An Update on the Risks of CO_2 Sequestration A Case Study: Alberta Canada

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Co-Authors and Acknowledgements

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HSE ISSUES RAISED ABOUT RE-INJECTION AND SEQUESTRATION IN U.S. AND CANADA

- Regulatory
- Economic
- Transportation
- Air Emissions and Global Warming
- Community Health
- Seismicity
- Surface and Ground Water Contamination
- Toxic Chemicals Management
- Community Opposition

RECENT DEVELOPMENTS: HUGE ECONOMIC UNCERTAINTY & ENVIRONMENTAL CHALLENGES

- Bankruptcies, Corporate Re-Organization, Downsizing, Mergers and Acquisitions
- **Ripe time to purchase assets for less!!**
- Blowouts from Acid Gas injection in Texas and Louisiana
- Minor Injection induced earthquakes
- Continued litigation concurrent with shut ins
- Long term storage of carbon projects initiated despite environmental and economic concerns

RESEARCH AND HISTORICAL DATA ON ISSUES

- Underground Injection Control (UIC) Record in U.S.
- Basis for Chinese Regulations Developed in 2011.
- Alberta Research proved up cryogenic capture of H_2S and liquid injection of Acid Gases (H_2S and CO_2) in Alberta
- Technology spread to U.S. particularly Texas and Colorado

HISTORY OF INJECTION AND SEQUESTRATION IN CANADA

- First CCS Leases Granted in Alberta in May 2011
- Allows Exploration of Field and Determination of Numbers of Wells Later
- Alberta Experience in Western Canada providing guidance to Eastern Canada
- Initial Regulatory Protocols for Emergency Planning zone

SHELL ADDRESSES HSE ISSUES RAISED RE-INJECTION AND SEQUESTRATION

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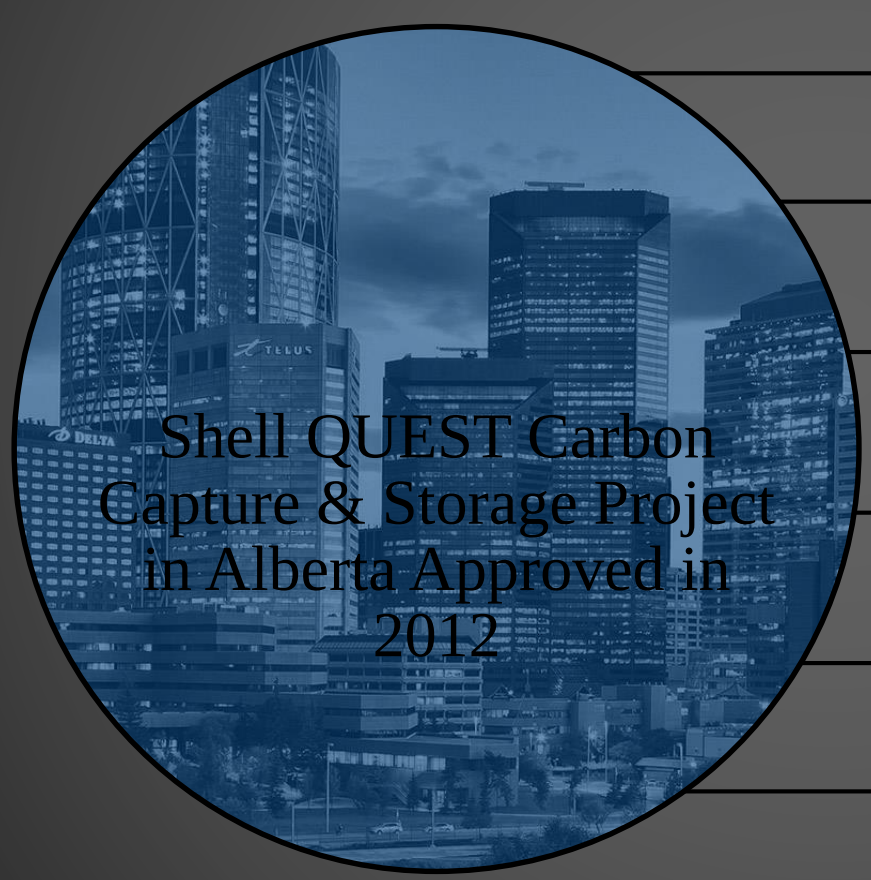
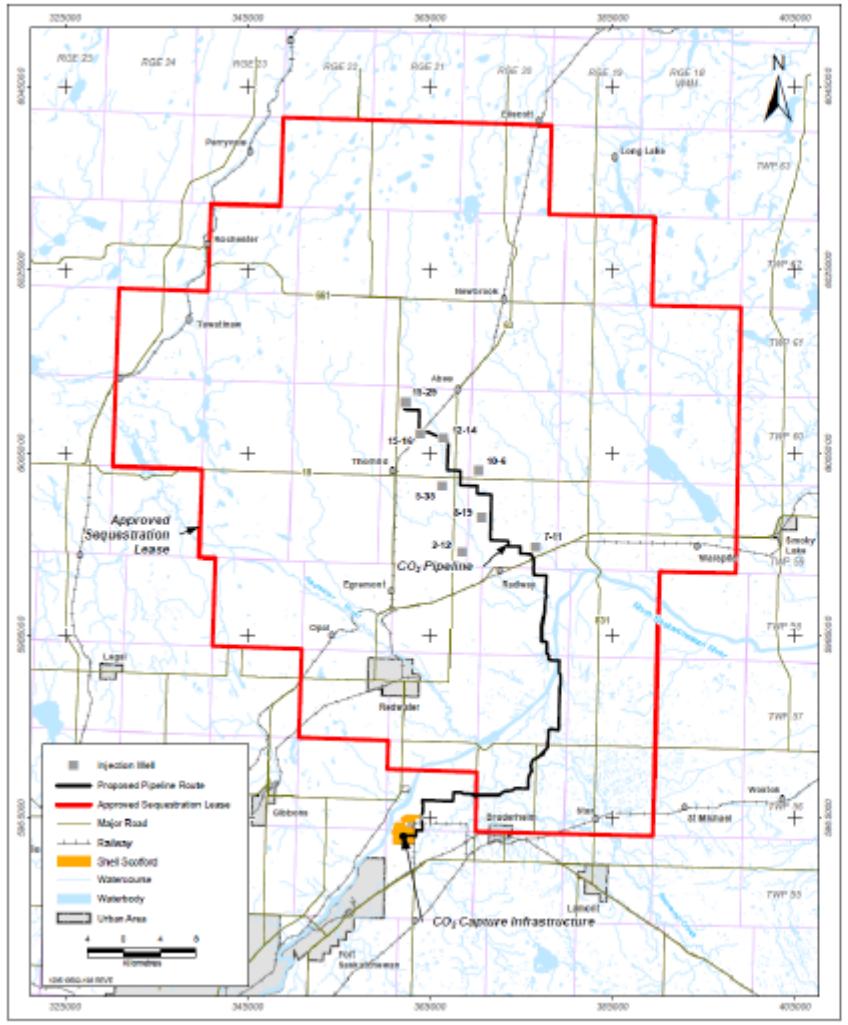


- Scotford Upgrader
- 1.2 Mtpa CO_2
- 80 km 30mm line
- 3-8 Wells
- 2000 m in saline
- +39 Townships in Area of Interest

SHELL ADDRESSES HSE ISSUES RAISED RE-INJECTION AND SEQUESTRATION



- Capture and Compression
  - Capture at Shell Scotford Upgrader- amines
  - CO_2 source 3 x HMUs (SMR technology)
  - Up to 1.2 Mtpa CO_2 ; CO_2 > 95% purity
- Pipeline
  - Agricultural lands with distributed population
  - 12 inch line; about 80 km length
  - Laterals pipelines from main to wellheads
- Disposal Scheme
  - 3-8 wells
  - Target zone is saline aquifer- over 2000m depth
  - 39+ townships Area of Interest (AOI)
- MMV Program
  - To verify containment and storage performance
- Project Status
  - July 2012- Regulatory Approvals
  - Sept 2012- Final Investment Decision!!

QUEST MAJOR REGULATORY APPLICATIONS

- Injection-Disposal Application (ERCB Dir 51)
- Pore Space Tenure (Alberta Energy)
- Well & Pipeline Licenses (ERCB Directive 56)
- Capture Infrastructure (ERCB OSCA)
- Disposal Permit (ERCB Directive 65)
- Alberta Environmental Assessment
- Environmental Impact Assessment by (Environment Canada)
- MMV Plan & Closure Certificate (Alberta Energy)

ALBERTA FRAMEWORK ADDRESSES REGULATORY GAPS

Alberta Carbon Capture & Storage Statutes Amendment Act (2010)

- *Enables Gov't to assume Liability for Stored C02 Project Operators*
- *Clarified ownership of Pore Space (i.e. Province of Alberta)*
- *Enables Alberta to create Post-Closure Stewardship Fund*
- *Enables Alberta to issue Tenure Agreements (pore space tenure)*

Alberta Carbon Sequestration Tenure Regulation (April 2011)

- *Administrative details on permits/ carbon sequestration leases*
- *Framework for MMV Plans and Closure Plans*

Alberta Regulatory Framework Assessment (2011/2012)

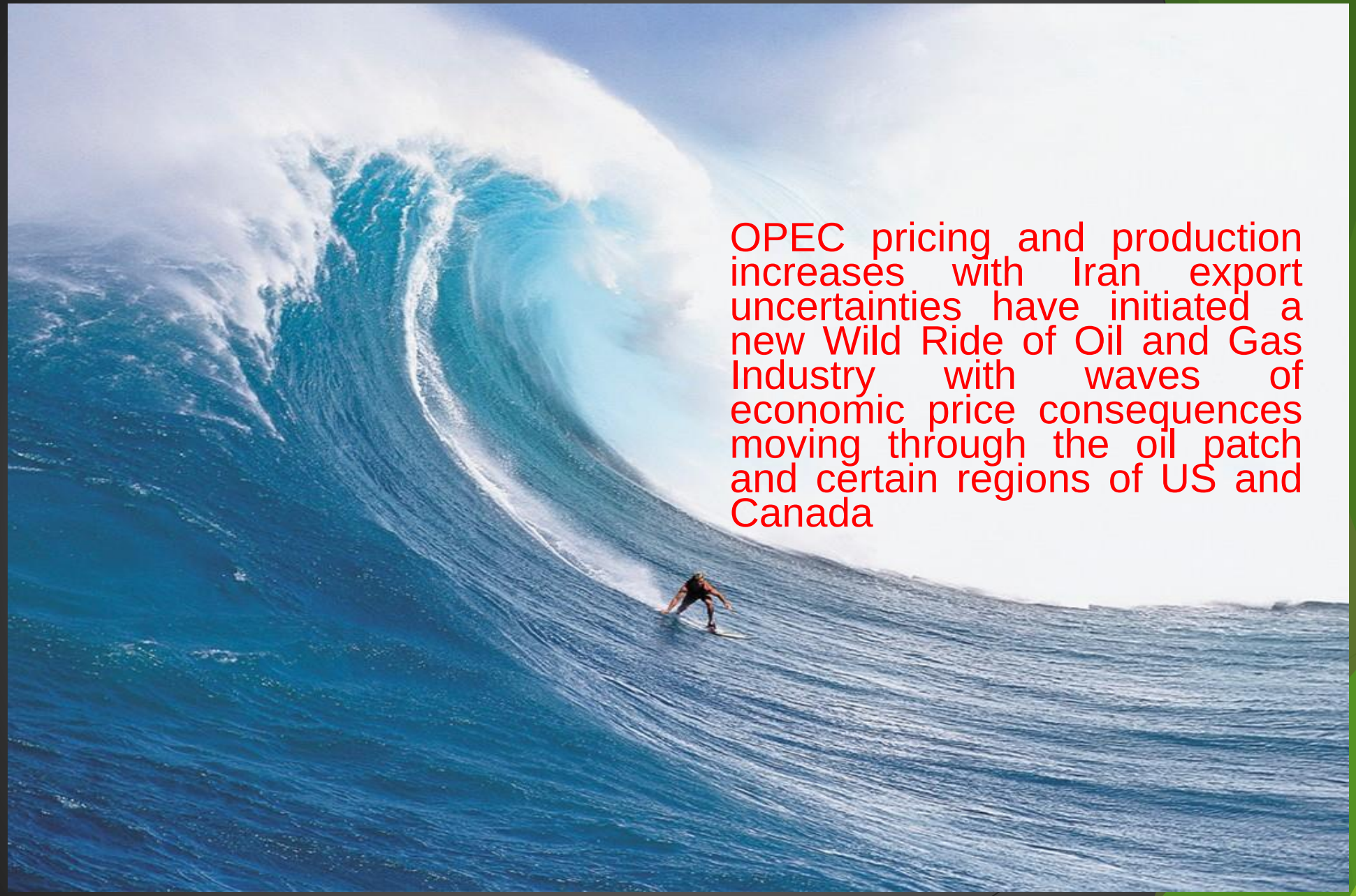
- *Multi-stakeholder Review for CCS*
- *Provides Recommendations on How Framework GAPS can be addressed*

COMPARING CANADA WITH U.S.

- Notifications of Surface Occupants extends 1.6 km (1 mi) radius in Canada versus usual ¼ mile in U.S.
- Preference for Saline Areas with no history of oil and gas development, without old wells in Canada
- Provinces assume long-term liability
- Canada requires 3-year monitoring measurement and verification plans
- Granting of Permits in U.S. may limit liability
- Tenure in Canada - 5-Year Evaluation and 15-Year Renewable Sequestration Leases

RECENT CCS DEVELOPMENTS

1. Shell's Quest is one of first commercial demonstrations of cost-effectiveness of Long Term Carbon Storage
2. Permian Basin also has demonstrated long term storage of carbon, about 60% of EOR Injected carbon remains
3. Texas NRG project delayed
4. Other commercial projects proceeding.


OPEC pricing and production increases with Iran export uncertainties have initiated a new Wild Ride of Oil and Gas Industry with waves of economic price consequences moving through the oil patch and certain regions of US and Canada

MAJOR ISSUES CONFRONTING INJECTION IN U.S. BESIDES ECONOMICS

Practice of Injection in Old Fields

- Releases in Texas & Louisiana

Practice of Injecting H_2S in Highly Lethal Concentrations

- Three releases in Texas

Injection-Related Earthquakes

- Can we limit injection rates and effectively limit earthquake occurrence and magnitude

U.S. CASE STUDY DATA REVIEW

- Acid Gas (AG) releases in Louisiana and Texas demonstrate importance for aggressive review and plugging of old wells
- Enforcement of EPA guidance on injection well location and zone siting and re-plugging of old wells is under review and being tested in US courts
- Texas/Pennsylvania courts award damages

Conclusion: Despite the risks, we can no longer hide our heads in the Sand about the opportunities for carbon sequestration