Unconventional Gas Production

Opportunities and Challenges - Shale Gas

Report, May 2013

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Engineering Energy: Unconventional Gas Production

Securing Australia's Future – Project Six

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Scope

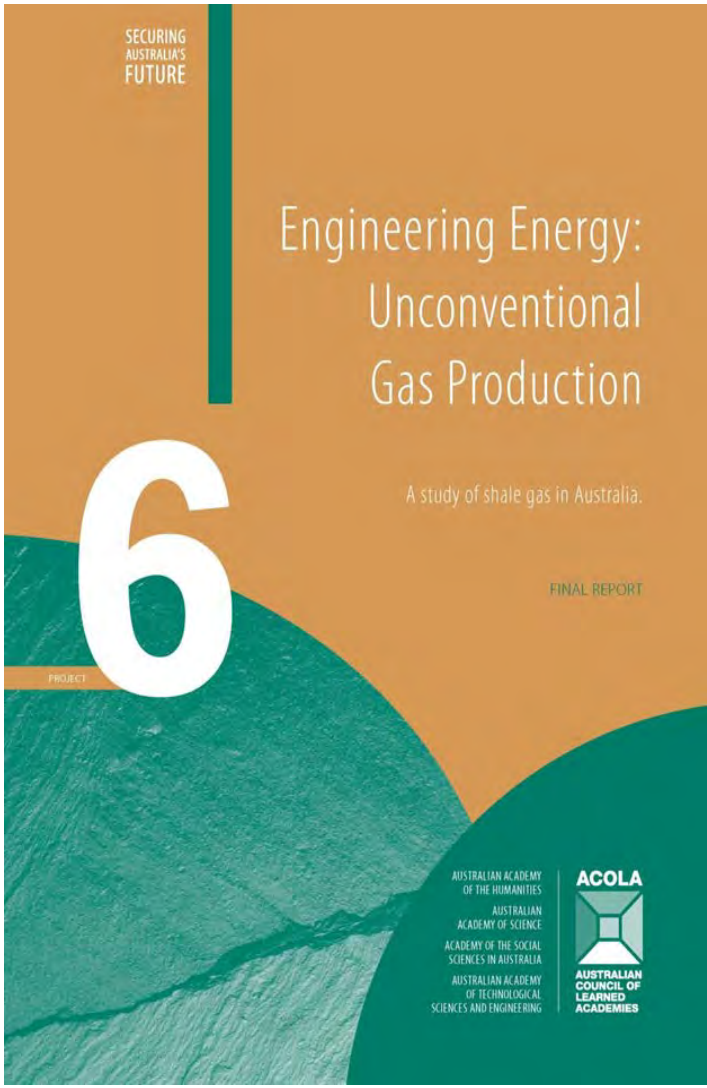
What have we got? Where is it?
- Global Gas Supply & Demand
- Gas Resources & Reserves

Economic extraction
- Technology & Engineering
- Infrastructure
- Financial Analysis

Impact on environment
- Landscape & Biodiversity
- Water Resources & Ecosystem
- Induced Seismicity
- Greenhouse Gas Emissions
- Community Issues

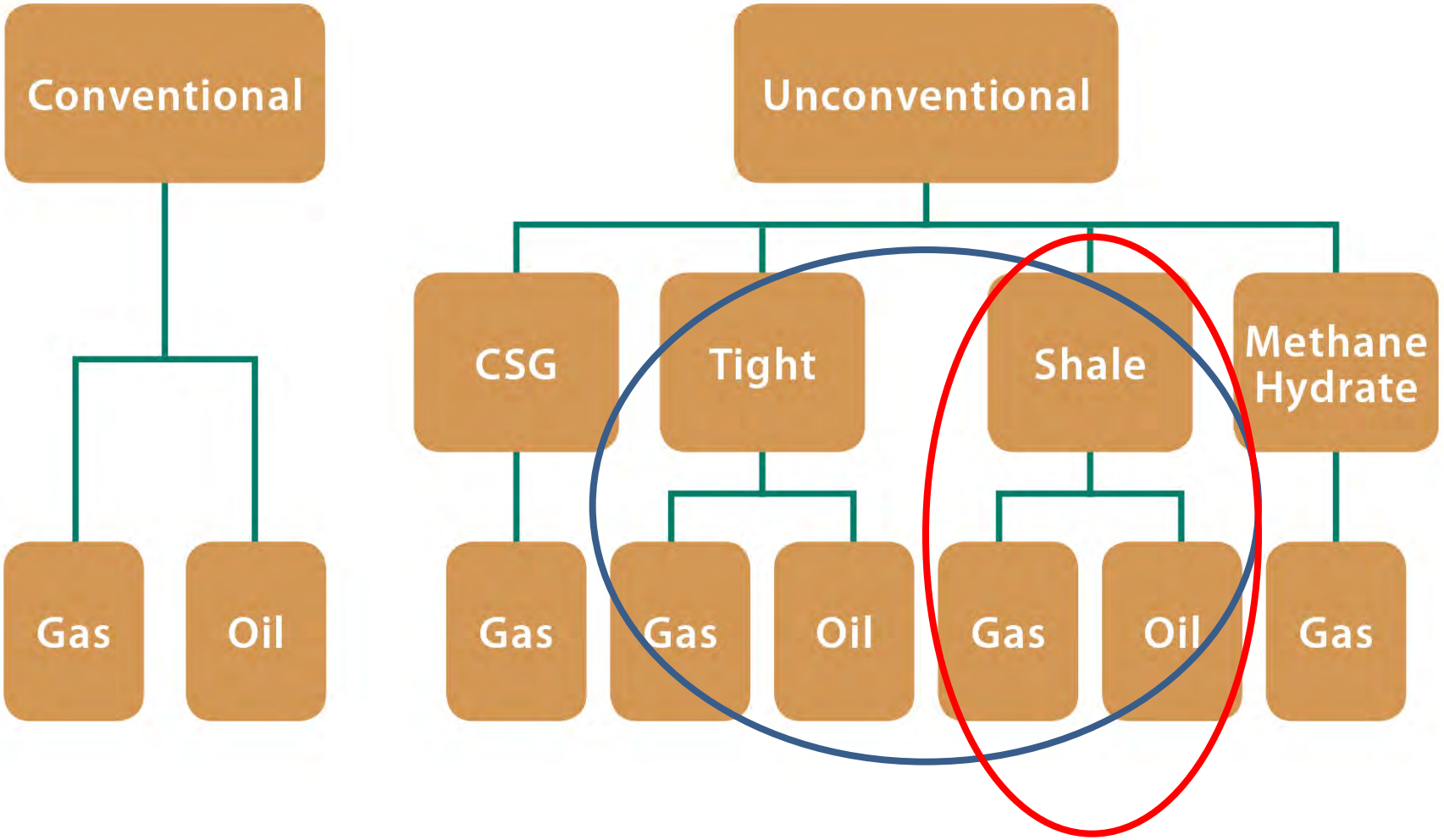
Governance
- Monitoring & Regulation
- Knowledge Needs

- {Not: Reduce fossil fuels?}



*Report available at: www.**acola.org.au***

Conventional and Unconventional Gas
Defined by its geology not by its gas type.
Natural gas is mostly methane



Difference between Shale Gas and CSG

Both composed of methane but...

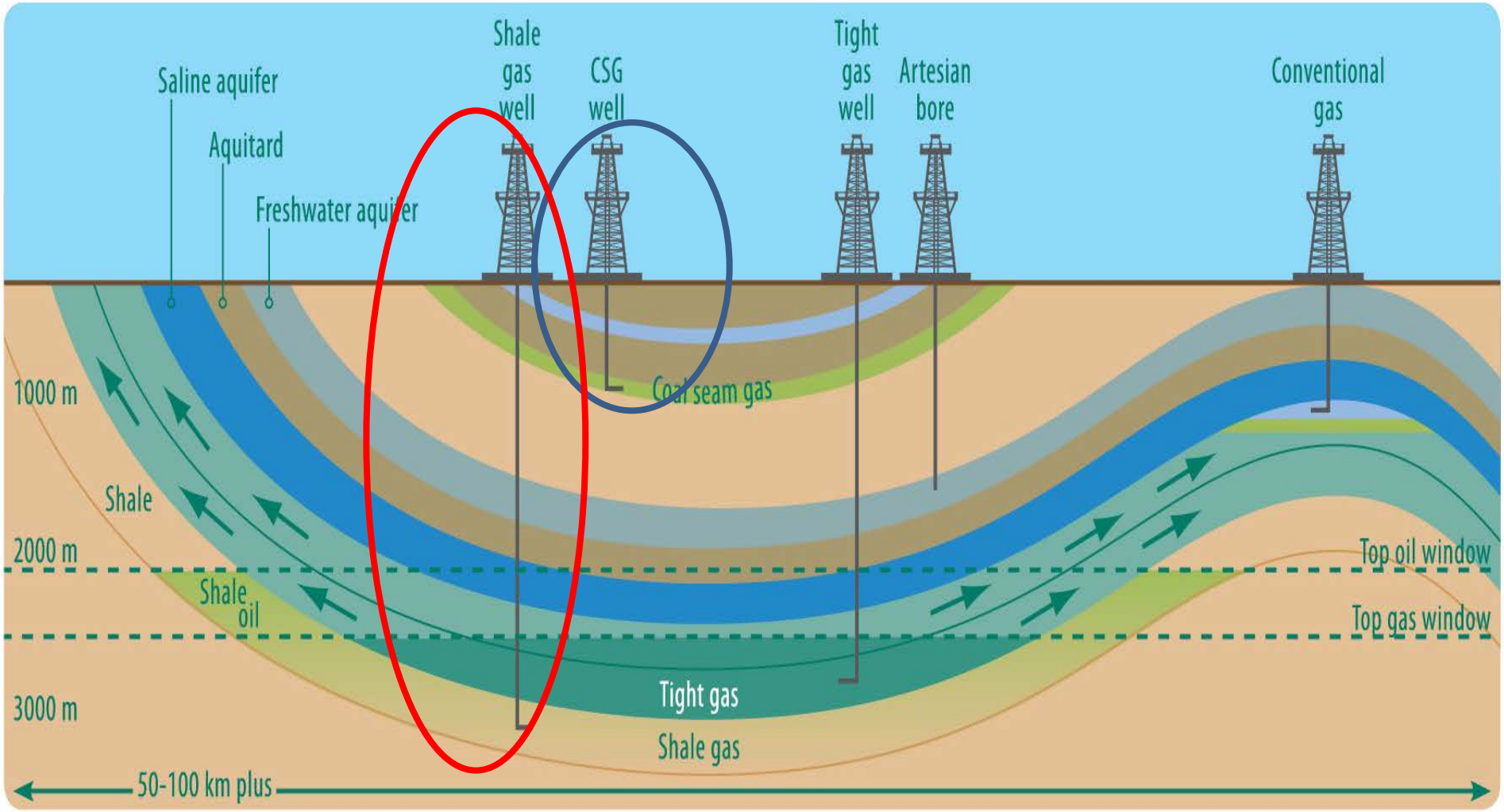
Coal Seam Gas

- Mainly in eastern Australia
- Depth ~ 300-1000m (wells cheap)
- Generally only methane
- Occurs only in coals
- Fracking sometimes necessary
- Massive amounts of produced water
- Consequential lowering of the water table
- Monitoring easier–shallow
- Well defined (2P) reserves
- Available infrastructure & markets

Shale Gas

- Especially N, W & Central Australia
- Depth approx. 2000-3000m
- Can contain valuable petroleum liquids
- Occurs in fine siltstones and shales
- Fracking always necessary
- Very little produced water
- Significant quantities of fracking fluids
- Monitoring more difficult - deep
- No defined reserves, only major resources
- Limited infrastructure & few markets

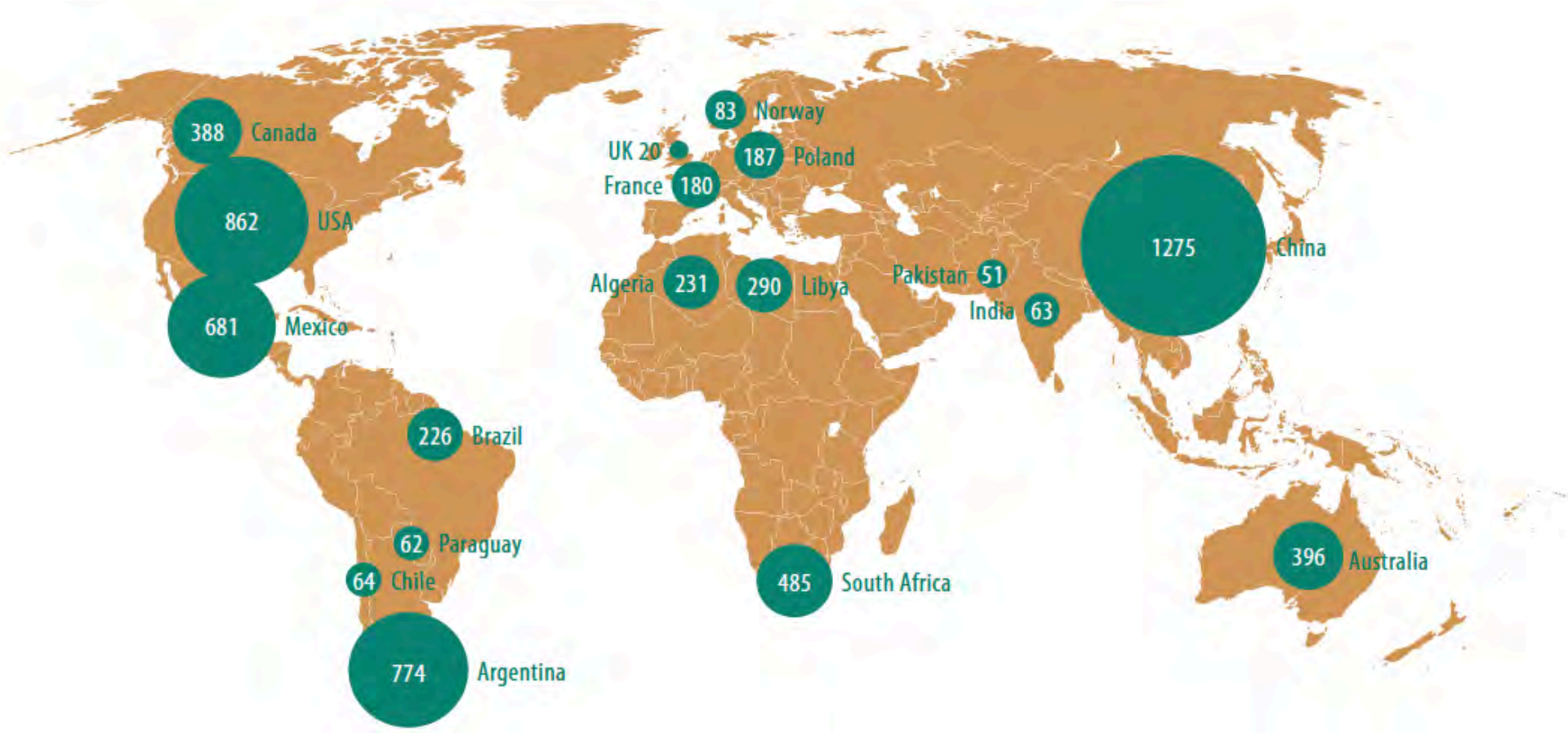
Conventional and Unconventional Gas



Source: US Energy Information Administration 2010.

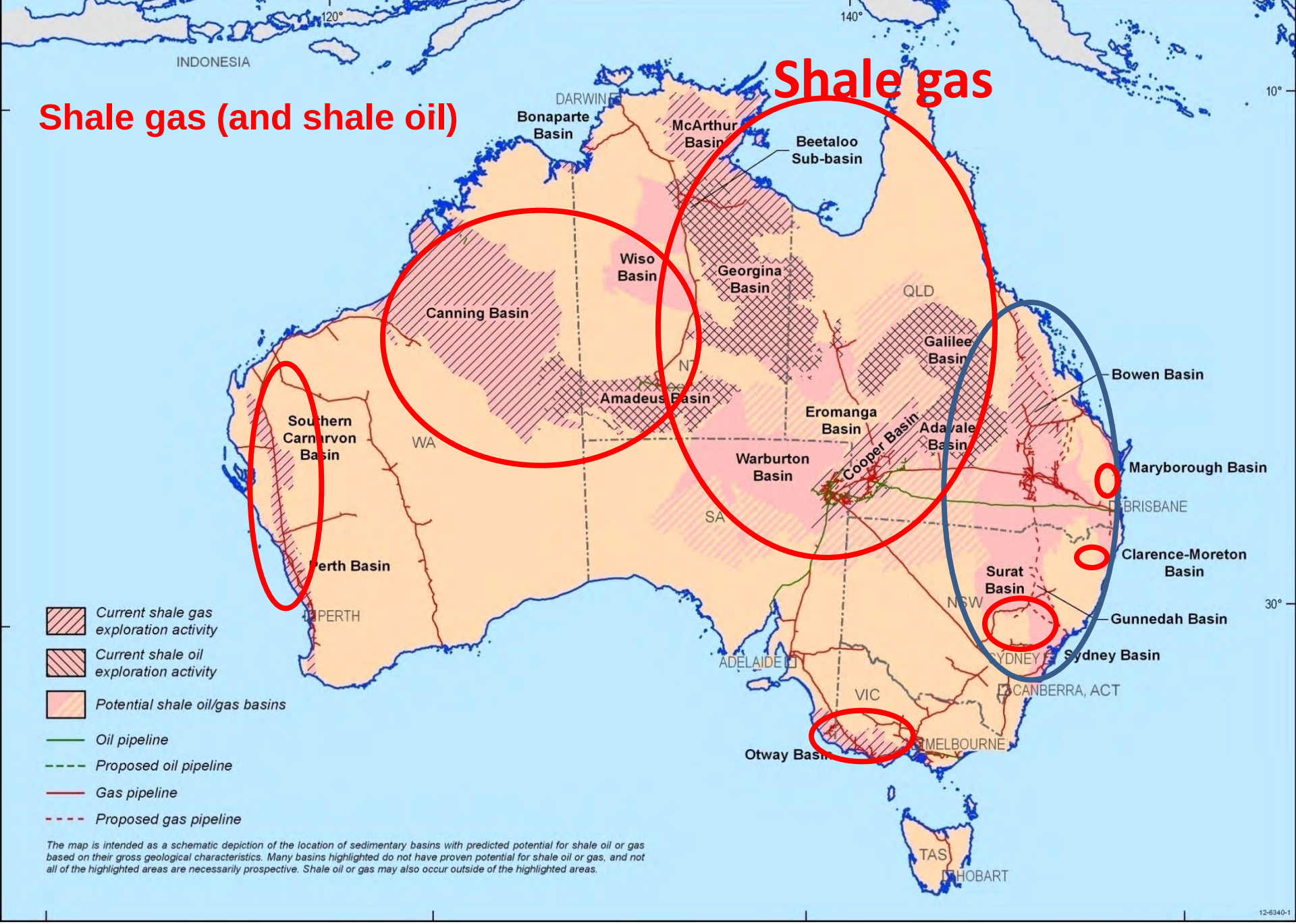
World Shale Gas Resources

(Australia gas consumption: 1.38 tcf/y)



Estimates of technically recoverable shale gas resources (trillion cubic feet, tcf) based on 48 major shale formations in 32 countries (EIA 2011) Russia, Central Asia, Middle East, South East Asia and central Africa were not addressed in the Energy Information Administration report from which this data was taken.

Source: EIA 2012


Shale gas (and shale oil)
Shale gas
INDONESIA
120°
140°
10°
30°
DARWIN
Bonaparte Basin
McArthur Basin
Beetaloo Sub-basin
Wiso Basin
Georgina Basin
Canning Basin
QLD
Galilee Basin
Bowen Basin
NT
Amadeus Basin
Eromanga Basin
Cooper Basin
Adavale Basin
Southern Carnarvon Basin
WA
Warburton Basin
Maryborough Basin
BRISBANE
SA
Clarence-Moreton Basin
Perth Basin
Surat Basin
NSW
Gunnedah Basin
PERTH
SYDNEY
Sydney Basin
ADELAIDE
CANBERRA, ACT
VIC
Otway Basin
MELBOURNE
TAS
HOBART
Current shale gas exploration activity
Current shale oil exploration activity
Potential shale oil/gas basins
Oil pipeline
Proposed oil pipeline
Gas pipeline
Proposed gas pipeline
The map is intended as a schematic depiction of the location of sedimentary basins with predicted potential for shale oil or gas based on their gross geological characteristics. Many basins highlighted do not have proven potential for shale oil or gas, and not all of the highlighted areas are necessarily prospective. Shale oil or gas may also occur outside of the highlighted areas.
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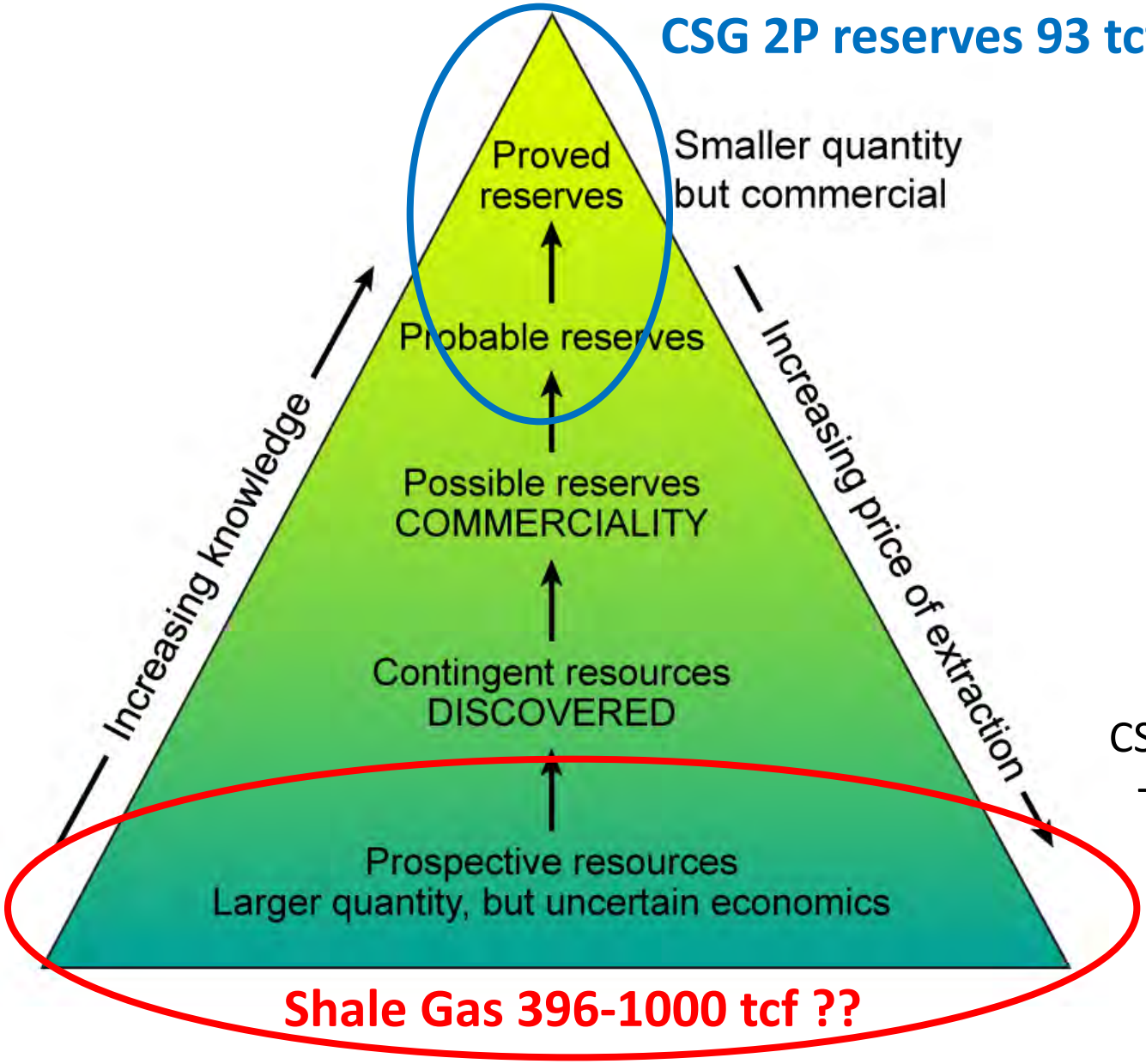
Resources and Reserves



Conv. Gas
167 tcf

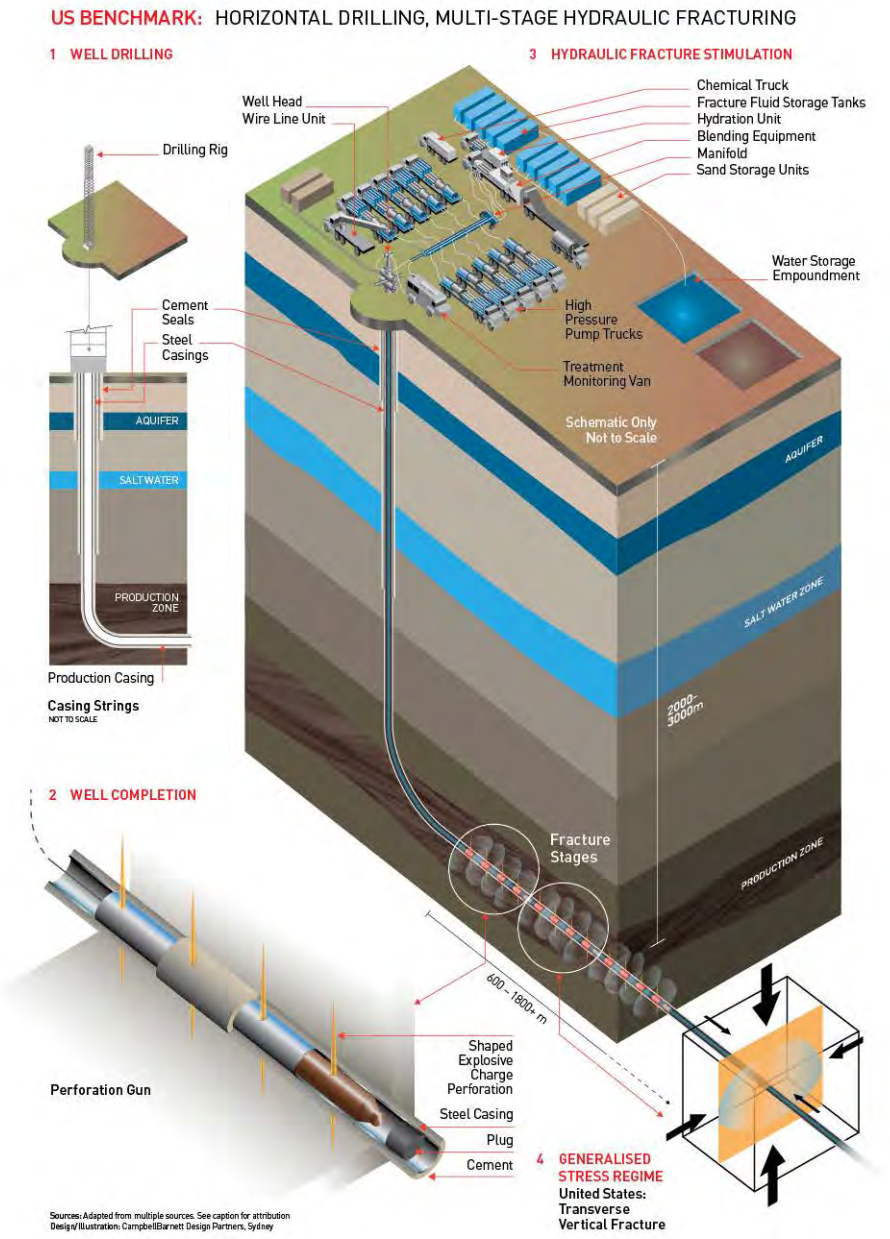
CSG 203 tcf
T.G. 20 tcf

Technology and Engineering

Central technology components for shale gas include

- Reduced drill time
- Well completions
- Horizontal drilling
- Multiple wells from a single well pad
- Multiple hydraulic fracturing (fracking)
- Real time sensing technology

All of these are **applicable to Australia – but with tailoring** to suit particular Australian geological, environmental and economic conditions



Well Drilling and Hydraulic Fracturing in Australia

1. Relief / Flowback lines
2. Backpressure pump and water supply
3. 15k psi fracture stimulation wellhead
4. Pump units
5. Proppant storage
6. High pressure pump lines
7. Diesel fuel storage
8. Blenders
9. Control vans
10. Water supply
11. Water tanks
12. Electric wireline unit
13. Chemicals and additives
14. Gel hydration blender

Infrastructure

- Suitable drilling rigs in short supply - may delay development
- Pipeline & roads **far less developed** than the USA - access to domestic markets more restricted.
- Cost competitive **manufacturing opportunities** may be limited
- Access to specialist skills an issue

- Could provide **infrastructure stimulus** to areas that currently lack it
- Possible thousands of jobs

Economics: Drivers and Financial Analysis

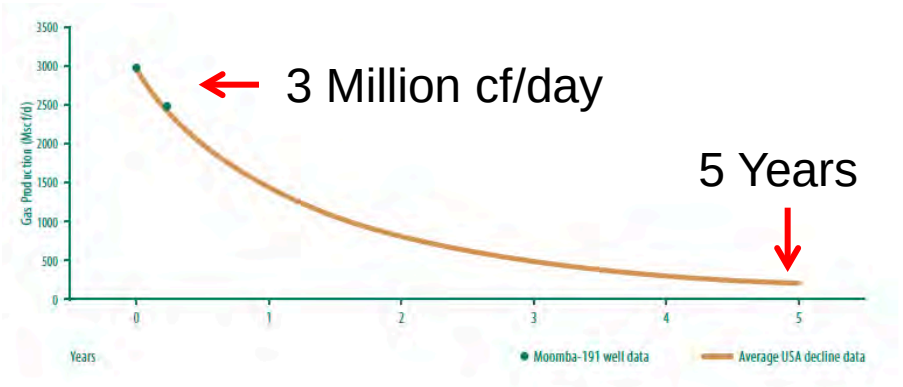
Drivers

- 2P reserves of CSG almost fully committed to export LNG from 2015-2016
- Cost of US shale gas possibly at or below some gas price projections for E Australia
- Shale oil and NGLs can be a driver for overall shale gas economics

Analysis

- Current low price of US shale gas not sustainable ($3/ GJ)
- Capital intensity of shale gas extraction is significantly higher in Australia than US
- Estimate of well head prices for shale gas $6-9/GJ – cf east coast domestic prices of $4/GJ, netback price of $10 GJ for gas to Japan

Shale Gas Well Decline Curve



Landscape and Biodiversity

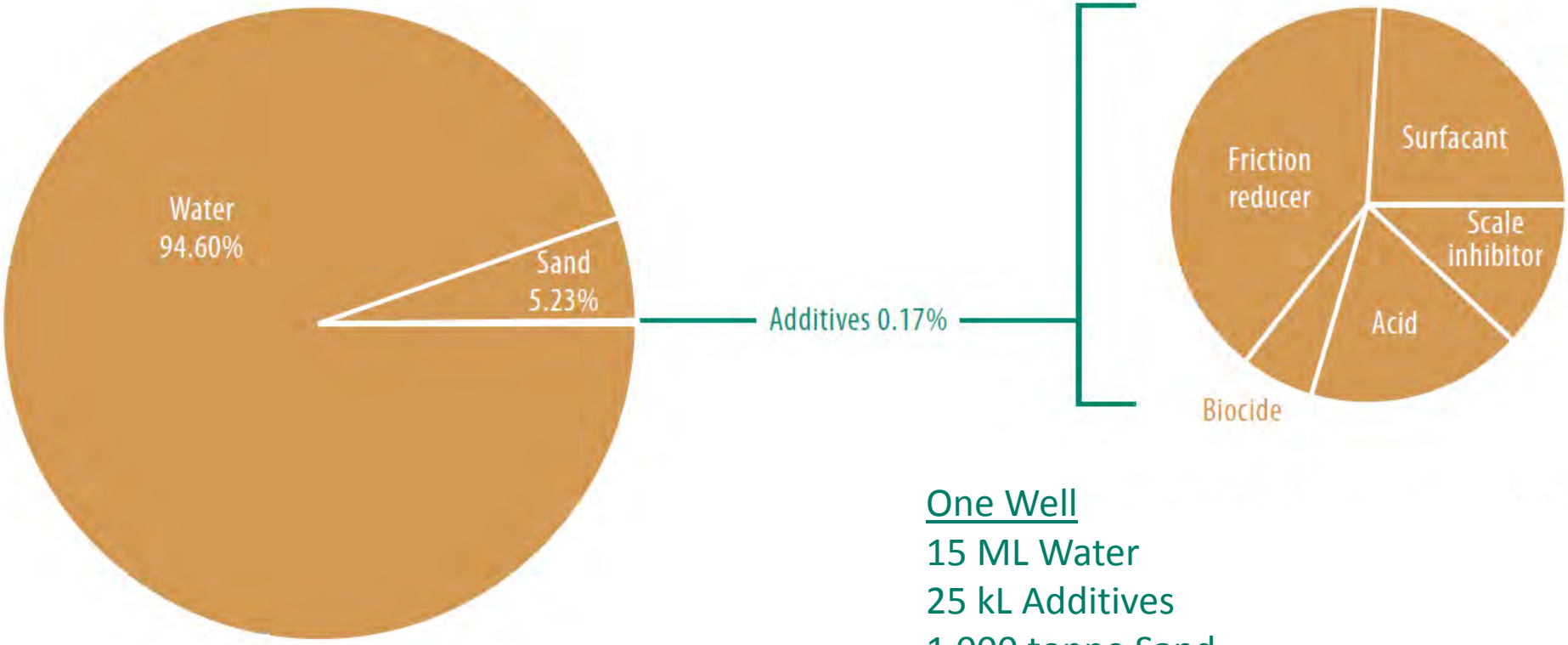
Shale Gas – aggregated and cumulative impacts

CSG, Queensland

Cooper Basin

- Infrastructure-related surface disturbance might include:
  - Fragmentation of habitats, landscape function
  - Loss of ecological communities, threatened species habitats
  - Increase in invasive species
- Prior strategic environmental assessment desirable
  - Use of cumulative risk assessment tool

Composition of Fracking Fluid



Source: British Geological Survey

<u>One Well</u>

15 ML Water

25 kL Additives

1 000 tonne Sand

Water

The volume of water used for shale gas fracking is large ; the total amount of **water produced** over the life of the project is small; the reverse of CSG

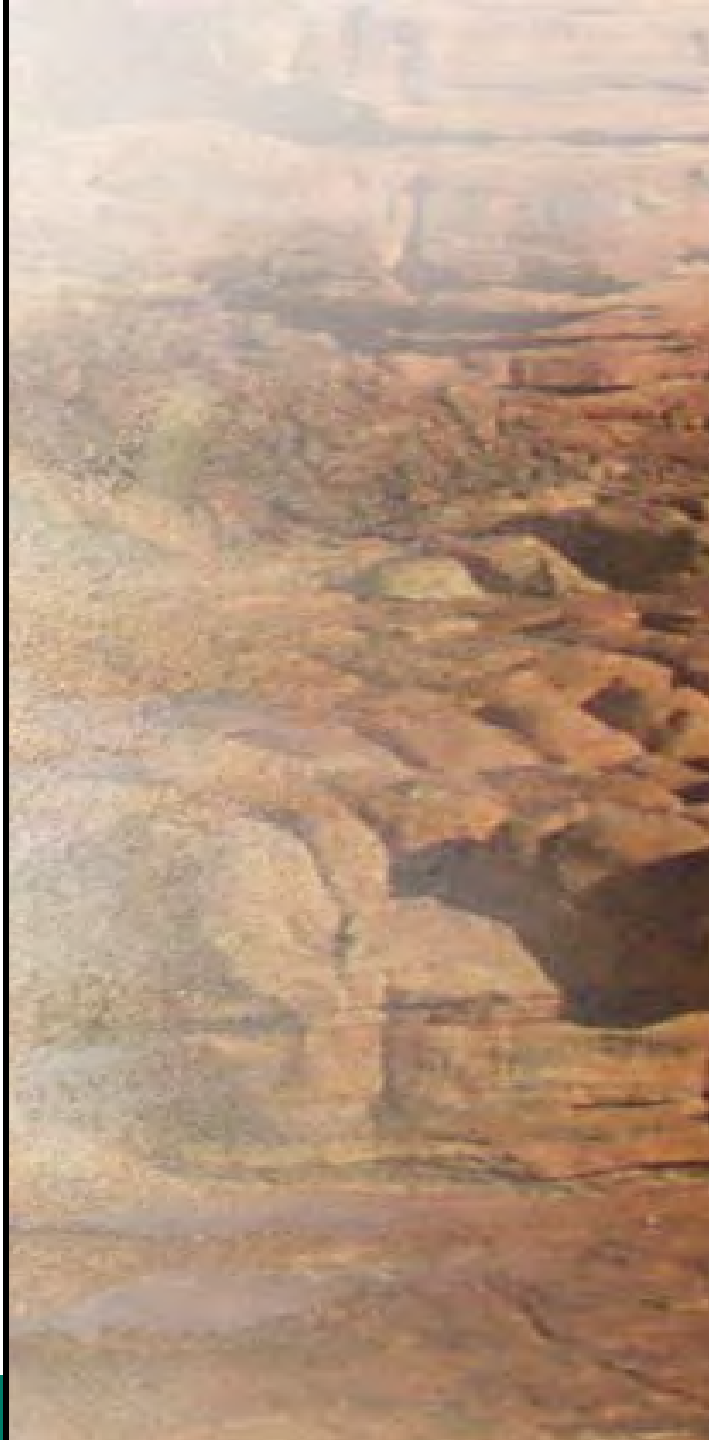
Parameter (unit)	Quantity for One Well	Annual Well Development		Coal Seam Gas
		Low	High	
Number of Wells	**1**	**20**	**500**	1
Water Consumption (ML)	**15**	**300**	**7,600**	
Flowback (ML)	**7.5**	**152**	**3,800**	
Produced Water (ML)	**0.28**	**5.7**	**142.5**	**7 – 300 ML/well/yr**

Summary estimates for impact assessment of natural gas production in the New York City water supply watershed. Source: New York City Department of Environmental Protection, 2009.

NSW Government, Managing Coal Seam Gas Produced Water

Induced Seismicity

- Many cases of induced seismicity in Australia associated with large dams, mining and geothermal
- Overseas evidence suggests re injection of produced water can result in induced seismicity of 3-4 magnitude
- Very few cases of low magnitude induced seismicity from **fracking**
- Leading practice involves geological characterisation of faults, real time monitoring, and prescribed ‘cease work’ triggers



Greenhouse Gas Emissions

- GHG Emissions at: extraction, production & use
- In addition to ‘usual gas’ GHG emissions, shale gas produces extra emissions – at initial well completion (flowback)
- “Green completions” can minimise methane emissions at Flowback
- Using shale gas in gas turbines results in ~20% more emissions than conventional gas, but 50-75% emissions of black coal – significant GHG emissions reductions
- Some shale gas may be high in CO2 and carbon capture and storage may needed.

Community Issues

- CRITICAL: Gaining and retaining a **Social Licence to Operate. Need:**
- **Building trust and respect**
  E.g. a transparent approach to collection and dissemination of data
- **Dialogue** - how shale gas development might address other societal priorities such as improved infrastructure?

- **Native Title or Aboriginal Lands**; important scale and impact of developments is fully understood
- Existing compensation schemes appropriate?
- Some overseas health concerns regarding emissions; limited data for CSG in Australia does not indicate a problem.
- Need for health risk assessment in potentially impacted local populations

Best Practice

- Reliable resource-reserve assessment
- Excellent baseline data
- Informed risk assessment – holistic approach
- High integrity well completions
- Effective monitoring
- Effective mitigation and remediation strategies
- A transparent Regulatory Regime
  & companion Codes of Practice
- Meaningful consultation

Office of the Chief Scientist: Recommendations – June 2013 PMSEIC

- **Recommendation 1**
  Support the scientific, economic and social research required to facilitate the safe and sustainable development of a new source of natural gas and oil
  - including social acceptance & effective management regimes & regulatory frameworks.

- **Recommendation 2**
  Develop a comprehensive environmental risk assessment plan to monitor, and mitigate impacts of exploration and production on landscape and biodiversity.

- **Recommendation 3**
  Research to understand the structure and dynamics of Australia's sedimentary basins that contain natural gas and oil associated with shale.

- **Recommendation 4**
  Through relevant frameworks (e.g. Commonwealth and COAG) build an efficient, transparent and effective regulatory system to achieve a resilient "compact" between the industry and communities.

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THANK YOU

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DISCLAIMER

- This presentation summarises outcomes of the ACOLA Review of Unconventional Gas in Australia
- The Review, which focuses on shale gas, was undertaken to inform government policy
- The Review was not undertaken as a guide to investing in shale gas, or other resources, or to any activities or industries that might relate in any way to shale gas
- Investors in shale gas-related projects or resources should obtain their own independent advice