$0.75</td>
<td>3.04</td>
<td>3.82</td>
<td>5.54</td>
</tr>
<tr>
<td></td>
<td>$0.50</td>
<td>4.30</td>
<td>6.03</td>
<td>11.98</td>
</tr>
<tr>
<td>0.10</td>
<td>$1.50</td>
<td>1.73</td>
<td>1.95</td>
<td>2.31</td>
</tr>
<tr>
<td></td>
<td>$0.75</td>
<td>3.39</td>
<td>4.36</td>
<td>6.74</td>
</tr>
<tr>
<td></td>
<td>$0.50</td>
<td>4.99</td>
<td>7.48</td>
<td>22.72</td>
</tr>
<tr>
<td>0.31</td>
<td>$1.50</td>
<td>12.09</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$0.75</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>$0.50</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Payback period: **< 4 years** - beyond 15 years - infinite

VMT: Vehicle Miles Travelled per Year  mpg: Miles per Gallon

LNG for Articulated Trucks – Summary

• Replacement of diesel with LNG as a transport fuel for heavy articulated trucks that distribute Australia’s critical freight would provide a significant energy security enhancement.

• *Left to market, LNG penetration* of diesel fuel for trucks likely to be *only ~ 5% or less over 5 years.*

• The key economic factor for *truck operators,* assuming refuelling infrastructure is available, is *payback period - 2 years or less can be decisive.* The increased cost and availability of NG trucks is a central issue.

• The *key barrier* for LNG transport fuel penetration significantly beyond 5% is the *cost and commercial risk of scaling up to LNG plant around 1 M t/a capacity.*

• *Commercially-available technology* for LNG as a transport fuel for Australian truck requirements has been developed for all aspects of the supply chain – *but there are availability issues.*

• LNG offers important *life-cycle GHG emission reductions* over diesel with reductions at the *20% level,* together with around *50% noise reduction.*

• Overall, LNG as a transport fuel for heavy trucks is *still ‘below the line’* with regard to current supply chain economics in Australia, due to a number of detailed factors. *None of these factors appear to be insurmountable however.*

• LNG for heavy articulated trucks is only likely to happen through the *development of a compact between government and industry to forge a national roll-out plan.* Both *metropolitan* and *major highway scenarios should be considered.*

• LNG for trucks initiative *aligns well with TIC truck plan* submitted to government.
Key Recommendations

• The priority action to assess a road freight natural gas supply chain in Australia is for government and industry to jointly convene a task force of supply-chain stakeholders to examine the economics, policy and regulatory settings, costs and benefits, prospective routes and hubs to commence deployment, and examine the commercial readiness of infrastructure and technical options.

• Where the use of natural gas in road transport falls short of commercial viability in the immediate future, as a second key step the Federal Government, in consultation with state governments through the Council of Australian Governments (COAG) process, should consider the findings of the task force to determine whether intervention by regulation and government investment is appropriate.

• In the context of Australia’s energy security risk profile and to achieve greater resilience, government intervention to accelerate the uptake of natural-gas-fuelled heavy road freight beyond penetration rates anticipated from market forces alone may be appropriate.

• More specifically, establishment of natural gas supply-chain infrastructure at Port Botany, Port Melbourne and Port Brisbane hubs for metropolitan freight distribution, in addition to the key long-haul Melbourne–Sydney–Brisbane freight corridor, should be considered.

• In this consideration, Australian assembly of natural gas trucks, their emissions and safety benefits, and issues related to accessing commercial-ready fit-for-purpose natural gas engines, require detailed deliberation.
Case for Nuclear in Australia's Energy Mix?

In the context of coal and gas: driver – emissions

Some Numbers:

- Emissions – Electricity generation largest contributor to global CO₂ emissions
  2003 – 40% (10 Bt CO₂), 2030 projection – 50% of increase
- World – Average penetration of nuclear in electricity generation ~15%
- Australia – Total electricity generation ~ 250 Twh
  – 15% nuclear penetration = 5 x 1000 MW reactors
  – Uranium oxide exports ~ 8,000 – 12,000 tonnes
    = 250 – 375 Twh
    or 100 – 150% Australia's electricity generation

- Australia's uranium oxide exports displace ~ 400 Mt CO₂ each year (relative to black coal)