ZeroGen

smarter, cleaner power

Presentation at Carbon Sequestration Leadership Forum (France)
Overcoming Barriers to CCS Deployment

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27 March 2007

ZeroGen: smarter, cleaner power

- **Project Overview**
- **Carbon transport and Storage**
- **IGCC and Capture**
- **Stakeholder Engagement**

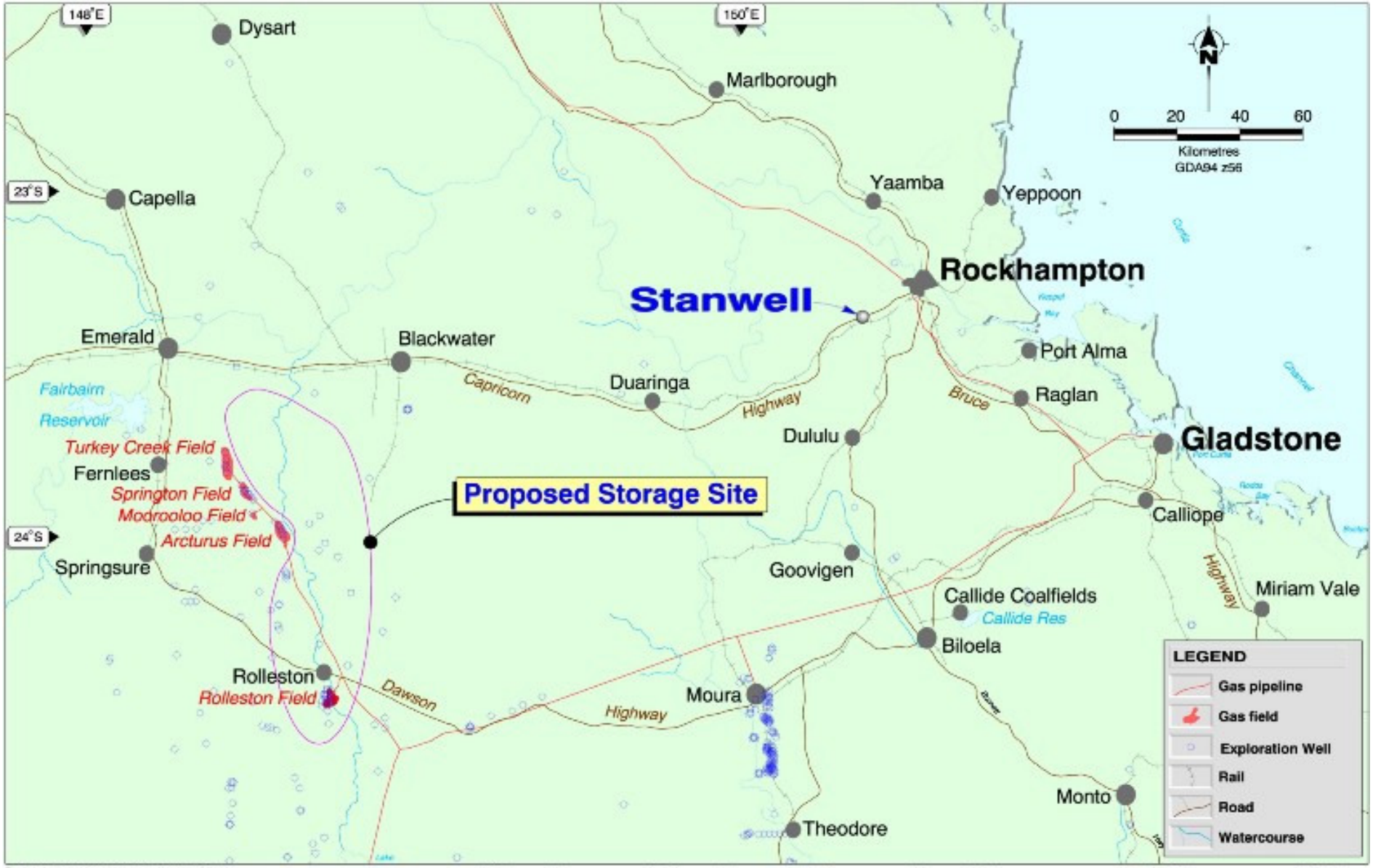
Who is ZeroGen Pty Ltd?

- ZeroGen Pty Ltd is owned by the State Government of Queensland.
- The ZeroGen Clean Coal Demonstration Project (the Project) is being developed by Stanwell Corporation Limited (Stanwell) on behalf of ZeroGen Pty Ltd.
- Stanwell is a Government-owned electricity generator based in Queensland, Australia. It is one of Australia's leading generators of environmentally responsible, reliable electricity with a diverse portfolio of coal-fired thermal, wind and hydroelectric power generation facilities in Queensland and other states.
- Stanwell has no inherent experience with geological investigations but has received technical support from Shell, a global leader in technical solutions for CO_2 management, to provide the necessary experience to design and appraise the Carbon Capture and Storage (CCS) project.
- ZeroGen's alliance with Shell will enable relevant oil & gas industry technology and best technical and operational practices are applied to develop an environmentally and commercially acceptable storage solution.

Project Overview

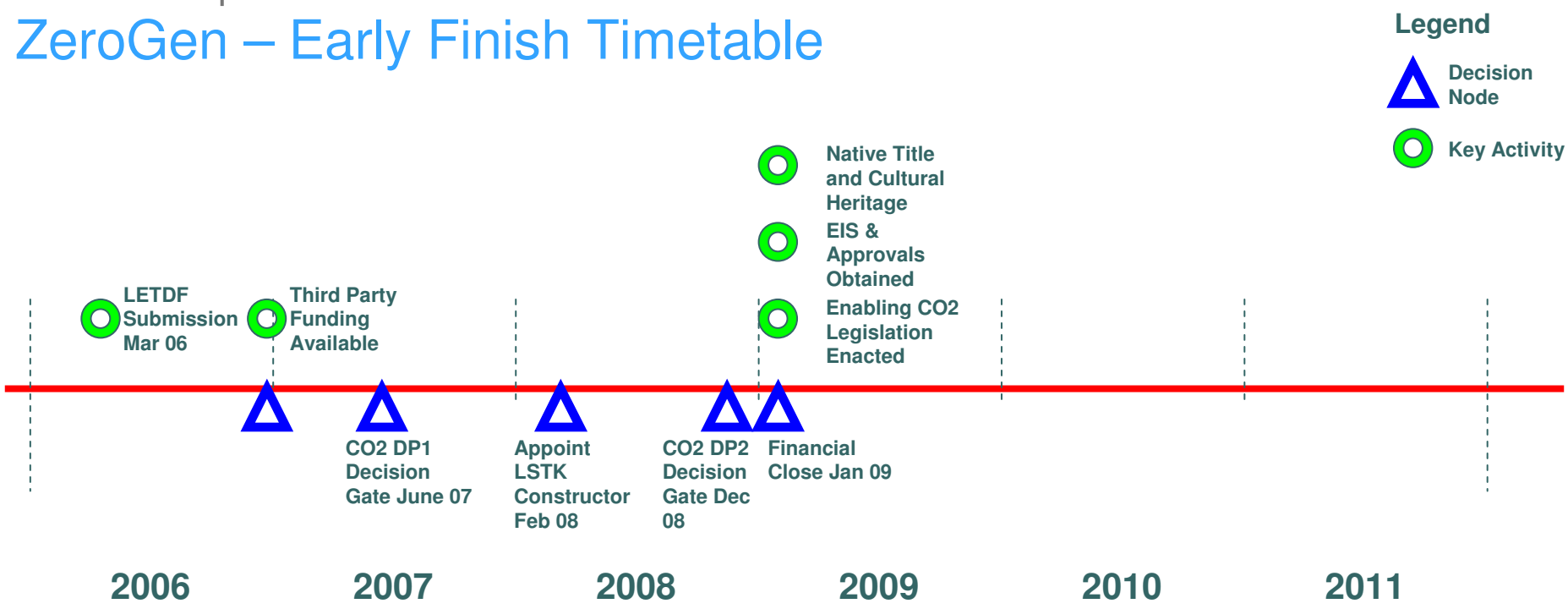
The fundamental objective of the Project is to generate knowledge - technical, regulatory, commercial and stakeholder - that will facilitate the commercial deployment of clean coal technologies.

- ZeroGen is a first-of-a-kind clean coal demonstration power project involving Carbon Capture and Storage (CCS) with Integrated Gasification Combined Cycle (IGCC) and using commercially available equipment.
- CCS is the critical enabling technology as it allows the necessary deep cuts in CO_2 emissions from fossil fuels.
- The proposed IGCC will generate between 60 - 80MW and approximately 300,000 to 400,000 tonnes CO_2 per annum.
- The size of the demonstration plant allows the learnings to be scaled for commercial deployment.
- ZeroGen's feasibility study is well advanced - Environmental Impact Statement process, stakeholder engagement process and design are proceeding as planned.



Northern Denison Trough - Proposed Storage Site

ZeroGen – Early Finish Timetable



Gasification Plant

Complete PreFeasibility Study

Front End Engineering EIS & Approvals

Detailed Design

Plant Construction

Plant Ramp-Up

CO_2 Compression, Transport and Injection

Drilling Evaluation Program (DP1 and DP2)

Well & Pipeline Construction

Rev 3

Geological Storage Potential in Australia

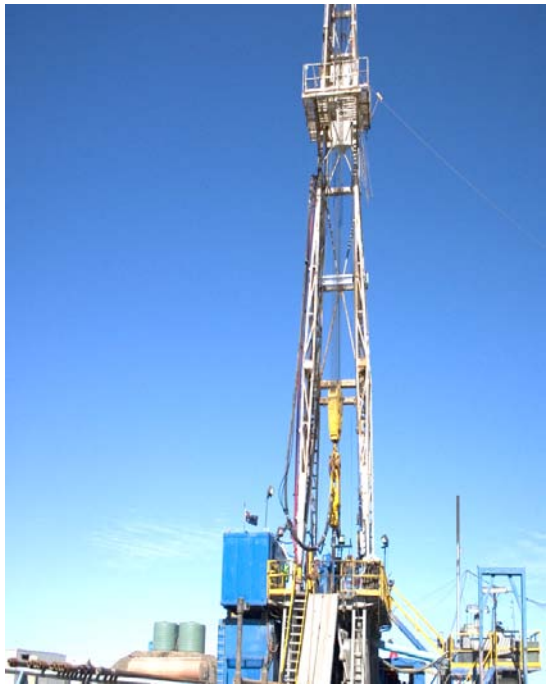
- Geological storage options for CO_2 include saline aquifers, depleted oil and gas reservoirs, unmineable coal seams and the use of CO_2 in enhanced oil, gas and coal seam methane recovery, and solutions will be regional.
- The Northern Denison Trough site was selected based on considerable research into suitable locations for CO_2 storage in Australia.
- The Northern Denison Trough appears an ideal test site for CO_2 storage because it is a sedimentary basin that has successfully trapped and stored large volumes of natural gas including CO_2 for millions of years and it has a low level of seismic activity.
- Additional storage potential for large-scale CCS applications are seen in the vicinity (e.g., Galilee Basin, Wunger Ridge, Roma Shelf), but require further investigation.

Carbon Transport and Storage

- The CCS solution is fundamental to the success of any clean coal technology.
- ZeroGen is engaging with oil and gas companies operating in other areas of the Northern Denison Trough to search for synergy in the implementation of CO_2 injection.
- This may lead to other investigations including the safe storage of CO_2 in nearby depleting gas fields or for future benefits, such as enhanced gas and coal seam methane production.
- ZeroGen's search for the optimal storage solution will contribute to the development of a regulatory framework. It will also contribute to the effective exploration of other large-scale storage possibilities in Queensland's geological basins.

Drilling Investigation Program - Objectives

To acquire geological, geophysical, reservoir and drilling engineering data to prove safe and reliable CO_2 containment in geological structure.



Drilling Program 1 (DP1) 2006/07 **"Site Identification"**

Determine:

- Suitability of reservoir for storage and injectivity.
- Cap rock robustness.
- Minimum depth for supercritical CO_2.
- Optimal well and completion design.
- Storage risk & uncertainties.

Drilling Program 2 (DP2) 2007/08 **"Site Verification"**

- Data acquisition to:
  - Reduce subsurface uncertainties to acceptable level.
  - Quantify Storage & Injection Potential.
  - Optimise the storage implementation plan.
- Test monitoring and verification technology.

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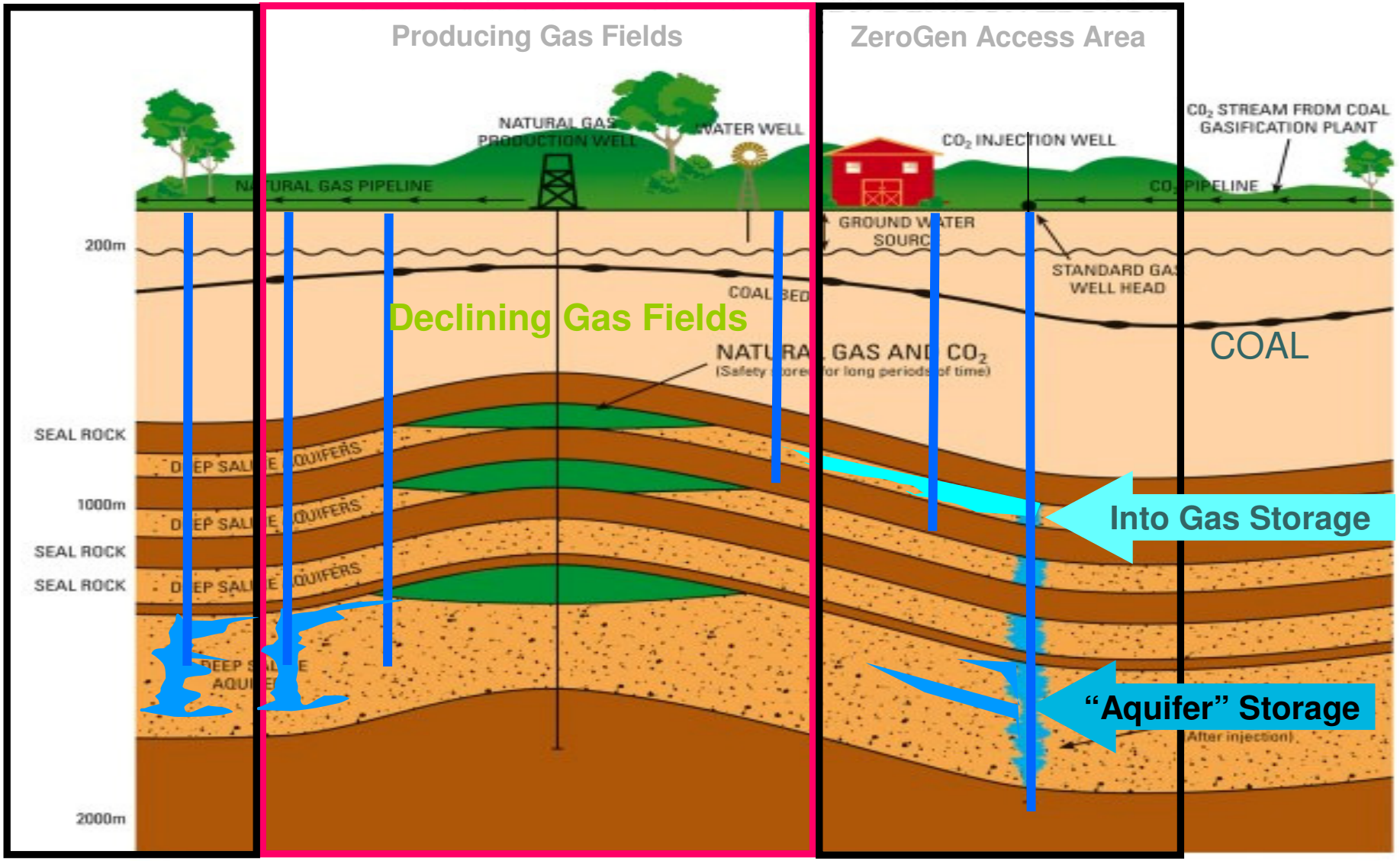
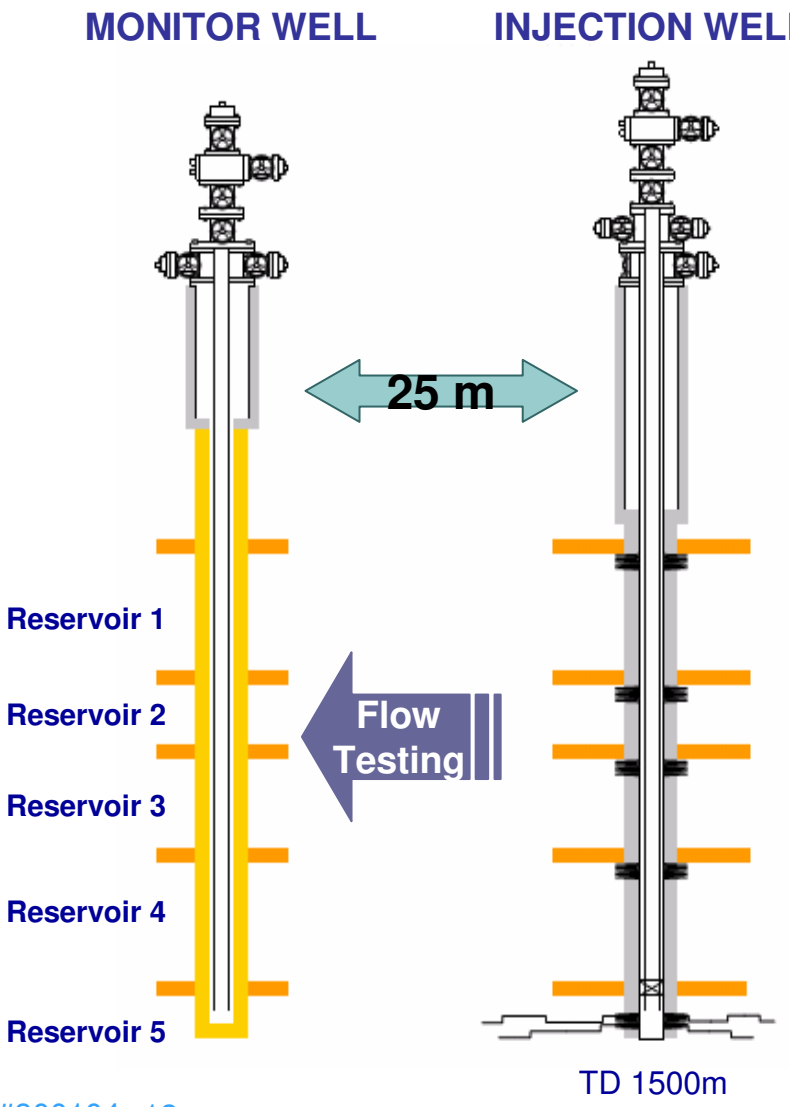
CO_2 Storage Concept Forward Plan



Drilling Investigation Program

- ZeroGen's drilling investigation program is well in advance of other CCS power projects in Australia.
- The first phase of the drilling program DP1 has been completed with the drilling of two test wells in the Northern Denison Trough.
- This has resulted in substantial first-hand operational and technical learnings on how to effectively drill and evaluate injection sites.
- The extensive log and core data acquired forms the basis of the required comprehensive containment analysis to fully describe the reservoir storage potential, storage risk and uncertainties.

Drilling Investigation - Injection Site



Acquired
- High Quality Wireline Logs (electrical, acoustic etc.)
- High Quality Core >> 150m of reservoir & seal rocks
- Rock Strength Data

To assess
- Storage Potential
- Reservoir & Cap Rock characteristics
- CO_2 - Rock chemical interactions
- Cap Rock effectiveness

Planned Water Injection Test on 5 reservoir zones
- Perforation "under-balanced"
  - Shallow Reservoir
  - Deep Reservoir
- Water Test after perforation
- Stimulate injection through fracc'ing
- Water Test after fracc'ing
- Airlift and Produce-Inject Monitoring well

To assess
- Injection Potential & Optimal Completion
- Reservoir Flow characteristics
- Reservoir strengths during injection
- Injection improvement by reservoir stimulation
- Injection depth critical phase fluid

Drilling Investigation – CO_2 Storage Forward Concept Plan

- Verify safe aquifer storage potential – Identify reservoir sweet spots within structural containment.
- Verify safe gas storage potential in declining gas field.
- Define operational synergy of declining gas production & CO_2 storage.
- Select efficient CO_2 monitoring & verification system.
- Develop Field injection plan:
  - ➔ Aquifer “terminal” storage
  - ➔ Gas “temporary” storage for future use in EGR and ECBM

Drilling Investigation Program - Learnings

- ZeroGen's initial water testing technique was not adequate for the type of low permeable rock encountered. Core analysis indicates good reservoir potential at 800 meters.
- Ongoing water injection testing is expected to provide learning's critical to the well count, one of the major project cost drivers, ie:
  - the injectivity potential of the low permeable rock.
  - the most optimal well design and injection completion techniques.
- ZeroGen has developed a new injection testing program with the assistance of Shell and Halliburton perforation specialists. It will include under-balanced perforation, high-energy guns and near-well bore reservoir stimulation techniques (mini-frac).

Exploring Technical Barriers to Carbon Storage

- **Modeling and reservoir simulation**
  - Subsurface CO_2 Containment Model for ZeroGen demonstration storage site & Northern Denison Trough.
  - Accurate simulation of injected CO_2 propagation through time.
- **Cost**
  - Location of suitable reservoir 'sweet spots' that reduce well count.
  - Definition of cost effective CO_2 facilities and well designs.
- **Quantified risk assessment** to allow liability consideration.
- Selection of the most effective CO_2 **monitoring & verification techniques**.
- **Permit and regulatory framework**.

ZeroGen IGCC – Development History

- Initial concept studies in 2002 indicated that 420MW IGCC with carbon capture would cost approximately AU$1.2 billion.
- Shell were selected in 2005 as preferred gasification technology provider after international Expression of Interest process for 200MW IGCC demonstration plant.
- Shell prepared the pre-feasibility study for 200MW IGCC plus CCS demonstration based on GE-9E CCGT – capital cost per unit of net power output was 1.5 to 1.8 times higher than data from publicly available studies.
- Significant Project reviews undertaken over 2006-2007 to identify the best value for money proposition for a demonstration project.
  - Considered a range of GT options, from small open cycle GT, up to a full-scale commercial CCGT (~500MW), to a combined cycle with proven high hydrogen operation; optimisation of gasification through partial water quench, optimisation of coal feed configuration, review of water handling.

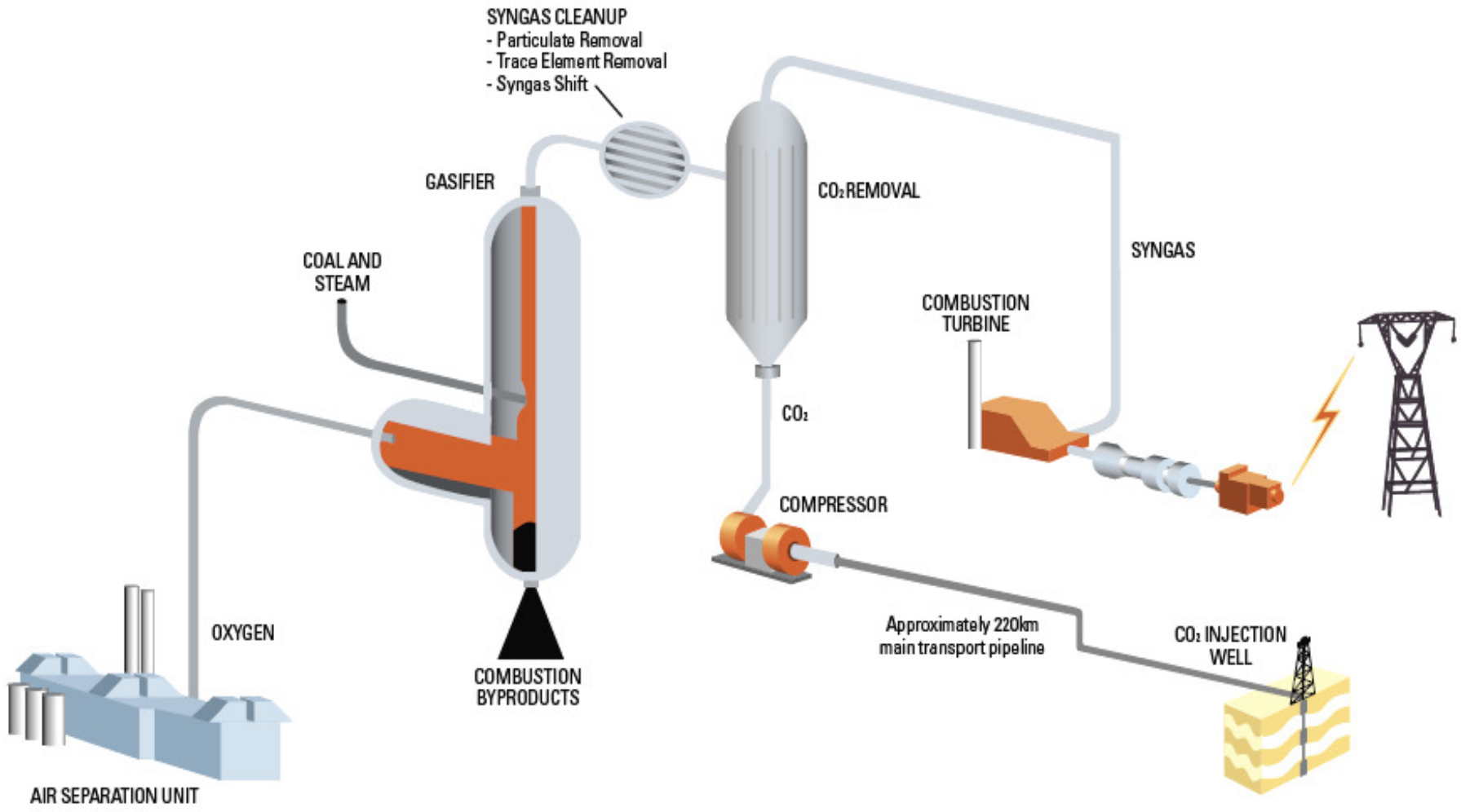
ZeroGen IGCC – Development History

- All elements demonstrated in ZeroGen (gasification, syngas cleanup, gas turbine, CO_2 capture, transport and storage) needed to be readily scaleable for application in merchant IGCC plant with CCS.
- Capital cost of deployment of current generation IGCC technology (without CCS) at 550MW net power output is estimated to be in excess of AU$1.9 billion. The addition of CCS will add additional costs and risk.
- Process integration risk has been identified as the single largest risk to deployment of the technologies that make up an IGCC plus CCS demonstration project.
- **It was therefore assessed that a demonstration plant costing approximately AU$1.0 billion at 60 - 80MW would provide the same knowledge benefits with lower risk when compared to a 550MW commercial scale plant (with CCS) costing in excess of an estimated AU$2.8 billion.**

Preferred Configuration

- Shell partial water quench gasifier – optimal for hydrogen production with shift.
- GE-6B gas turbine in CCGT configuration – most experience on hydrogen syngas offering lower risk for reliable CO_2 production.
- Capital costs for the demonstration project estimated at approximately AU$1billion.

ZeroGen Demonstration Project Schematic



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IGCC Development - Learnings

- Costs used from public domain literature significantly underestimate capital costs of IGCC (and SCPF) in current construction market.
- More recent cost estimates (EPRI [2006] – Texas IGCC / SCPF fuelled with Powder River Basin coal) are more representative of current construction market conditions, and correlate with current ZeroGen real market price testing.
- Demonstration Plants are required to optimise designs, improve reliability and reduce costs
- Tangible commercial experience of gas turbine operation on high hydrogen syngas fuel is scarce – need to demonstrate at appropriate scale for eventual deployment in full-scale commercial IGCC plant. GT vendors claim that high hydrogen machines can be produced at large commercial scale now.

Stakeholder Engagement - Context

- Stakeholder acceptance of CCS as a safe solution to reducing CO_2 emissions is a critical challenge to deployment.
- Australian context - Climate change issues are front and centre of public debate. Research by ACNielsen and cLET indicate 90+% of Australians rate climate change as vital to the nation's future.
- cLET research on stakeholder perspectives to LET's in Queensland found, "Such a consensus is rare on any issue suggesting a seismic shift is occurring in public thinking… Whatever the source, Australians clearly want their energy a) clean, b) affordable."
- Environmental NGO's actively lobbying policymakers for new coal-fired power stations only with CCS as part of a portfolio of low-emission generating technologies. Also, GHG emissions and their cost is increasingly the focus of legal challenges to new proposed coal mines.
- Legal challenges to new coal mine development in Australia. Australian Financial Review (13 March 2007) reports a proposed mine is required to include $AUD109/tonne CO_2 ($US 85/tonne from Stern Review) cost of GHG emissions as part of environmental permitting process. This is a test case.

Stakeholder Engagement - Learnings

- Positive approach - **Linking the ability of technologies** being demonstrated by ZeroGen to enable **deep cuts in CO_2** emissions as part of a **portfolio of solutions** to climate change and **supporting future of coal related jobs** (~13,000 in Queensland).
- Initially, **almost no understanding of CCS or IGCC technologies** among government, business and community.
- Very large number of stakeholders (over 50 groups) at international, national, state and local levels. **Critical to establish trust from day one**.
- Inform, inform them again, then inform them again. **All stakeholders matter**. Very strategic and intensive engagement program to build ownership.
- **Build broad coalition of support outside of traditional power sector** – E.g., AgForce Queensland, largest rural lobby group with 7,000 members, supports ZeroGen as a key to reducing the impact of climate change on their businesses.
- **Aboriginal groups** in project zone support ZeroGen's potential environmental benefits.

Going Forward – key activities

- Proving safe and reliable CO_2 containment in geological structure – continue the three stage process:
  - Drilling Program 1 (DP1) 2006/07 – Confirm reservoir & injection potential and suitability of the cap rock of identified storage site. (in Progress)
  - Drilling Program 2 (DP2) 2007/08 – Site verification; gather the data for optimised field injection design and test monitoring and verification technology.
  - Develop the storage forward concept plan.
- Maintaining the public confidence of CCS as being “safe”. Learn by doing.
- Encouraging local engagement in ZeroGen to combat the global problem of climate change by “thinking global and acting local”.

Project Funding

- AU$20M to date on the pre-feasibility study and DP1 evaluation.
- AU$100M committed to complete feasibility study by Queensland Govt.
- AU$200M available from Queensland Govt for construction.
- Up to AU$100M from Shell if equity option is accepted.
- Submission in 2007 to Australian Federal Government for substantial funding.
- Australian Coal Association considering significant funding.

Project Participants

Queensland Government

Rockhampton City Council

Fitzroy Shire Council
THE BIG RIVER SHIRE

Emerald shire council

Duaringa Shire Council
FAITH · WORK · SERVICE

SUNSHINE GAS LIMITED

Shire of Bauhinia

EPRI ELECTRIC POWER RESEARCH INSTITUTE

AGFORCE

Rockhampton Regional Development

CENTRE FOR LOW EMISSION TECHNOLOGY

CCSD
COOPERATIVE RESEARCH CENTRE FOR GREENHOUSE GAS TECHNOLOGIES

CO2CRC