Supporting Development of 2nd and 3rd Generation CCS Technologies

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CSLF Policy Group Meeting

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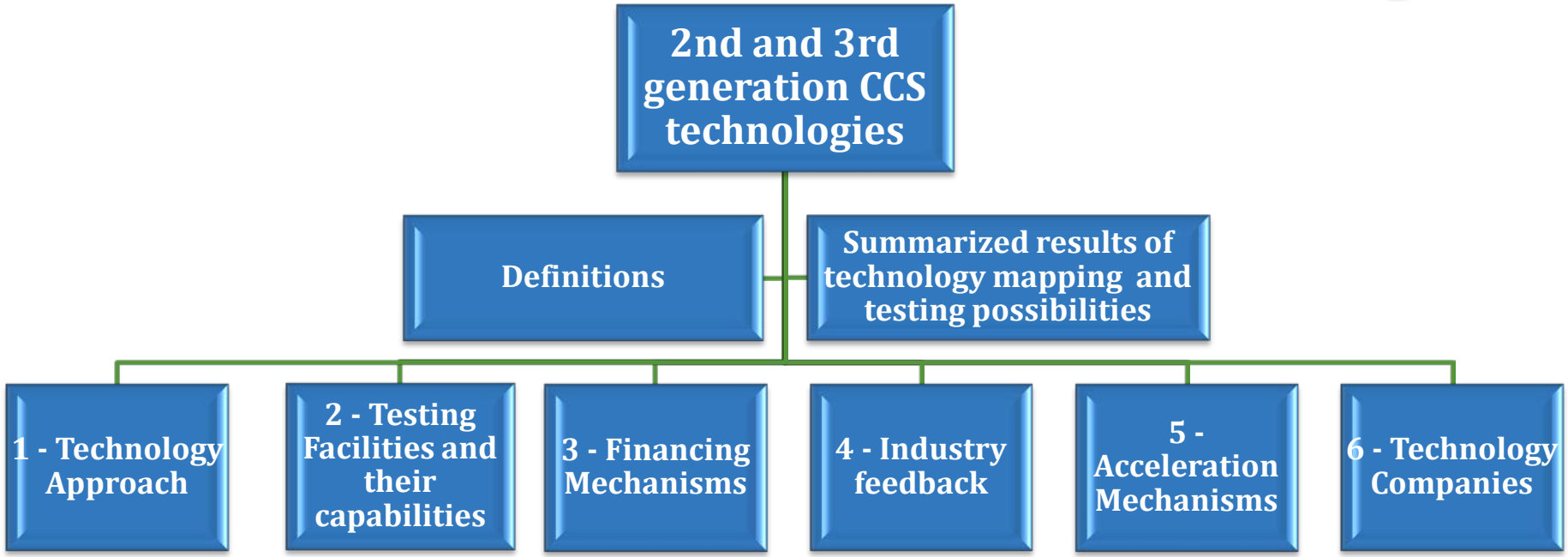
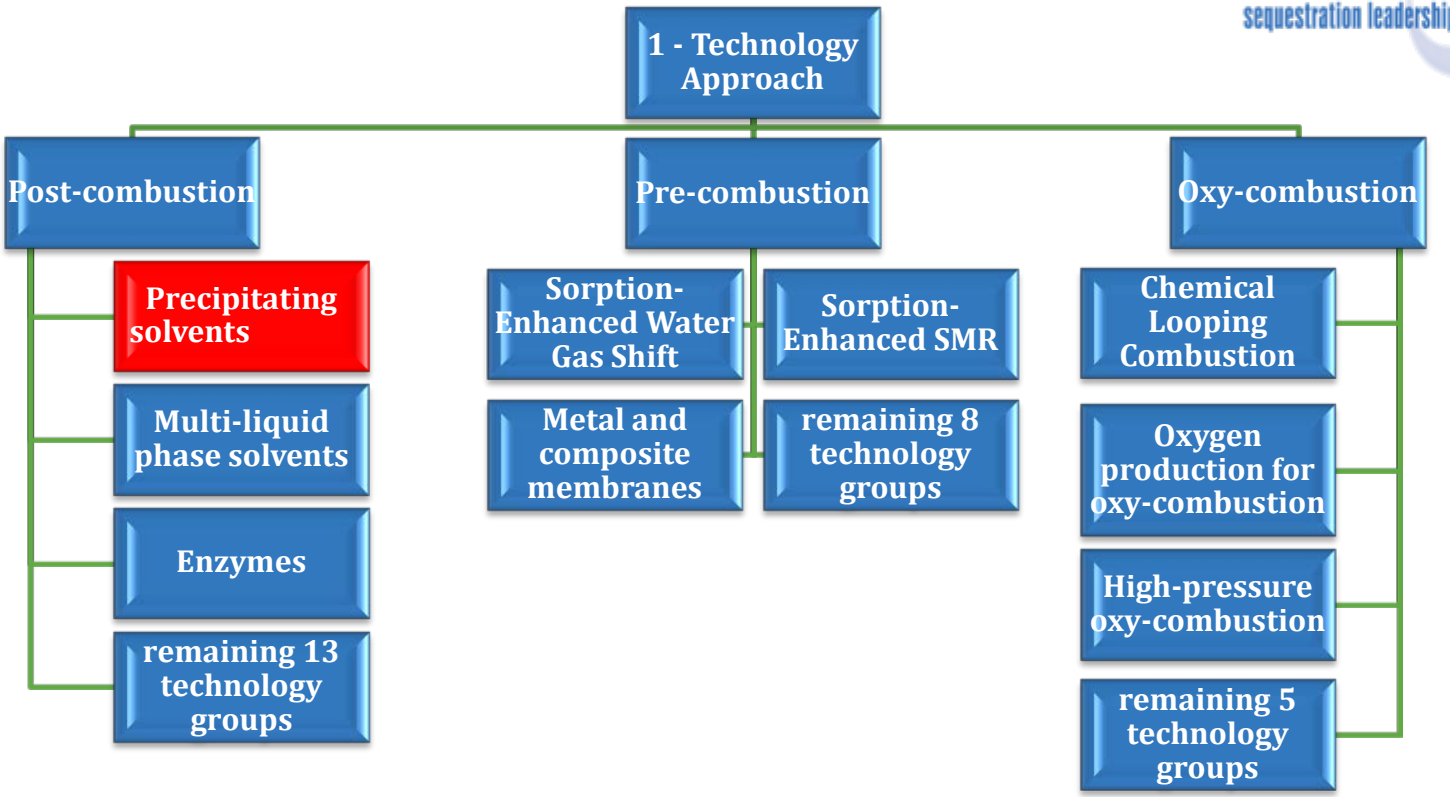
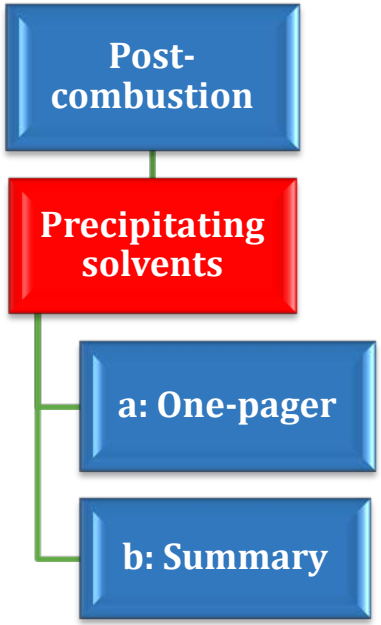
Site map for 2nd and 3rd generation CO2 capture technologies – 1st Tranche



1 – Technology Approach



1 – Technology Approach
(Drilling down to technology grouping)



a: One-pager (example)

Precipitating solvents

General description

Certain solvent systems form a precipitate (i.e. a solid phase) upon absorption of CO_2. Examples include the case when inorganic carbonates are used as main buffer components and for solvents based upon amino acid salts. The precipitation may be utilized as a way of creating a highly concentrated CO_2-rich phase by sending the concentrated slurry to regeneration, while part of the solvent is recycled to the absorber.

Possible application

Power sector, cement industry,…

Potential

Potential advantages include:

- Reduced energy requirement due to lower solvent volumes for desorption. Energy consumption numbers are reported as competitive to amine systems
- Possible lower degradation of the solvent
- Desorption at higher pressure is also possible
- High stability comes in addition. The concept typically utilizes low cost chemicals and is based upon well- known separation principles.

Who is involved?

Precipitating solvent concepts have been/are investigated by e.g. SINTEF/NTNU [X1], TNO [X2, X3], Shell Global Solutions, Alstom (Chilled ammonia), University of Melbourne, CSIRO, CO2CRC.

Maturity, challenges and status

- Activated potassium carbonate has been tested by Shell Global Solutions in pilot/lab-pilot scale [X4].
- Chilled ammonia with precipitation has been tested by Alstom, but they presently operate the process without precipitation [X5, X6]
- The University of Melbourne has already brought the activated potassium carbonate concept to pilot scale [X7]
- The impact of SO_2 and NO_x and the need for reclaiming of solvent needs further investigation.

In general, the operation of packed absorbers with precipitation requires some development and optimization of packing materials. The technology must still be validated at larger scale, including operability issues in order to reveal the true potential.

a: One-pager (example) – cont'd

Possible pathways for technology qualification

These include:

- Further lab and pilot testing is recommended. E.g., the inherent potential in solid ammoniabicarbonate/carbamate crystals is judged to merit further investigation and should be studied in lab-scale before moving forward to pilot scale.
- Further research on packing materials and optimization of liquid/gas ratios is recommended.
- Thereafter, the next step would be on-site testing with real flue gas at e.g. a few tenths of tonnes of CO_2/hour.

Infrastructure required and available testing facilities

Infrastructure requirements include

- Basic equipment for characterization of crystals formation
- Equipment for solid-liquid separation and heat exchangers

The concept can utilize the existing infrastructure at TCM and NCCC (*not confirmed*).

Environmental impact

The concept potentially scores high on environmental impact as long as inorganic carbonates are used as the main component. When using NH_3, HSE hazards must be addressed.

Generation and expected time to commercialization

Technologies in this group are considered 2nd generation that can be commercialized in the 2020–2025 timeframe.

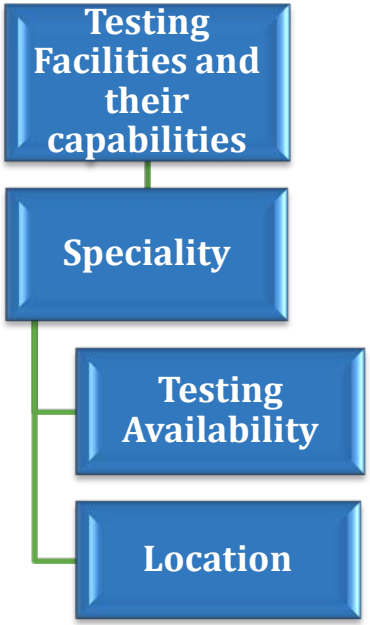
b: Summary (example)

Precipitating solvents

When absorbing CO_2 certain solvent systems form a precipitate. Amino acid salts or carbonate solvent systems are among examples, in which precipitation of neutral amino acid or bicarbonate salts occur. The use of precipitating solvents has potentially several advantages over traditional solvents. As the equilibrium CO2pressure remains constant when the CO2 loading continues to increase the absorption can be maintained, potentially leading to improved absorber performance such as increased stability and absorption capacity, increased kinetics, higher cyclic loading and reduced energy consumption during regeneration compared to amine systems.

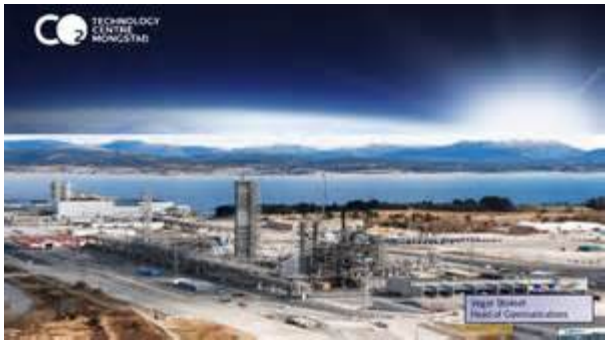
- Maturity: Lab scale testing
- Key Challenges: Further lab tests needed to determine the impact of SO_2 and NO_x
- Some players: Shell Global Solutions, Alstom, CSIRO, SINTEF/NTNU, TNO, University of Melbourne

2 – Testing Facilities

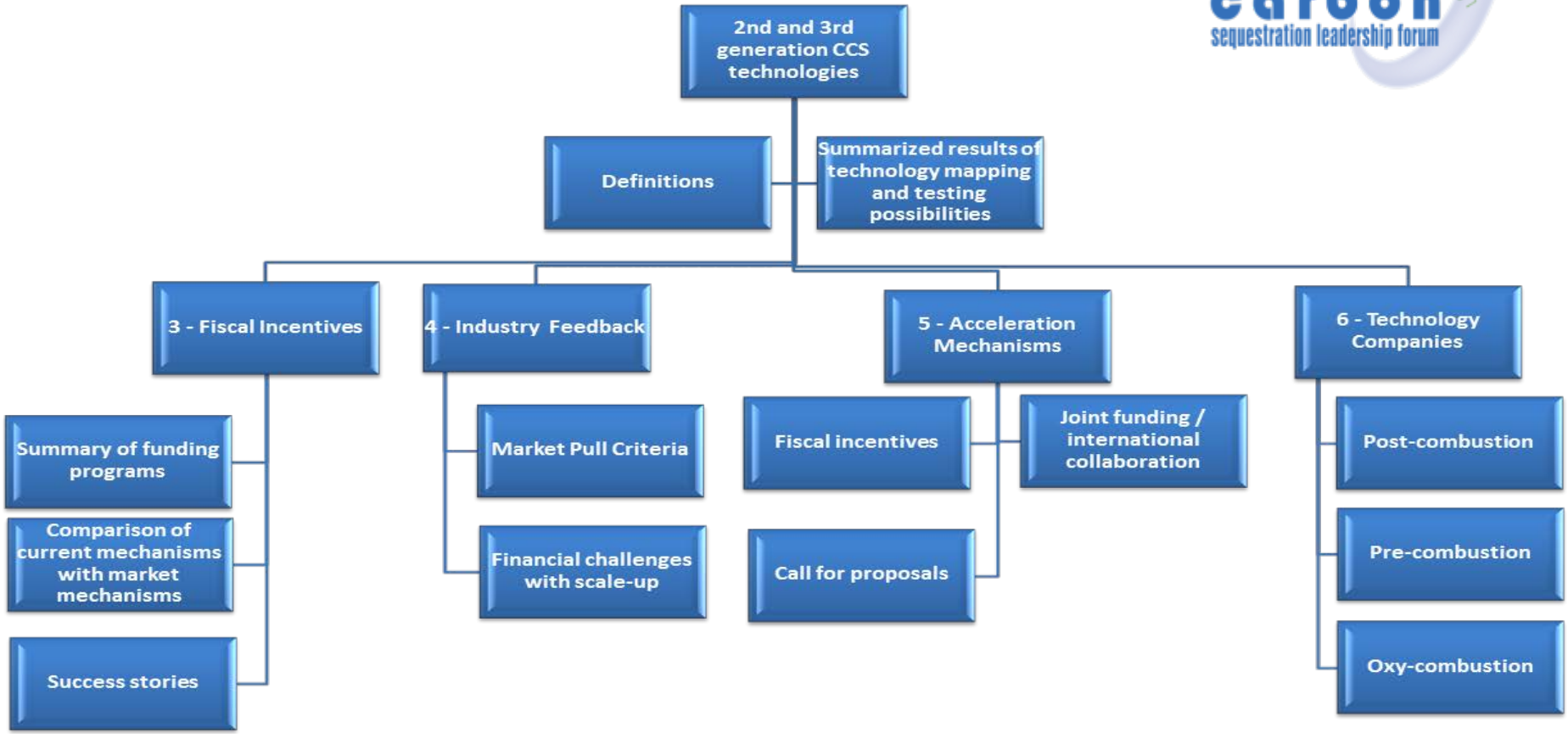


2 – Testing Facilities (Examples)

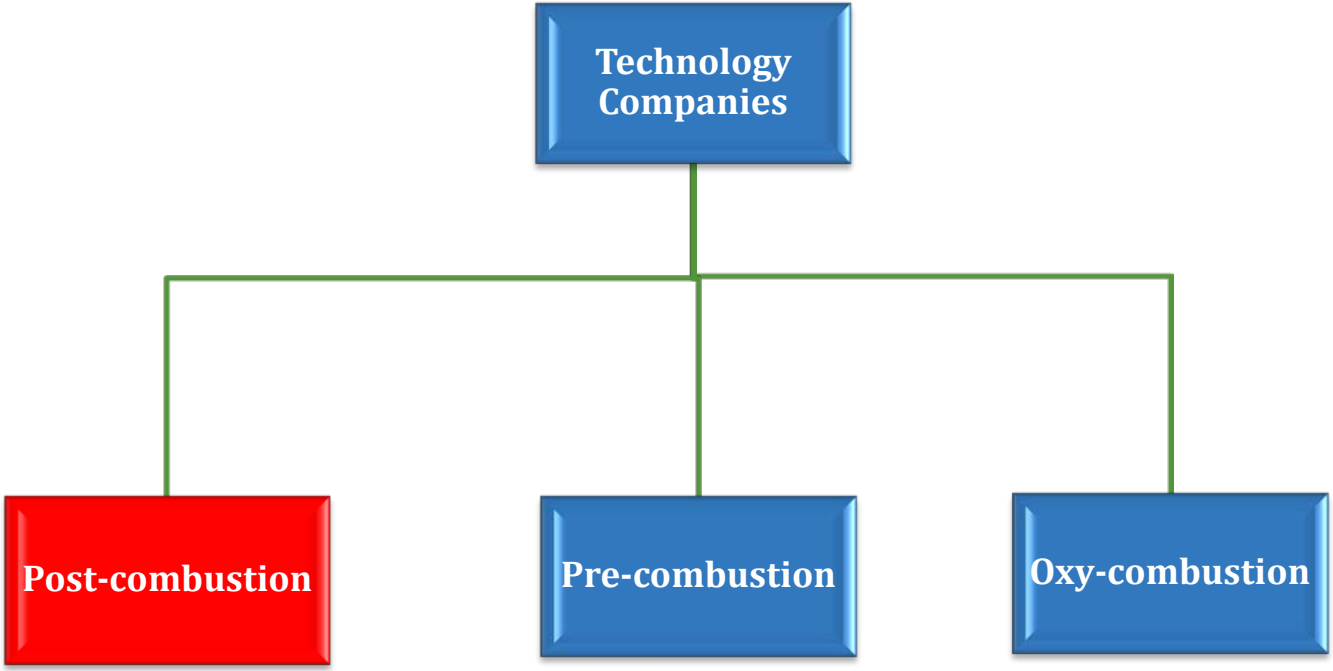
CCTF under construction to be operational in 2015 -
Photo provided by and is property of SaskPower



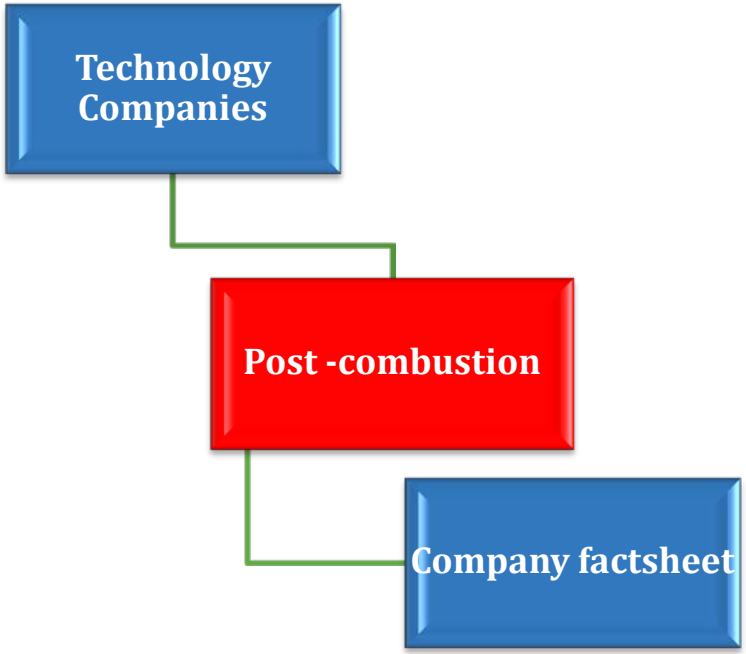
Summary of Remaining "Boxes"



6 – Technology Companies



6 – Technology Companies (Grouped by Technology Approach)



Company factsheet (example)

CO2 Solutions Inc.

Company Overview

Based in Quebec City, Quebec, CO2 Solutions Inc. ("CSI" or the "Company") is the leader in the field of enzyme-enabled carbon dioxide (CO2) capture. The Company plans to launch the technology commercially in 2015 for the efficient post-combustion capture, industrial utilization and sequestration of CO2.

Technology Overview and Status

CSI has developed an innovative approach to solving the significant cost challenges associated with conventional chemical (amine) carbon capture technology. The technology is built around the use of the extremely powerful enzyme catalyst, carbonic anhydrase (CA), which efficiently manages CO2 during respiration in all living organisms.

In an industrial CO2 removal system, CA dramatically accelerates energy-efficient, but kinetically limited solvents. Based on this principle, simple aqueous salt-based solutions such as potassium carbonate can be accelerated by the enzyme to provide CO2 absorption kinetics similar to chemical amine solvents while allowing for the use of low-grade, nil-value heat from the industrial effluent source plant for the subsequent regeneration of the solution and production of pure CO2 for reuse or sequestration. The technology is protected by 44 issued patents in Canada, the U.S., Europe and other key jurisdictions.

In 2013, the Company demonstrated at lab scale that its technology is at least 30% less expensive than existing technology and that the engineered enzyme can withstand the rigors of the industrial application. In early 2014, the technology completed large-bench scale testing at approximately the 0.5 tonne-CO2/day scale where the same performance metrics were validated under flue gas conditions.

In April, 2014, CSI announced that it will install and operate a field pilot of the technology capturing about 15 tonnes-CO2/day at Husky Energy's Pikes Peak South (Saskatchewan) heavy oil site from a natural gas fired once-through steam generator (OTSG). Subject to a positive review by Husky of the pilot results, an agreement provides for Husky to consider the use of CSI's technology for commercial CO2 capture projects.

Company factsheet (example) – cont'd

Public Funding

CO2 Solutions received $4.7 million from Natural Resources Canada through the ecoENERGY Innovation Initiative (ecoEII) as well as a $500,000 in grant funding from Alberta's Climate Change and Emissions (CCEMC) Corporation for the optimization and pilot testing of its technology for application in the Alberta oil sands. The project is supported by a $2.3 million private sector contribution from CO2 Solutions and energy industry partners.

Related Developments / Partnerships

On September 26, 2014, CSI announced the signing of an Agreement with the University of North Dakota Energy & Environmental Research Center (EERC). With the Agreement, CSI joins EERC's program Advancing CO2 Capture Technology: Partnership for CO2 Capture (PCO2C) Phase III as a sponsor. Under the program, CSI will test its technology at EERC's existing testing facility using natural gas and coal flue gas in December, 2014. The program's goal is to evaluate several CO2 capture technologies that are among the most advanced systems under development for application to power and steam generation plants. The tests will have approximately twice the capacity of the Corporation`s largest testing to date. Data from the EERC program is expected to provide valuable input for the pilot initiative to run with Husky Energy in 2015. Additionally, it will provide additional performance benchmarking of CO2 Solutions' enzyme-accelerated process against other solvent-based processes. The testing program is supported financially in part by the U.S. Department of Energy (DOE).