



NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

# Overview of Carbon Capture and Storage (CCS) Activities in Canada

*Eddy Chui*

*CanmetENERGY-Ottawa*

CSLF Technical Group Meeting

Regina

16 June 2015

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## Canada's Approach on CCS

- Canada recognizes the potential of CCS to: reduce GHG emissions from fossil fuel production and use, enhance energy security, and build on our natural advantage and R&D base
- Canada's strategy includes:
  - Implementing large-scale demonstration projects to prove the technology while learning-from-doing;
  - Advancing CCS globally by sharing Canadian knowledge and expertise;
  - Improving the CCS business case by reducing technology costs through research and development of 2<sup>nd</sup> and 3<sup>rd</sup> generation technologies; and
  - Promoting innovation in Canada's clean energy technology sector.

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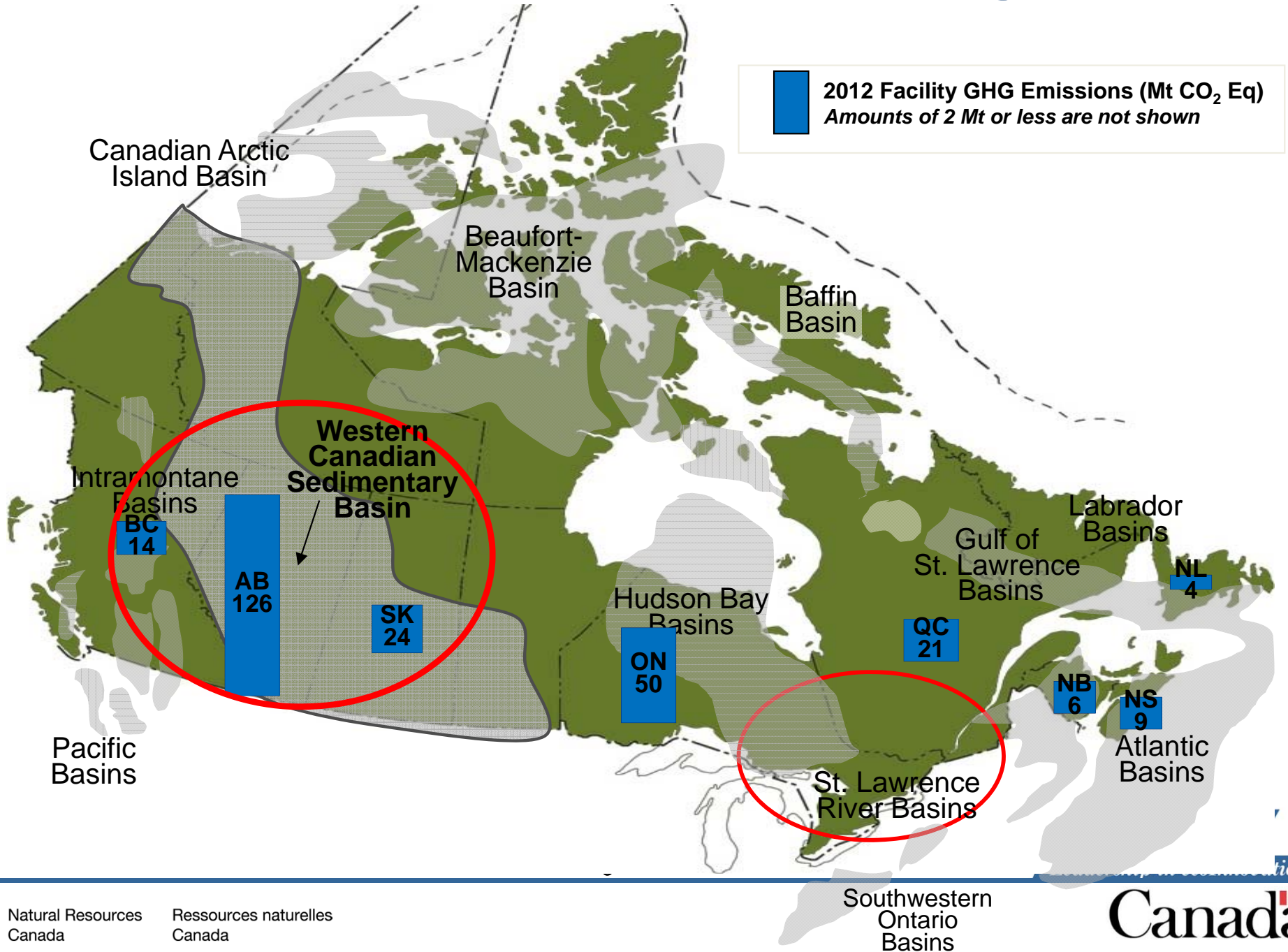


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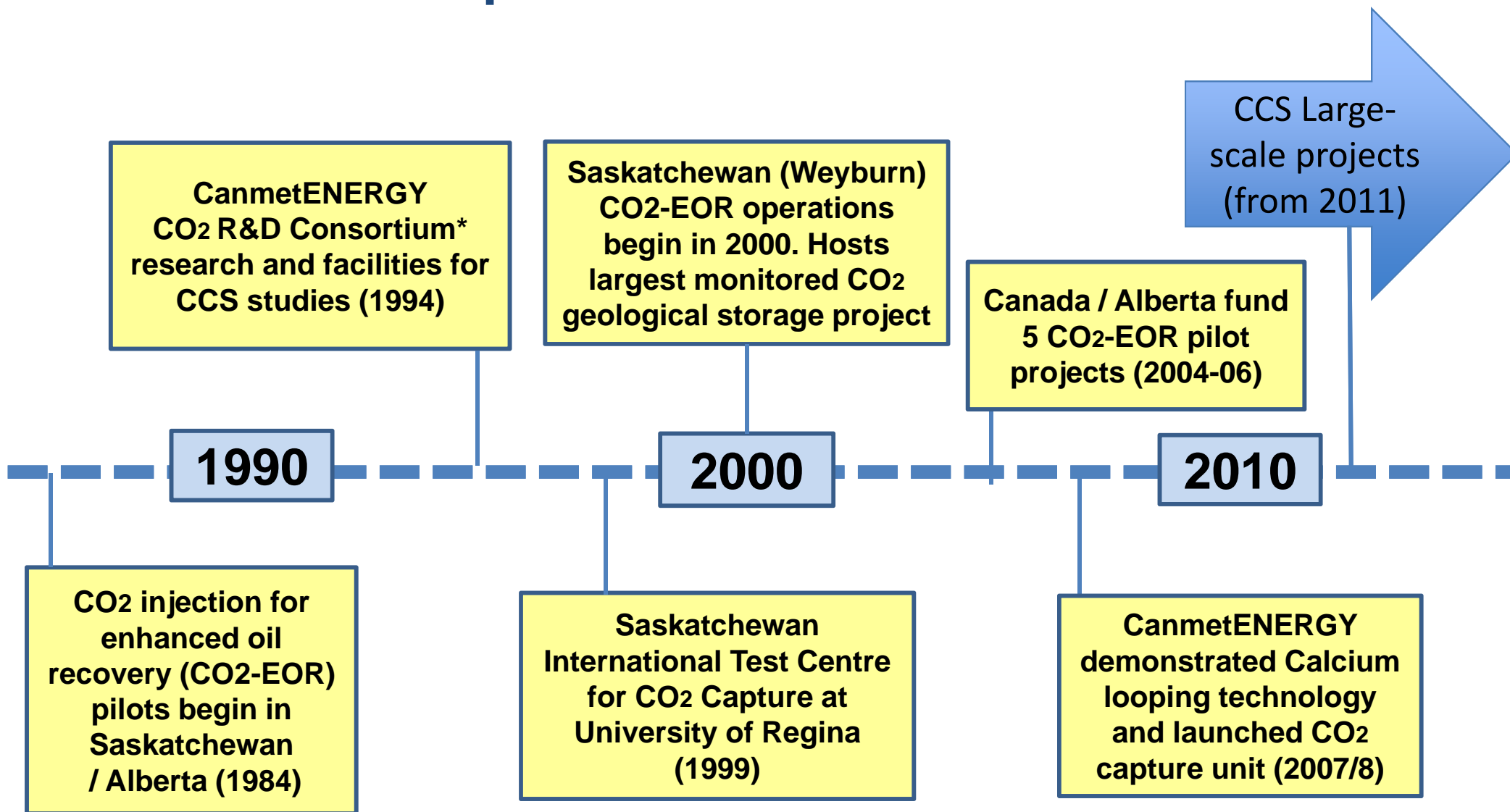
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# Canada's natural CCS advantage



# Canada is a CCS pioneer with over 3 decades of RD&D



\*Note: Phases 1-9, 2000-10, CSLF recognized project

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# Support by Governments in Canada (since 2008)

- **Federal Government (over \$580M)**

- Budget 2008 - \$240M for SaskPower's Boundary Dam CCS project
- Clean Energy Fund (CEF) – \$150M for 2 large-scale CCS projects in Alberta
- ecoENERGY Technology Initiative (ecoETI) - \$112M for CCS initiatives led by industry, universities and federal laboratories.
- ecoENERGY Innovation Initiative (ecoEII) - \$27M for 2<sup>nd</sup> and 3<sup>rd</sup> generation capture technologies and CO<sub>2</sub> storage
- Program for Energy Research and Development (PERD) - \$28M provided to federal laboratories for R&D related to CCS

- **Provincial Governments (over \$1.2B)**

- Alberta CCS Fund – \$1.24B for 2 large-scale CCS projects in Alberta
- Funding also provided through Alberta's Climate Change and Emissions Management Corporation (CCEMC), Saskatchewan's Go Green Fund, etc.
- As well, SaskPower, a provincial utility, invested over \$1B in CCS

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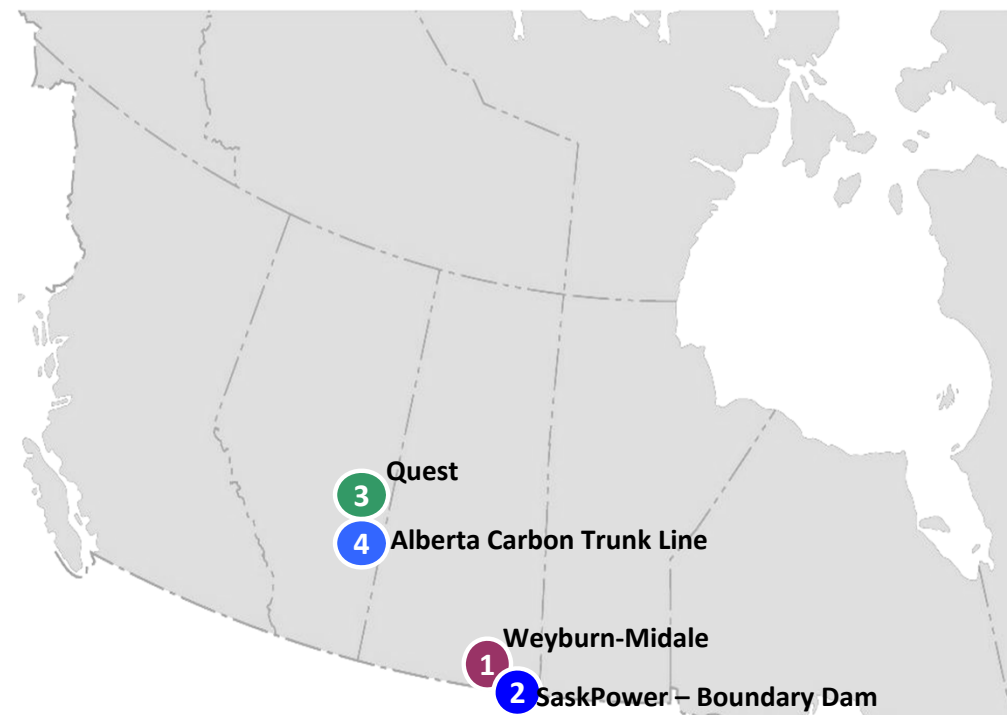
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# Canada is active in large-scale CCS demonstrations

- With four large-scale projects operating / under construction
  1. Weyburn-Midale Project (2000)
  2. SaskPower Boundary Dam (Launched October 2014)
  3. Quest Project (Launch expected in Fall 2015)
  4. Alberta Carbon Trunk Line (Operational in 2017)



Federal-Provincial investments in CCS RD&D of over \$1.8B with potentially up to \$4.5B in public-private investment in CCS initiatives

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# Our investments are already paying off

World's first commercial coal-fired power plant with CCS now a reality!

**Julio Friedmann, Deputy Assistant Secretary, Clean Coal, US Department of Energy:** *"This project is a culmination of a dream. Projects like this show the world that this is not only a viable technology but a required technology."*



**Bellona President:** *"Finally, people cannot say that this is unproven technology. It will be much harder to reach climate targets without CCS."*



**IEA Executive Director:** *"Getting Boundary Dam up and running is a great example of how Canada is a leader in CCS... I wish the plant operator every success in showing the world that large-scale capture of CO2 from a power station is indeed not science fiction, but today's reality."*



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# Alberta's Quest Project



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# The Alberta Carbon Trunk Line



North West Redwater Partnership Sturgeon Refinery –  
Under construction



<http://www.enhanceenergy.com/actl>



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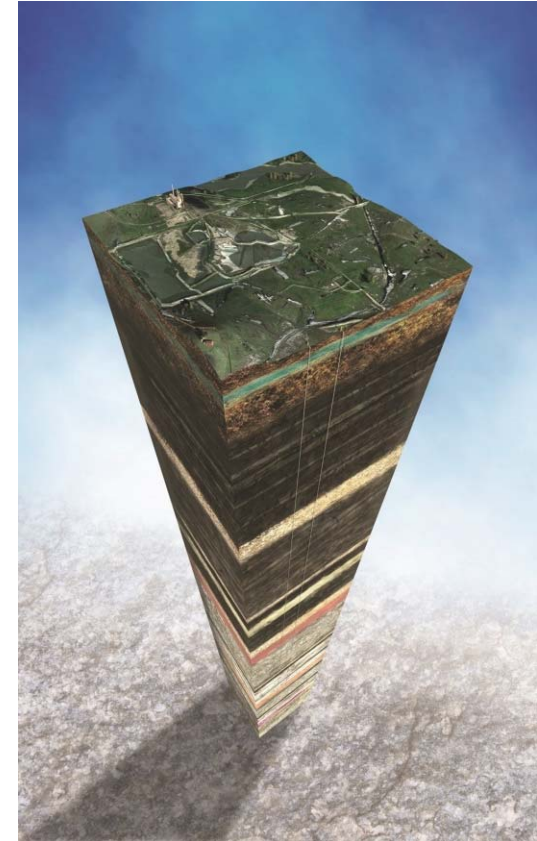
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# AQUISTORE: CANADA'S FIRST CO<sub>2</sub> STORAGE PROJECT

- Demonstrating the ability to store CO<sub>2</sub> underground in deep saline formations.
- Comparing cutting edge measurement, monitoring, and verification technologies for economics and efficacy.
- Unique 'field laboratory', accessed by 26 organizations across 7 countries.
- Aquistore is unique – buffer storage for a commercial CO<sub>2</sub> capture plant and active oilfield EOR operations.
- Injection commenced April 16, 2015.



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# SASKCO<sub>2</sub>USER – CO<sub>2</sub> AND EOR IN SASKATCHEWAN

- Continued monitoring of a CO<sub>2</sub> – EOR project in an industrially active area.
- Investigating the life-cycle of a CO<sub>2</sub> EOR project to CO<sub>2</sub> storage.
- Building upon Saskatchewan and Canadian research excellence over the past 15 years.
- Projects include:
  - Induced seismicity
  - Wellbore integrity
  - Injection well design
  - Reservoir mineralogy impacts
  - Modelling integration



# CMC Research Institutes' Field Research station



# Canada is also home to world-class private sector expertise toward a new generation of lower-cost CCS

Company	Technology	Piloting Activities include
Saskatchewan-based HTC CO2 Systems Corp.	The HTC LCDesign™ advanced post combustion amine CO2 capture technology	- HTC CO2 Systems Corp. is applying its LCDesign™ technology and Delta Purification System™ technology at Husky Energy's Pikes Peak South heavy oil facility in Lashburn, Saskatchewan. The pilot project is expected to begin by July 1, 2015.
Quebec-based CO2 Solutions Inc. (\$4.7M from NRCan's ecoEII Program)	Enzyme-enabled CO2 capture technology	- Results of 1 tonne-CO2/day pilot testing at the University of North Dakota's Energy & Environment Research Center show cost of \$39/tonne including compression to 2250psi - 10 tonne-CO2/day field demonstration in collaboration with Husky Energy successfully commissioned in May 2015 near Montreal; plant will operate for ~2,500 hours on flue gas of natural gas fired boiler and is supported by NRCan's ecoEII
BC-based Inventys Thermal Technologies Inc.	Patented VeloxoTherm post-combustion CO2 capture technology	- The company is working on pilot plant demonstration projects - Funding from the UK Energy Technologies Institute to demonstrate advanced capture technology in gas-fired power (underway)
Nova Scotia-based CarbonCure Technologies	Develops and licenses technology that sequesters CO2 in concrete during its manufacturing resulting in improved material and environmental performance	- The company is on track to license its technology to 30 manufacturing facilities in North America and enter emerging markets, driven by market demand for green building products, benefits for economics, and CO2 reduction potential
SaskPower Carbon Capture Test Facility (CCTF - \$1.3M from NRCan's ecoETI Program)	Facility is designed to provide evaluation of amine post-combustion technologies	- CCTF will launch on June 18, 2015 - After initial demonstration by Hitachi, the CCTF will provide a unique platform to evaluate further technologies - Member of the International Test Center Network

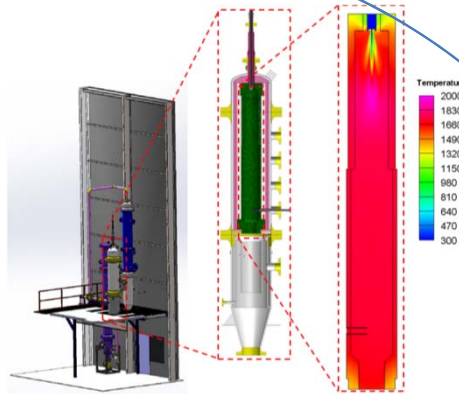
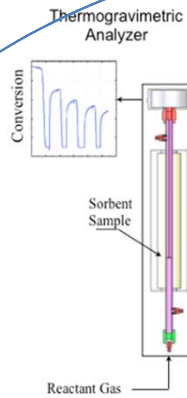


# In addition to being a funder of CCS technologies, NRCan labs also perform CCS R&D

## Our Focus in the Innovation Process

**Conception**

**Implementation**



Pre-Commercial Demo



Formulation of ideas  
Bench scale testing

Pilot-scale demo  
Model development  
Scale-up modeling

Prototype demo

Full-scale application

\$10s to \$100sK

~\$Millions

~\$10sM

\$100sM or higher

CanmetENERGY CFF

Technology Providers

Other R&D Performers

End Users



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# Oxy-Pressurized Fluid Bed Combustion (Oxy-PFBC)

## Need in Power Sector and Oil Sands Producers

Reliable power and steam production from solid fuels (coals or petroleum coke) that is cost competitive with natural gas technologies with near zero emission

### Potential Benefits

- provide steam and power at a lower price than natural gas by 2022 even under a low price gas scenario
- lower GHG intensity
- higher efficiency, fuel flexibility

Progress: 1 MW<sub>th</sub> pilot plant under construction

Total Program scope: \$20.5M



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# G2 System using Supercritical CO<sub>2</sub> Turbine

## Need in Power Sector, Oil Sands & Tight Resource Producers

- Highly efficient, mobile, water conserving power plants with near zero emission
- Enhanced recovery with reduced water demand

### Potential Benefits

- Very compact, 350x smaller than conventional plants, suitable for remote applications
- 30% less CO<sub>2</sub>, 40% drop in cost of electricity and 50% reduction in capital expenditure (CAPEX) with value-added by-products (pipeline-ready CO<sub>2</sub> for EOR and energized fracking, clean water at 9000 liter/MW<sub>e</sub>)



### Progress:

- Engineering design of the 50 kW pilot-scale facility about 90% completed
- New IP and patent (WO/2012/159189 – PCT/CA2011/000593)





# Pressurized Chemical Looping Combustion (P-CLC)

## Need in Power Sector and Oil Sands Producers

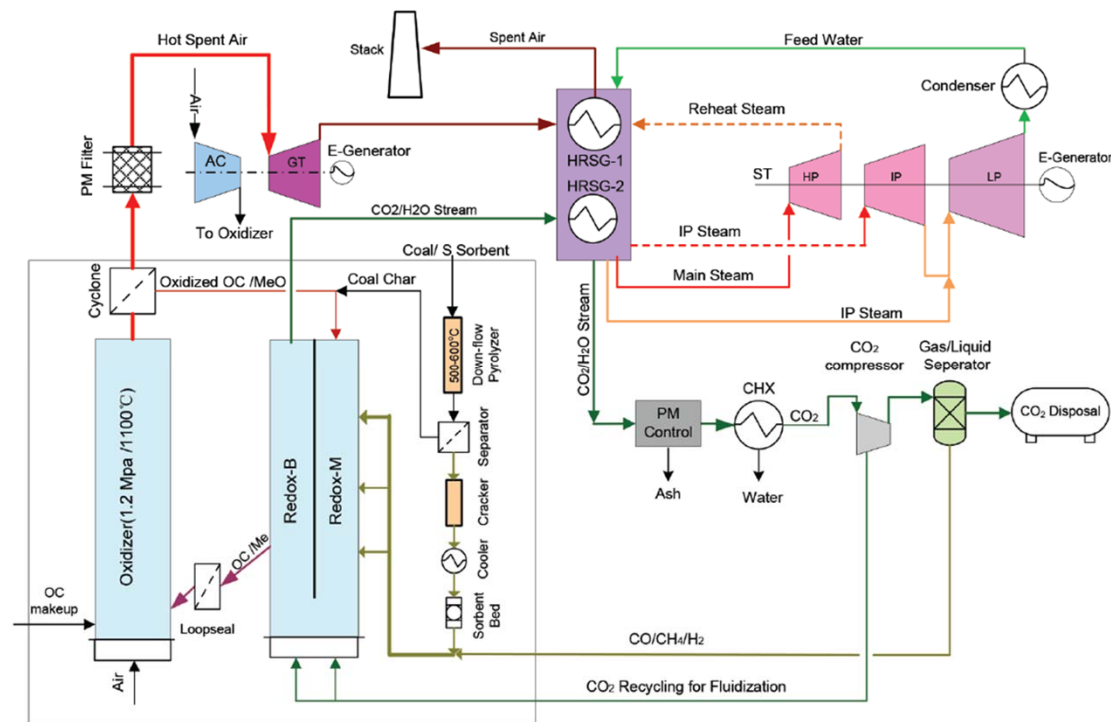
A competitive and promising technology in efficiency and cost to produce heat, hydrogen and power from solid fuels (vs. natural gas) with near zero emission

### Approach

- Using Canadian oxygen carriers, such as ilmenite and iron ores
- Chemical looping steam reforming for hydrogen production, an advanced process integrated between conventional steam reforming and CLC

### Benefits

- Very high efficiency 40 to 47% HHV for 96% CO<sub>2</sub> capture (Worley Parsons)
- Cost of CCS power reduced by 25% (Worley Parsons)
- Reduce oil sands emissions and increase productivity
- Suitable for current and potential future NO<sub>x</sub>, SO<sub>x</sub>, and CO<sub>2</sub> regulations



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# CO<sub>2</sub> Storage and Utilization

## Needs for Tight Resource Producers and Power Sector

- Address gaps in knowledge related to injecting impurities into geologic reservoirs
- Improve recovery rates of tight resources

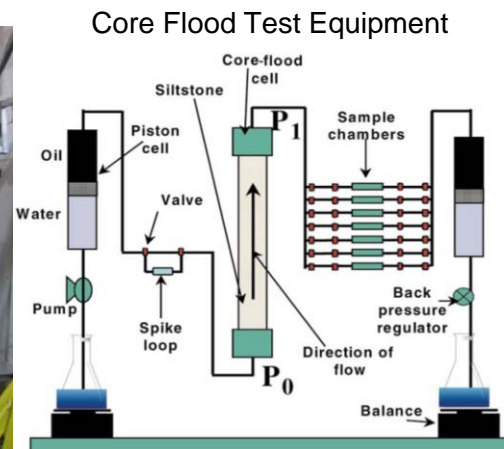
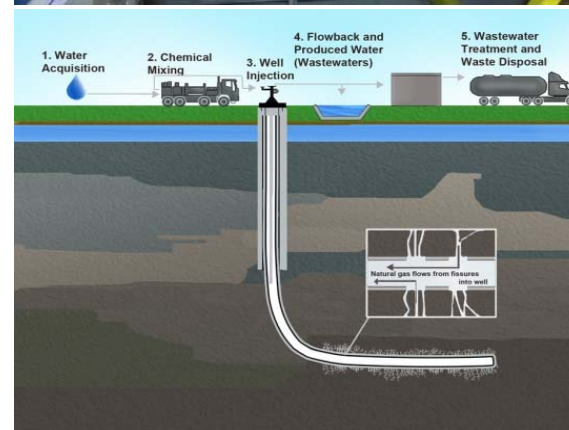
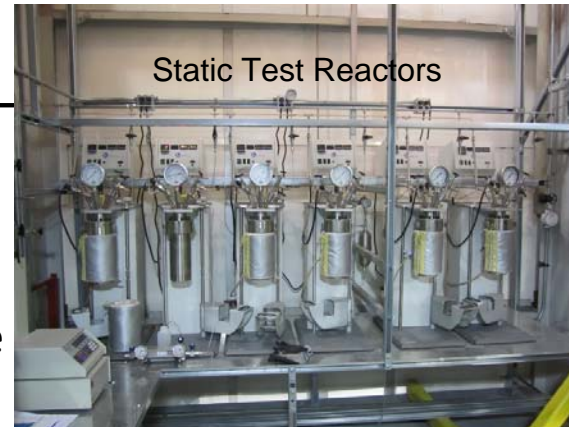
### Focus

#### Effects of Impurities on CO<sub>2</sub> Storage Operations

- Determine the impact of impurities (H<sub>2</sub>S, SO<sub>2</sub>, O<sub>2</sub>) in the injected flue stream on the reservoir and on wellbore integrity
- ISO Standards development for CCS

#### Enhanced Production in Shale and Tight oil and gas reservoirs

- Use of CO<sub>2</sub> for improved reservoir production and recovery efficiency



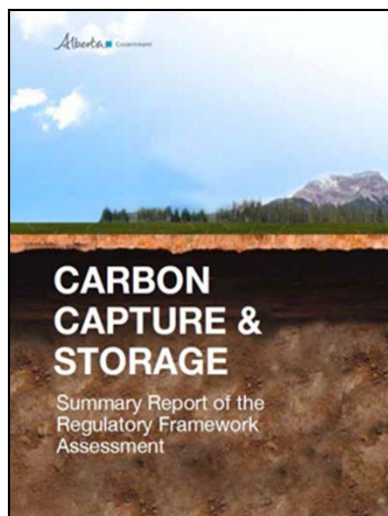
Basal Cambrian Sandstone

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# Canada also continues to advance CCS through regulatory development and public engagement

- Federal regulations for coal-fired power generation
  - Published in 2012, with specific provisions for the adoption of CCS
- Provincial regulations advancing - Alberta at the forefront globally
- Public information and education efforts
  - In addition to federally funded work such as Pembina's recent study on successful public engagement practices, Canadian project proponents, such as Shell, have been recognized as world-leading in this area



# As well as through ongoing International Engagement

- Canada-US (Clean Energy Dialogue / Energy Cooperation MoU)
  - Includes joint Canada-U.S. CCS activities in collaborative R&D, promoting knowledge sharing, and facilitating bilateral opportunities
- Canada-UK Joint Statement on CCS
  - Joint Statement refreshed on November 18, 2014, signed by UK Energy Minister and Deputy Minister of Natural Resources Canada
- Multilateral CCS Engagements
  - Canada participates in a number of CCS-related international fora such as the CSLF, the IEAGHG, the CEM, etc.
  - SaskPower also participates in the International CCS Test Centre Network
- Other Bilateral / Trilateral CCS engagements
  - Canada maintains bilateral CCS-related agreements with governments in Norway, Japan, China, Korea, and Mexico (North American trilateral)

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## In Summary:

- Canada has parlayed its natural CCS advantage and strong R&D foundation into a position of global leadership;
- Canada is proving CCS at scale while learning-from-doing;
- Canada is contributing to the global effort to advance CCS; and
- Going forward, focus is on strengthening the CCS business case through continued R&D of 2nd and 3rd generation technologies, while collaborating with key international partners.

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