THE GOOD

- Increases Energy Production
- Regulated (ERCB is a world leader)
- Creates lots of good jobs
- If done correctly, it can be a very environmentally friendly way to produce energy – What the Frac?

THE BAD

- Current Slickwater/Freshwater treatments are not sustainable in dry or water depleted environments

REALLY, It’s not that bad

- Water and Air contamination

The UGLY

- The Bad Press and Lack of Transparency
- Pumping at high pressures – safety must be enforced and followed!
Presentation Outline

- What is Hydraulic Fracturing (aka Fracin’, Fracking, Stimulation)?
- The Oil and Gas Well Development Process
- Types of Fracture Treatments
- Myths and Truths of Hydraulic Fracturing
- A quick comparison with other sources of energy production
- The future of Hydraulic Fracturing
- Question period
What is Hydraulic Fracturing aka Fracin’, Fracking, Stimulation?

**Engineer’s Definition:** is the process of transmitting pressure by fluid or gas to create cracks or to open existing cracks in underground rock. These cracks are then usually filled with sand to produce a more permeable pathway for oil and gas to travel to the wellbore.

- 1947 Standard oil – first treatment – Kansas (Commercial by 1950)
- Over 175,000 wells in Western Canada hydraulically fractured, over a million worldwide
- Currently over 60% of all wells completed in this manner
- Can increase production up to x1000

**Public’s Definition:** Fracturing has come to represent nearly every phase of the well development cycle from drilling to production
Oil and Gas Process

http://www.youtube.com/watch?v=Dr7WP2UB85k

Step 1 – Geology
Step 2 – Seismic Recording
Step 3 – Pad Construction
Step 4 – Drill the well
  - Surface Casing
  - Production Casing
Step 5 – Cement the Wellbore
Step 6 – Run logs (Bond logs)
Step 7 – Frac (60% of wells)
Step 8 – Lease clean up
Step 9 – Production - tie into pipeline or tanks
The most important step

- Cementing the wellbore!!

Please Note: casing and borehole width have been exaggerated for clarity
Ensure total Isolation

Casing should be cemented from total vertical depth to surface – Always practiced in Canada, sometimes in USA

Surface Casing is placed below water table

Leak tests and bubble tests (GM and SCVF)

-If a micro annular leak occurs, it can be fixed!

Fracturing occurs **after** the vertical part of the well has been **drilled, cased and cemented**.
Types of Fracture Treatments

1. Hydrocarbon Fracs - Frac Oil, Propane and soon Liquid Natural Gas Fracs

- No water used
- 3 additional chemicals: Activator (Ferric sulphate), Gellant (Phosphorus Acid) and Breaker (Magnesium oxide)
- Flowback can be 100% reused, recycled or sent to production
- Cost of product can be retrieved if set up properly
- Increased risk of fire or spill – Extra Safety precautions needed
Types of Fracture Treatments

2. Foam Fracs

- 70-95% CO2 or N2
- 30-5% water
- CO2 and N2 is taken from the atmosphere (greenhouse friendly)
- Gellant, surfactant, Breaker used

- Expensive and not as robust (viscous) as Frac oil or crosslinked water
- 100% N2 is often used for Coal Bed Methane Fracs
3. Crosslinked Water Fracs

- Water used (very viscous and robust)
- Gellant, Crosslinker, Surfactant, Clay Control, Breaker
- Used for 85% of conventional wells that are fractured
Types of Fracture Treatments

4. Slick Water Fracs

- Recently in the media
- Used for tight gas and shale gas (unconventional rock)
- Friction Reducer only chemical needed*
- Little to no viscosity, fast pump rates, lower sand concentrations and larger volumes of water needed.

- Shale Oil and Gas represents ~ 1% of total water use in the USA (Golder Associates)
- 15.9 MM m3 water used in Alberta in 2011 (CAPP)
- 0.6 barrel of fresh water is used to produce 1 barrel of Oil in Alberta (Rudy Tamayo)
- There has been an 854% increase in proppant use over the last 5 years in North America (Chris McCullough, Fracknowledge)

* Several Studies show that extra chemical actually decreases production, Economides
SOLUTIONS TO WATER USAGE:

- Engineering Optimum Fracs
  - Information Age – Service data bases, Accumap, FracKnowledge, etc.
- N2 and CO2 assists
- Re-use and/or recycle frac fluid
- Use of produced and sourced salt water
Why frac? Why Now?

The Unconventional has now become Conventional!

What Makes an Unconventional Reservoir?
Frackin’ Allegations

Fracking Allegations – however, several studies and articles* clearly discusses the issues and concludes fracturing is safe

- Fracturing process contaminates drinking water - False
- Fracturing uses “toxic soup” of chemicals – False, but there is room for improvement
- Fracturing causes cancer ??? – IT DOES NOT
- Fracturing will decrease tourism and land value - False
- Fracturing causes earthquakes – True
- Shale exploration is unregulated - False
- Oil companies are beating down the door to frac at any cost - False
- The Public is 100% against oil companies and fracturing - False

Frackin’ Allegations

Public Concerns

• Water Usage
• Truck Traffic
• Road construction
  – No Spider Webs
• Air and water contamination
• Life span of wells
• Lack of Transparency!

Why the Bad Rep?
What can we do about it?

Photo courtesy of Audrey Mascarenhas, Questor Technology INC
Let’s Frac

- Ground water is usually <100m
- Fracture treatments are generally 1000m-4000m TVD
- Frac height = 30m - 100m
- Frac width = 1mm - 3mm
- Frac length = 100-800m
- With proper well construction, shallow groundwater aquifers are protected from fracturing fluids and hydrocarbons in the well bore using cement and steel casing – CEMENT JOB IS VIP
- ERCB just concluded that 23 well bore communications happened since 2009. – All within the same zone! (frac height is contained)
Ground Water Contamination

“There are 0 incidents of ground and water contamination due to Hydraulic Fracturing”*

* Almost all contamination is due to the lined pits, which are not used in Canada. Spills and poor or improper cement account for a small number contamination.

“The potential for chemical contamination of underground or surface sources of fresh water during all phases of well development comes exclusively from: Road transport of components or fuel, onsite storage and surface mixing of fluids” – George King, SPE 152596

“Fire from tap was naturally occurring”
COGCC
Poisoned fish in Gasland did not happen from fracin’!!
Let’s get back to the frac

- Often Closed system (no open pits)
- No spill regulation
- Lease is cleaned with vacuum truck
- Lease can be restored to natural environment
- Produced fluid can be reused, treated or disposed in a disposal well
It’s Not “Toxic Soup”

- “Gasland” mentions that over 750 chemicals are used during the fracturing process – can be 1 - 10 additives.
- Frac jobs are 99.5% water (or HC) and Sand
- Slick water fracs need 1 – 2 additives: FR (Biocide should be added if surface water is used)
  - Biocides, Surfactants, Clay Control and Acid are sometimes added (depended on the formation, completion type and salesman)

Most additives are environmentally friendly
  or
  can be!
WHAT'S ENVIRONMENTAL FRIENDLY??

HOW DOES ONE PRODUCT COMPARE WITH ANOTHER??

- Encana is using a third party called Intrinsik to test toxicity of chemicals used.

OTHER MODELS INCLUDE:

- CHARM MODEL, WHIMIS
- SCJRS, SmartCare, Multichem – Naturaline products

- Are results open to the public?
## Hydraulic Fracturing Fluid Product Component Information Disclosure

| Fracture Date: | 07/23/2012 |
| Province: | BC |
| Region: | Komiex |
| Well Number: | 29625 |
| Operator Name: | Nexen Inc. |
| Well Name: | NEXEN INC. HZ KOMIE B-A077-H/094-0-08 |
| Longitude: | -122.051102 |
| Latitude: | 59.233428 |
| Long/Lat Projection: | NAD83 |
| Production Type: | Undefined |
| True Vertical Depth (TVD): | 5,000 |
| Total Water Volume (m³): | 66,331.61 |

### Hydraulic Fracturing Fluid Composition:

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Supplier</th>
<th>Purpose</th>
<th>Ingredients</th>
<th>Chemical Abstract Service Number (CAS #)</th>
<th>Maximum Ingredient Concentration (% by mass)**</th>
<th>Maximum Ingredient Concentration in HF Fluid (% by mass)**</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>Operator</td>
<td>Carrier Fluid</td>
<td>Fresh Water</td>
<td></td>
<td>100.00%</td>
<td>0.46400%</td>
<td>-</td>
</tr>
<tr>
<td>FR-8</td>
<td>Trican</td>
<td>Friction Reducer</td>
<td>Petroleum distillate</td>
<td>64742-47-8</td>
<td>26.00%</td>
<td>0.02727%</td>
<td>-</td>
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<tr>
<td>Frac Sand - regular</td>
<td>Trican</td>
<td>Proppant</td>
<td>Ammonium chloride</td>
<td>12125-02-9</td>
<td>1.50%</td>
<td>0.00143%</td>
<td>-</td>
</tr>
<tr>
<td>HCl 10%</td>
<td>Trican</td>
<td>Acid</td>
<td>Crystalline silica</td>
<td>14809-60-7</td>
<td>100.00%</td>
<td>0.03568%</td>
<td>-</td>
</tr>
<tr>
<td>GSI-2</td>
<td>Trican</td>
<td>Scale Inhibitor</td>
<td>Hydrochloric acid</td>
<td>7647-01-0</td>
<td>10.00%</td>
<td>0.03954%</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Water</td>
<td>7732-18-5</td>
<td>50.00%</td>
<td>0.35582%</td>
<td>-</td>
</tr>
<tr>
<td>Si-2</td>
<td>Trican</td>
<td>Scale Inhibitor</td>
<td>Acetic acid, 2,2'-oxybis-, sodium salt (1:2)</td>
<td>35249-89-5</td>
<td>4.00%</td>
<td>0.00500%</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Non-hazardous ingredients</td>
<td></td>
<td>98.00%</td>
<td>0.00143%</td>
<td>-</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Methanol</td>
<td>07-56-1</td>
<td>20.00%</td>
<td>0.00122%</td>
<td>HMIRC #7036</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Organic phosphonate 1</td>
<td></td>
<td>30.00%</td>
<td>0.00183%</td>
<td>HMIRC #7036</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Organic phosphonate 2</td>
<td></td>
<td>10.00%</td>
<td>0.00183%</td>
<td>HMIRC #7036</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ammonium chloride</td>
<td>12125-02-9</td>
<td>10.00%</td>
<td>0.00001%</td>
<td>HMIRC #7036</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Amine salt</td>
<td></td>
<td>5.00%</td>
<td>0.00013%</td>
<td>HMIRC #7036</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Oxycarboxylated polyamine</td>
<td></td>
<td>5.00%</td>
<td>0.00031%</td>
<td>HMIRC #7036</td>
</tr>
<tr>
<td>Ingredient</td>
<td>Common Name</td>
<td>Frac Fluid use</td>
<td>Common use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>------------------------</td>
<td>-----------------------------------------------------</td>
<td>--------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gellant</td>
<td>Guar bean gum</td>
<td>Water viscosifier, forms gel to suspend sand</td>
<td>Thickener used in cosmetics, toothpaste, and sauces</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gellant</td>
<td>Cellulose polymer</td>
<td>Water viscosifier (thickener) to suspend sand</td>
<td>Thickener for cosmetics and household products.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crosslinker</td>
<td>Borate salt</td>
<td>Increases gel viscosity</td>
<td>Used in laundry detergents, hand soaps and cosmetics.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gel Breaker</td>
<td>Sodium borate salt</td>
<td>Gel breaker to lower viscosity for efficient cleanup</td>
<td>Laundry detergent and pharmaceuticals</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gel Breaker</td>
<td>Cellulase/Hemicellulase</td>
<td>Gel breaker (enzyme) to lower viscosity for efficient cleanup</td>
<td>Used in commercial food processing, laundry detergents, and pharmaceuticals.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Friction Reducer</td>
<td>Polyacrylamide</td>
<td>Minimizes friction between fluid and pipe</td>
<td>Flocculant for water treatment, soil conditioner for farming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clay Control</td>
<td>Chlorine compound</td>
<td>To prevent clay swelling when contacted by water</td>
<td>Additive for feed/farming</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flowback Enhancer</td>
<td>Surfactants</td>
<td>Promotes the return of fluid from the formation to the wellbore</td>
<td>Cosmetics</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scale Inhibitor</td>
<td>Phosphonate</td>
<td>Prevents scale from forming on pipes</td>
<td>Pharmaceuticals, water treatment, desalination systems.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pH Control</td>
<td>Sodium or potassium carbonate</td>
<td>Maintains effectiveness of gel crosslinker</td>
<td>Used in washing soda, soap, hot tubs and water softeners</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrier Fluid</td>
<td>Mineral oil</td>
<td>Carrier fluid for powdered additives</td>
<td>Cosmetics, pharmaceuticals, lubrication electric components</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bactericide</td>
<td>DBNPA (amide)</td>
<td>Kills bacteria in mix water</td>
<td>Cooling tower treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Frac well treatment</td>
<td>Hydrochloric Acid</td>
<td>Cleans and dissolves scale</td>
<td>Cleaner (muriatic acid), stomach acid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carrier Fluid</td>
<td>Propylene Glycol</td>
<td>Freeze proofing of water based carrier fluids</td>
<td>Pharmaceuticals (cough syrup), food processing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
It's not “Toxic Soup”

- A generic Slick Water Frac uses 400m³ to 1000m³ of water per stage.
- A horizontal well averages 15 stages
- \(1000m^3 \times 15 = 15,000m^3\) of water
- Friction reducer is added at .4 to 1 litre/m³
- 15m³ or 15,000 litres of FR per well!
  - Make sure the additives used are non-toxic!
How Does FR and other Frac Chemicals Score?

- **Product Classification:**
  - Category A: No Further Action Required
  - Category B: Practices and/or Controls Required
  - Category C: Further Review Required
  - Do Not Use List

**Completion has:**
- Category A – 28% products
- Category B – 50% products
- Category C – 3% products

42 Unknowns (18%)

* Due to recent testing, service companies have stopped using several Category C chemicals. A renewed focus on developing greener products has developed.
What about the earthquakes?

Earthquakes

- Seismic activity potentially resulting from fracturing measures less than 3.5 on the Richter scale
- Horn River, B.C. (2.5-3.5)
- Blackpool, England (1.5-2.3)
- Seismic activity is contained in a small area

Richter Scale (worldwide):

<table>
<thead>
<tr>
<th>Magnitude</th>
<th>Impact</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 2</td>
<td>Minor</td>
<td>Rare</td>
</tr>
<tr>
<td>2 – 3.9</td>
<td>Moderate</td>
<td>49,000 / year</td>
</tr>
<tr>
<td>3.9 – 5.8</td>
<td>Strong</td>
<td>1,000 / day</td>
</tr>
<tr>
<td>5.8 – 7</td>
<td>Great</td>
<td>8,000 / day</td>
</tr>
<tr>
<td>&gt; 7</td>
<td>Major</td>
<td>1 / per year</td>
</tr>
</tbody>
</table>

Each level is 10 x stronger than the previous level

Earthquakes in the news have 10,000 more energy

“none of the events cause any injury, property damage or posed any risk to public safety or the environment”  BC Oil and Gas Commission Study concluded after recording 272 seismic events from April 2009 and December 2011 (approx 8000 treatments), (August 30, 2012)
Micro-seismic monitoring of fracture events for each staged stimulation allows the lateral and vertical envelope of the fracture stimulates rock to be determined.

- Dots represent individual micro-seismic events that occur during the fracturing of the reservoir.

Track of the horizontal wellbore

4000 m
Air Pollution

- Emissions from trucks - Use of LNG engines (future), Reduction in Idle Time
- Flaring vs Incinerators
- Use of CO2 decreases Greenhouse Gases
Comparison with other sources of energy

- Fracturing can actually be environmentally friendly – WHAT THE FRAC???
- An average horizontal well produces 1.15 Mcf/day = 300,000 MWh and uses a smaller/same environmental footprint of wind turbine
- Wind Energy = 3285 MWh/turbine
- Solar = Hopefully someday
- Hydro = large footprint
Comparison with other sources of energy

- 30% Demand increase for power in Alberta since 2000
- Fossil Fuels will continue to be the main source of energy
- Presently, NG has 1% of sulfur, 30% of N2, 50% CO2 Oxides omitted compared to burning Coal

**Alberta’s Electricity Mix (2010)**

<table>
<thead>
<tr>
<th>Source</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal and Petcoke</td>
<td>44%</td>
</tr>
<tr>
<td>Natural Gas (and oil)</td>
<td>41%</td>
</tr>
<tr>
<td>Hydro and Tidal</td>
<td>7%</td>
</tr>
<tr>
<td>Wind</td>
<td>6%</td>
</tr>
<tr>
<td>Other (Imported Power, Oil, Etc.)</td>
<td>2%</td>
</tr>
</tbody>
</table>
Truths/Benefits

- Better for our environment, even better for the economy
- Royalties from the natural gas – reduction in taxes!!! (Alberta Rate = 5%-40%)
- Jobs in almost every sector
  - Fire fighters, medics, accountants, engineers, construction, accommodations, welders, steel, manufacturing, govt jobs, environmental scientists, entrepreneurs, teachers

“Nothing promotes prosperity like prosperity”

Charities, fundraisers, sports, healthcare, education all benefit
The Future of Fracturing

- Looks like Natural Gas will be the future – Hydraulic Fracturing will increase!
- Safety will continue to be of first priority!
- Industry is learning and improving all the time
- Robust regulations to ensure best practices are being used and enforced by all involved – ERCB is a continuing world leader – i.e IRP 24
  - Water wells should be at least 200m away from drilling pad (Directive 027 – ERCB)
  - Verification of good cement bond/integrity is needed
- Ensure “Greener” Additives are used
- Natural Gas Engines and equipment will be added
- Use of Incinerators were appropriate
- Reducing the use of fresh water
  - Engineering Optimum Fracs
  - N2 and CO2 assists
  - Re-using and/or recycling frac fluid
  - Using produced and sourced salt water
- Transparency requires cooperation from all sides of the debate
  - Full disclosure of Environmental ranking of additives used in frac fluids

“Let’s Practice Safe Frackin’!”
Valuable Resources

- www.fracfocus.ca
- www.ercb.ca
- CSUR
  Canadian Society for Unconventional Resources
- CAPP
  Canadian Association of Petroleum Producers
-SPE 152596
  Excellent paper from George E. King, Apache

"Perform our job in a manner that protects the environment, leaving the environment (well site) in better condition than we found it, going above and beyond compliance with the law, and, cleaning up after ourselves, including cleaning up our past occurrences"
Special Thanks

- Kevin Heffernan, CSUR
- Dave Browne, Trican
- Dave Jeffers, Multichem
- Audrey Mascarenhas, Questor
- Dale Leckie, Nexen
- Kathy Brooker, BA
Thanks for your time

Question and Comments!

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