Chevron’s Business-Driven Actions on Greenhouse Gas Emissions Management: Gorgon Project and Other Examples

International Workshop on CO2 Capture and Storage
Tokyo, Japan

Arthur Lee

20 February 2006
Business-Driven Actions on Greenhouse Gas Emissions Management

• Strong Centralized Greenhouse Gas Management
• Management Processes and Tools Integrated to Business
• Carbon Markets Team
• Partnerships
Importance of Climate Change Issue to Chevron

**CO₂ and methane emission sources**

- **Production**
  - Combustion and rotating equipment, flaring, venting
  - Gas associated with oil production

- **Transportation**
  - Pipelines
  - Vessels
  - Vehicles

- **Refining and Petrochemical Production**
  - Heaters
  - Boilers

- **End Use**
  - Customer use of gasoline, diesel, and coal

**Sources**
- CO₂
- Methane

**Emission**
- CO₂
- Methane
- Primarily CO₂
- CO₂

*International Workshop on CO₂ Geological Storage, Japan ‘06*
Chevron’s Climate Change Position and Action Plan

**Position:** We at Chevron Corporation are responding to increasing climate change concerns by integrating an action-based approach into our business strategy.

**Plan:** 4-Fold Plan predicated on **ACTION**

- **Support flexible & economically sound policies and mechanisms that protect the environment**
- **Reduce greenhouse gas emissions (GHG) and increase energy efficiency**
- **Pursue business opportunities in promising innovative energy technologies**
- **Invest in research, development, and improved technology**
Organization of the Climate Change Steering Council and Supporting Teams

- Additional teams will be added as needed
Actions and Results

Greenhouse Gas Emissions Accounting To Become Standardized --CVX SANGEA™ software has role

CVX Energy Efficiency Improved 24% from 1992. US Refinery Plans an Additional 10% by 2012 via API Commitment to the US.

CVX OpCos Set Emission Goals for 2005 and Forecast 2005-07

CVX To Reduce Upstream Flaring/Venting in Nigeria and Angola. F/V is 24% CVX GHG

Gorgon Project – State-of-art CO2 Reinjection Program Planned in Australia (2-3 million metric tons per yr)
*Emission calculations made following Guidelines accounting and reporting procedures and Compendium emission estimation methods.

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## Capital Projects GHG Evaluation Flowchart

<table>
<thead>
<tr>
<th>GHG Evaluation Tools</th>
<th>GHG analysis integral to early examination of alternatives - Early Phase 2</th>
<th>GHG analysis of key project alternatives - Late Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phase 1</strong></td>
<td>No GHG analysis required</td>
<td><strong>Phases</strong></td>
</tr>
<tr>
<td>- GHG Management Primer</td>
<td>- GHG Emissions Projector</td>
<td>- GHG Mitigation Planning Tool</td>
</tr>
<tr>
<td>- GHG Screening Tool</td>
<td>- Example Project GHG Evaluations</td>
<td>- Contact GHG Management Expert Resource</td>
</tr>
<tr>
<td>- Mergers &amp; Acquisitions Tool</td>
<td>- Document analysis in Appropriate Request</td>
<td>- Detailed GHG analysis of chosen alternative - Phase 3</td>
</tr>
<tr>
<td>- GHG Forecasting</td>
<td>- Capture GHG learnings and improved processes</td>
<td>- Look back</td>
</tr>
<tr>
<td>- Lessons learned</td>
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</tr>
</tbody>
</table>

**Screening Tool**

- "Small"
- "Medium"
- "Large"

**Begin Phase 1 Planning for Capital Projects**

*SANGEA™ is a trademark of the American Petroleum Institute*
Carbon Markets Team (CMT) Organizational Functions

CMT Organizational Structure

CMT Management

A
Policy & Business Planning

B
Credits Management

C
Consulting & Project Advocacy

Network of Experts in Credit Management, Law, Tax, Public & Govt Affairs, as needed

Source: Evolution Markets

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SETTING THE SCENE ... INCREASING LEVELS OF POLICY DEVELOPMENT

1992 – U.N. Framework Convention on Climate Change

1997 – The Kyoto Protocol (156 nations ratified; US and Australia have not ratified)

2001 – Marrakech Accords (Clean Development Mechanism)

**UNITED STATES 2005**
(1) California Executive Order
(2) Gulf Coast climate damage suit
(3) NE States regional GHG initiative

**EUROPE 2005**
EU Emissions Trading Scheme (impact on CVX operations in the UK and Netherlands)

**CANADA 2005**
(1) Voluntary Agreement with Autos
(2) Regulatory Proposal for Large Sources

**AUSTRALIA 1995 and 2003**
Voluntary Greenhouse Challenge Agreement 2003 (Gorgon)

**Int’l Flaring Standard 2004**
(CVX’s operations in Angola, Nigeria, Kazakhstan, Indonesia)
Climate Change Policy Drivers

G8 Gleneagles Plan of Action on Climate Change, Clean Energy and Sustainable Development recognizes that advances in a portfolio of technologies are critical for the stabilization of greenhouse gas concentrations.

**Technology common ground**

- G8 nations disagree over the Kyoto Protocol
- G8 Plan of Action is the common ground.

**In the transport area, G8 Gleneagles Plan of Action commits the nations to:**

- Launch a Global Bioenergy Partnership to support wider, cost-effective, biomass and biofuels deployment, particularly in developing countries where biomass use is prevalent
- Encourage the development of cleaner, more efficient and lower-emitting vehicles
- Promote their deployment by adopting ambitious policies to encourage sales of such vehicles, including public procurement to accelerate market development
Climate Change Policy Drivers

**G8 Gleneagles Plan of Action on Climate Change, Clean Energy and Sustainable Development** recognizes that advances in a portfolio of technologies are critical for the stabilization of greenhouse gas concentrations.

**Technology common ground**

- G8 nations disagree over the Kyoto Protocol
- G8 Plan of Action is the common ground.

**In the CO2 capture and storage technology area, G8 Gleneagles Plan of Action commits the nations to:**

- Acceleration of the development and commercialization of carbon capture and storage (CCS) technology by endorsing the objectives and activities of the Carbon Sequestration Leadership Forum (CSLF)
- Working with the IEA and the CSLF to hold a workshop on short-term opportunities for CCS in the fossil fuel sector, including from enhanced oil recovery and CO2 removal from natural gas production
- Collaboration with key developing countries to research options for geological CO2 storage
Business-Driven Actions

- Gorgon Project
- Climate Change Related Joint Industry Projects
- Operating Companies’ and Business Units’ Activities in Support of 4-Fold Action Plan
- “Practical Hydrogen” – Hydrogen Infrastructure Development
Australia: Vast Resources Offer Clean Fuels Promise and GHG Advances

- CVX is 1/6 Equity Owner in NWS LNG Venture
- CVX is also Operator and Lead Developer of Gorgon LNG with more than 40 TCF in Greater Gorgon area.
Gorgon Development Plan

- Jansz Field
- Gorgon Field
- Subsea tie-back to Barrow Island
- 2 x 5mtpa LNG trains & CO₂ Injection on Barrow Island
- Domestic Gas Connection to the mainland
- LNG Exports
- Karratha
- Onslow
- Existing Domestic Pipeline
- North West Shelf

AUSTRALIA

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Gorgon CO₂ sequestration will be the largest such project in the world.

It will be managed through:

- Greenhouse Gas Management Strategy
- Environment, Social and Economic Review commitments
- Greenhouse Gas Management Plan
- Environmental Impact Assessment process (EIS/ERMP)

“Greenhouse gas management is part of our business”

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Gorgon Gas Development Greenhouse Gas Management Strategy

The Gorgon Development Greenhouse Gas Management Strategy for a Barrow Island development is to:

- Demonstrate via lifecycle analysis that a Gorgon gas development and LNG export results in a net reduction in global greenhouse gas emissions relative to other fossil fuel alternatives.
- Design the production facilities to incorporate current best practices in thermal efficiency and greenhouse emission control where practicable.
- Develop a project to re-inject the removed reservoir CO₂ into the Barrow Island Dupuy saline reservoir, unless it is technically infeasible or cost-prohibitive. This will involve:
  - Pursuing a stepwise process to: develop a reservoir CO₂ re-injection project, demonstrate technical feasibility, and ensure costs to the project are not excessive.
  - Selling treated gas to meet domestic gas customer requirements and re-inject the removed reservoir CO₂.
  - Commencing re-injection as soon as practicable after the processing facilities commissioning and start-up process.
  - Implementing re-injection of reservoir CO₂ by installing a single train of injection equipment, sized for the full volume of reservoir CO₂.
- Investigate potential synergies with existing Barrow Island operations and implement measures that minimise greenhouse emissions and enable full use of associated gas production where practicable.
- Pursue projects and opportunities which provide net conservation benefits and enhance greenhouse gas removal from the atmosphere.
- Continue existing funding for greenhouse gas related research and development projects such as CRC’s and technological research.
- Review options for funding additional value-added research and development or demonstration projects.
- Pursue potential opportunities for external sale or use of separated reservoir CO₂ as a chemical feedstock or enhanced recovery agent.
- Develop a contingency plan that could provide a partial offset for reservoir CO₂ if a sequestration project proves infeasible. Options may include:
  - Maturing alternative re-injection sites that could be developed in the future such as a depleted gas reservoir.
  - Creation of emission reductions or offsets external to the Gorgon gas development.
  - Sequestration opportunities such as forestry.
- Additional research funding.
- Meet the commitments within the LNG Action Agenda including the revision of the existing Gorgon Greenhouse Challenge Cooperative Agreement.
- Continue to advocate increased use of gas based fuels, in preference to more carbon intensive options, to reduce greenhouse emissions.
- Participate constructively in the development of greenhouse policy at both the State and Commonwealth level.

Paul Oen
Gorgon Area General Manager
EIS/ERMP - Combined federal state environmental assessment

Public release 12th September

Followed by a ten week public comment period

Environmental approval mid 2006
To ensure the efficient use of capital resources, CO₂ injection is planned to be implemented using injection equipment sized to handle the expected rate of reservoir CO₂ removed from the incoming gas stream to the gas processing facility. Venting of reservoir CO₂ will be required during commissioning, periods of maintenance and equipment downtime associated with the injection equipment or for reservoir constraints. Full redundancy in the CO₂ injection system to eliminate venting as a contingency, cannot be justified given the impact on project financial viability.

In the unlikely event that the proposed CO₂ injection should prove technically infeasible or cost prohibitive, such as if it is determined that a large number of additional injection wells are required, the Gorgon Joint Venturers will consult with government with the intent of maximising the injection of CO₂ within the commercial constraints of the Gorgon Development.

At any time the Joint Venturers consider that the injection of reservoir CO₂ represents an unacceptable risk to the environmental values of Barrow Island, or a safety risk, then CO₂ injection operations would be suspended and the remaining reservoir CO₂ vented to the atmosphere.
Greenhouse Gas Emissions - Efficiency Improvements

13.3.1

1998 Concept - Greenhouse Challenge Agreement
Use of Sub-Sea Production System
LNG Technology Improvement
Improved Waste Heat Recovery
Reservoir CO2 Injection
Reference Case Emissions Efficiency
Potential for Further Reductions Based on Performance Targets

Tonnes CO2e / Tonne LNG

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Predicted Annual Emissions

13.3.4

<table>
<thead>
<tr>
<th>Emissions Source</th>
<th>LNG Processing</th>
<th>Domestic Gas Processing</th>
<th>Island Infrastructure Support</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPA CO₂e</td>
<td>TPA CO₂e</td>
<td>TPA CO₂e</td>
</tr>
<tr>
<td>Gas Turbine – Gas Processing Drivers</td>
<td>1 612 000</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Gas Turbine – Power Generation</td>
<td>1 287 000</td>
<td>200 000</td>
<td>60 000</td>
</tr>
<tr>
<td>Fired Heaters</td>
<td>71 000</td>
<td>28 000</td>
<td>Nil</td>
</tr>
<tr>
<td>Flare – Events</td>
<td>60 000</td>
<td>Minor</td>
<td>Nil</td>
</tr>
<tr>
<td>Flare – Pilots</td>
<td>2 000</td>
<td>Minor</td>
<td>Nil</td>
</tr>
<tr>
<td>Fugitive Emissions</td>
<td>Less than 1 000</td>
<td>Less than 1 000</td>
<td>Nil</td>
</tr>
<tr>
<td>Transport</td>
<td>Nil</td>
<td>Nil</td>
<td>10 000</td>
</tr>
<tr>
<td>Diesel Engines</td>
<td>Less than 300</td>
<td>Minor</td>
<td>Minor</td>
</tr>
<tr>
<td>Reservoir CO₂ Vented</td>
<td>500 000</td>
<td>180 000</td>
<td>Minor</td>
</tr>
<tr>
<td>Total</td>
<td>3 534 000</td>
<td>409 000</td>
<td>70 000</td>
</tr>
</tbody>
</table>

EIS/ERMP also contains estimates of emissions during construction and decommissioning.

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Greenhouse Gas Emissions – Comparative Benchmarking (LNG)

Comparative Greenhouse Gas Emissions

Australian LNG

North West Shelf (1998) 0.59
North West Shelf (2003) 0.49
North West Shelf - Train 4 0.35
Dawin LNG - 10 MTPA Design 0.44
Gorgon Development 0.46

International LNG Developments

North West Shelf - Train 4 0.44
North West Shelf - Train 4 0.46
Gorgon Development 0.46

Gorgon Development

Sokhna 0.35
Oran LNG 0.22
Mega LNG 0.34
Atlantic LNG 0.36
RasGas 0.39
Qatargas 0.39

Tonnes CO₂e / Tonne LNG

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Reservoir CO₂
Setting the scene  13.4

Expected gas composition of reservoir CO₂ (99% CO₂)
Experience with CO₂ injection
Assessment of CO₂ injection sites (Central East Coat)
Geology of Barrow Island
  Stratigraphy
  Structure
CO₂ behavior in the subsurface
  Phase behavior of CO₂
  Trapping mechanisms
    Solution trapping
    Residual gas trapping
    Mineralogical trapping
    Large-scale geometric trapping
Injectivity/tortuosity compromise
Baffles and Barriers
Operational Phase
Post Operational Phase
CO₂ Injection Development Concept

13.4.2

CO₂ compressors and pumps integrated into gas processing facility

7 injection wells drilled from 2 or 3 drill pads

CO₂ pipelines

Fit for purpose monitoring program

Commitment to make data from the ongoing monitoring available to the public
Barrow Island Stratigraphy

13.4.3

Target reservoir for CO₂ injection

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Reservoir Simulation
13.4.5

Reservoir Simulation
Single injection well simulation
Full reservoir simulation
Pressure field
Displaced formation water
Deviations from simulation predictions
High permeability layers
Down dip migration
Existing wells

DM E-W : 5yrs
The JVs believe that existing statutory regulation & Common Law provide appropriate mechanisms for managing liabilities associated with CO2 injection.

The Gorgon JV proposes that its day-to-day involvement with the site continue after the cessation of injection operations.

The Post-Injection Phase would end once agreement was reached with government that the closure criteria for the site had been met.

Reference to the Draft Regulatory Principles

Prior to site closure, government would need to be satisfied to a high degree of certainty that:

- Future land use objectives defined at the time of project approval have been met.
- The residual risks of leakage & resulting liabilities are acceptably low.
- The ongoing costs associated with the site are acceptably low or are otherwise appropriately managed.
Comparison of Global CO$_2$ Re-Injection Projects

- Sleipner (Utisra Reservoir) is the only active CO$_2$ sequestration project in the world today

**Active CO$_2$ EOR Projects**

- Gorgon
- In Salah
- Rangely
- Snovit
- Sleipner
- Lost Hills
- Weyburn
- Frio
- Vacuum
- West Pearl
- Queen

**Comparison of Global CO$_2$ Re-Injection Projects**

- Mass of CO$_2$ (MMt)

- Active storage project into saline aquifer
- Planned storage project into saline aquifer
- Active CO$_2$ EOR Projects

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Linking the Gas Value Chain

Forging strong links all along the gas value chain is critical to the commercialization of the significant volumes of remote natural gas resources throughout the world.
West African Gas Pipeline (WAGP)

Gas transmission system owned and operated by WAPCo, extending from the ELPS to landfalls in Benin, Togo and Ghana

Existing Escravos-to-Lagos Pipeline System (ELPS)

Owned and operated by NNPC
Climate Related JIP Involvement

Partial List …

- CO2 Capture Project
- CO2CRC
- IEA Weyburn
- MIT Carbon Sequestration Initiative
- WestCarb (DOE Regional Partnership)
- Global Gas Flaring Reduction Partnership
- Industry Consortia: API, IEA, IPIECA (chairs Climate Change Working Group), CO2NET
Chevron Energy Solutions -
Solar Photovoltaic Installation
(Public Library, City of Richmond, CA)
Darajat Geothermal Expansion

• 110 MW Expansion of Darajat geothermal power project

• Will help meet electricity demands of Java, Madura and Bali, where supply shortages are anticipated

• Will help Indonesia avoid more than 400,000 tons per year of CO2 emissions

• Darajat’s geothermal resources are abundant, clean, renewable.

• Resource operated by Chevron Energy Indonesia Ltd (CTEI)
Chevron Technology Ventures

Find, Launch, and Grow New Energy Technology Businesses

- Add new intellectual capital and organizational capability
- Create options in disruptive technologies
- Augment core R&D
- Add value chain extensions
- Adding a new operating sector

Hydrogen Business Unit
Emerging Energy Business Unit
Molecular Diamonds LLC
Venture Capital Equities

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Technology Ventures: Renewable Energy Systems

Solar Mine project in the Midway-Sunset heavy oil field

Renewable energy systems integrated into oil field operations

Nerefco Project, Rotterdam refinery
Advanced Batteries

- The power behind hybrid vehicles
- COBASYS has completed construction of an NiMH Battery Plant

- COBASYS signed a cost-sharing contract to continue the development of NiMH batteries under the sponsorship of the U.S. Department of Energy’s FreedomCar initiative

New Manufacturing Facility
Springboro, Ohio
Practical Hydrogen - Navigating the Transition
Public - Private partnerships play a central role

Today  Transition Stage  Future

R&D
Demonstration projects
Specialized stationary power applications

Petrochemical

• Test bed for new component technologies
• Community interaction, outreach, and education

Distributed economic hydrogen-based energy & transport systems

Prototype fleet and energy infrastructure systems

• Sufficient size and complexity
• Cost-efficient - leverages the existing energy grid

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U.S. DOE Hydrogen Fleet & Infrastructure Demonstration & Validation Project

5 year project to showcase practical application of H2 technology. Chevron is consortium leader and fuel supplier; Hyundai-Kia Motors the vehicle supplier; and UTC Fuel Cells will supply the FC stacks.

Develop and demonstrate safe, convenient, reliable H2-based distributed power generation, FCVs and vehicle fueling infrastructure.

Educate key audiences about H2 as potential fuel for transportation and power generation.

Sites and fleet operators: HATCHI, SoCal Edison, AC Transit and U.S. DOD.

Fueling for up to 32 H2 FCVs.

Integrated Codes & Standards, Education & Outreach Plans.
Opportunities in Early Markets for Hydrogen

High-Quality Distributed Power

• Fuel cell installation in Bellaire, TX and San Ramon, CA

Vehicle Fleets

• AC Transit Fuel Cell Bus Program
• US Department of Energy Project
The Hydrogen Highway: moving to the next phase

Distributed \( \text{H}_2 \) production, stationary power generation, and fleet fueling
The Hydrogen Highway: moving to the next phase (18 February 2005)

Chino, California

Hydrogen Fueling Dispenser

Unveiling at Chino, California

Groundbreaking at Orlando, Florida
Business-Driven Actions on Greenhouse Gas Emissions Management

Strong Centralized Greenhouse Gas Management
- Executing the Four-Fold Action Plan
- Climate Change Steering Council

Management Processes and Tools Integrated to Business
- Carbon management systems integrated into business planning
- Multiple emissions-reducing project activities

Carbon Markets Team
- Centrally coordinates trading and credit activities worldwide

Partnerships
- Key opportunity areas to address technology and business development