

### **Agave Energy Company – New Mexico**

- Preliminary design calculations for a 0.5 MMSCFD acid gas injection scheme including water content, hydrate formation and phase envelopes. The acid gas composition is 52% H<sub>2</sub>S, 46% CO<sub>2</sub> and 2% hydrocarbons.

### **Allen Energy - Como, Texas, USA**

- Preliminary design calculations for a 2 MMSCFD (60% H<sub>2</sub>S, 40% CO<sub>2</sub>) injection scheme including water content and phase envelopes.

### **ATCO Midstream - Golden Spike**

- Engineering and technical auditing of the detailed design for a 40 MMSCFD sour gas plant involving 450 HP acid gas (50% H<sub>2</sub>S, 49% CO<sub>2</sub>) injection, turbo expansion and coldbox, ethane extraction, mole sieve, and mercaptan removal. Project management and engineering management, EPC contract development and administration, start-up services.
- AENV permit application. EUB permit applications and audit manuals.
- Study of third party gas processing options.
- Process design, permitting and project management for a 12 MMSCFD sacrificial sweetening system. Project included Solar compressor upgrades, replacement of trays with structured packing and construction management.
- Acid gas volume: 212 m<sup>3</sup>/d. Acid gas compression: 450 HP.

### **Bear Cub Energy – Texas, USA**

- Troubleshooting of suspected hydrate formation and high wellhead pressures in a sour AGI process on the tail end of a gas plant.
- The team conducted an on-site investigation of current operations combined with process simulation to replicate suspected hydrate formation conditions and provided recommendations.
- The AGI process section consisted of 2 x 100% 5-stage motor driven 600 BHP reciprocating compressors with acid gas feed conditions of 3.0 MMSCFD gas containing 55% H<sub>2</sub>S and 43% CO<sub>2</sub> with a discharge pressure of 1280 psig.

### **Chevron Canada Resources - Bigoray**

- Preliminary design and process review for a 0.9 MMSCFD acid gas (20% H<sub>2</sub>S, 80% CO<sub>2</sub>) low-pressure acid gas injection scheme, including injection pressure estimation and water content calculations.
- Design of a novel dehydration unit for acid gas using low temperature methanol injection.

## **Devon Canada Corp (formerly Anderson)**

### **Normandville**

- Permitting, engineering, drafting and project management of a sour gas plant: 20 MMSCFD, 3000 HP compression (inlet & sales), 200 HP refrigeration, 20 USGPM amine sweetening, 50 HP acid gas re-injection compression.
- 2002 Expansion: Stabilizer, LPG bullet and pump skid.
- Acid gas composition: 67% H<sub>2</sub>S and 32% CO<sub>2</sub>. Acid gas compressor: 50 HP @ 2000 psig discharge. Acid gas pipeline: 1.5km with wellhead pressure of 1750 psig. Acid gas rate: 0.1 MMSCFD.
- 2004 Expansion: Installation of condensate flash tank.

### **Puskwaskau**

- Design and project management of a sour gas plant: 20 MMSCFD, 1,478 HP compression, 200 HP refrigeration, 20 USGPM amine sweetening, 125 HP (45% H<sub>2</sub>S, 51% CO<sub>2</sub>) acid gas re-injection rate: 0.106 MMSCFD, 50 HP water disposal pump, and 40 HP recycle compression.
- Permitting and public consultation.
- Plant modifications including incinerator installation and replacement of heat exchangers.

### **Rycroft**

- Design and project management of a 24 MMSCFD sour gas plant including 125 USGPM amine sweetening, 350 HP refrigeration, C<sub>5+</sub> production, 3000 HP primary gas compression, 250 HP acid gas injection and 1200 KW power generation.
- Acid gas composition: 70% H<sub>2</sub>S, 29% CO<sub>2</sub>. Acid gas rate: 0.8 MMSCFD, Acid gas compression: 250 HP at 1220 psia discharge. Acid gas pipeline: 500m with 1218 psia wellhead pressure.

### **West Culp**

- Design and project management of a 20 MMSCFD sour gas plant including 125 USGPM amine sweetening, 350 HP refrigeration, LPG production, oil battery modifications, solution gas compression, 3000 HP primary gas compression, 250 HP acid gas injection and power generation.
- AENV permit application.
- AEUB permit application and audit manual.
- Acid gas rate: 2190 lb/hr. Acid gas composition: 48-80% H<sub>2</sub>S, Balance of CO<sub>2</sub>. Acid gas rate: 0.6 MMSCFD, Acid gas compression: 250 HP at 1220 psig. Wellhead pressure 800 psi.

## **Elk Point Resources Inc. - Saddle Hills**

- Detailed design, procurement and construction management for an 8 MMSCFD MDEA amine gas sweetening plant with 2 stage 700 HP inlet / sales compression, CO<sub>2</sub> removal and glycol dehydration.
- Equipment and piping layout for the addition of inlet compression, amine sweetening and dehydration facilities.

## **Encana**

### **Deep Panuke, NS**

- Preliminary design of an offshore acid gas injection scheme to inject 4.5 MMSCFD of acid gas with an approximate composition of 25% H<sub>2</sub>S and 75% CO<sub>2</sub>.
- Study included compressor design (1200 HP), phase equilibrium calculations and water content.
- Scenarios studied included blending the acid gas with condensate prior to injection.

### **Weyburn, Saskatchewan**

- Evaluation of the water content of the CO<sub>2</sub>-rich stream and the potential for the formation of an aqueous phase or hydrates in the injection gas distribution system.

## **Glencoe Resources – Joffre**

- Design and specifications for a CO<sub>2</sub> sales compressor package with a single stage reciprocating compressor driven by electric Motor.

## **Hanover Russell - Tulsa, OK, USA**

- Design and optimization of an acid gas injection scheme for the disposal of up to 9 MMSCFD of acid gas (55% H<sub>2</sub>S, 45% CO<sub>2</sub>) including injection pressure calculation, water content optimization and compression design.
- Design and fine tuning of an acid gas injection scheme to dispose 0.3 MMSCFD of about 55% H<sub>2</sub>S and 45% CO<sub>2</sub> including injection pressure estimation, compressor sizing, phase equilibrium calculations, and water content and knockout.

## **HTC Energy - Regina**

- Process simulation and cost estimation of 300 T/D CO<sub>2</sub> recovery plant

## **HTC Pureenergy - Canada**

- Preliminary engineering and project management for a total installed cost estimate at ± 25% for an onshore facility entailing 4355 tonne/day CO<sub>2</sub> capture from flue gas with amines, 73 MMSCFD (0.68 x 10<sup>6</sup> m<sup>3</sup>/day) dehydration and 24,500 hp (18.3 MW) of compression for offshore EOR. This facility was an add-on to an existing 420 MW gas fired combined cycle power plant in Norway.
- Provided the total installed cost lump sum estimate for the dehydration and compression sections.

## **Husky Oil Operations Ltd. - Rainbow Lake**

- Engineering and process evaluation/audit of existing acid gas injection facility which includes 2 x 1000 HP four-stage compressors.
- Acid gas composition: 76% H<sub>2</sub>S, 23% CO<sub>2</sub>. Acid gas rate: 2.7-4 MMSCFD. Acid gas compressor discharge at 1490 psig into a 200m pipeline.
- Project management including engineering, procurement, construction management, operation training and commissioning for a third acid gas compressor unit.
- Process review for sales oil tank odour issues.
- Interstage cooler hydrate formation prediction and estimation of methanol injection requirements.

### **James E. Smith & Assoc. – Tyler, Texas**

- Design of a 3MMSCFD acid gas injection scheme inject (about 50% H<sub>2</sub>S and 50% CO<sub>2</sub>). Including injection pressure estimation, compressor sizing, phase equilibrium calculations, water content and knockout and budget cost estimation. Several scenarios were investigated.

### **John Brown Hydrocarbons – London, England / Kharg Island, Iran**

- Conceptual design, preliminary equipment selection and project budget for an 85 MMSCFD acid gas (55% H<sub>2</sub>S, 45% CO<sub>2</sub>) injection project on Kharg Island.
- Front end engineering and design of 85 MMSCFD acid gas injection facility including acid gas compression (45,000 HP), sour water treatment, acid gas pipeline, wellhead and wellbore completion. Management of core and reservoir studies undertaken by IOOC in Canada.
- Acid gas injection training course.
- Management of core and reservoir studies to support acid gas injection design.

### **KCS Resources - Texas, USA**

- Preliminary design calculations for a 2.5 MMSCFD acid gas (50% H<sub>2</sub>S, 50% CO<sub>2</sub>) injection scheme.

### **Kinder Morgan CO<sub>2</sub> Company – Texas, USA**

- Kinder Morgan CO<sub>2</sub> Company is the leading U.S. transporter and marketer of carbon dioxide for Enhanced Oil Recovery (EOR). A key asset, the SACROC Unit located in West Texas, is one of the largest oilfields and one of the oldest operating CO<sub>2</sub> capture and injection projects in the U.S.
- The SACROC Unit processes over 620 MMSCFD of gas for CO<sub>2</sub> capture and injection while recovering over 30,000 bpd of oil and 15,000 bpd of NGL liquids. Kinder Morgan desired to maximize production and thus requested Gas Liquids Engineering Ltd. to carryout the following two projects.

#### Capacity Increase Project

- Identified an additional 90 MMSCFD capacity with minor equipment modifications.
- The primary scope involved process review, simulation, major equipment rating and cost estimation for modifications for inlet separation, dehydration, filtration, chilling/separation, booster compression, gas and liquid amine treating, NGL recovery and condensate stabilization.

#### Expansion Project

- Generated the FEED for a 240 MMSCFD expansion train for CO<sub>2</sub> capture, injection and liquids recovery.
- The primary scope involved design basis memorandum generation, engineering process design, capital cost estimation and data sheet package development involving inlet separation, dehydration, filtration, refrigeration, liquids separation, heating and water-cooling.
- The secondary scope involved to varying degrees process review, cost estimation and data sheet package generation for modifications of all affected downstream processes such as molecular sieves, amine systems, NGL recovery, condensate stabilization and Puraspec. Process design review of MEA liquid/liquid contactor replacement internals, technical consultation for amine systems change-out.
- Process design review of MEA liquid/liquid contactor replacement internals, technical consultation for amine systems change-out.

- Provided economic consultation for the 240 MMSCFD membrane design including financial perspectives and strategic advice.



Kinder Morgan CO<sub>2</sub> Company – Texas, USA

### **Longview - Arkansas, USA**

- Design calculations for a proposed scheme for the injection of 1.5 MMCFD of sour gas (6% H<sub>2</sub>S, 6% CO<sub>2</sub>) including injection pressure estimation, water content, compressor sizing and hydrate calculations.

### **Long Petroleum – Shreveport, Louisiana**

- Design of a process for the injection of 1.5 MMSCFD of sour gas (6% H<sub>2</sub>S and 6% CO<sub>2</sub>) with particular focus on injection pressure estimation, phase equilibrium, hydrate formation and prevention and preliminary compressor sizing.

### **Mazeppa Gas Processing Partnership - Mazeppa**

- NGL and CO<sub>2</sub> recovery studies.

### **Moiibus - Acheson**

- Preliminary design of a sour gas plant (7 MMSCFD) and acid gas injection scheme (80% CO<sub>2</sub>, 20% H<sub>2</sub>S).

### **Novagas Canada Ltd (doing business as TCM) - Zama**

- Design, procure and direct the construction of an acid gas (35% H<sub>2</sub>S, 65% CO<sub>2</sub>) pipeline tie-in and wellhead injection facilities. Plant integration required, re-architecture of the SCADA system. Project completed successfully under constraints of spring breakup and maintaining current operations.

### **Numac Energy Inc (now Devon Canada Corporation)**

#### **Joffre**

- Preliminary design engineering of a crude oil/butane blending facility. Responsible for developing the project definition and AFE preparation.
- Designed and managed installation of CO<sub>2</sub> and water injection pipelines for pattern 10 and 11 into five injection wells.
- Designed and managed installation of emulsion pipelines for patterns 10 and 11 through 3 production wells.

#### **Red Creek**

- Installation of a 200 HP sour (12% H<sub>2</sub>S and 3% CO<sub>2</sub>) compressor package.

### **O’Ryan Oil & Gas – Odessa, Texas, USA**

- Design of an acid gas injection scheme (1 MMSCFD and 80% H<sub>2</sub>S, 20% CO<sub>2</sub>).

### **PDVSA/Tivenca – Maracaibo, Venezuela**

- Conceptual design of multiple processing options for 1200 MMSCFD gas stream including CO<sub>2</sub> removal, ethane recovery, turbo-expander facility, mercury removal and a nitrogen rejection facility.

### **Quadrise Canada Fuel Systems Inc. / Quadrise Energy Systems – Calgary**

- Feasibility study for a 63 MW power station utilizing heavy oil for producing both electrical power and CO<sub>2</sub> for enhanced hydrocarbon recovery.
- Preliminary design of an injection scheme for a flue gas stream (87.5% CO<sub>2</sub>, 1.6% SO<sub>2</sub> and other components including oxygen and nitrogen). The proposed injection rate was approximately 65 MMSCFD.

### **Regency Gas – Dallas, Texas, USA**

- Design of an acid gas injection scheme for the disposal of 2 to 4 MMSCFD of gas (10% H<sub>2</sub>S, 87.5% CO<sub>2</sub> and light hydrocarbons)

### **Spectra Energy - Fort Nelson, B.C.**

- Design basis memorandum, project specifications, engineering for a 120 MMSCFD acid gas recovery, transportation and injection system.
- Process design, preliminary drawing set and cost estimation for a 120 MMSCFD, Sour CO<sub>2</sub> injection plant addition to an existing facility. The injection facility consisted of 4 x 33%, 4-stage centrifugal gas driven compressors (15,000 HP) and TEG dehydration units. Study included the addition of HRSG and power generation facilities along with integration of steam processes into the existing plant utilities system. Full Monte Carlo risk analyses were performed on the prepared cost estimates and design and construction schedules.

**Solex Energy Inc.(now Altagas) - Harmattan**

- Design, equipment specifications, procurement and project management for a \$1.5M loading terminal expansion.
- Design equipment specifications and project management for a new CO<sub>2</sub> recovery facility to produce 200 t/day CO<sub>2</sub>.
- Converted surplus equipment and piping into a 600 bbl/d frac oil system.
- Completed pipe sizing calculations CO<sub>2</sub> recovery project.
- Design, equipment specification as well as procurement for adding a new CO<sub>2</sub> recovery facility to the existing gas plant. The CO<sub>2</sub> production capacity is 19800 lb/h. The project includes CO<sub>2</sub> filtration, sweetening, dehydration, refrigeration, storage and truck loading facility.
- Project engineering and procurement for the reapplication of a 1750 HP, five stage CO<sub>2</sub> compressor to a 1000 HP three-stage CO<sub>2</sub> compressor. The project included a torsional analysis and flywheel design for the new configuration.