Radio Frequency Heating

Innovating Oil Extraction with Radio Frequency Heating

June 18, 2019
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History of Acceleware

Acceleware founded 2004

Focus on software and seismic products 2007

RF studies with US super-major oil company 2010

AXE modular RF tank tests & patent filing 2015

Successful RF XL 1:20 scale field demo 2017

GE partnership announced, additional RF XL Patents filed 2016

Signed commercial-scale pilot agreement with Prosper Petroleum Ltd. 2018

Commercial-scale pilot ready 2019

Complete commercial-scale pilot deployment of multiple RF XL systems 2020

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RF Heating - History
Use of Electromagnetic Energy

• Has been explored as an EOR method since 1948
• Earliest field tests were in Russia in 1969

• Limitations have included:
  ➢ Electrically inefficient
  ➢ High frequency operation
  ➢ High cost of generators, power limitations
  ➢ Short horizontal (<500m) or vertical wellbore designs

Acceleware observed limitations of current EM technologies
RF Heating - 101
How does it work?

- Electromagnetic Energy applied
- Oil & rock are non-polar
- Connate water absorbs EM energy volumetrically

= In-situ Steam
RF XL – How it works

RF XL efficient delivery of energy to reservoir
RF XL - Ideal Reservoir

- Bitumen or Heavy Oil
- Thickness 10-25 m
- Water Saturation 10-35%
- Permeability > 3 Darcie
- Porosity > 25%
- Possible applications in carbonate reservoirs
- Testing ability to desiccate and crack thin shale layers

Photo of McMurray Oilsands
ref: (http://calindragoie.blogspot.com/2013/11/drilling-and-completion-technologies.html)
RF Heating vs. SAGD
RF XL Comparison

Similarities
• 1000m Hz section & well design
• Use of steam & gravity drainage methods

Differences
• SAGD - heating occurs primarily at interface
• RF process - heating occurs at interface and beyond
• Reduced losses & no superheating of steam = lower energy intensity
• SOR < 2.0 vs industry average of 2.5-3.5
RF XL - Testing and De-risking
RF XL - GE Converter Development
High-Power, High-Efficiency, Long-life power platform

Key advantage to RF XL

- Proprietary design & IP
- GE SiC transistors and power converter platform
- 2 MW maximum power per unit
- Stackable modular design
RF XL – Benefits vs. Current Recovery

- Lower CAPEX – no steam generation or associated pipeline infrastructure
- Lower OPEX – lower chemical processing requirements
- Lower GHG’s (25% - 100%) \(^1\)
- No external water source
- No solvent required
Next Steps

• Execution of RF XL pilot
• Commercialization of RF XL
• Apply RF to improve bitumen by rail
• Apply photo voltaic solar or other renewable sources in heavy oil application
• Zero GHG heavy oil production
## Antenna Designs

### Dipole-Based RF System
- **Efficiency**: 80-85%
- **Energy Losses**: 15-20% at 500m depth
- **Well Length**: > 500m
- **Cost**: $5/m
- **Power**: Max 1 MW

### RF XL System
- **Efficiency**: 98%
- **Energy Losses**: 5% at 500m depth
- **Well Length**: 500–1000+ m
- **Cost**: $1/m
- **Power**: Up to 6 MW

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<tr>
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<th>Dipole Antenna Designs</th>
<th>RF XL Design</th>
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<tbody>
<tr>
<td>Efficiency</td>
<td>80-85%</td>
<td>98%</td>
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RF XL - Project Progress

- Prosper Petroleum agreement signed for test site
- AER application submitted
- GE Global Research RF converter development
- Scovan Engineering Surface Facilities design completed
- Drilling & Completion design in final stages
- Internal simulations and de-risking tests ongoing