Permanent Downhole Distributed Fiber Optic Monitoring
DTS Monitoring Applications

- Flow Rate Measurement
- Water Injection/Breakthrough Monitoring
- Vacuum Insulated Tubing Monitoring
- Gas Production
- Water Production
- Low Flow Rate Measurement
- Flow Behind Casing
- Gas Lift Valves
- Steam Flood
- SAGD
- Inter Well Connectivity
- Chemical Injection Monitoring
Advantages of Optical Sensors

- No down-hole electronics
- Immune to shock/vibration and electromagnetic interference
- High reliability
- High temperature performance > 300 Deg C
- Extremely small < 500m - easily deployed
- Point and distributed sensors
- Multiplexing capabilities
Distributed Temperature Installation Options

Single Ended

Double Ended

Check Valve

SE
0.2 C Resolution 0.15 C
0.5 C Accuracy 0.25 C

DE

Turn around Sub

Typical performance based upon a 20 minute measurement period
Reservoir Surveillance Basics

- Drilling infill wells and sidetracks can increase your recoverable reserves
- The average well has some form of reservoir surveillance performed on it less than once every two years
- Reservoir surveillance is key to understanding the performance of your reservoir
  - optimum placement of infill and sidetrack wells –
  - information on single well performance
Continuous Reservoir Surveillance

- Shifts the major cost of surveillance from OPEX to CAPEX (very small proportion of CAPEX)
- Provides data in real time – without a 2 year wait (events can be observed as they happen – and an immediate response taken)
- No well intervention required (safety, no loss of production)
- Reliability of electrical sensors has been the major drawback so far (they need to last 5+ years)
Water Injection/Breakthrough Monitoring

- Warmback
- Injection

- Geothermal gradient
- Turn around sub
- Major injection zones indicated by slow warming
- Cross-flow behind casing

Temperature (Deg C) vs Depth (m)
Flow Distribution

Measured vs Predicted Temperatures

Geothermal Gradient

Perforations

Large inflow at the heel of the well
Water production at the toe

Flow Rate (bpd)

Depth (m)

Geothermal
Thermal model
Porosity
Temperature

Pore Volume

Depth (m)
Monitoring Gas Wells

- Calculated 9.5MMscfd Flow
- Calculated 2.5MMscfd Flow
- Geothermal -40 Deg F

Temperature (Deg F) vs Depth (ft)
Steamflood – Observation Wells

Steam leak

Measurements over time

Temperature (Deg F)

Depth (ft)
Steamflood – Injectors/Producers
Steamflood - Modelling

Temperature into formation

Confidential
SAGD Production

Steam Soak

Steam Injection Period

Heating From Injector

Heat Loss Zone

Time

Depth