# D-054 Performance Presentation

## Poplar Creek ET-DSP™ Step Three Field Test

## Experimental Scheme Approval No. 10457H

## Location 09-13-090-10W4

## January 1, 2015 to December 31, 2013


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**Peter Johanson, CFO**
**E-T Energy Ltd.**


*An Integrated Technology Strategy*
*Focusing on Next Steps*

February 26, 2016

# Forward Looking Statement

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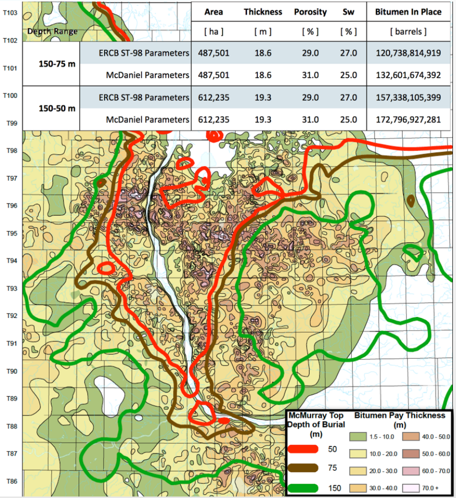
# Presentation Outline

# The Oil Sands



| Depth Range | | Area [ ha ] | Thickness [ m ] | Porosity [ % ] | Sw [ % ] | Bitumen In Place [ barrels ] |
|---|---|---|---|---|---|---|
| 150-75 m | ERCB ST-98 Parameters | 487,501 | 18.6 | 29.0 | 27.0 | 120,738,814,919 |
| | McDaniel Parameters | 487,501 | 18.6 | 31.0 | 25.0 | 132,601,674,392 |
| 150-50 m | ERCB ST-98 Parameters | 612,235 | 19.3 | 29.0 | 27.0 | 157,338,105,399 |
| | McDaniel Parameters | 612,235 | 19.3 | 31.0 | 25.0 | 172,796,927,281 |



## The Resource

1. **Too deep** to mine - **too shallow** for SAGD
2. Quality resource **towards the surface**
3. Near **infrastructure**

## Mining ?

ET-DSP™ **can replace** mining.

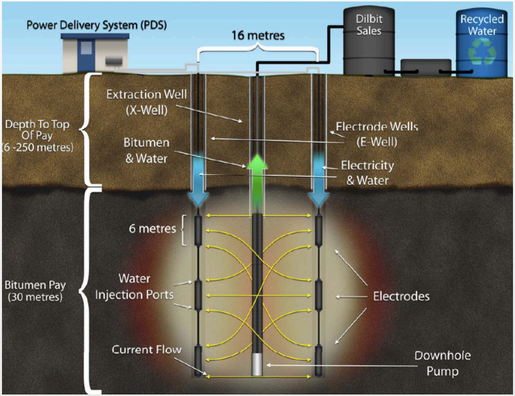
The technology was originally developed to replace mining.

## Deeper ?

Depths to 250 m are achievable with current materials technology.

# The ET-DSP™ Process

The ET-DSP™ technology combines the features of electro-thermal heating with heat transfer by convection. **Here is how it works:**



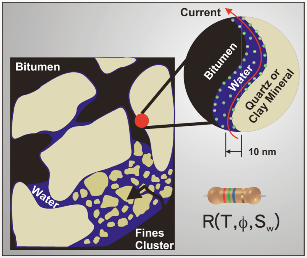

## Main Features of the Process

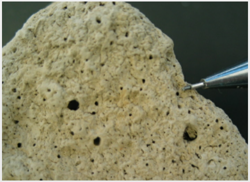
1. Electrical **current flows from electrode to electrode** through the connate water within the formation, heating the bitumen especially near the electrodes.
2. A **negative pressure gradient** is established to pull heated and mobilized fluids to conventional production wells.
3. The introduction of the **convective heat transfer by injection of water** into the ends of the electrodes results in a 5 - fold increase in reservoir heating.

# At the Pore Level

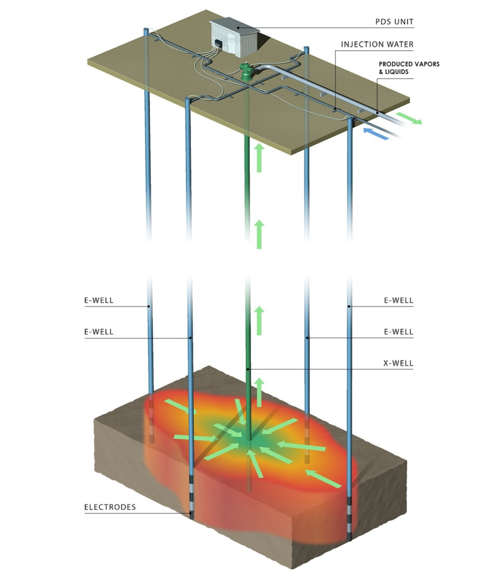
## More Features of the Process

1. The conduction path is the connate water thus heating less water and more oil resulting in improved thermal efficiency.
2. The charge distribution at the oil-water boundary alters the IFT resulting in little sand production and minor emulsions.
3. Boiling and cooling (water to vapour phase changes) in the pore space improves the recovery factor.
4. Electrical heating of clays creates permeable paths for oil to flow to the production wells.



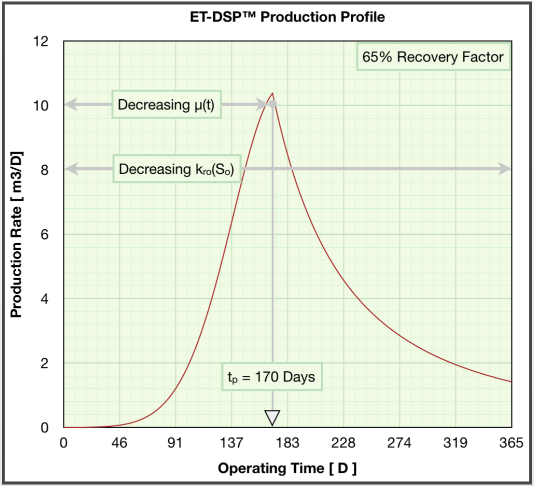
# Field Level




## Heating the Formation

1. Each equilateral triangle of electrodes defines an element with the electrodes spaced on 16 m centres.
2. Two elements create a diamond shape with extraction wells located in the middle of the diamond.
3. Extraction wells are part of the neutral system with ground currents providing heating.
4. Non-potable water is injected into the electrodes at low rates (0.3 gpm on average) and low pressure.
5. Production commences in 60 to 90 days from the start of heating.

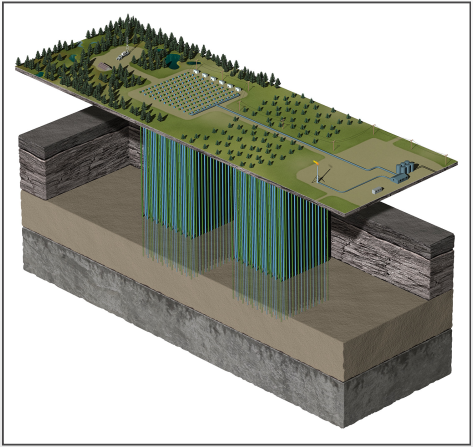
# Production Profile




## Features

1. One year production cycle
2. Peak temperature coincides with minimum oil viscosity
3. Bitumen can be produced at lower temperatures than in SAGD
4. Model published in McGee [1]

# Commercial Development



### Development Features

1. **Annual** temporal & moving footprint
2. Full restoration in **less than ten years**
3. Surface equipment is long life and **reused**

### A Lot of Wells

10,000 bopd requires **1,000+** wells drilled annually

### A Small Footprint

10,000 bopd is 33 ha

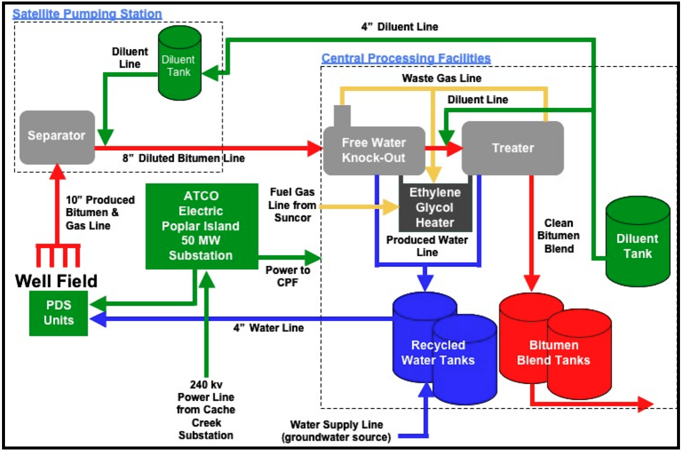
# Drilling Drilling Drilling

| | Activity | Minimum | Maximum | Commercial | Comment |
|---|---|---|---|---|---|
| 1 | Drill Through Cement | 15 | 120 | 30 | Cement plug thickness varies considerably from well to well (2 to 8 m). Commercial operations will ensure thicknesses of not more than 1 meter. |
| 2 | Rig Move | 44 | 120 | 30 | Move times from well to well will be reduced by reducing the number of drilling equipment that needs to be moved |
| 3 | Drilling Fluid Treatment | 51 | 60 | 30 | Proper chemical treatment of the drilling fluids will mitigate any foaming issues and therefore eliminate water change outs. |
| 4 | Fluid Handling | 56 | 90 | 30 | Hoses & larger sized fluid holding tanks will be used in the commercial phase to reduce Fluid Handling times. |
| 5 | Drill to TD | 173 | 360 | 90 | Drilling times will be reduced by **(1)** twice the water circulation capacity (1.3 to 2.5 m3/min), **(2)** increase top drive rotary speed from 110 to 200 rpm, **(3)** drill with larger diameter drill pipe, and **(4)** extend the surface casing another 10 meters into the clays. |
| 6 | Wiper Trip | 41 | 90 | - | A Wiper Trip or well clean out is needed to ensure that the well is free of debris and clay for a successful electrode install. This activity is eliminated by drilling with a higher water rate and extending the casing further past clays. |
| 7 | Lower Electrode | 27 | 75 | 15 | A fit for purpose rig would be designed to eliminate the time consuming steps needed to position the electrode over the well for lowering into the wellbore. |
| 8 | Start Stop | 30 | 90 | - | As can be expected with a single shifted crew, Start-Stop activities consume a lot of time and creates an interruption to drilling activities that will not occur during commercial operations. |
| | **Total** | ***437***<br>***7.29***<br>***3.3*** | ***915***<br>***15.25***<br>***1.6*** | ***225***<br>***3.75***<br>***6.4*** | **Minutes**<br>**Hours**<br>**Electrode Wells Per Day** |

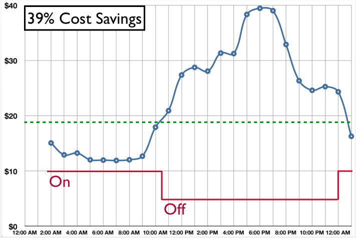
## Grid Power

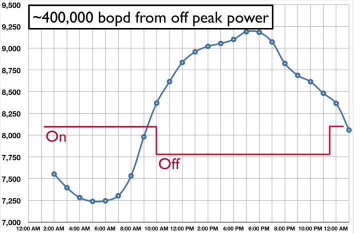
1. A fit for purpose drilling rig and operation is essential for enabling commercial operations.
2. Drilling performance needs to be greater than three wells per day - these metrics have been achieved with conventional methods, a fit for purpose rig can achieve six wells per day
3. Seven drilling rigs, drilling an average of three wells per day are are sufficient to execute a 50,000 bopd commercial project
4. Capital Cost: $740 per bopd

# PDS Units vs Steam Generation / Water Treatment



# Electrical Energy



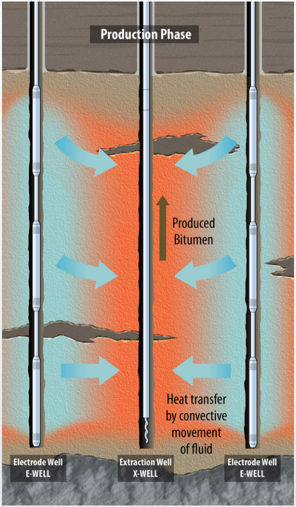

## Grid Power

1. Energy price and power supply in Alberta varies hourly [2].
2. Power can be controlled to take advantage of off peak hourly power pricing with a potential energy cost savings of up to 40 percent.
3. Available off peak power from the Alberta pool is sufficient to support a large commercial project.

## Energy Requirements

1. Energy: 75 kWh per barrel
2. Power: $3\frac{1}{2}$ kW per bopd
3. Average Cost: $7.39 per barrel

# Water Production / Injection




## Water Usage

1. Provides voidage replacement
2. 1 $m^3$ per $m^3$ of produced bitumen
3. Water quality not an issue, produced water is re-injected
4. Minimal water treatment is required
5. Average Cost: $0.13 per barrel

# Scheme Progress

## E-T ENERGY TECHNOLOGY DEVELOPMENT TIMELINE:

| 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | PURPOSE | RESULT | KEY LEARNING |
|---|---|---|---|---|---|---|---|---|
| XT1 | | | | | | Proof of concept on half-spacing of 8 metres to demonstrate in-reservoir performance | > 2000 bbl of bitumen produced using 3.5 kW/bbl of power and 70 kWhr/bbl of energy | Progressive cavity pumps are key to successful production; electrode completion redesign |
| | T2 | | | | | Test new electrode drilling and completion technique; test screens in production wells; test 16 metre spacing | > 500 bbl of fluids produced; mini-electrodes used to revive failed electrodes | Eliminate metal in electrode wellbore; reduce cable handling at installation; fine-tune extraction well completion |
| | XT3 | | | | | Test 18 metre spacing of electrode wells | Heating occured, but at slower rate | For saturation condition at Poplar Creek, 16 metre spacing is likely optimal |
| | | | XT1-A | | | 4 X-well pattern designed to test 16-m spacing and new design of electrodes | Failure of downhole cable connectors and hose failure | Revise connector design; All future completions to provide casing protection to top of formation |
| | | | | XT1-A MINI | | Re-activation of a portion of XT1-A using mini-electrodes to gather reservoir and performance data | No failures | Reliable method to rejuvanate an electrode |
| | | | | Step 1 & 2 | | Test revised completion methodology for casing and conduit protection, with small spacing to accelerate | Begin heating this week | |
| | | | | | Step 3 | Nine X-well pattern for definitive demonstration of recovery factor and EOR | Long lead items in procurement | |
| | | CCEMC Scope | | | Step 4 | 1,000 bbl/d pilot as demonstration of commercial-scale operations | | |

## Background

1. Received initial EUB approval Jan 30 2006, #10457A, as an experimental scheme.
2. Confidential status from Jan 2006 to Jan 31 2011.
3. Most recent approval for experimental scheme amendment dated Mar 19 2013, #10457H (expires Jan 31 2017).
4. Finished construction, begin heating and production for Step 3, in the 2012 calendar year.

# E-T Energy Progress to Date

## Summary

1. **Invest $80 million** to date on delineating lease and piloting.
2. **287 million barrels** contingent recoverable resource from independent resource evaluator.
3. Demonstrate **sand free** bitumen production from 2007 onwards in four consecutive field tests.
4. Operate Step 3 to establish **commercial** technical and economic inputs.
5. Continue with **Research and Development** on subsurface electrode connection and cable delivery system.
6. Execute a larger field test to **demonstrate commerciality**.

# CCC and the Oil Sands

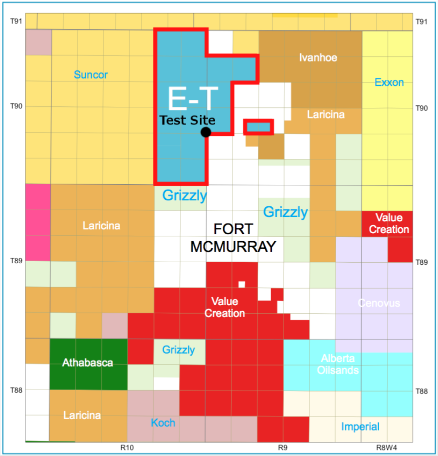
**Bitumen**

1. Revenue measured at a **discount** to WTI : 0.6 to 0.8 times WTI.
2. **Requires** the addition of expensive diluent for transportation.
3. **Depends** on pipeline access, e.g. Keystone or Northern Gateway to open markets for optimal pricing.

**Diesel**

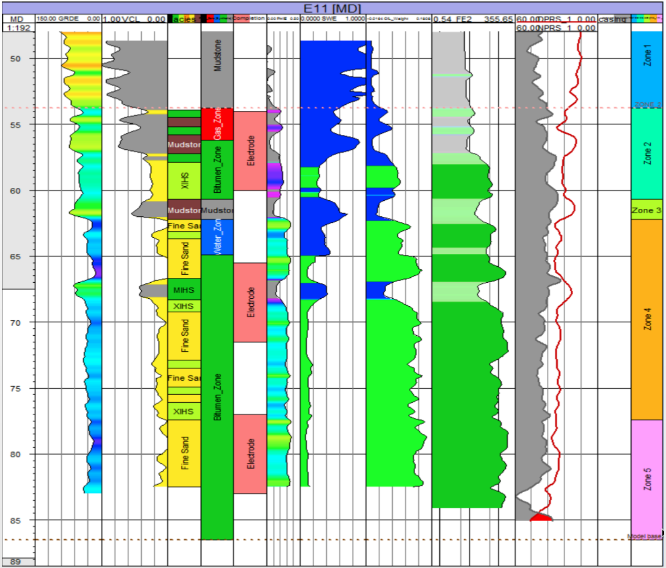
1. Revenue measured at a **premium** to WTI : 1.8 to 1.9 times WTI.
2. **No** diluent needed.
3. Diesel sold to **local markets**. Does not need Keystone or Northern Gateway pipelines to realize optimal pricing.

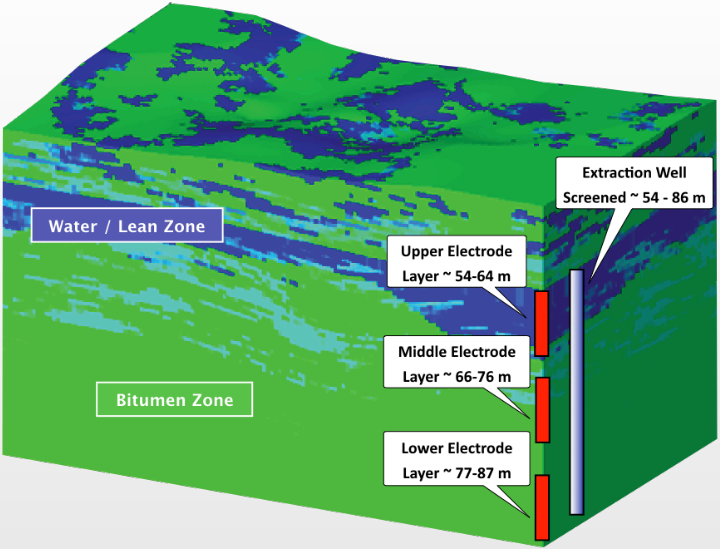
# Location: 09-13-090-10-W4M



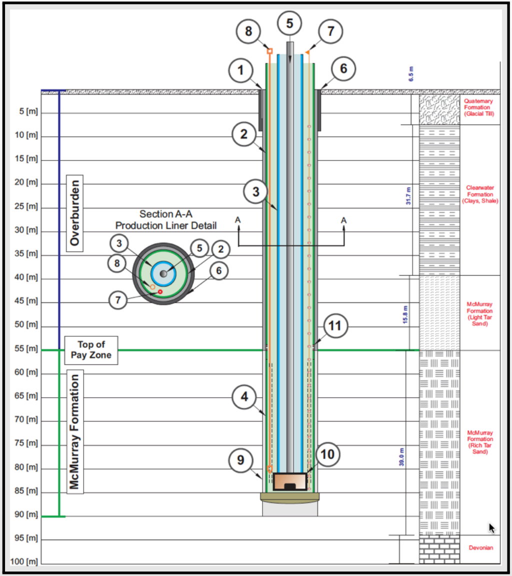

# Step 3 CCEMC/Total Field Test

- Stop power to electrodes on March 31, 2013.
- Continue production operations to May 11, 2013.
- Continue data monitoring to June 30, 2013
- Demob Tank Farm, Battery, Glycol Heater, Office Trailer, Storage Tents in October, 2013.
- Complete Demob by December, 2013.
- Abandon wells/clear site; completed October 2014.
- Site Reclamation remains to be done.


E11 [MD]
MD
1:192
GRDE
VCL
Facies
Completion
SWE
FE2
DPRS
NPRS
casing
Mudstone
Gas_Zone
Bitumen_Zone
Water_Zone
Electrode
Mudstone
XIHS
MIHS
Fine Sand
Zone 1
Zone 2
Zone 3
Zone 4
Zone 5
Model base


Water / Lean Zone
Bitumen Zone
Extraction Well
Screened ~ 54 - 86 m
Upper Electrode
Layer ~ 54-64 m
Middle Electrode
Layer ~ 66-76 m
Lower Electrode
Layer ~ 77-87 m

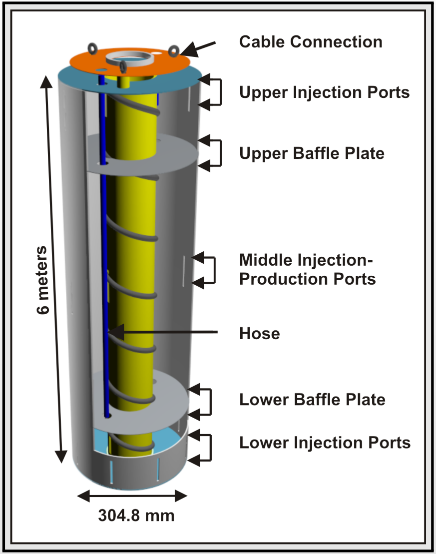
# The Extraction Well




## Extraction Well

1. Conventional Drilling.
2. 70% of the equipment is reusable
3. Progressive Cavity Pump
4. Surface Casing with Thermal Cement
5. Downhole Temperature Monitoring
6. Hydraulic Drive Unit

# The Electrode Well




## Electrode Well

1. Drill large diameter wellbore with fit for purpose drilling rig,
2. Three electrodes in each E-Well,
3. Bundle of cables and hoses to surface (most of it reusable),
4. Surface Casing with Thermal Cement,
5. Each E-Well abandoned after use,
6. Electrode wellhead (recoverable), and
7. Completed with surface casing.

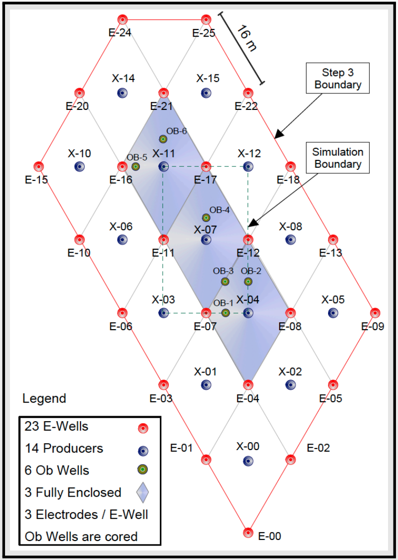
## Step 3 Operations Summary

| | | |
|---|---|---|
| **Phase I (All Electrodes On)** | | |
| Begin heating to electrodes | Jan 31, 2012 | |
| Begin bitumen extraction | June 25, 2012 | |
| Days of heating prior to extraction | 146 days | |
| Turn off the Upper electrodes | July 4, 2012 | |
| Days of heating to all electrodes | 155 days | |
| Cumulative energy to all electrodes | 3,400,000 | [kW•hr] after 155 days |
| Cumulative energy to Upper electrodes | 1,010,000 | [kW•hr] after 155 days |
| Average electrode power to July 4, 2012 | 13.25 | [ kW ] |
| **Phase II (Upper Electrodes Off)** | | |
| Days of heating | 270 days | |
| Cumulative energy during Phase II | 2,441,000 | [kW•hr] after 270 days |
| Average electrode power | 8.19 | [ kW ] |
| Shut off power to all the electrodes | March 31, 2013 | |
| **Step 3 Totals** | | |
| Days of operations | 425 days | |
| Stop bitumen extraction | May 11, 2013 | |
| Terminate data monitoring | June 30, 2013 | |
| Cumulative bitumen extraction | 621.64 | [ $m^3$ ] |
| Cumulative energy to Middle & Lower electrodes | 4,831,000 | [kW•hr] after 425 days |
| Cumulative energy to all electrodes | 5,841,000 | [kW•hr] after 425 days |

# Key Learnings

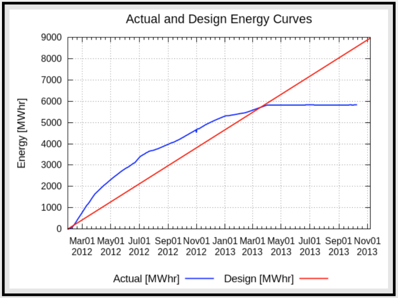
1. Electrode reliability key to effective reservoir heating
2. Critical production aspects: (a) significance of high water ratio and (b) even vertical heat distribution within electrode well.
3. No significant sand production, even at high fluid production rates.
4. Able to effective control and minimize heat to water zone.
5. Chemical injection increased recovery but need to quantify how much.
6. Advanced understanding of reservoir drive mechanisms in a low-pressure environment.

# Revised Simulation Study

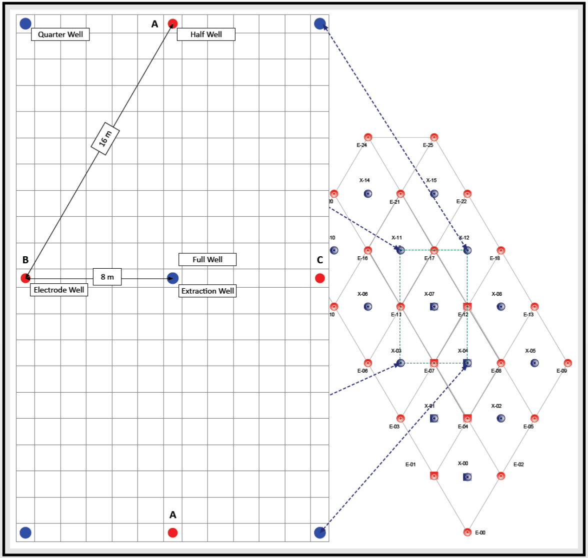



## Performance Expectations

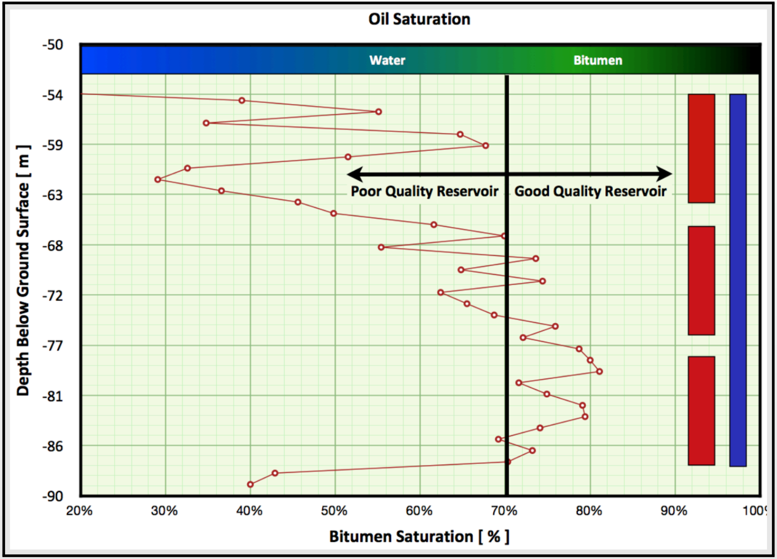
1. Match the geology.
2. Match the average input energy.
3. Based on the known geology, what are the performance expectations.



# Simulation Model



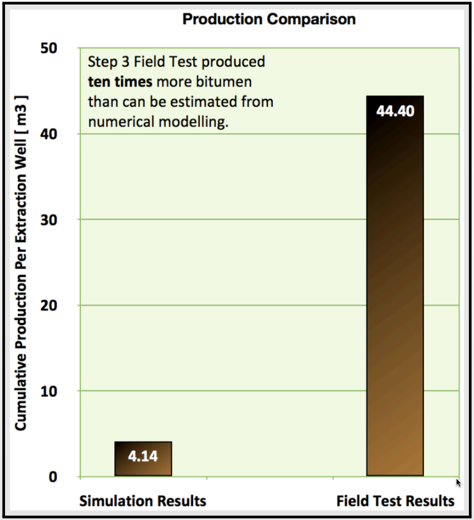
# Reservoir Quality



## Numerical Evaluation of Production Performance

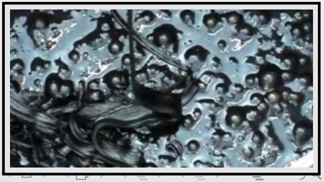
| Parameter | Simulation Results | Field Test Results | Units |
|---|---|---|---|
| **Phase I (All Electrodes On)** | | | |
| Phase I Electrical Energy | 1,065,243,000 | | [ GJ ] |
| | 295,901 | 3,334,194 | [ kW•hr ] |
| Duration | 155 days | 155 days | |
| Average Electrode Power | 13.26 | 13.25 | [ kW ] |
| Current Scaling Factor | 1.00 | | |
| **Phase II (Upper Electrodes Off)** | | | |
| Phase I + II Electrical Energy | 1,926,802,000 | | [ GJ ] |
| Phase II Electrical Energy | 861,559,000 | | [ GJ ] |
| | 239,322 | 5,802,316 | [ kW•hr ] |
| Duration | 270 days | 270 days | |
| Average Electrode Power | 8.21 | 8.19 | [ kW ] |
| Current Scaling Factor | 1.00 | | |
| **Cumulative production per well** | **4.14** | **44.40** | **[ $m^3$ ]** |
| **Step 3 EOR** | **13,237.55** | **1,235.55** | **[ kW•hr/bbl ]** |
| **Phase II EOR** | **13,237.55** | **1,235.55** | **[ kW•hr/bbl ]** |
| **Phase II $SOR_e$** | **98.84** | **9.23** | **[ - ]** |

# Revised Simulation Study Results




## Revised Expectations

1. The performance of ET-DSP™ within the Step 3 reservoir encountered **exceeded** our revised expectations for production and energy use.
2. Unlike steam injection technologies, it was possible to focus the heating into just the higher quality zones within the reservoir and provided the opportunity for improved energy efficiency.

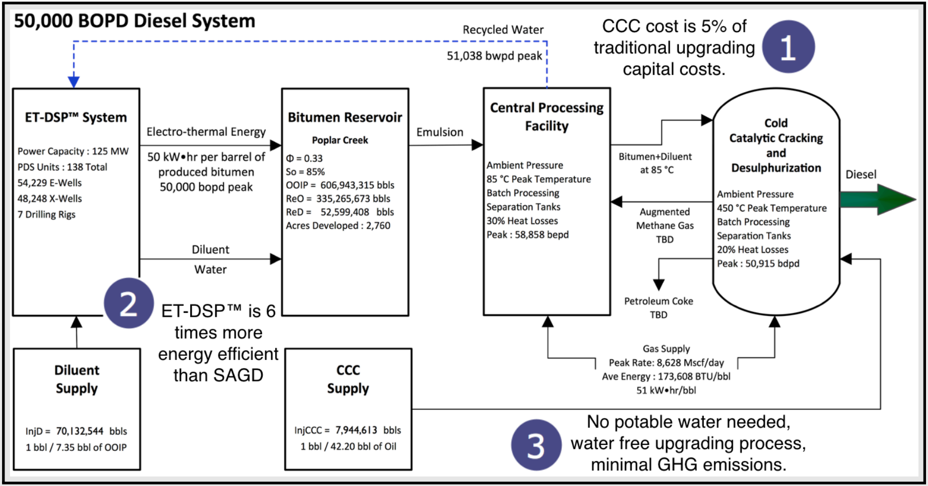


# CCC Due Diligence

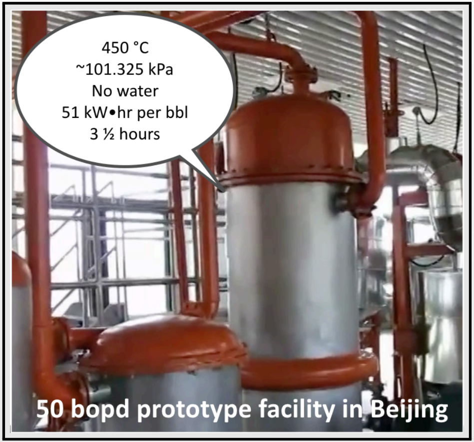
**Due Diligence Video**

Insert Video

# Vision for Next Steps



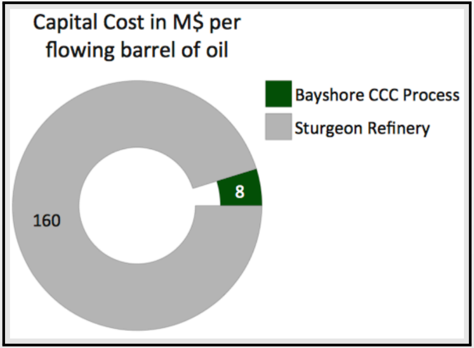
# Cold Catalytic Cracking (CCC)




## CCC Process

1. Chemical catalyst is used in a single stage pyrolysis process at 450 °C and atmospheric pressure to convert bitumen into diesel, methane gas, and a petroleum coke solid.
2. The path to diesel from the bitumen is a chemical reaction with the catalyst. Very little energy is needed in the process: 51 kWh per barrel.
3. Not a drop of water is used in the process. Energy is provided by natural gas augmented with the by-product methane gas.
4. The process only takes 3 to 4 hours for the bitumen to convert to diesel and its by-products.

# The Upgrading Challenge




## Challenges

1. The capital cost for upgrading, i.e., the Sturgeon Refinery presently under construction, is $160,000 per flowing barrel of oil compared to $8,000 for the Bayshore CCC Process.
2. The level of complexity of an upgrader is high. It uses hydrogen at high pressure / vacuums and temperatures, with multiple input and outputs. The CCC Process is basically a heated tank farm operating at atmospheric pressure and half the temperature.
3. Not a drop of water is used in the process. Energy is provided by natural gas augmented with the by-product methane gas.
4. The environmental footprint of an upgrader is substantial and brings into play a huge regulatory approval procedure. The CCC process does not use a drop of water and has relatively low GHG emissions.

# Small Scale Testing 2014/2015

72 hour batch test on Heavy Oil in May 2014:

- 83% (volume) recovery of Diesel,
- 7.3% (mass) Gas Yield,
- 19.4% (mass) Petroleum Coke Yield.

**Proven Technology**

50 bpd batch CCC Upgrader in Beijing Lab Facility has run all types of bitumen and heavy oils from Alberta, USA, Europe and Middle East â no failures have been experienced.

[McGee, 2012] Bruce McGee, Jonathan Backs, Laura Sullivan
Analytic Model for Estimating the Production of Bitumen From the ET-DSP™ Process With Economics and Comparisons to SAGD ,
*Submission to Canadian Energy Technology and Innovation, accepted for print*, 2012

[Alberta Power Pool, July, 2012]
Daily Power Pool Price, (http://ets.aeso.ca/)
Alberta Electric System Operator, 2012