ZeroGen: Low Emission Power with Carbon Storage

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China Australia Geological Storage of CO2 (CAGS)
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Forward looking statements include but are not limited to references to drilling success rates and plans, the form of carbon dioxide storage site and related developments, seismic activity, costs & margins, carbon dioxide injection rates and sources of change thereof, estimates of capacity related to geographic areas and geological formation, results of exploration activities, and dates by which certain areas may be developed or may come on-stream as well as other market and economic assumptions.

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Many factors are beyond the control of ZeroGen. The forward-looking statements contained in this document are expressly qualified by this cautionary statement

Outline

- Project Overview
- CO_2 Transport & Storage - update
  - *Current exploration program (Northern Denison Trough)*
  - *Alternative Basins strategy*
- Lessons learnt

ZeroGen History

- ZeroGen is fully owned by the Queensland State Government.
- ZeroGen Pty Ltd was established to…

  => facilitate the development and accelerated commercial deployment of low emissions coal technology to preserve Queensland's competitive position in power generation and to ensure the continued mining, use and export of Australian black coal.

- In 2003: two stage development with a smaller IGCC + CCS demonstration project (~ 40 MW) to be deployed by 2011 and a commercial scale project to follow.
- In December 2007, the Clean Coal Council expressed a strong sentiment to steepen the risk curve and pursue a more meaningful demonstration.
  - Stage 1: a 120 MW Gross demonstration (sited at Stanwell) with10 years operation, capturing 100,000 tpa of the CO_2 and truck to the proposed sequestration site in Denison Trough, followed by
  - Stage 2: commercial-scale IGCC CCS project
- In the second half of 2008, ZeroGen's board and stakeholders clarified the ZeroGen mission to…

  => develop a commercial scale, integrated IGCC with CCS project in Queensland to operate by 2015-2017..

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Project Overview

Integrated commercial scale IGCC + CCS with two components:

- **Power Plant with Capture (designed and built by MHI)**
  - 530MW (gross) IGCC power plant (~ 400 MW Net at 65% capture)
  - CO_2 capture level 65 (initial) - 90%
  - CO_2 captured > 2,000,000 tonnes per year (at 65% capture) over 30 years
- **Carbon Transport & Storage**
  - Supercritical CO_2 will be transported via a dedicated project pipeline
  - Supercritical storage in deep sandstone formations
  - One area (Northern Denison Trough) is the primary focus of the ZeroGen CO_2 storage initiatives
  - Main technical contractors: Shell (subsurface Eng.), MBA (Geology), AGR (Eng.)
  - Identification, delineation and establishment of development plans for a sustainable CO_2 storage solution ……by 2011 –2013.

Estimated cost: $4,334.4 M (total)

- IGCC facility: $3,254 M
- CO_2 Transport & Storage: $736 M
- Developments: $344M (pre-feasibility: $128 M)

Funding:

- Funded by the Queensland State Government and the Australian Coal Association Low Emissions Technologies Ltd (ACALET)
- MHI contribution
- Shortlisted for the Commonwealth Government's Flagship CCS Program

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Power plant site selection

- Power plant location chosen to minimize the long-run cost of power.

Trade-off studies (technical & commercial) which optimize:

- *Fuel Specification & Cost*
- *Revenue – Gas Turbine output power, Marginal Loss Factor*
- *CO_2 Transport Cost (distance & corridor geography from Plant to Storage)*
- *Network Connection Cost*
- *Water Supply Cost*
- *General Site Development*
- *Sustainability & Development Risk*

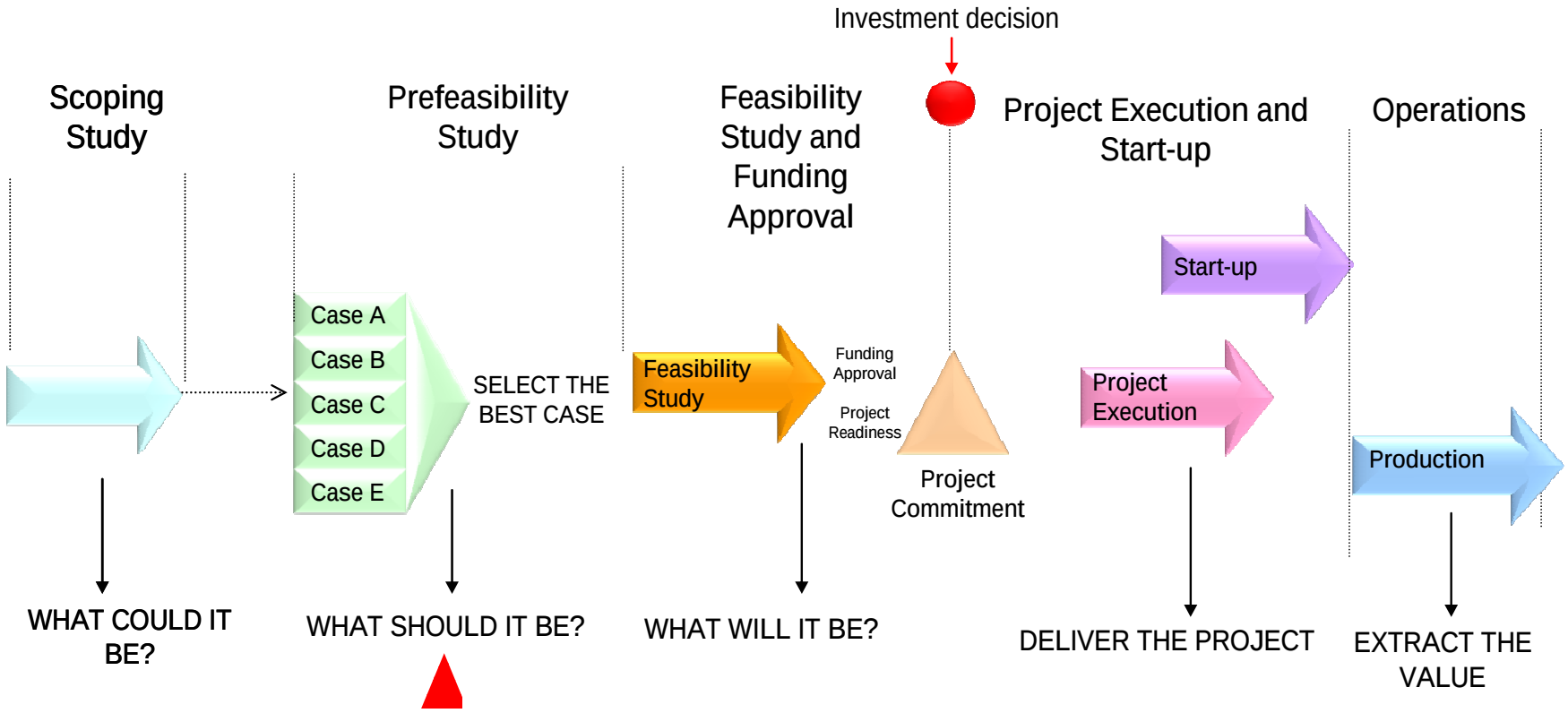
- Currently shortlisted to 3 mine-mouth options which:
  - *Are within 100 km of the CO_2 storage field; and*
  - *Have independent rail access for fuel procurement security / flexibility.*

- Selection to be finalised in Q1 2010, with single preferred case to carry forward to the Feasibility Study.

Project development is proceeding to schedule

- Project development includes Storage Appraisal & Project Development in **Parallel**...

Q3–Q4 2008`		Q2 2009	to	Q3 2010	Q4 2010	to	Q4 2011	Q1 2012	to	Q4 2015	2016 →



- **Prefeasibility Study Completion:** ***June 2010***
- **Feasibility Study & FID Completion:** ***December 2011***
- **Plant Operational:** ***October 2015***

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Carbon Storage – Zerogen Current Exploration Programme

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ZeroGen Storage project review process

The Objective

- To delineate a sustainable, probability adjusted storage capacity of **60 million tonnes with a total sequestration cost (transport & storage) ≤ $50 per tonne CO_2** (including Cost of Capital and O&M).
  - *Pre-Feasibility Study will seek to demonstrate this objective to a P_{50} level of confidence, by Q2 2010.*
  - *Feasibility Study will seek to demonstrate this objective to a P_{75} level of confidence, by Q3 2011.*

- ZeroGen Storage Plan:

=>The Northern Denison Trough is the base case and an advanced *prospect* including field exploration on ZeroGen's GHG tenements; but it is NOT certain that the NDT will prove suitable as a storage option for this project ***(sufficient certainty not until Q3 2011)***

=>Alternate Basins investigations in Queensland for potential storage sites if NDT proves not to be commercially viable

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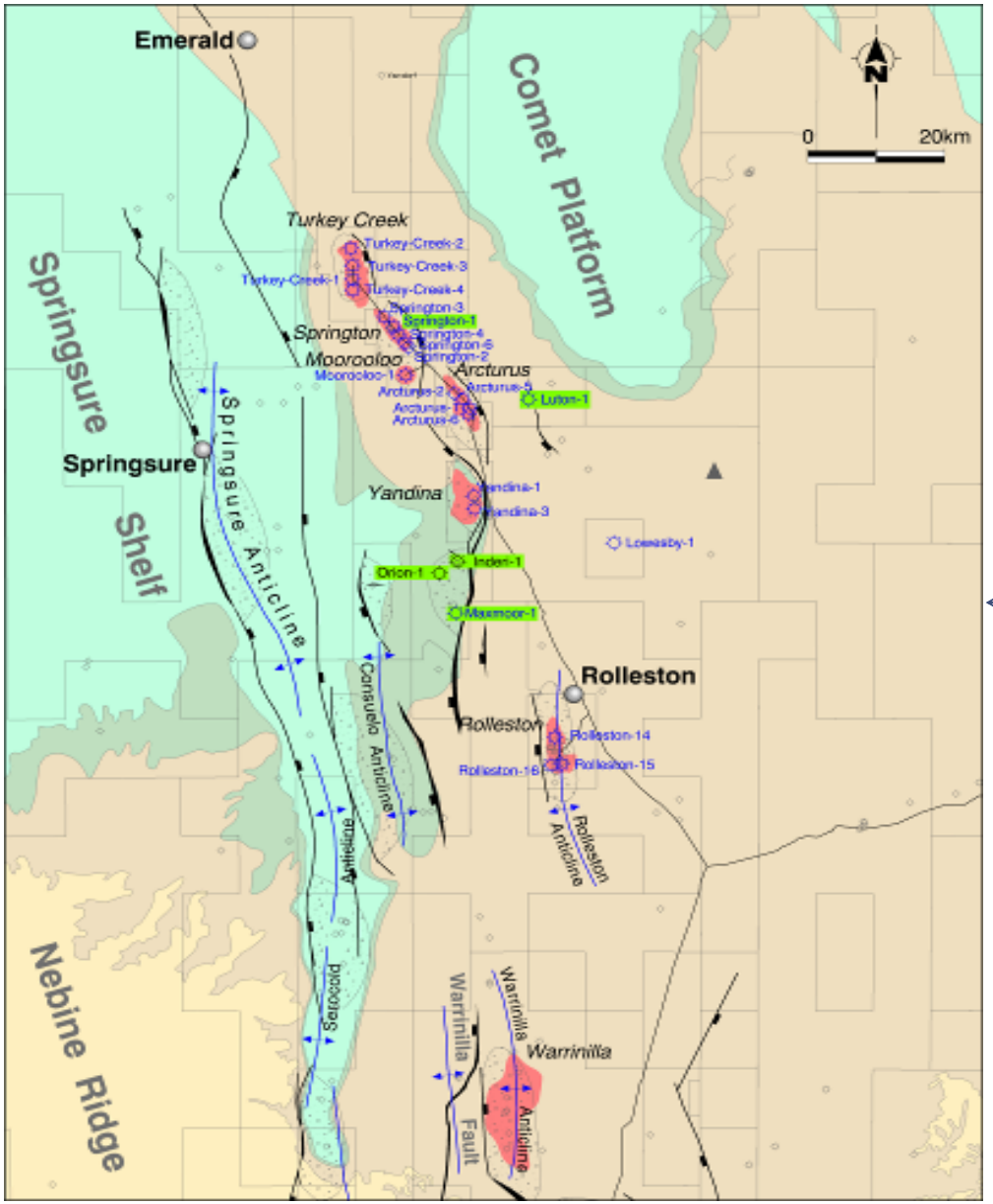
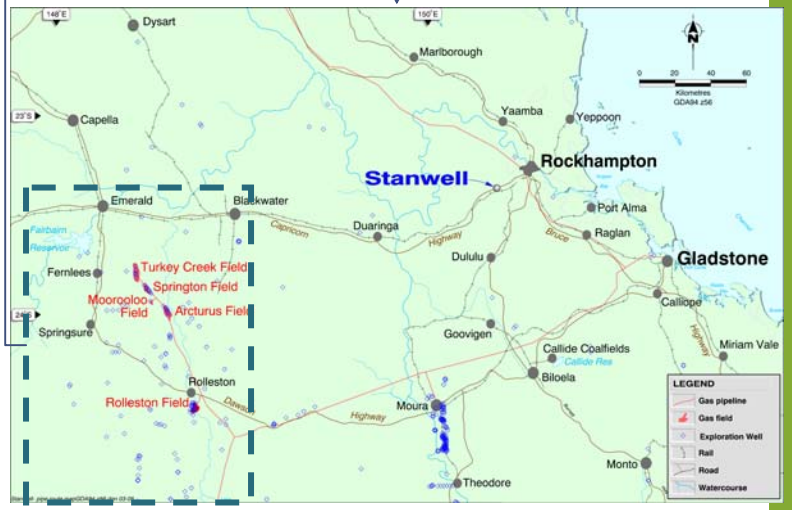
Northern Denison Trough: location





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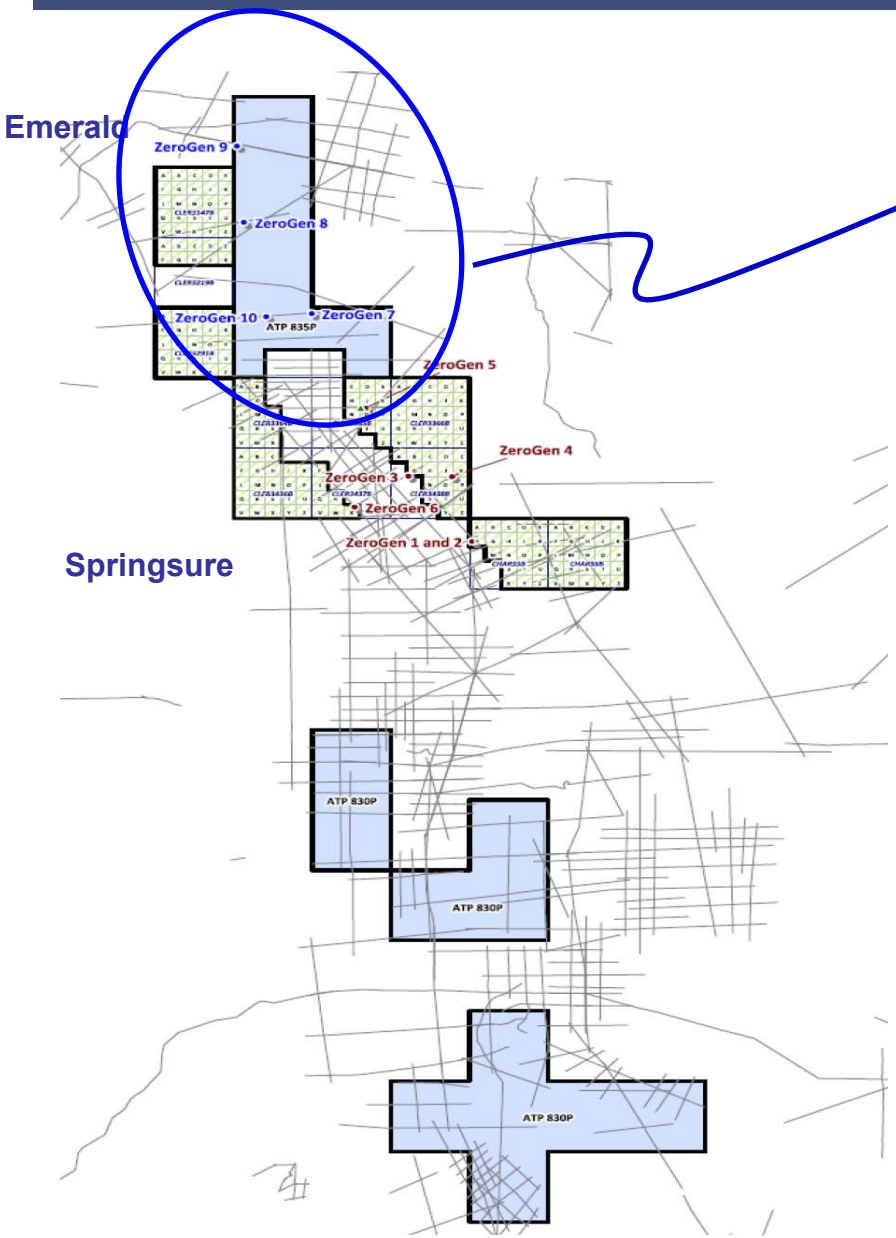
Northern Denison Trough: ZeroGen GHG tenements



Most prospective storage targets

- *Tenements are essential to any exploration programme*
- ***ZeroGen has acquired Greenhouse Gas Exploration Permits, under the new Greenhouse Gas Storage Act.*** *(Passed & Assented February 2009)*
- *Can be converted to* ***GHG Storage Leases.***
- *So far these are the only GHG tenements granted under Queensland Legislation.*
- *Total area of tenements = 1,225.5 Km².*

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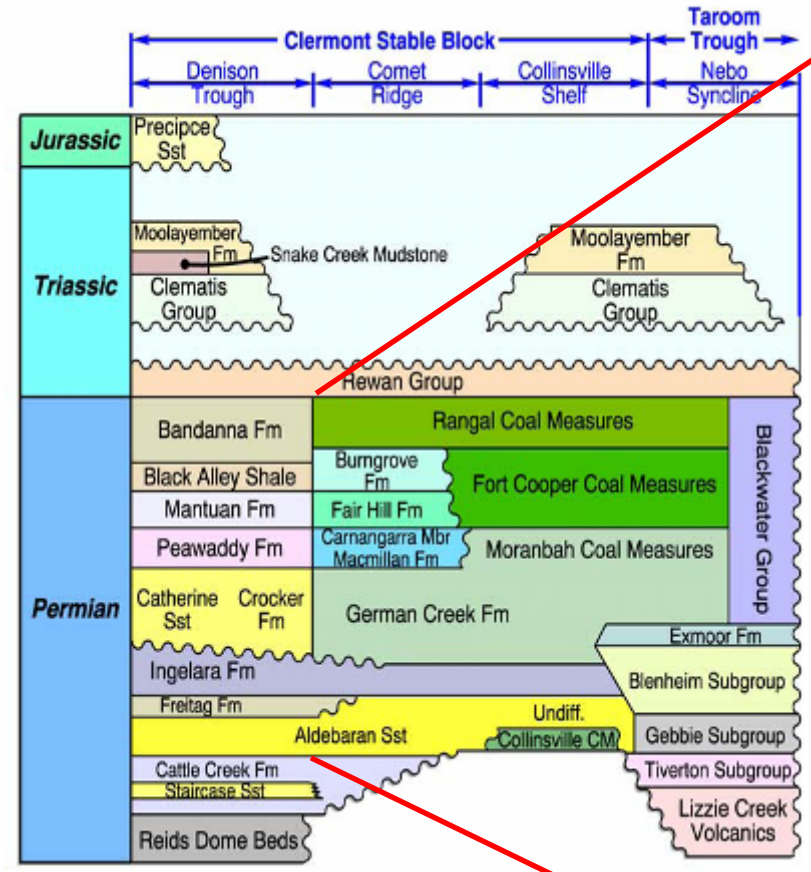
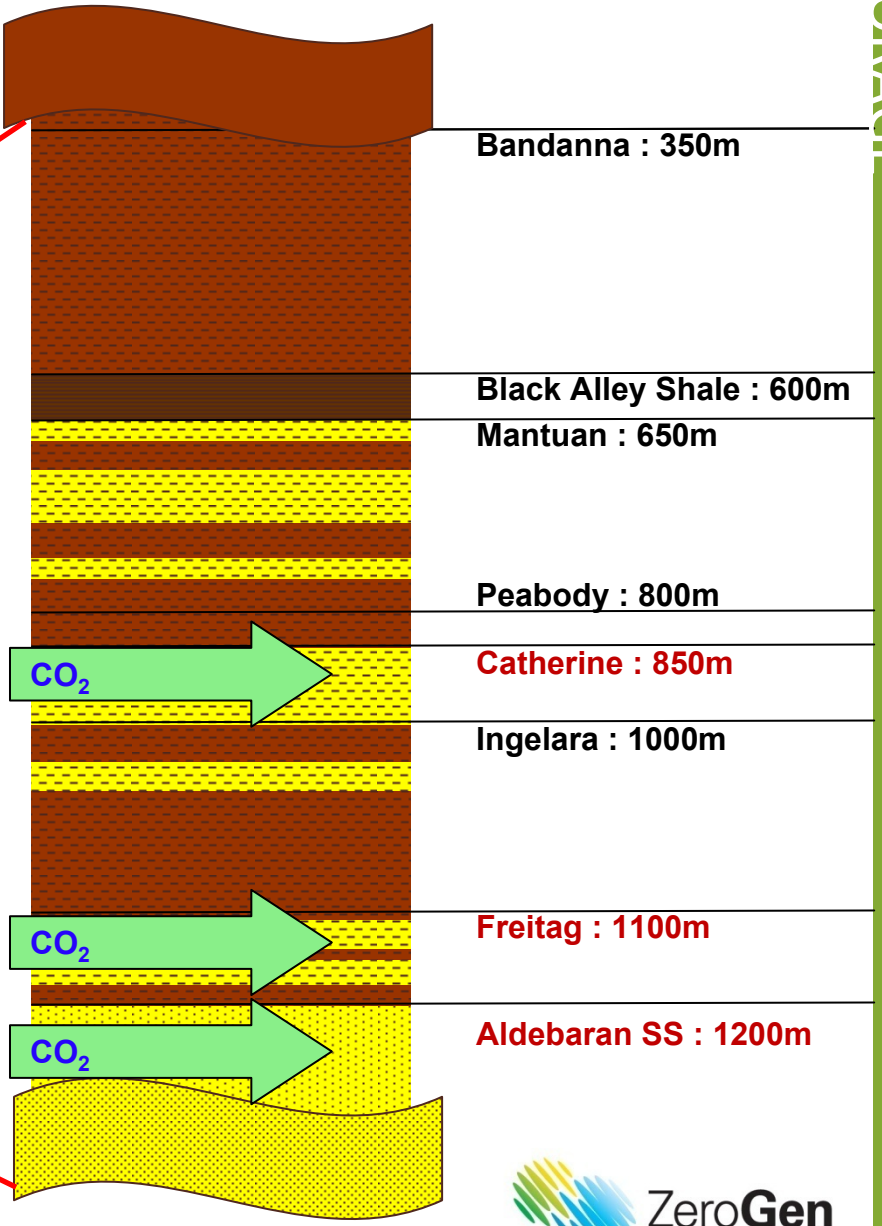
Stratigraphy (Bowen Basin)





Injection would occur below 900m

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Evaluation of Economic Storage Resource

The Storage Evaluation Process must be able to quantify the outcomes of the Exploration Program

- 3 key issues to resolve storage uncertainty:

1. Storage Capacity & Containment

Low risk – *adequate pore space will exist under ZeroGen's acreage*
– *geological seal of high integrity means secure storage*
– *low permeability means CO_2 plume does not migrate far from well*

2. Cost of Transport & Storage; and

Low Risk – *pipeline cost & unit cost of wells are well understood*
Critical Issue *is* ***storage cost*** – *driven by Total Well Count*
– *depends on reservoir injectivity & connectivity*

3. Confidence Level / Probability measure.

Probabilistic methodology to determine P_{50} or P_{75} etc.

Methodology to determine Well Count Distribution

- A probability distribution for the expected well count is established.
- First need sufficient data / knowledge of the critical variables,
- And a **Statistical Assessment** of those variable/parameters **-**
  - **Injectivity**
    - **Reservoir kH**
    - Well Skin Factor
    - Relative Permeability (k_{AIR} /k_{WATER})
    - Capillary Pressure
    - Relative (directional) Permeability (k_h /k_v)
  - **Reservoir Continuity / Connectivity**
- A ***Monte Carlo*** type simulation is then run in conjunction with the single well reservoir modelling which will provide a distribution of possible well counts.

=> For the Denison Trough option, **ZeroGen needs ≤ 80 wells or ≥ 75 TPD per well.**

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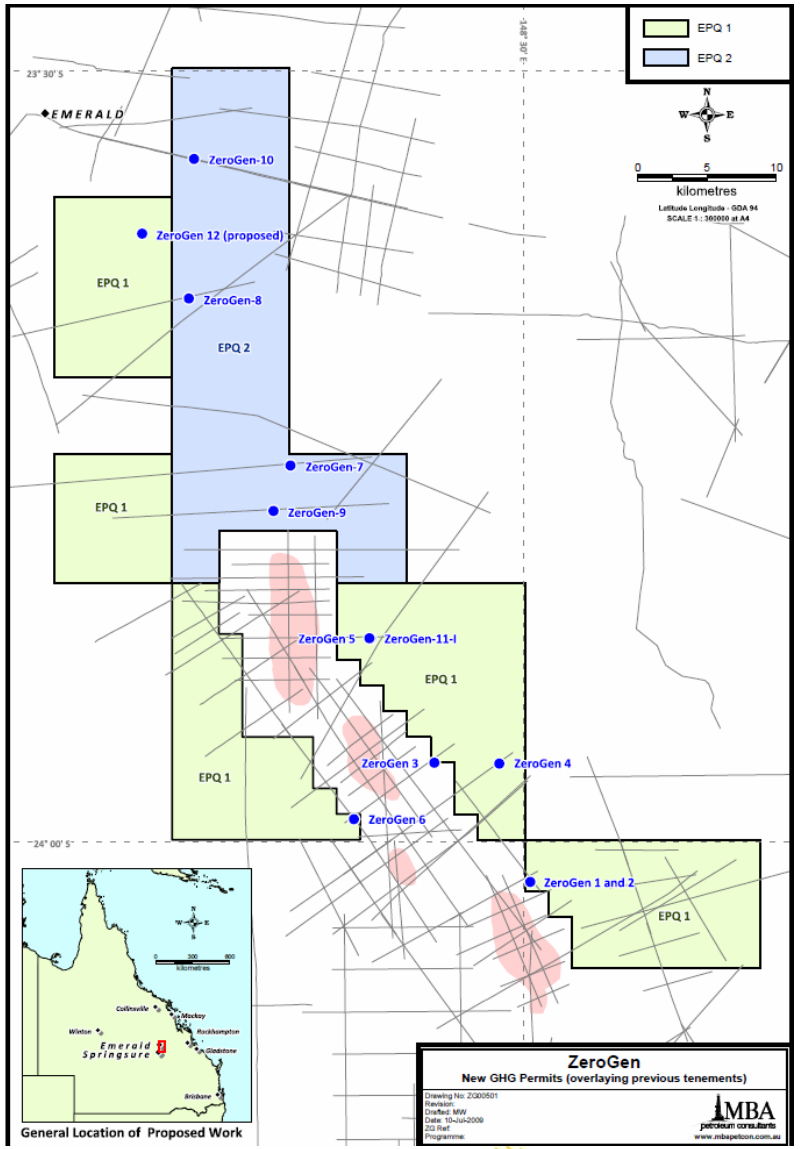
ZeroGen DP1 & 2b - Operations

- 2006 DP1: (ZG1 & 2) first wells drilled in prospective storage site
  - Demonstrated reservoir quality similar to updip gas fields but at subcritical depth
  - Proved water injectivity into low permeability rock
- 2007-8 DP2a: (ZG3-6) stratigraphic core holes drilled to 1300m in EPQ1
  - Identified predictive reservoir quality relationships
  - ZG5 intersected high permeability Catherine fluvial sand at supercritical depth
- 2009 DP2b: 5 stratigraphic core holes drilled (ZG7, 8, 9, 10, 12) in EPQ1 and 2
  (ZG9 deepened to investigate entire Aldebaran Sandstone section); ZG12 drilled entire Aldebaran)
- 2009 DP2b: drilling ZG11 for short term H_2O/CO_2 injection test
  - Air drilled to minimise formation damage
  - 30m NW of ZG-5 cored well



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2009 Exploration Program (Drilling)

Objectives

- Validate the geological model
- Address security of storage through confirming the presence of regional seals
- Provide geological data as input for reservoir modelling (Capacity & Injectivity)

Preliminary results

- 5 Core Wells (ZG7, ZG8, ZG9, ZG10, ZG12) successfully drilled and cored
- Moderate to high permeability reservoirs at supercritical depth in Catherine Sandstone (100 mD to 1,000 mD).
  - ZG10 and ZG12 excellent Catherine – up to 1D permeability (ZG5 with 550mD)
- Low to moderate permeability reservoirs in Freitag and Aldebaran (<1 mD to 100mD).
- Confirmation of new geological model predicting an improved permeability to the North / North West.

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New Geological Model

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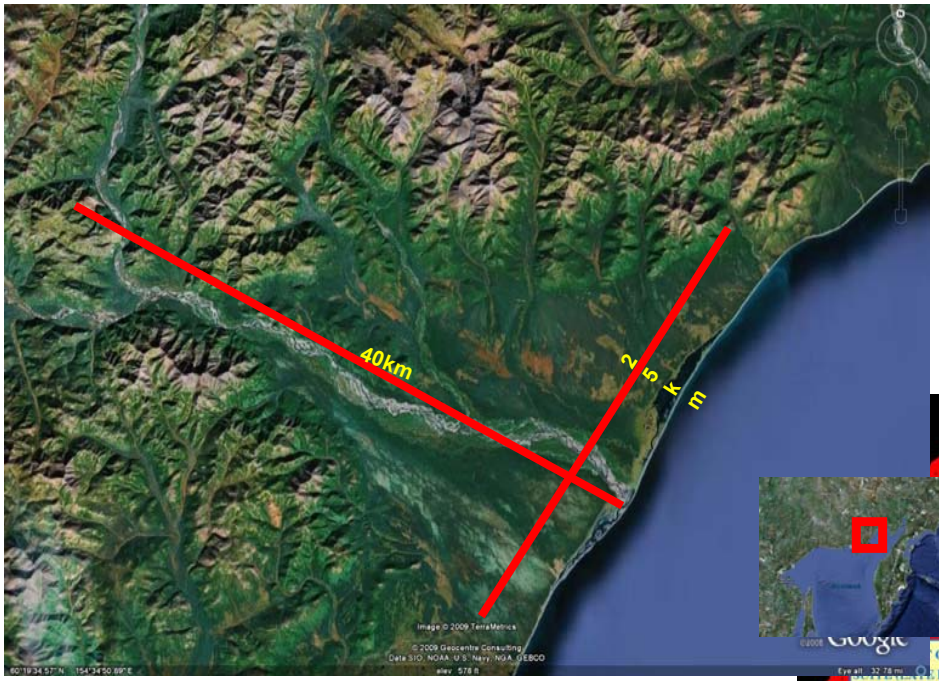
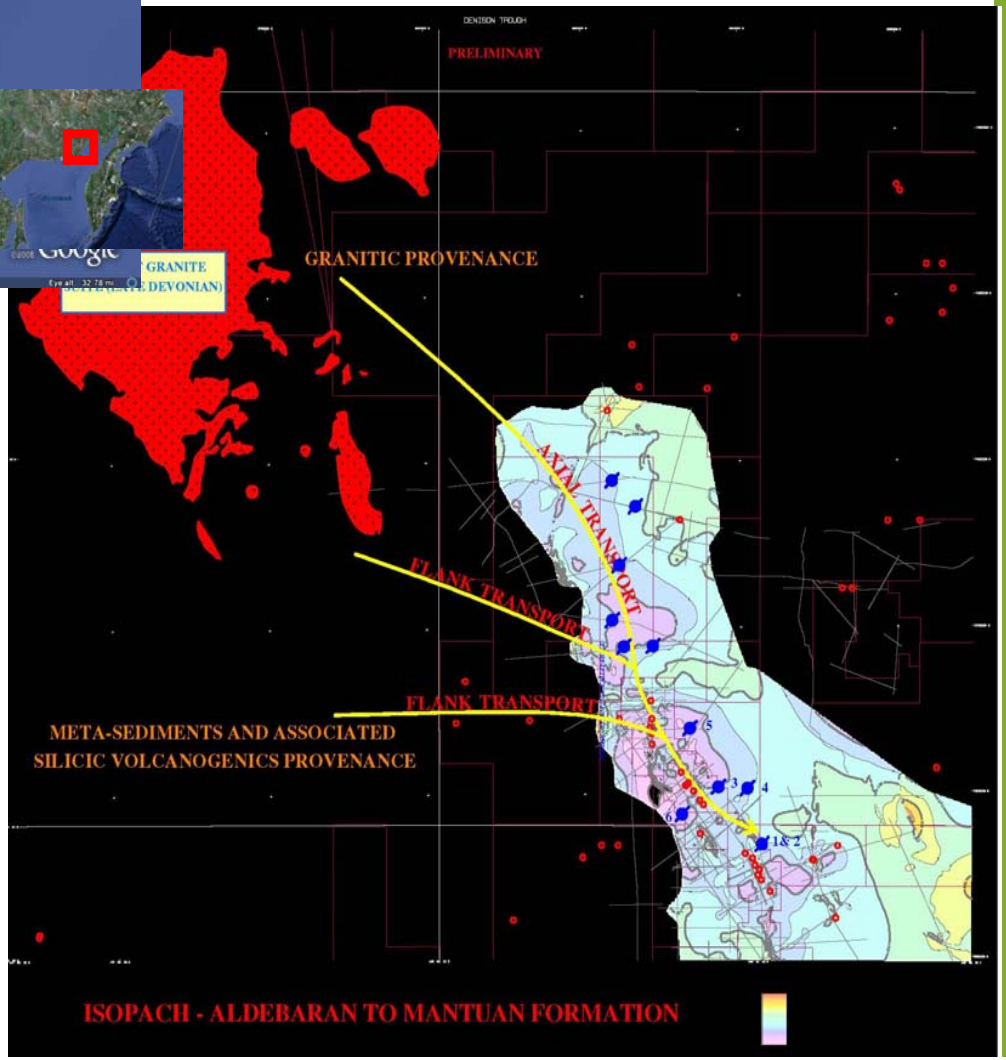


Catherine Modern Analogue:
Fluvio-deltaic depositional environment with distributed channels



2009 injection testing: Objectives & Operations

Objectives

- Determine injectivity into a range of low, medium & high permeability reservoirs
- Determine reservoir connectivity (the presence of boundaries)
- Validate water as an analogue for CO_2
- Formation water sampling
- Demonstrate the use of seismic as a monitoring tool

Operations

- **ZG11 CO_2/H_2O injection tests**
  - Injection Testing at ZG11 commenced 4Oct 2009
  - Three CO_2 injection tests - 1400 tonnes (limitations on the volume of CO_2 available) into High, Medium and Low permeability reservoirs for the purposes of calibrating reservoir models
  - Two water injection tests to correlate of water vs CO_2 (to enable lower cost future testing)
  - VSPs before and after CO_2 injection

- **4 * Water Injection Tests** (ZG#7 / ZG#8/ ZG#9/ ZG#10) to establish reservoir connectivity.
  - ZG 7 and ZG 9 are located 3.5 km apart
  - Injection October – February 2010
  - Pressure monitoring to continue into 2Q 2010

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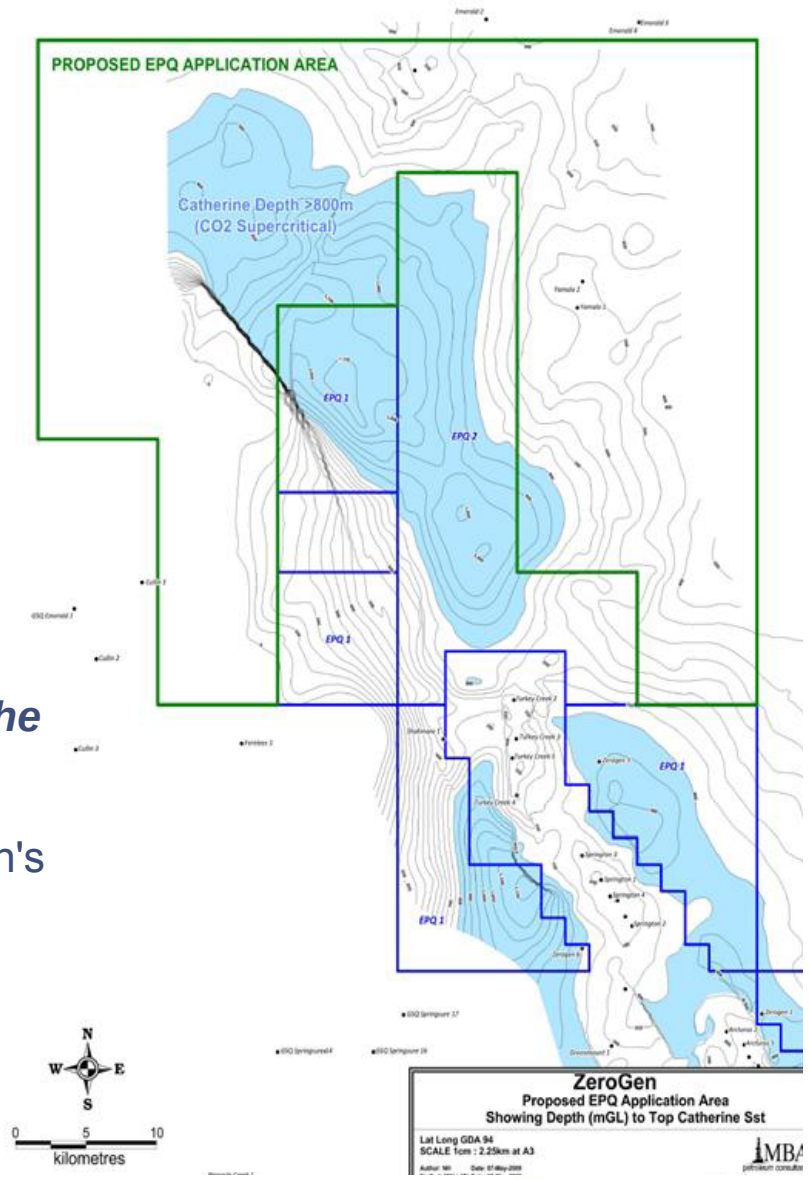
Future work program in Northern Denison Trough

- Current drilling and testing program will be completed by 31 March 2010
- Analysis of results during 1Q & 2Q2010
- Prefeasibility Study Report submitted by 30 June 2010
- If the results demonstrate a P50 level of confidence of being able to sequester 60 million tonnes CO_2 ≤ $50 per tonne, will proceed to the Feasibility Study

Because of the recent interpretation of the geological model

=> A new area is required to increase ZeroGen's reservoir capacity.

- 2D seismic over expanded and existing tenement area in Q2 2010.
  - *Improve structural interpretation.*
  - *Determine extent of basin*
  - *Location of faults (connectivity & containment).*



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Carbon Storage: Zerogen's Alternative Basins strategy

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Risk management – portfolio theory applies

- ZeroGen is examining alternative storage options in case the Northern Denison Trough should prove uneconomic.
- Alternatives are also subject to development risk.
- There are many reasons for storage sites to "fall-over"
  - *Having only one option is vulnerable to common risks*
    - Geological play risk,
    - Local sensitivities (environmental, commercial, public ...), political ... Great Artesian Basin (*92% of Qld high graded storage potential is within the GAB);* competition for the same resources (CSG, O&G)
- A multi-tenement, multi-play explore and appraise program to diversify risk is the most credible strategy given the levels of confidence, time scale and scale required.
- For increased confidence in success … Zerogen must:
  - explore a *number* of possible sites with a diverse range of risks, and;
  - *be exposed to* (not necessarily control 100%) a portfolio of options
- ZeroGen's Alternate Basins suggested strategy: to initiate and enable a multi-user storage hub with an Early Development Scheme (EDS) in which it is a founder but not necessarily the sole member.

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Alternative Basins progress

- Preliminary view
  - Sufficient certainty in NDT not be reached until Q3 2011.
  - ZeroGen storage requires a contingency plan – outside the NDT

  - *A risk-diverse portfolio can be constructed and explored in the Surat Bowen.*
    - But "starting the conversation" on GAB storage is *very* important
  - *Estimate, a A$240M exploration phase to "find" material volumes (100s Mt)*
  - 3 to 4 tenements needed for exploration
    - Ultimate opportunity is >500Mt and 5–20Mt pa.
  - *Unit finding and development costs significantly lower than NDT*
  - An economic carbon storage & transport hub should be considered in Queensland:
    - with an expandable 2 mln t pa Early Development Scheme (EDS) which could be tied to a large scale demonstration CCS project by 2017
    - capable of accommodating more than 500 million tonnes CO_2 from Queensland's major emitters (over 20 mln t pa from stationary sources) to be tied in as the supply-side develops.

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Conclusions – lessons learnt

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Key points to take away (1)

- ZeroGen Exploration Programme is the world's most advanced dedicated CO_2 Exploration Programme
- ZeroGen has had encouraging results from drilling on EPQ1 and EPQ2 incl. high perm zones in Catherine Sandstone...but
  - The target reservoir sequence extends to the NW of EPQ1 & EPQ2 => additional acreage is required
  - More exploration & appraisal work is required to reach sufficient certainty
- The program to prove an economic storage resource requires extensive testing data acquisition including:
  - *Desktop investigations; Seismic surveys; Drilling multiple stratigraphic wells; Analysis & testing of drill core; CO_2 & Water Injection testing; Production testing, etc...*
- Overall the process from identifying a storage target to developing an economic storage resource is >$100 million over at least 4 years.
- Never underestimate time required for getting commercial arrangements financial approvals, regulatory permits, etc...(especially for a FOAK CCS project)
  - These could delay the project development...

Key points to take away (2)

- **Storage is on the critical path for CCS**
- **Exploration & Appraisal phases are costly, lengthy and without any guarantee of success**
- **There are many reasons for any site to "fall-over"...=> need several exploration options (sites, plays) to diversify risk *(not all "eggs in one basket)***
  - A multi-tenement, multi-play explore and appraise program is the most credible strategy given the levels of confidence, time scale and scale required.
- **GHG Tenements must be large…**
- **Releasing acreages for exploration is crucial to accelerate CCS development**
- **Search, appraise, develop big & collaboratively (risk sharing) because**
  - Capital is scarce
  - Cost/risk for E&A in QLD likely too rich for single projects
  - Size of storage has nothing to do with of size of emitter.
  - QLD's problem is bigger than a single project
- **Would a Carbon Transport & Storage Hub be the way forward**
  - To maximise the chances of contingency storage for FOAK CCS Projects?
  - To stimulate and enable broad, post "demo" uptake of CCS?
  - To assure Low Emissions in the long term?

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Thank you

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