Shell Amines for CO$_2$ Capture

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Reserves: Our use of the term “reserves” in this presentation means SEC proved oil and gas reserves.

Resources: Our use of the term “resources” in this presentation includes quantities of oil and gas not yet classified as SEC proved oil and gas reserves. Resources are consistent with the Society of Petroleum Engineers 2P and 2C definitions.

Organic: Our use of the term Organic includes SEC proved oil and gas reserves excluding changes resulting from acquisitions, divestments and year-average pricing impact.

Shales: Our use of the term ‘shales’ refers to tight, shale and coal bed methane oil and gas acreage.

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Amine CO$_2$ Removal System

An absorbent is a substance which has the ability of extracting some substances from a liquid or gaseous medium with which it is in contact.

Stripping is a mass transfer process in which an undesired component (e.g. solute, gaseous pollutant, in this case CO$_2$) in a liquid stream transfers to a vapour stream under favourable conditions.
Shell Technologies for CO\textsubscript{2} Capture

**Oil and Gas**
- Wellhead
- Upstream Processing
- CO\textsubscript{2}/H\textsubscript{2}S separation

**Post Combustion**
- Coal
- Gas
- Biomass
- Power Plant (SCPC, CCGT)
- CO\textsubscript{2} separation
- Syngas

**Pre Combustion**
- Coal
- Oil
- Gas
- Gasification & Shift
- CO\textsubscript{2} separation
- CO\textsubscript{2} compression

**Oxyfuel**
- Coal
- Oil
- Gas
- Biomass
- Power Plant (Boiler + Steam Turbine)
- CO\textsubscript{2} separation
- Proprietary Technology

**Industrial processes**
- Coal
- Gas
- Biomass
- Process
- CO\textsubscript{2} separation
- Raw Material
- Gas, Ammonia, Steel

- CO\textsubscript{2} Capture / Production
  - Reliable
  - Economic
  - Flexible

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Shell ADIP* & ADIP-X* - Optimized for High Pressure Applications

- Mature, Widely Deployed Technology

- More than 500 Shell operating facilities and licensees have applied the ADIP technology since the 1950s.

- ADIP-X technology introduced in 2000 for cost-effective CO₂, H₂S and COS removal. Our current references remove CO₂ to under 50 ppmv from approximately 20 vol% CO₂ in the feed.

Comparison to other High Pressure Solvents

✓ Faster CO2 and COS removal through enhanced reaction kinetics

✓ Higher loading capacity, reducing the solvent circulation rate and allowing smaller equipment

✓ Reduced steam requirements because of its lower solvent circulation rate and heat of reaction
Cansolv CO₂ Capture Overview

- Regenerable amine-based solvent for selective post combustion CO₂ capture
- Systems can be guaranteed for bulk CO₂ removal up to 99%.
- Highly adaptable to a wide variety of applications
Global Shell involvement in CCS projects

- Industrial scale projects in operation
- Planned industrial scale project - FEED completed
- Involvement through Shell Cansolv technology – no Shell equity

- Quest
- TCM
- Peterhead (cancelled)
- Gorgon
- Boundary Dam
Shell Cansolv at Saskpower’s CCUS Project, Boundary Dam 3
1 mm tonnes/year CO\textsubscript{2} capture for enhanced oil recovery

- First commercial-scale post-combustion carbon capture system at a coal-fired power plant
- Demonstrates the viability of large-scale post-combustion CO\textsubscript{2} capture
- Uses Shell Cansolv CO\textsubscript{2} technology. Captures up to 90% CO\textsubscript{2}, high or low SO\textsubscript{2} content
- Enables EOR with CO\textsubscript{2} from 150 MW power plant fluegas
- Meets stringent CO\textsubscript{2} regulations
- CO\textsubscript{2} permanently stored
Only Post-Combustion CO₂ Capture Technology with De-Risked Scale-up and Proven Constructability

- Proven and repeated design across industries with guaranteed performance
- Also capable of Low-pressure, Pre combustion Capture
- HSSE focused – With partners, 4 million on-site man hours, 0 Lost Time Injuries during Boundary Dam 3

Source: Shell Cansolv Project Data
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Gas Flow (Nm³/h)
CO₂ Capture for Natural Gas Power Plants

- Further CO₂ reduction will be required to meet COP21 Targets
- Natural gas conversion project must plan for future regulation
- As oil price increases, demand for CO₂ used for EOR also expected to increase