



**WorleyParsons**  
resources & energy

EcoNomics™

# CO<sub>2</sub> Pipeline Risk & Operational Integrity

Gasification Technologies Workshop  
Terre Haute, Ind. – July 1, 2010





- ▶ Leading professional services provider to the energy, resource, and complex process industries
- ▶ Organized into the following Customer Sector Groups:



### Upstream Hydrocarbons

- Fixed Offshore Facilities
- Floating Production Systems
- Subsea Systems
- Offshore Pipelines
- Onshore Pipelines
- Onshore Production Facilities
- Processing Plants
- LNG
- Terminals



### Downstream Hydrocarbons

- Refining
- Petrochemicals
- Chemicals
- Polymers
- Gasification
- Sulphur Management



### Power

- Coal-Fired Plants
- Advanced Coal
- Nuclear
- Gas Turbine/ Combined Cycle
- Air Quality Control
- Integrated Gasification Combined Cycle (IGCC)
- Transmission & Distribution
- Operations & Maintenance
- Renewable Energy



### Minerals & Metals

- Base Metals
- Coal
- Chemicals
- Ferrous Metals
- Alumina
- Aluminum
- Iron Ore
- Gas Cleaning

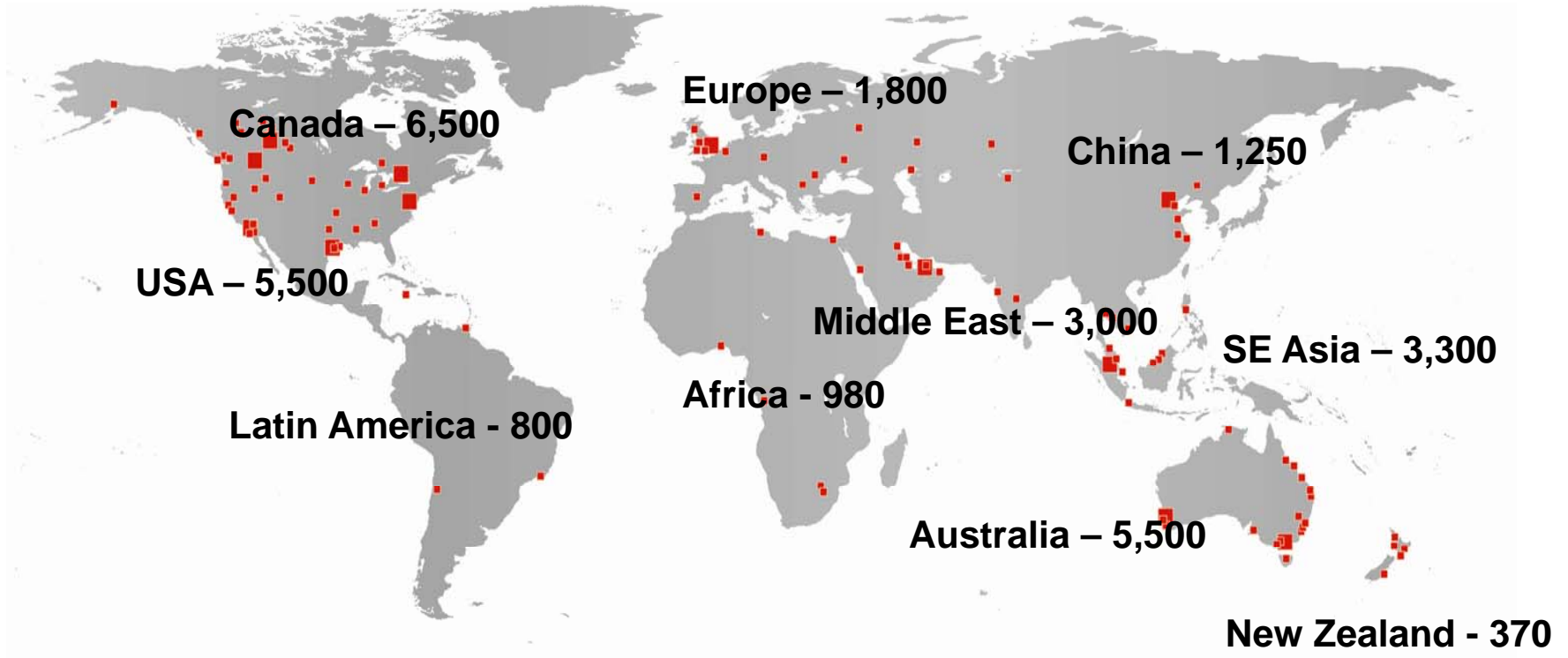


### Infrastructure & Environment

- Transport
- Buildings
- Industrial
- Defense
- Environment
  - ▶ Environment and Social Impact
  - ▶ Contaminated Sites
  - ▶ Environmental Strategy & Liability
  - ▶ Waste Management
  - ▶ Water Resources

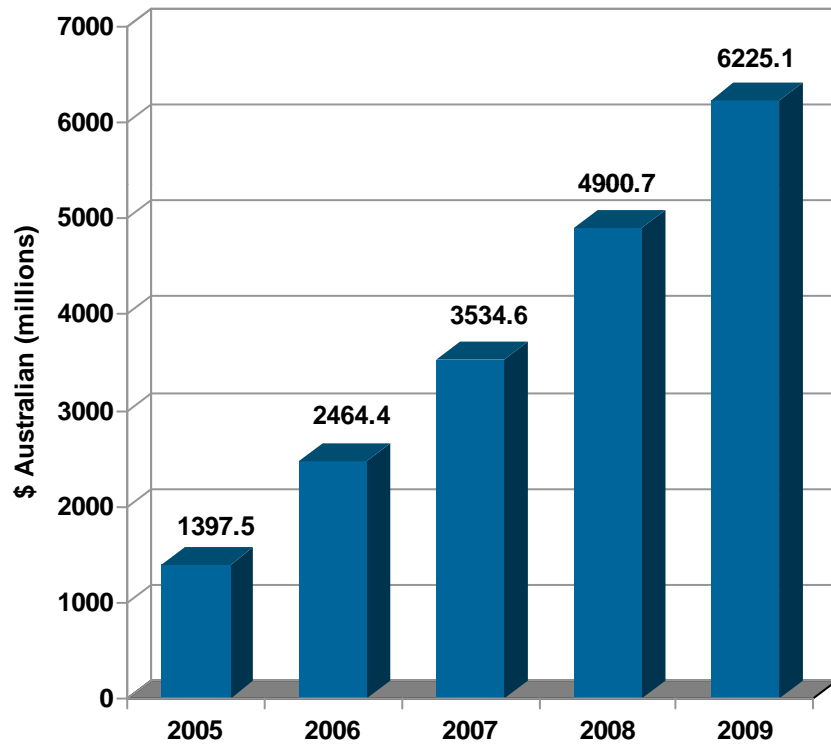


**120 offices | 38 countries | ~29,000 personnel**

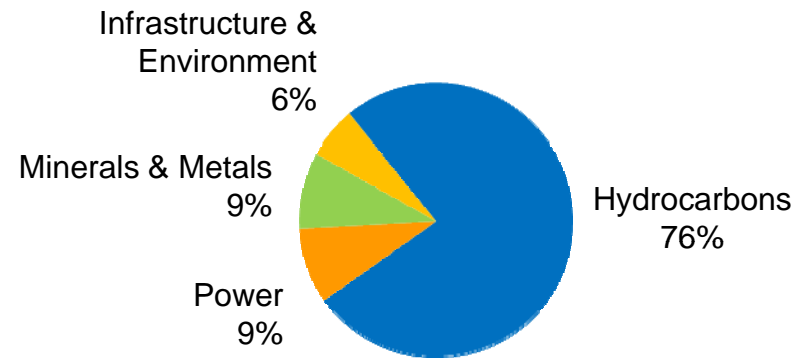




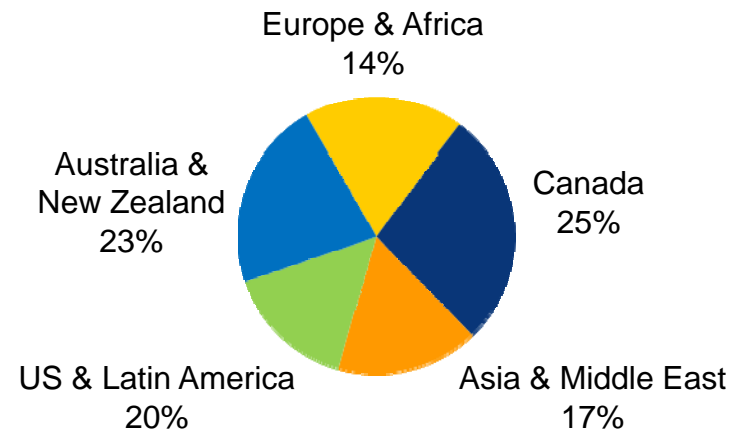
## Revenue by Year



## 2009 Revenue by Industry Sector



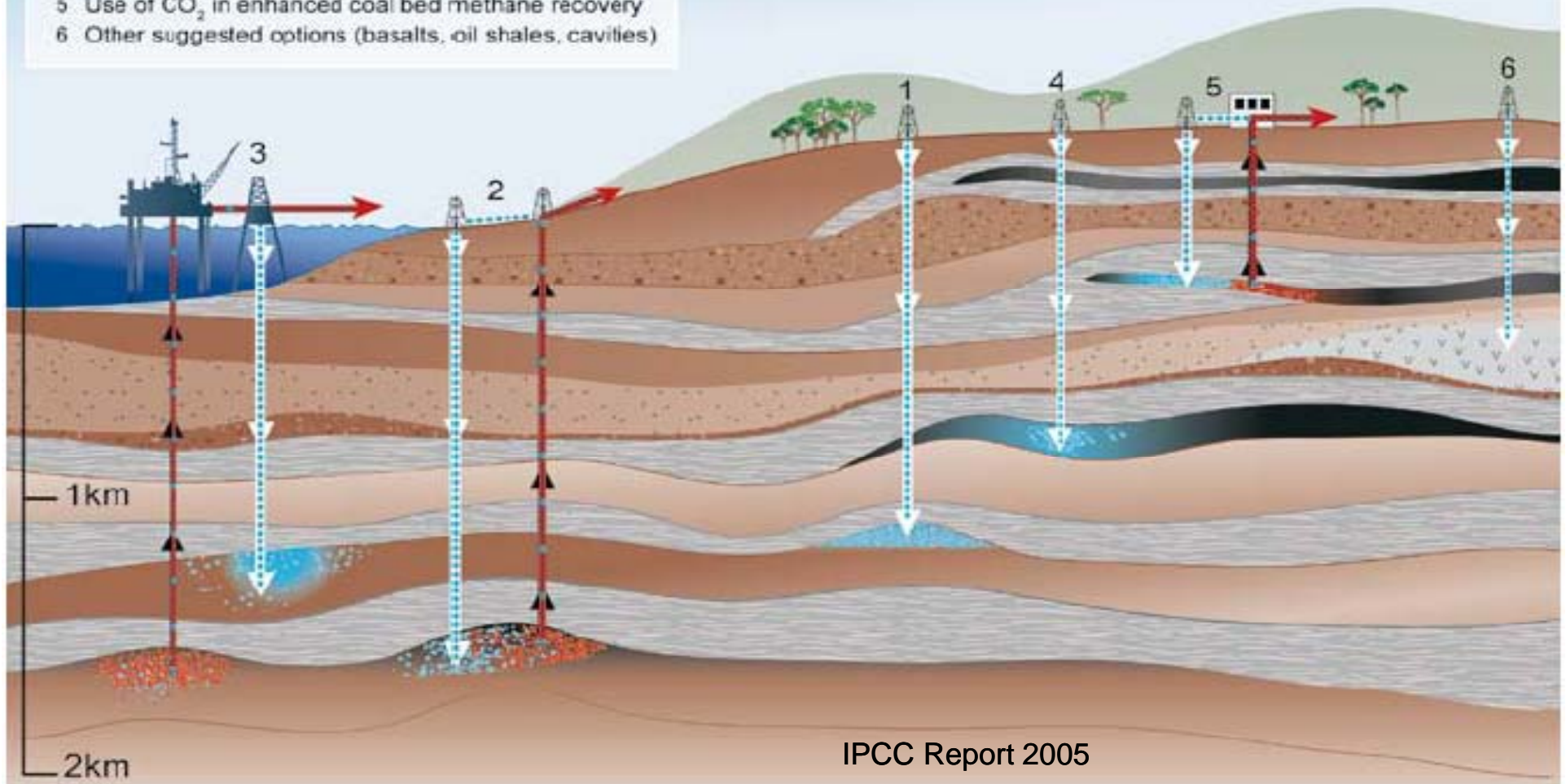
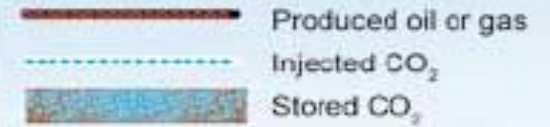
## 2009 Revenue by Region





## Geological Storage Options for CO<sub>2</sub>

- 1 Depleted oil and gas reservoirs
- 2 Use of CO<sub>2</sub> in enhanced oil recovery
- 3 Deep unused saline water-saturated reservoir rocks
- 4 Deep unmineable coal seams
- 5 Use of CO<sub>2</sub> in enhanced coal bed methane recovery
- 6 Other suggested options (basalts, oil shales, cavities)





## Current Operational Situation?

- ▶ **CO<sub>2</sub> pipelines have been operating in the US since 1972**
- ▶ **Currently > 4000 miles of CO<sub>2</sub> pipelines in operation (Texas, New Mexico, Colorado, Wyoming, North Dakota, Oklahoma, Louisiana, Mississippi and Alabama)**
- ▶ **All pipelines support EOR operations**
- ▶ **Excellent safety record: 12 incidents 1986 – 2006 (all in above-ground piping systems)**
- ▶ **No injuries or deaths in 38 years of operations**



## Current Regulatory Situation?

- ▶ **Federal: 49 CFR 195 – Hazardous Liquid Pipelines**
- ▶ **Enforcement: Office of Pipeline Safety (OPS) – a part of the Pipeline and Hazardous Materials Safety Administration (PHMSA)**
- ▶ **Industry Standard: American Society of Mechanical Engineers (ASME) Code for Pressure Piping B31.4, “Pipeline Transportation Systems for Liquid Hydrocarbons and Other Liquids”**
- ▶ **States: 14 States are certified by OPS to regulate intrastate liquid pipelines; the remainder default to Part 195**



## What's Different About CO<sub>2</sub> Pipelines ?

- ▶ **Nonflammable; odorless; colorless; heavier than air**
  - **Difficult to detect**
  
- ▶ **Operating pressures are higher (1400 - 3000 psi)**
  - **Most existing pipelines can't be converted to CO<sub>2</sub>**
  
- ▶ **For CCS, other constituents in the captured stream may be more problematic to safety (e.g. H<sub>2</sub>S)**
  
- ▶ **Pressure boosting with pumps (~ 100 mile spacing)**



## Unique Risks for CO<sub>2</sub> Pipelines

- ▶ **Leaking vapor could pool in low-lying areas**
  - Depends on terrain and meteorological conditions
  
- ▶ **High pressures mean high energy**
  - Rupture could resemble a localized explosion
  
- ▶ **For CCS, take-away from capture sources may cross densely populated areas**
  - But so do many hydrocarbon pipelines



## CCS CO<sub>2</sub> Pipelines – Perception is Reality

- ▶ **Pipelines in new areas; unfamiliar industry**
- ▶ **States may not have regulatory framework in place**
- ▶ **Land acquisition (siting) may be problematic without eminent domain rights**
- ▶ **Fewer pipeline routes may force common-carrier tariff arrangements**



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