Opportunities for the Reduction of Industrially Generated Carbon Dioxide (CO_2) in the South West

SOUTH WEST HUB
CARBON CAPTURE STORAGE

CRITICAL HORIZONS: Powering the Future of WA

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Overview

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- A range of strategies
- Coal internationally
- Coal opportunities
- Why Carbon Capture and Storage (CCS)
- Decarbonising Electricity
- South West Hub
- Modelling Results
- Next Steps

Disclaimer – The material in this presentation has been obtained from a range of sources and the views expressed by the presenters are not necessarily the views of those contributors.

IEA Blue Map 2017

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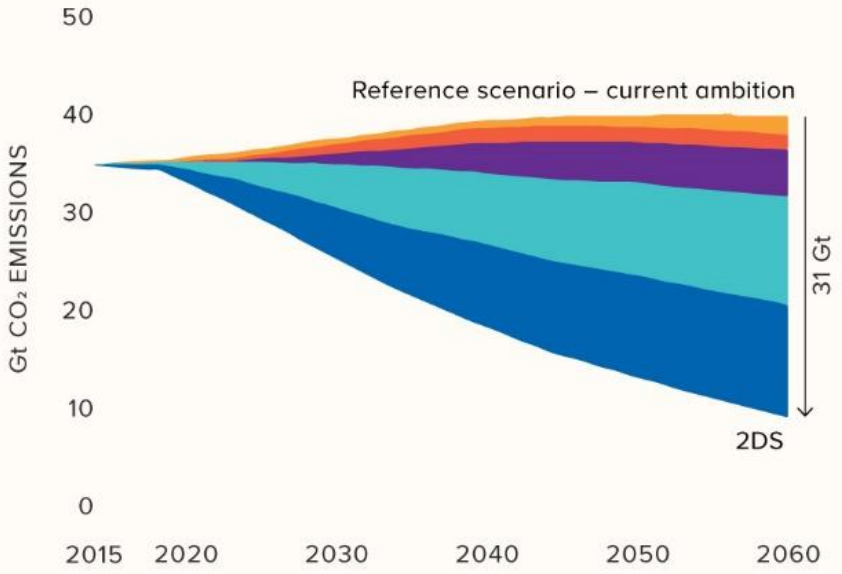
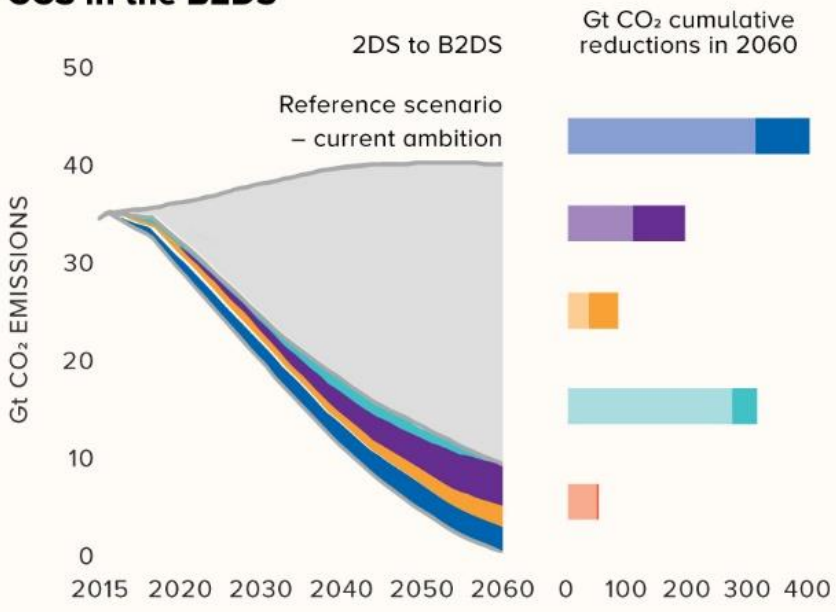
CCS in the 2DS



Source: International Energy Agency, "Energy Technology Perspectives 2017", Paris: OECD/IEA, 2017

- Efficiency 40%
- Renewables 35%
- CCS 14%
- Nuclear 6%
- Fuel switching 5%

CCS in the B2DS



Source: International Energy Agency, "Energy Technology Perspectives 2017", Paris: OECD/IEA, 2017

- Efficiency 34%
- CCS 32%
- Fuel switching 18%
- Renewables 15%
- Nuclear 1%

Coal and the Energy Trilemma

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Three goals of sustainable energy systems

- Affordability ✓
- Security and reliability ✓
- Low emissions X

==========

- Low emissions
  - Coal with CCS ✓

International Coal Demand – IEA 2017

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- Global demand for coal should remain nearly flat between 2017 and 2022
- Global coal consumption fell 1.9% to 5,357 million tonnes of coal equivalent (Mtce) last year, the second year of decline, because of lower gas prices, a surge in renewables and improvements in energy efficiency
- By 2022, global coal demand is expected to reach 5,530 Mtce
- “The energy system is evolving at a rapid pace all around us, with a more diversifying fuel mix, and the cost of technologies going down. But while everything else is changing, global coal demand remains the same”
  - » *Keisuke Sadamori, the International Energy Agency’s director for energy markets and security*

New generation capacity under development Global – as at June 2017

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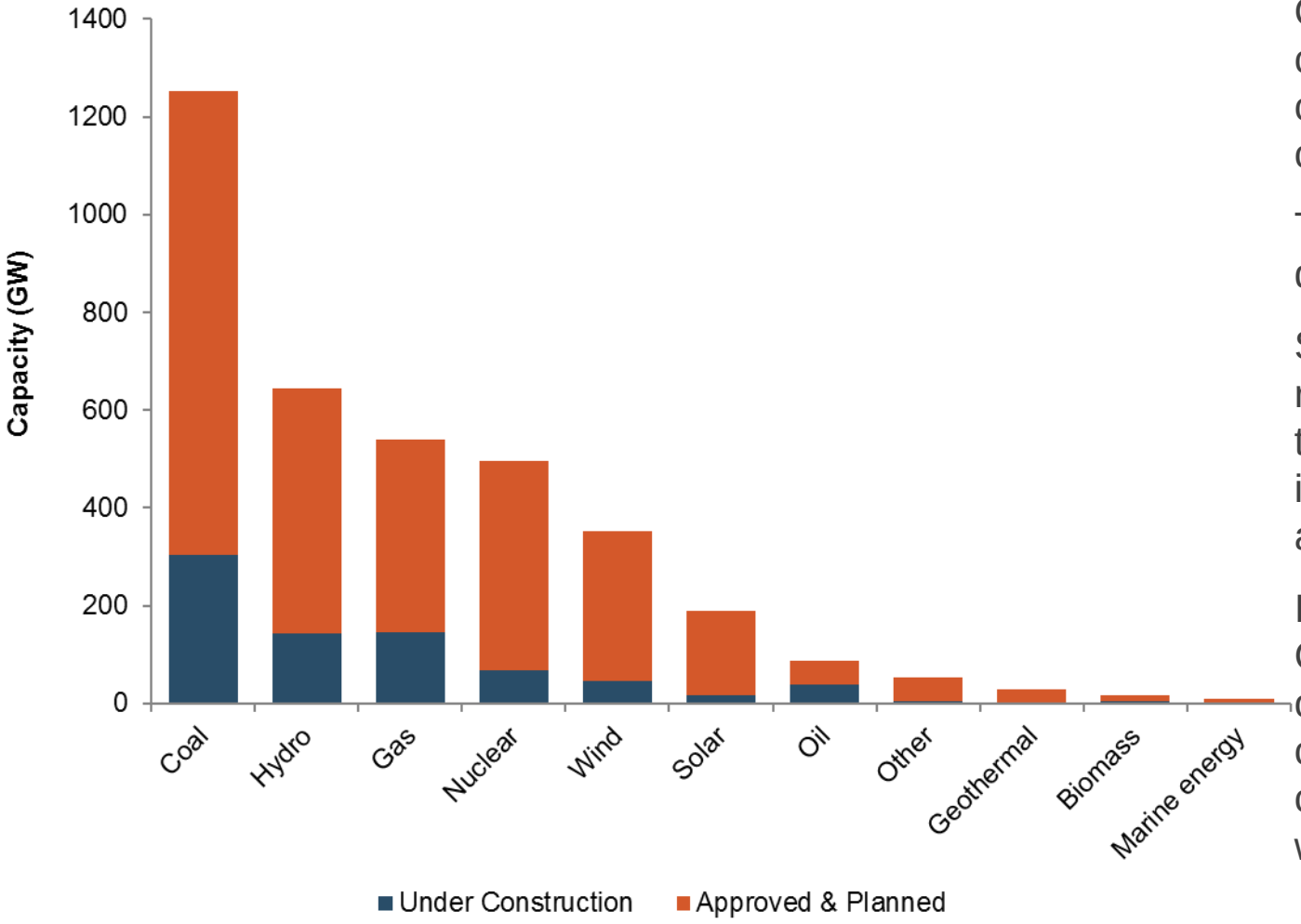

Over 300 GW of new coal fired capacity is currently under construction

There are plans to develop another 950 GW

Some of this will replace retiring older plants, but there will still be a net increase in capacity – and coal demand

In comparison, only 47 GW of wind and 17 GW of solar capacity are currently under construction around the world

Source: Enerdata

Global Electricity Mix 2014 - 2040

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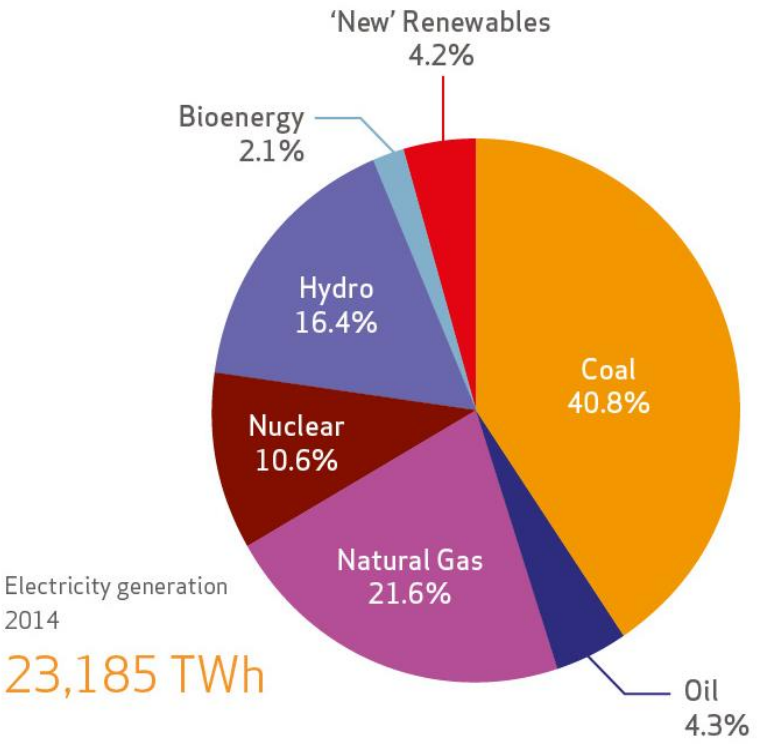
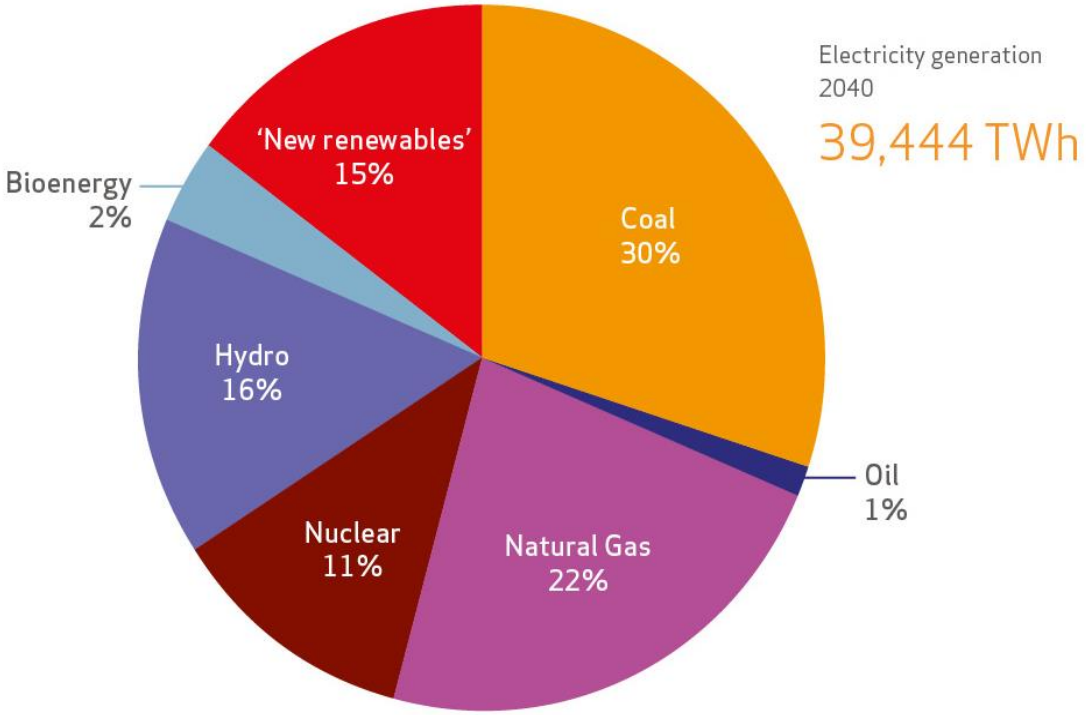
Global Electricity Mix





Source: IEA WE 02015 – New Policies Scenario and 2016 key Electricity Trends

Australian Coal Demand - Finkel 2017

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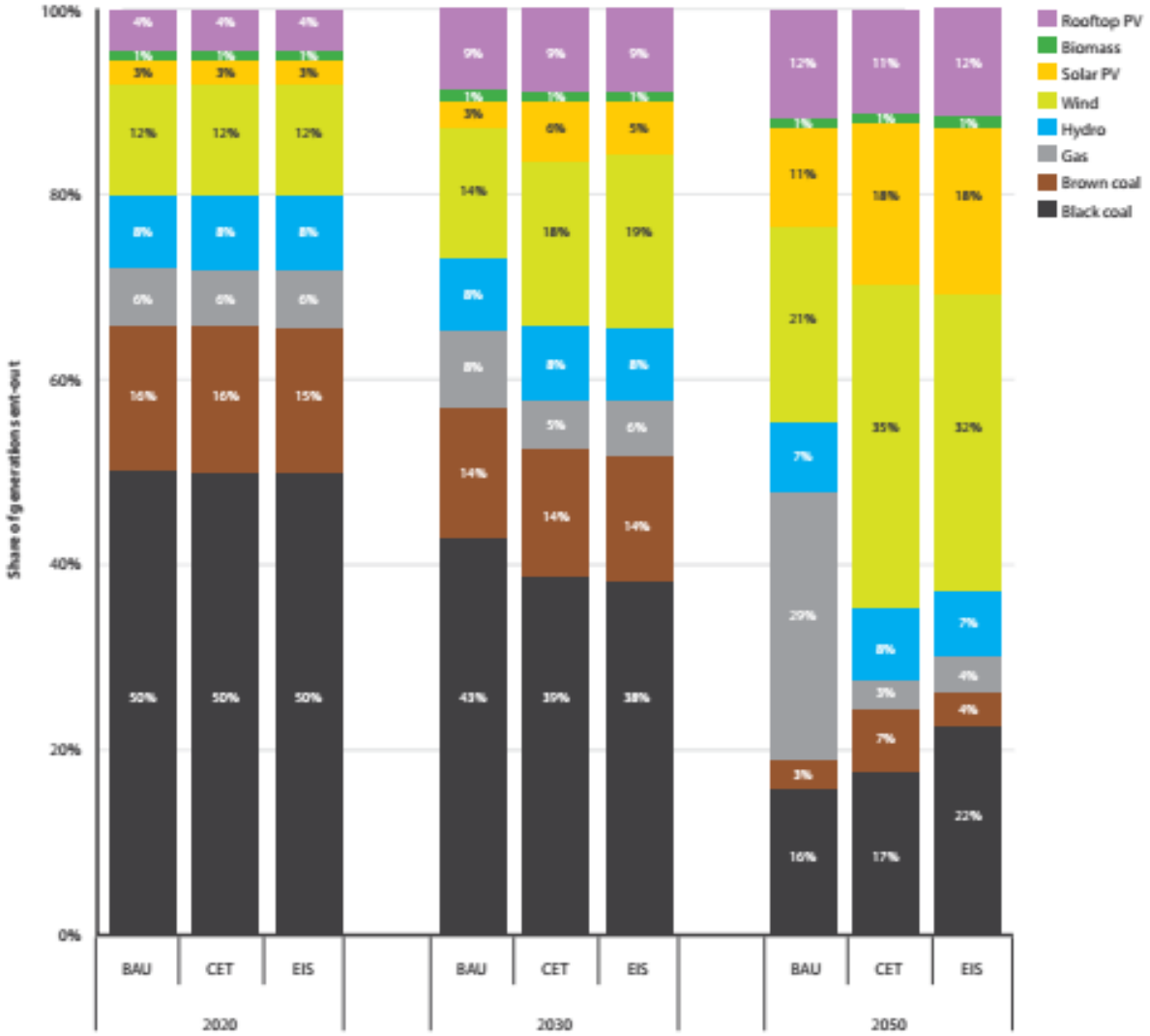
Figure 3.8: NEM generation mix, 2020, 2030, 2050[184]



HELE in Japan

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- Japan is planning to build 45 new HELE coal fired power stations *(ABC - 31 January, 2017)*

HELE Plant at Isogo (Yokohama)

- 2 x 600Mw units in Yokohama City
- Renewed in 2002 and 2007 to Ultra Supercritical
- Efficiency of 45% - generating 17% less CO_2

Don’t Forget other Coal Uses

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- Coking coal - is mainly used in steel production
- Other important users of coal include alumina refineries, paper manufacturers, cement production and the chemical and pharmaceutical industries
- Several chemical products can be produced from the by-products of coal. Refined coal tar is used in the manufacture of chemicals, such as creosote oil, naphthalene, phenol, and benzene. Ammonia gas recovered from coke ovens is used to manufacture ammonia salts, nitric acid and agricultural fertilisers. Thousands of different products have coal or coal by-products as components: soap, aspirins, solvents, dyes, plastics and fibres, such as rayon and nylon

Don't Forget other Coal Uses – and here are more

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Coal is also an essential ingredient in the production of specialist products:

- Activated carbon - used in filters for water and air purification and in kidney dialysis machines
- Carbon fibre - an extremely strong but light weight reinforcement material used in construction, mountain bikes, tennis rackets and various other sporting goods
- Silicon metal - used to produce silicones and silanes, which are in turn used to make lubricants, water repellents, resins, cosmetics, hair shampoos and toothpastes

Hydrogen Opportunities

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- WA coals have tested the best of black coals for gasification
- Must be linked to CCS
- Japan has hydrogen strategy
  - Victoria is pursuing the supply utilising brown coal and CCS
- Opportunities exist for Collie coal in hydrogen fertiliser and coal to liquids

10 THE AUSTRALIAN, FRIDAY, APRIL 13, 2018
theaustralian.com.au

Chief Scientist talks up green hydrogen

EXCLUSIVE

BEN PACKHAM

Chief Scientist Alan Finkel's hydrogen power strategy group says Australia could soon be "exporting sunshine" in the form of renewable energy-produced hydrogen, creating an industry that could rival Australia's LNG exports within decades.

The Turnbull government — beset by internal critics over its approach to energy policy — yesterday announced a $50 million investment towards a $500m world-first hydrogen project in the Latrobe Valley, which will produce the gas using brown coal.

But the Finkel-led strategy group sees so-called "brown hydrogen" as a stepping stone to "green hydrogen" produced using excess solar and wind capacity.

The group, which includes senior bureaucrats and industry representatives, has no formal authority but seeks to set a vision for hydrogen power, provide information to government and stakeholders, and support proponents of hydrogen projects.

In a recent meeting, the group discussed opportunities to "take advantage of our abundant wind and solar resources by 'exporting sunshine' as hydrogen", and "near-term opportunities to export hydrogen produced by fossil fuels".

Hydrogen has huge potential as a clean energy source, but is currently uneconomical to produce and export at scale. It can be created through electrolysis of water, or through gasification or particle oxidation of hydrocarbon fuels.

The group acknowledges the "green hydrogen story is more saleable than brown hydrogen" but says brown hydrogen is closer to being commercialised.

It believes the government needs to facilitate further technological development and uptake through regulatory oversight.

Japan is embracing hydrogen, which produces heat and water vapour when burned, in a national strategy to create an emissions-free "hydrogen society" by 2030.

Siemens head of strategy Martin Hablutzel, who sits on the strategy group, said the shift to green hydrogen, produced by excess solar and wind energy, would allow Australia to "export sunshine" on a large scale.

"We should have ambition to build an industry of that scale," Mr Hablutzel said. "We've got cheap land. And we have as-good-as-it-gets assets, solar and wind assets that are untapped."

He said a Siemens pilot plant in South Australia was already producing hydrogen from electricity, which was being injected into Adelaide's natural gas grid.

Another member of the group, Australian Renewable Energy Agency chief executive Ivor Frischknecht, said Australia's potential as a renewable-energy producer gave it an advantage as a hydrogen producer.

"As an export industry we are talking tens of billions of dollars, but that is some decades away," he said.

ARENA launched a $20m funding round last year to support the development of technology to enable hydrogen to be exported more efficiently using "carriers" such as ammonia.

The Latrobe Valley project is being delivered by a consortium of Japanese and Australian companies, including Kawasaki Heavy Industries, J-Power (Electric Power Development Co, Iwatani Corporation, Marubeni and AGL.

Pollies peddling different visions for Gippsland's future

The backdrop may be the same, but visits by Tony Abbott and Malcolm Turnbull to Victoria's coal country this week were miles apart.

On a charity bike ride through the Latrobe Valley on Monday, Mr Abbott called for a return to coal-fired power generation as he urged the Coalition to become the "party of low power prices" and increase baseload reliability.

It was a different vision from the Prime Minister yesterday.

On the site of the Loy Yang A power station, Mr Turnbull launched a "clean energy" world-first pilot project which will see coal turned into hydrogen to be shipped to Japan.

DAVID GURAGHTY

Malcolm Turnbull at Loy Yang power plant in Victoria

"It's amazing to think brown coal in Victoria is going to be keeping the lights on in Japan," Mr Turnbull told those gathered at the plant, including Liberal ministers Michaelia Cash, Josh Frydenberg, Tim Wilson and Nationals MP Darren Chester.

"It is critically important we invest in the energy sources of the future and we effect the transition from older forms of generation to new generation and do so seamlessly."

The $500m project, a joint venture between the federal and Victorian governments and a consortium of Japanese companies, will convert brown coal from AGL's Loy Yang mine into hydrogen at a nearby site. The gas will be transported by road to a liquefaction terminal at the Port of Hasting and then shipped to Japan.

The government says the pilot project will create 400 jobs, and if successfully commercialised will funnel thousands more to the region, which has high unemployment since the closure of Hazelwood.

"This project will ensure there are more jobs, for Latrobe Valley workers not just today but in decades to come," Mr Turnbull said. "This is the cutting-edge technology, this is energy of the future, it underlines the importance of having a technology agnostic approach to energy."

Japanese Trade Minister Daisaku Hiraki said the program was part of a wider response to the worldwide challenges associated with global warming.

"Australia and Japan bear responsibility to make it a successful project," he said.

The politicians in Victoria's Gippsland yesterday were there just days after the Pollie Pedal charity ride brought the former PM to the area. "If it's right and proper to export coal, surely it's right and proper to use it in this country and continue to be a country that makes things," Mr Abbott said on Monday.

SIMONE FOX KOOB

Government of Western
Department of Mines, Indu

Why Carbon Capture and Storage ?

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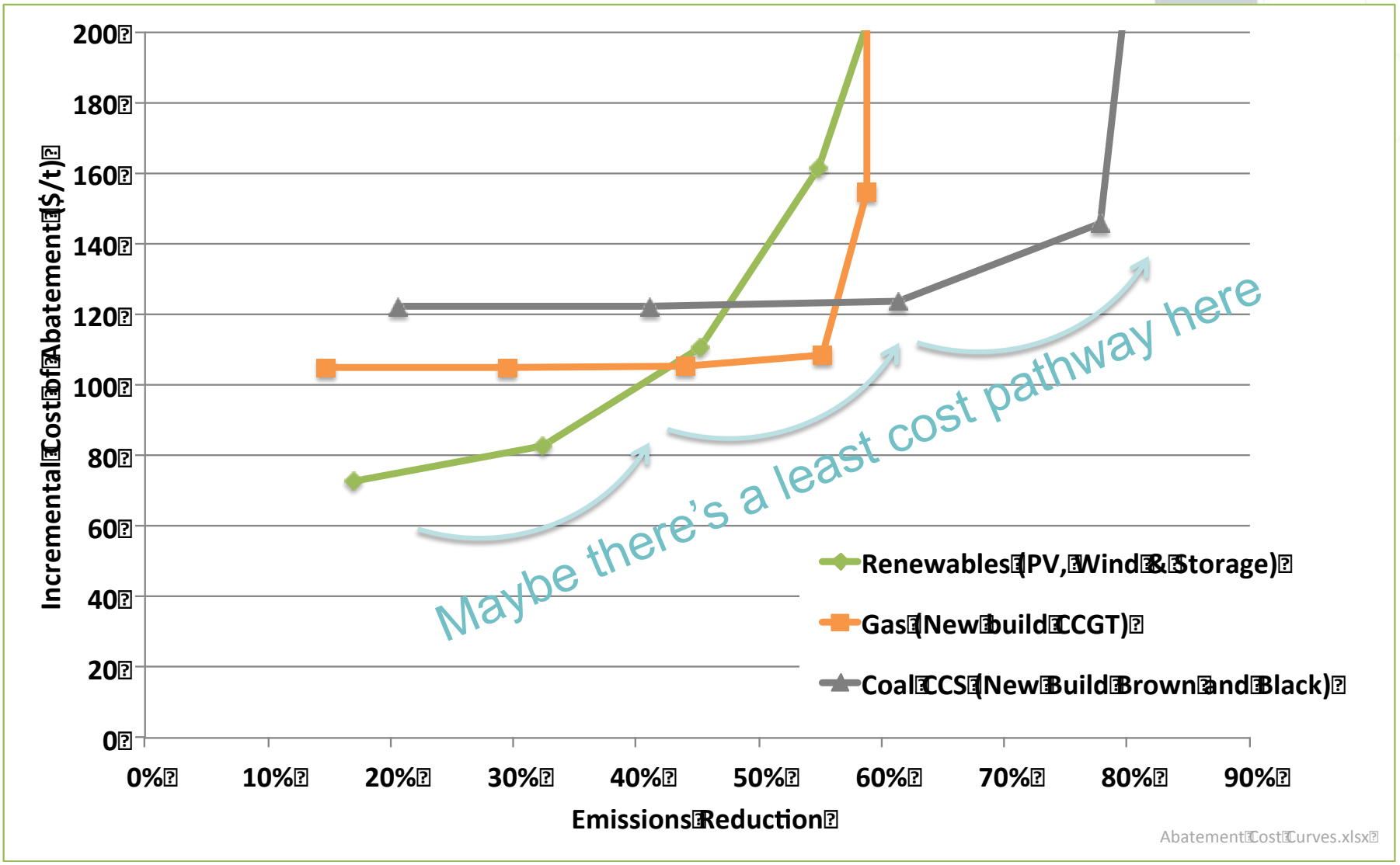
- CCS is an important part of the lowest-cost greenhouse-gas mitigation portfolio. Without CCS, overall costs to halve emissions by 2050 rise by 70%
- CCS is more than a strategy for “clean coal”. CCS is effective for all fossil fuel power sources (gas, coal & oil)
  - CCS technology must be adopted by biomass and gas power plants, in the fuel transformation and gas processing sectors, and in emissions-intensive sectors like cement, iron and steel, and chemicals manufacturing including Alumina
- The effect of building coal with Carbon Capture and Storage (CCS): the initial steps are more expensive than renewables, but the abatement cost curve crosses over around 45%, after which renewables becomes a more expensive way of decarbonising the system. Of all the options explored, CCS offers the potential to go the furthest, achieving 80% emissions reduction

NEM: Managing Flexibility Whilst Decarbonising Electricity

www.anlecrd.com.au



Large-scale CCS facilities

17 large-scale facilities are operational; more to come

Archer Daniel Midland – Decatur, Illinois
Corn to Biofuel to CCS

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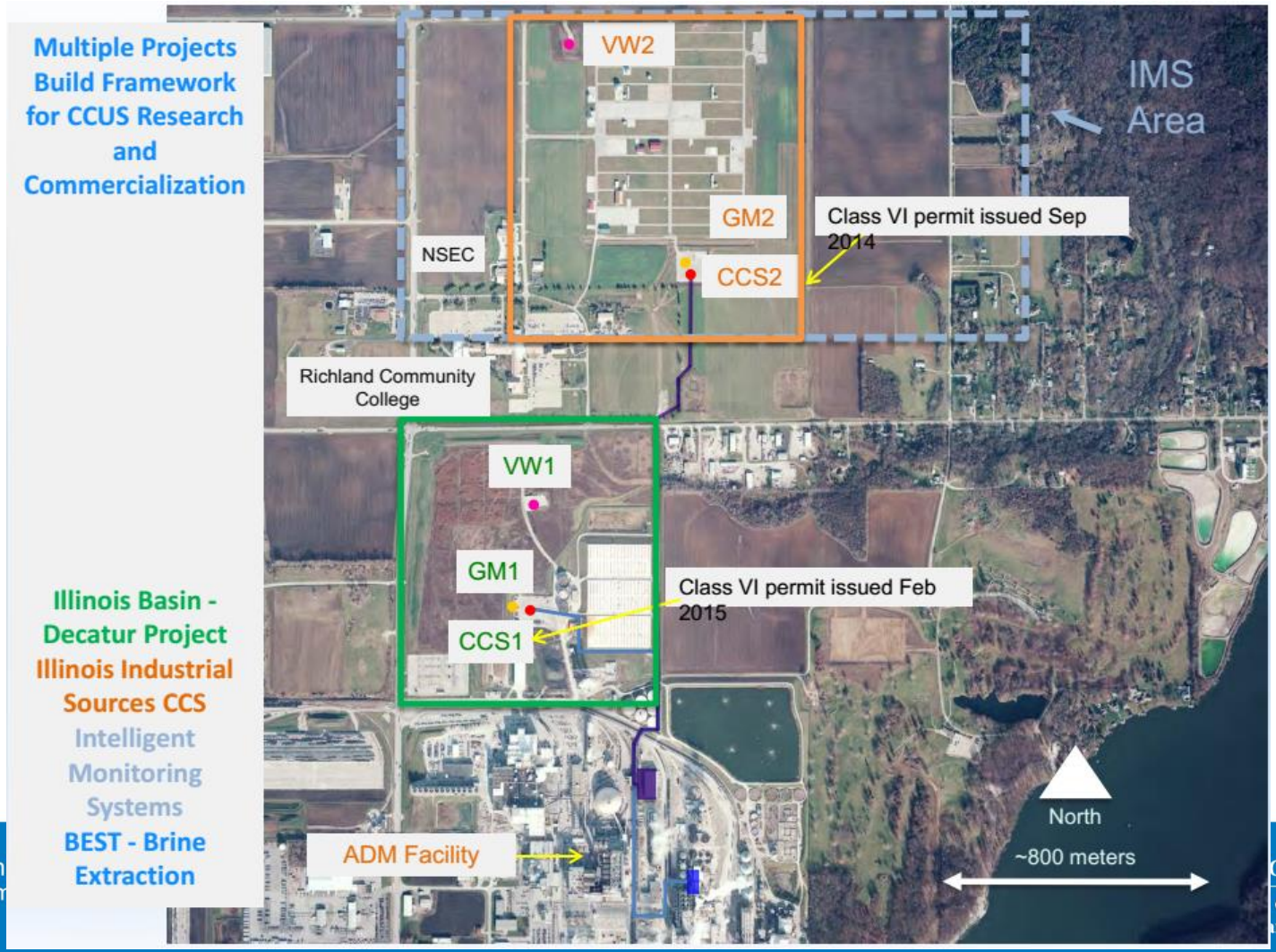
The project captures CO_2, and stores it safely almost a mile and a half underground



International and Australia

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Sleipner CO_2 Storage

LOCATION:
Central North Sea, offshore Norway

INDUSTRY:
natural-gas processing

CAPTURE CAPACITY:
1.0 Mtpa of CO_2

CO_2 CAPTURE START DATE: 1996

Over 17 million tonnes of CO_2 captured and securely injected deep below the seabed.

KEY ACTIVITY IN AUSTRALIA INCLUDES:

- **Commissioning of the Gorgon CO_2 Injection facility in Western Australia in 2018**
- Location of a proposed storage site and securing of a greenhouse gas permit for the CarbonNet facility in Victorian state waters
- Collation of baseline data on air, shallow groundwater and soil vapour for the Integrated Surat Basin Carbon Capture and Storage facility in Queensland
- Progression of drilling under Stage 3 of the CO2CRC Otway facility in Western Victoria, which aims to inject 40,000 tonnes of CO_2 for monitoring and verification
- Discussions between the Victorian government and Kawasaki Heavy Industries regarding the potential for brown coal to hydrogen production with CCS, with export opportunities to Japan

TOMAKOMAI: A MODEL FOR CCS INNOVATION

The Tomakomai CCS Demonstration Project, the first full-cycle CCS system in Asia, will capture and store more than 300,000 tonnes of CO_2 in sub-seabed reservoirs over a three-year period, and play an important role in showing how practical and necessary CCS is in meeting Paris climate change targets.

LOCATION : Near Industrial Centres

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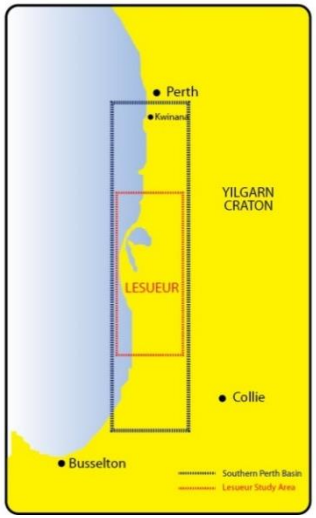

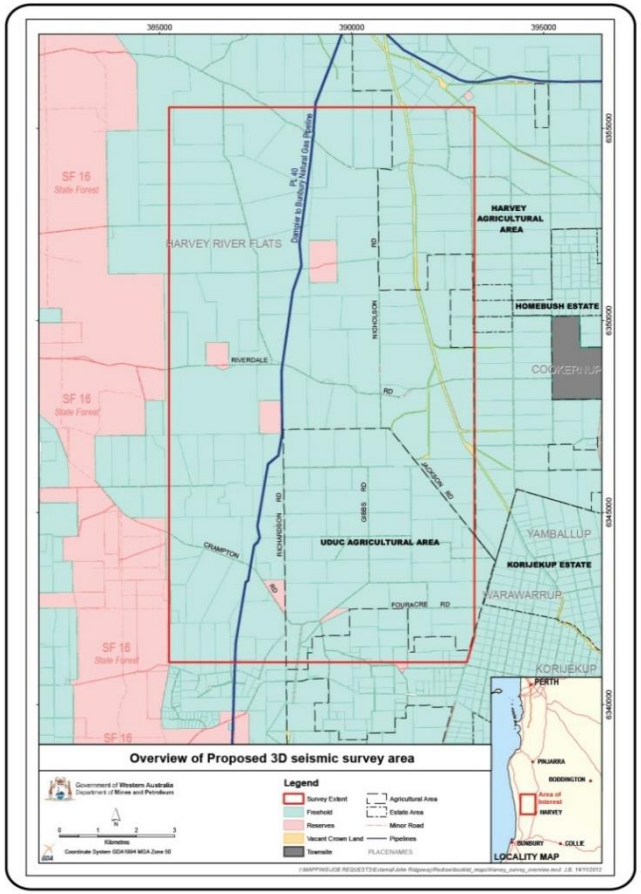

- In the heart of South West industry
- Agricultural and lifestyle area
- Project does not compete with potable water

New Data Acquisition with Extensive Community Consultation

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2011 2D Seismic

2012 Harvey-1 Well

2013 3D Seismic

2015 Harvey 2, 3 & 4

Stratigraphy: Regional & in the AOI

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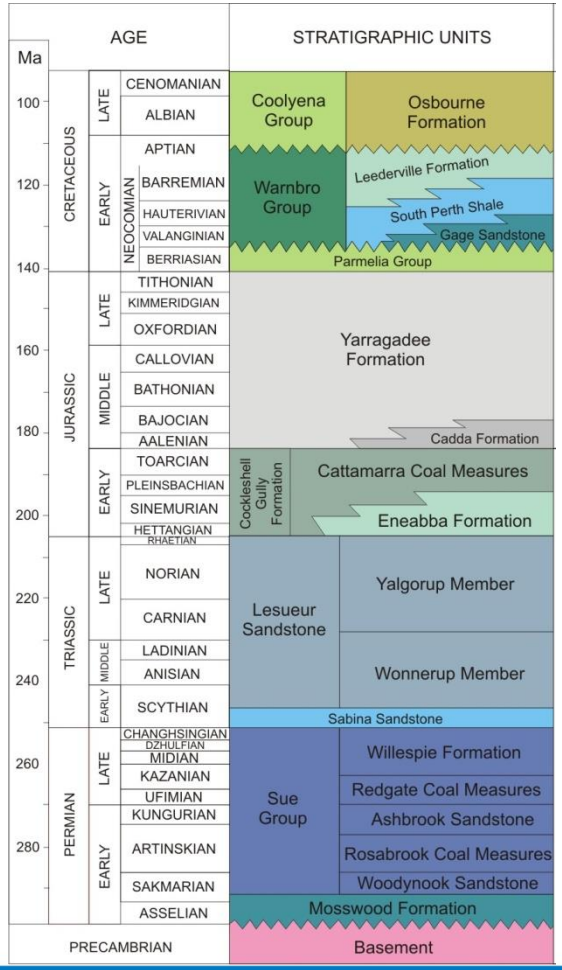
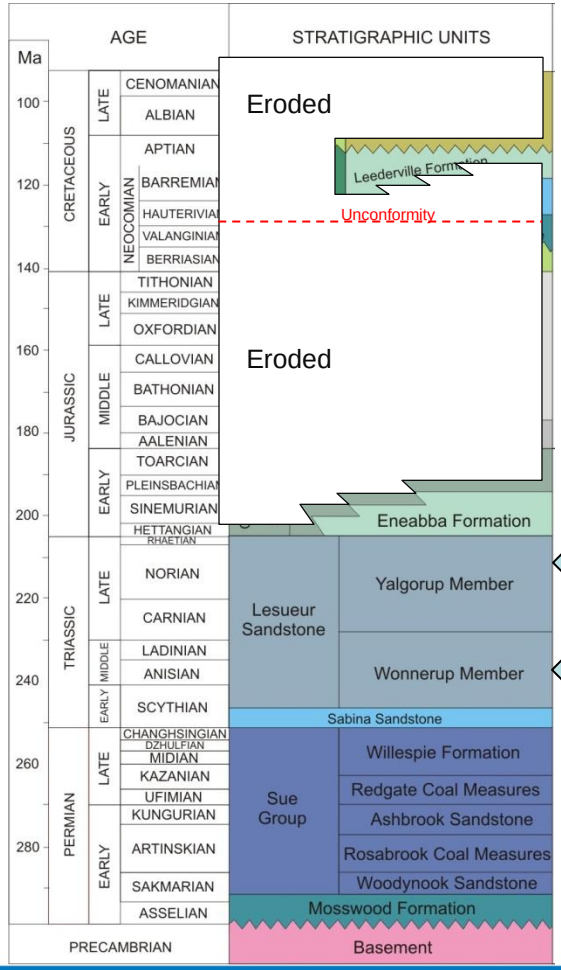
Perth Basin



Harvey-1



No basin resource conflict - absence of Yarragadee freshwater aquifer is critical to site selection

Lesueur Sandstone

Yalgorup

Wonnerup Sandstone 1500 metres thick

2010: South West Hub Project Concept

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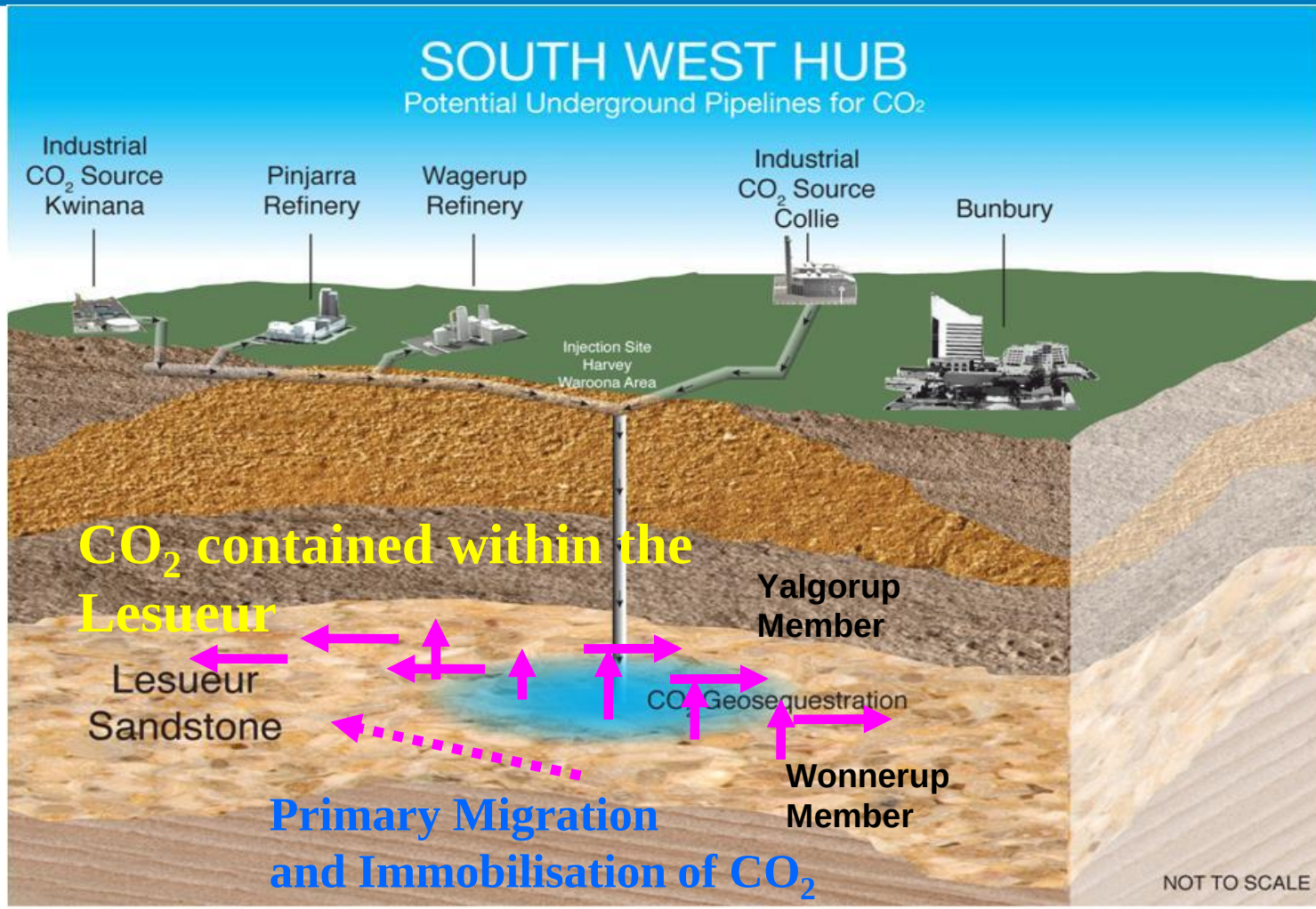
No CO_2 above 800m



Risk based approach to evaluating storage in the Lesueur

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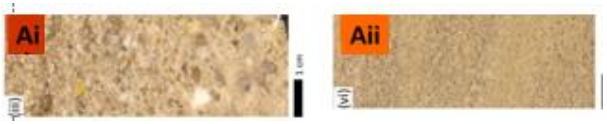
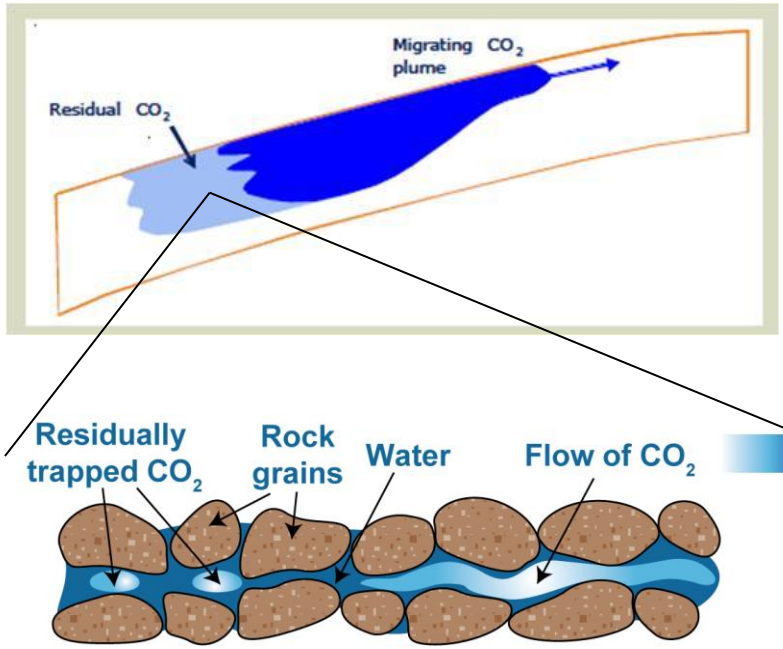
- Containment : Can we keep it in our storage complex?
  - Primary containment in the Wonnerup Member (Dissolution and residual trapping)



  - Secondary containment in the Yalgorup Member and below the Eneabba basal layer.



IPCC 2005, CO2CRC, CCP 2009

- Injectivity : At what rate?
- Capacity : How much?

Extensive Core and Log Data/Analyses

Routine Core Analysis (RCA)

- Grain volume and grain density
- Porosity and Permeability
- Permeability to brine
- Threshold Pressure to Carbon Dioxide

Special Core Analysis (SCAL)

- Flow studies
- Mercury Injection Analysis
- Geomechanical Analysis

Well	Run	Services
Harvey-2	1	Gamma-Resistivity-Dipole Sonic
	2	Seismic VSP
Harvey-4	1	Gamma-Resistivity-Dipole Sonic-Neutron-Density
	2	XRMI Image
	1	Gamma-Resistivity-Dipole Sonic-Neutron-Density
	2	XRMI Image CSNG Compensated Spectral Gamma
	3	MRIL Nuclear Magnetic Resonance
	4	RDT Reservoir Description Tool
	5	Seismic VSP
Harvey-3	1	Gamma-Resistivity-Sonic-Neutron-Density
	2	Gamma-Resistivity-Sonic-Neutron-Density
	1	Gamma-Resistivity-Sonic-Neutron-Density
	2	HSFT Formation Tester
	3	Seismic VSP

Four Generations of Models

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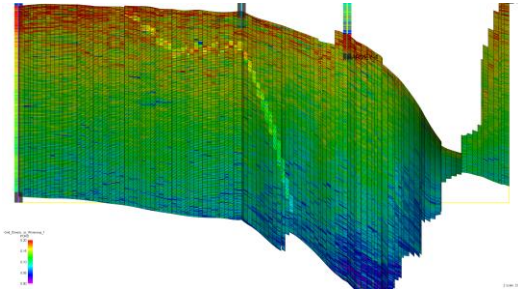
As more information became available, so did the level of sophistication and intensity of the models:

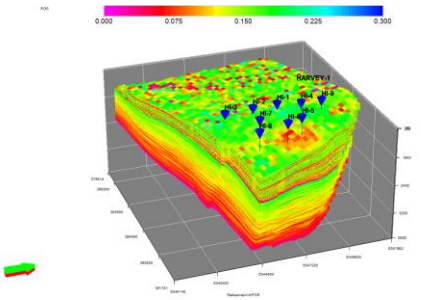


Generation 1 - >100 layers - 10 million cells

Generation 2 - 357 layers - 30 million cells

Generation 3 - >1,100 layers - 214 million cells

Dynamic model - 1.1 million cells



Generation 4 - current - 256 million cells

Dynamic model - 1.96 million cells

Reference Case - CO_2 Saturation at the end of 30 Years of Injection

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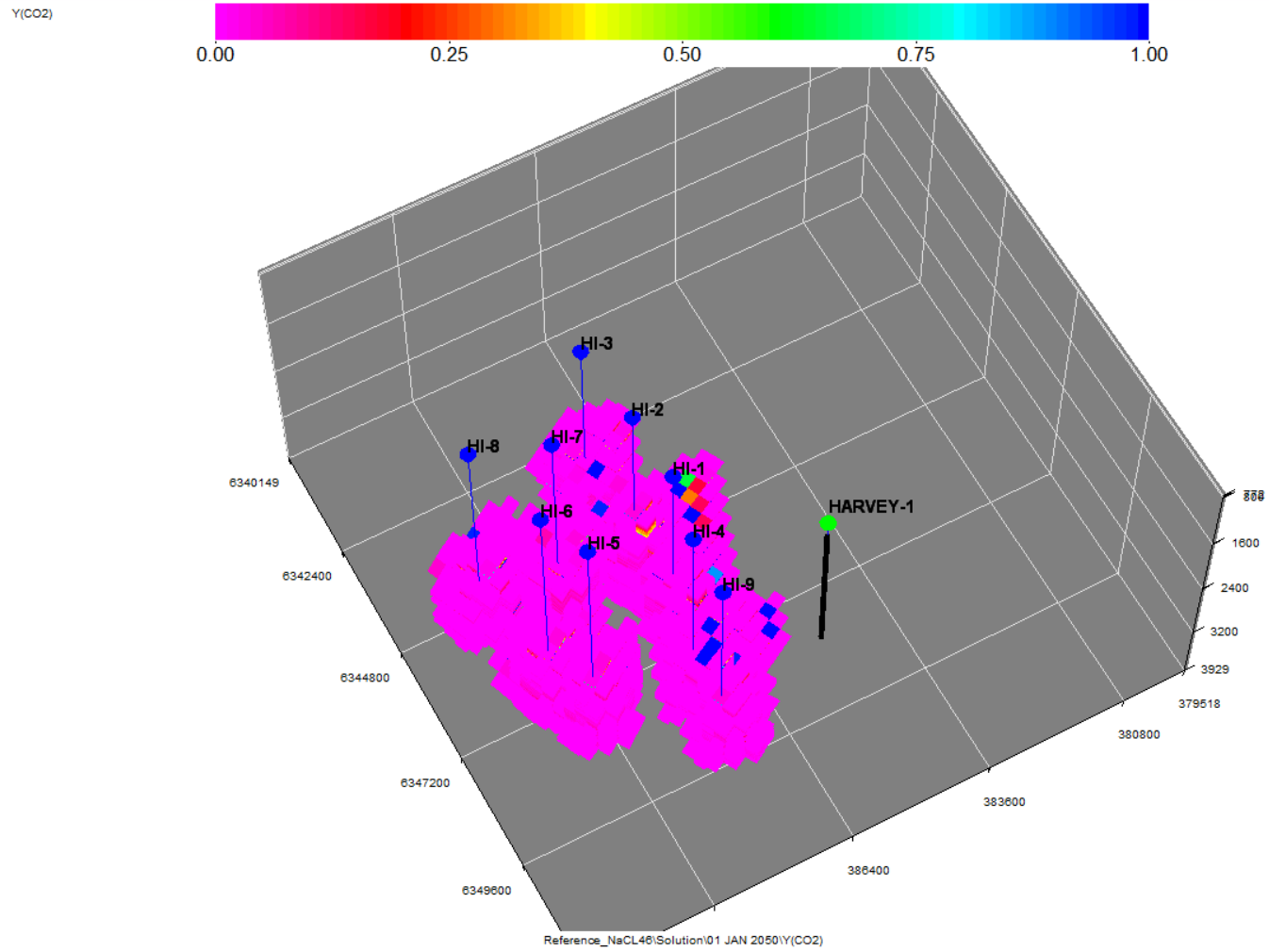

Reference Case - Mole fraction of CO_2 in the Water Phase 1000 Years

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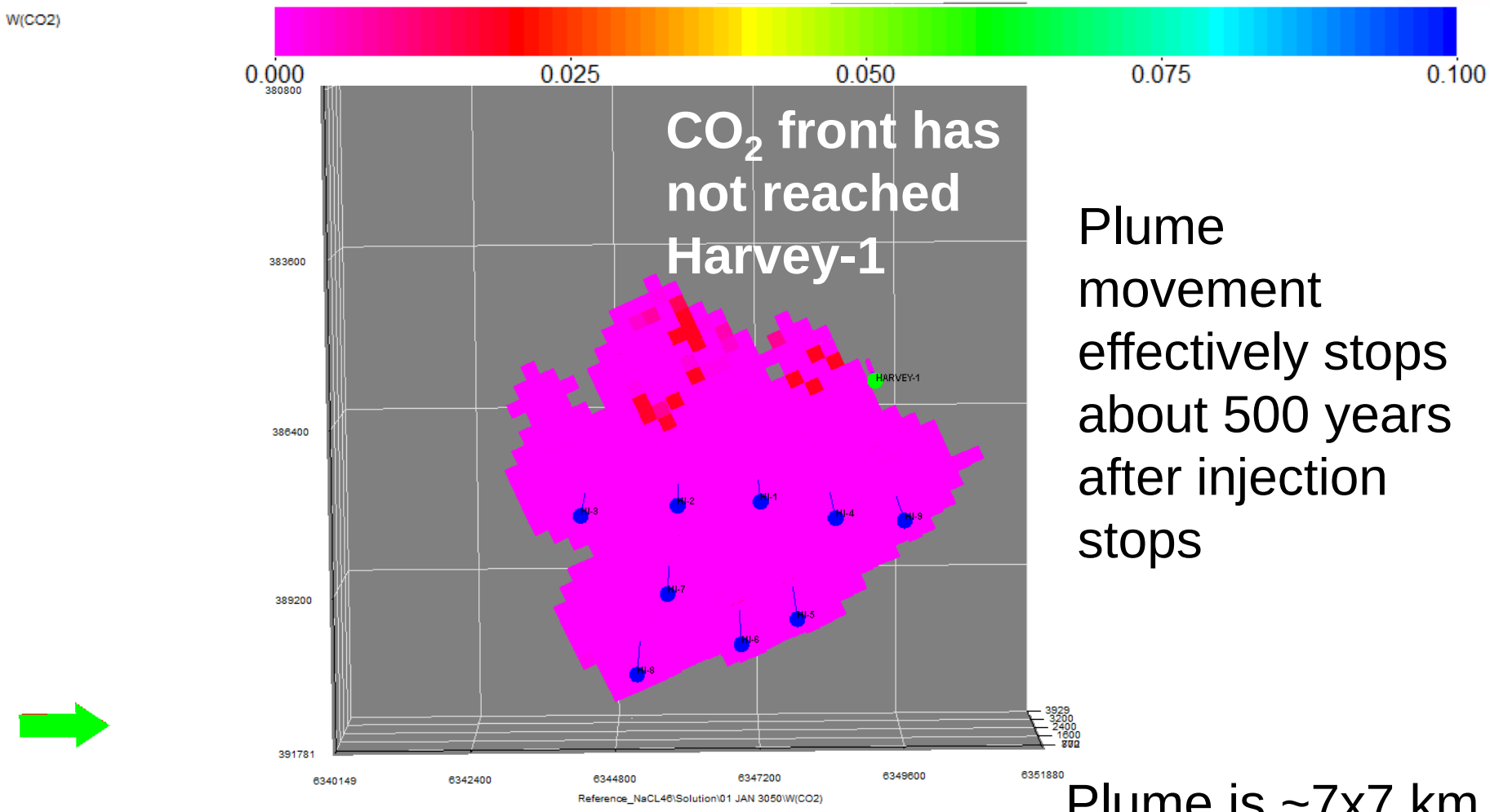

Plume movement effectively stops about 500 years after injection stops

Plume is ~7x7 km

Reference Case - Mole fraction of CO_2 in the Water Phase 1000 Years

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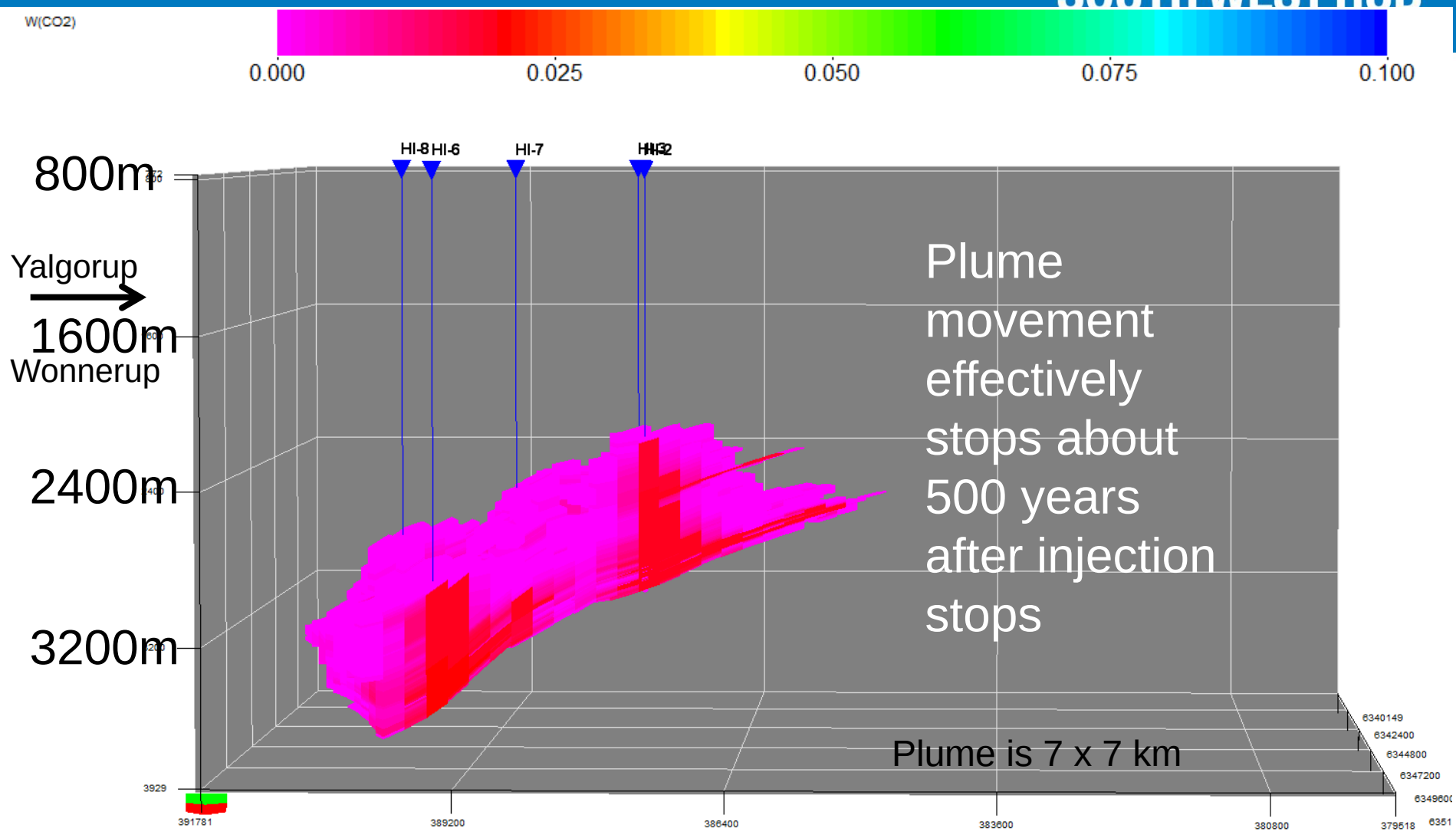

Reference_NaCL46\Solution\01 JAN 3050\W(CO2)

Stress Case – High Injection Rate
3 million tpa

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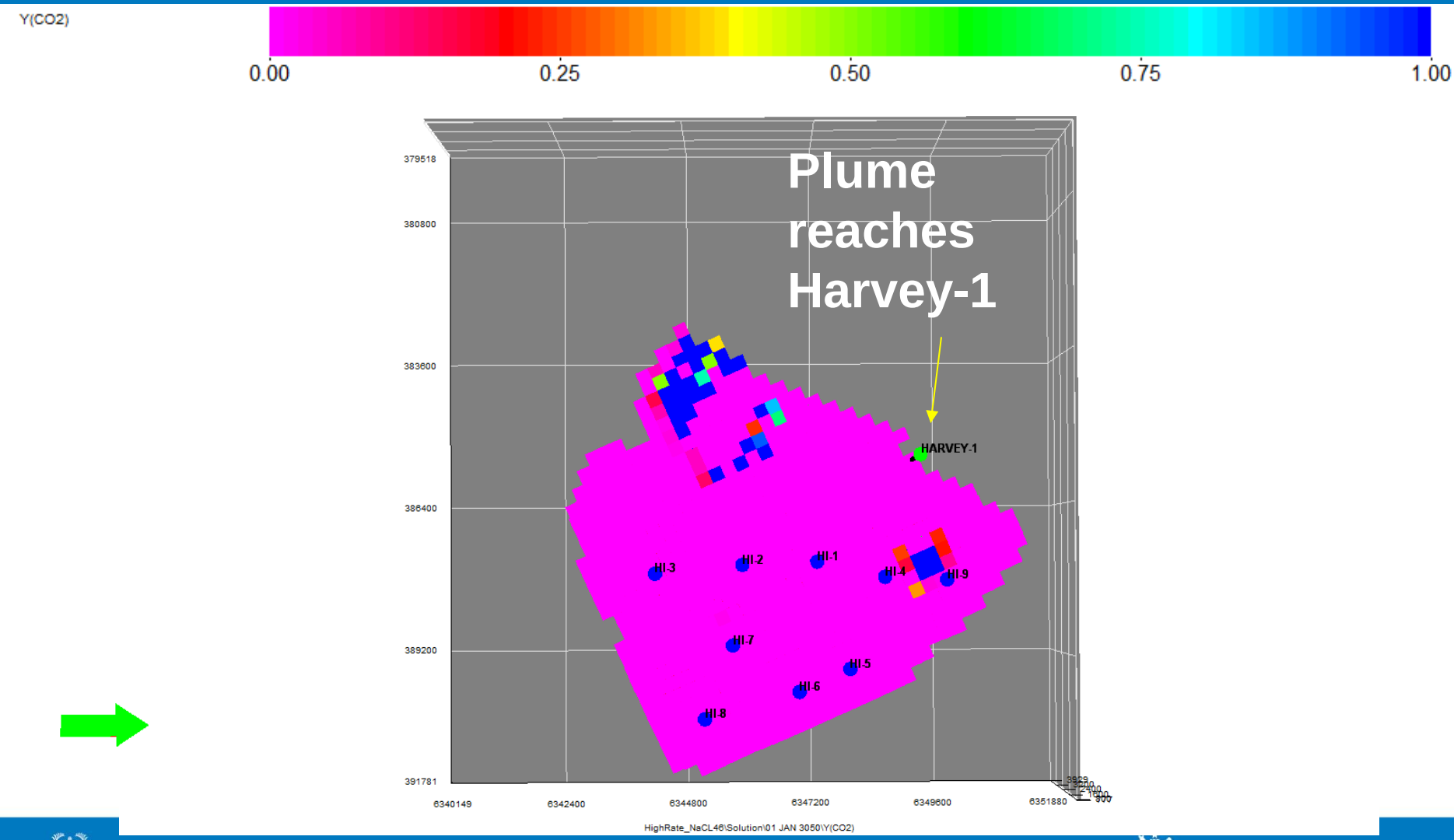

Stress Case – High Injection Rate after 1,000 years 3 million tpa

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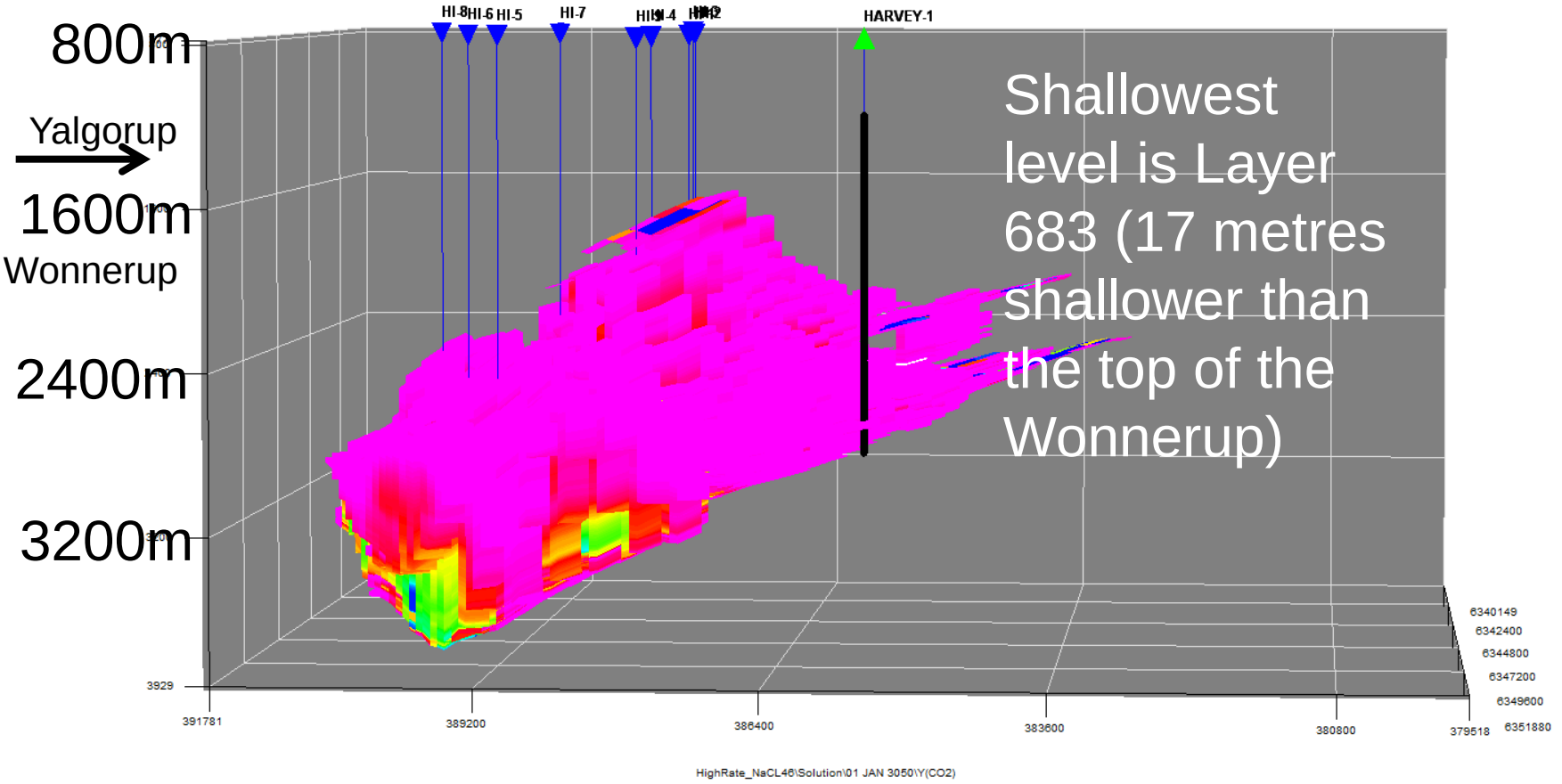

Shallowest level is Layer 683 (17 metres shallower than the top of the Wonnerup)

In the South West

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- The Lesueur represents the best opportunity for CCS in the South West
- The absence of the Yarragadee (potable water) is critical
- Future – more knowledge at depth – to 3,200 metres

Thank You

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www.dmp.wa.gov.au/ccs

www.dmp.wa.gov.au/wapims

www.ngl.org.au

www.anlecrd.com.au

www.nera.org.au

COLLIE MAIL - 2008

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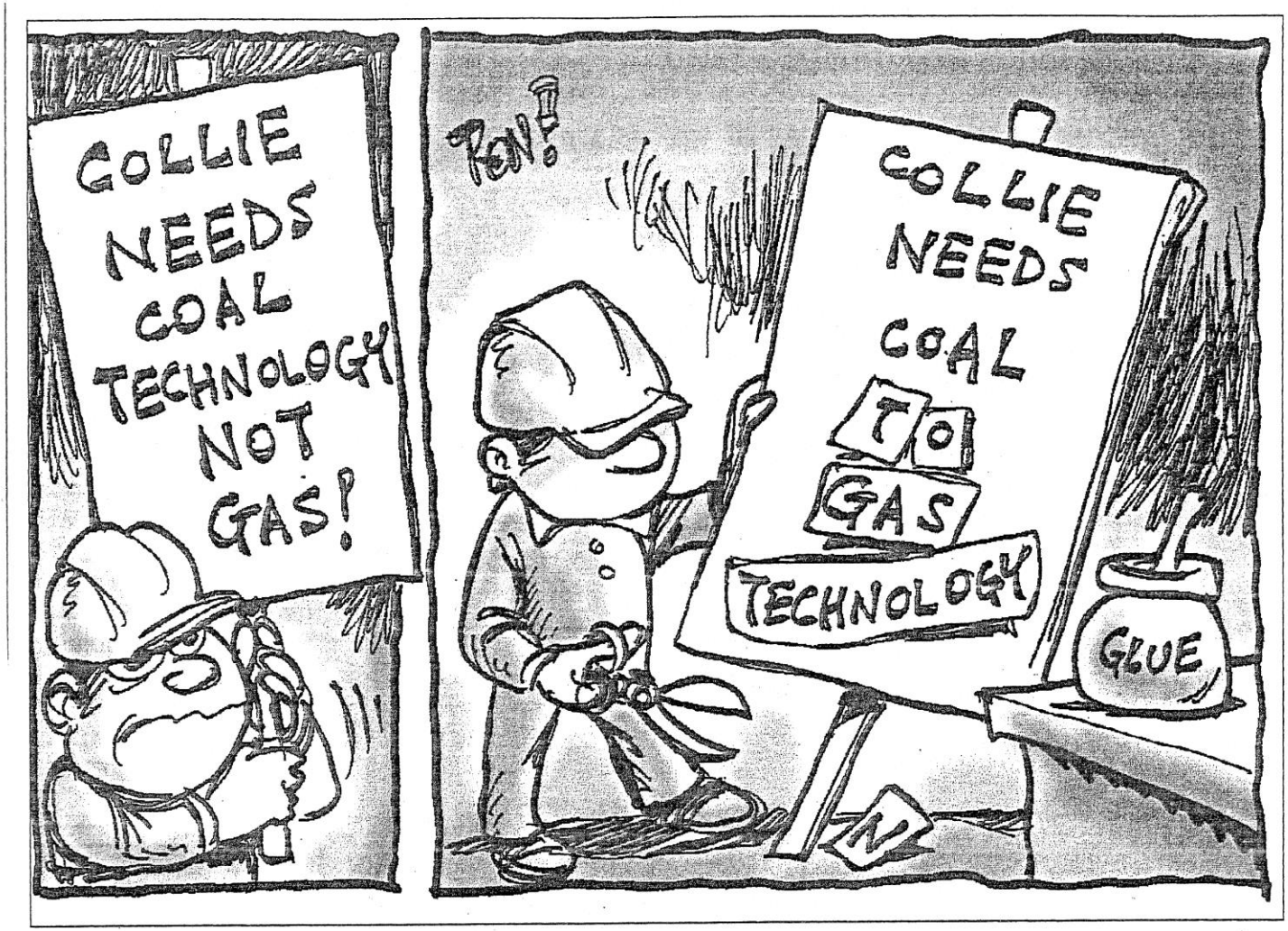
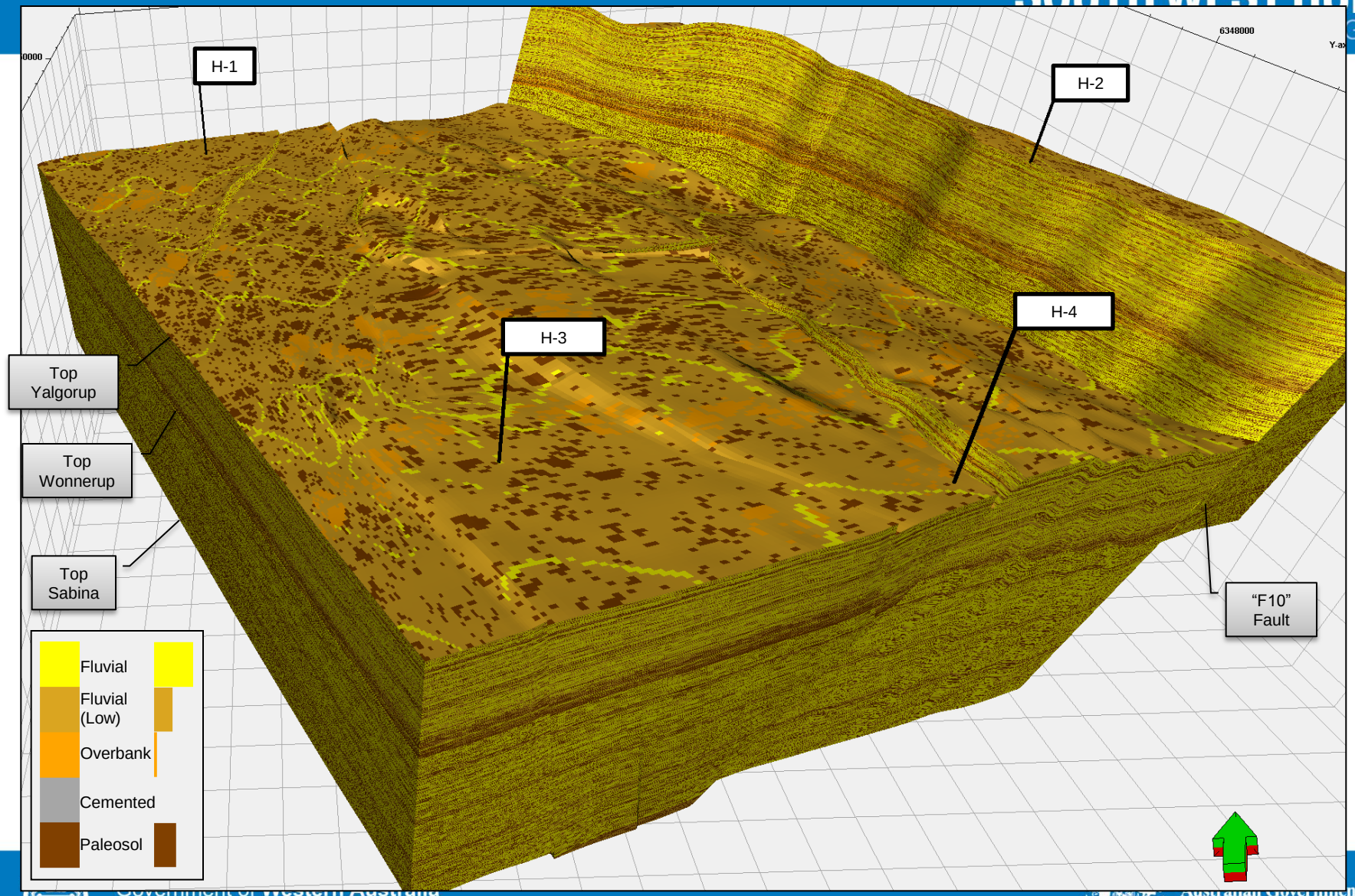
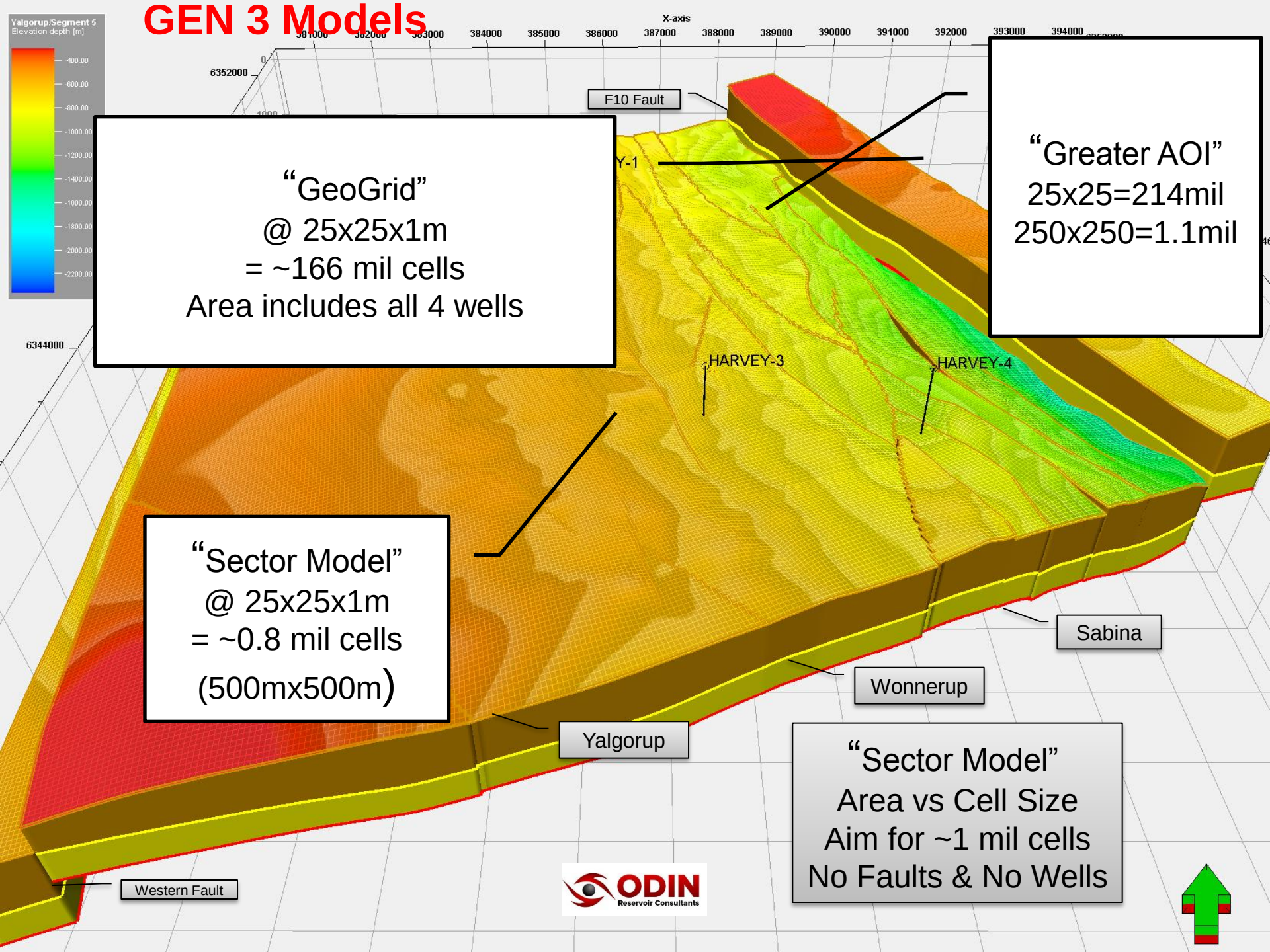


Gen 3 Models: Facies Distribution



GEN 3 Models



"GeoGrid"
@ 25x25x1m
= ~166 mil cells
Area includes all 4 wells

"Greater AOI"
25x25=214mil
250x250=1.1mil

"Sector Model"
@ 25x25x1m
= ~0.8 mil cells
(500mx500m)

"Sector Model"
Area vs Cell Size
Aim for ~1 mil cells
No Faults & No Wells

ODIN Reservoir Consultants