Unconventional Resource Development – A Look Ahead

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Objective: Provide a high level view of emerging operational and environmental technology trends for unconventional oil and gas development operations.

Key topic areas
- Workplace Safety
- Wellbore Integrity
- Water and Chemical Use
- Air Emissions
- Waste Management
- Footprint Management
- Public Interface

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Workplace Safety

- Is Safety a core corporate value?
- Is there unequivocal management commitment to safety?
- Is there a clear safety based management system?
- Is a change in the regulatory paradigm possible?
- A year from now...
A well has two primary functions:
- Protect groundwater
- Contain fluids

Broader implementation of performance based design and installation standards.
- Tubulars (casing and tubing) and connections
- Cementing materials and procedures

Continued improvement in verification and diagnostic tools.
- Pressure
- Temperature
- Acoustic

Methane migration (stray gas)
Water and Chemical Use

- Water reuse will increasingly become SOP in most regions. Drivers vary regionally;
  - Disposal costs
  - Scarcity, access, and competing uses
  - Induced seismicity concerns with disposal
  - Public support
- Water treatment technologies generally mature, but implementation/application technologies improving.
  - Mobile or transportable systems improve
  - Economics improve with scale
- Water alternatives will gain use.
  - Methane, propane, carbon dioxide, nitrogen
  - Technical aspects and cost will limit broad application
  - Re-fracturing may increase opportunities for use

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Water and Chemical Use (cont.)

- Water from non-traditional sources will increase.
  - Industrial or municipal effluents
  - High total dissolved solids (TDS) groundwater
  - Acid mine drainage (AMD) in Appalachia

- Evolution of chemicals toward lower persistence, bioaccumulation, and toxicity (PBT) characteristics will continue.
  - “Food grade” systems available
  - Trade-off with reuse or non-traditional waters will decrease
  - Diesel use essentially eliminated already
Air Emissions

- Emission reductions driven by EPA Subpart OOOO implementation will continue.
  - Increasingly applied to oil wells in addition to gas wells
  - Controls apply to completion and production operations, methane and VOC’s
  - EPA GHG emission data shows strong reductions in emissions 2011–13, which should continue moving forward
    - Challenges remain in Bakken region due to infrastructure constraints.

- Engine emissions (drilling and HF equipment) will continue to fall.
  - Equipment upgrades to Tier 4 engines
  - Fuel switching; diesel to methane or propane will occur but more limited
Waste Management

- Use of centralized treatment and holding facilities for reusable waste water likely to increase.
  - Use of tanks vs lined impoundments will vary regionally. General trend toward more tanks.
  - Treatment residuals management challenges likely to increase.
  - Solid waste management controls to increase (Naturally occurring radioactive material (NORM) limits for drill cuttings).
  - Operator due diligence improvements needed.
    - Inspections and audits
Footprint Management

- Continuing move to multi-well pad operations.
  - Trade-offs need to be understood by all and communicated.
  - Overall, unconventional development density lower than conventional development density.

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Footprint Management

- Existing conventional production area developed with vertical wells.
  - >200 wells/pads
  - >50 miles of roads
- Equivalent unconventional development.
  - 20 wells, 2 pads
  - <2 miles of road
- Trade-off is the areal extent of development.
Public Interface

- **Infrastructure demands; short term vs long term expectations.**
  - Continuing development will stabilize and improve demand structure.
    - Health care, housing, support facilities
    - Road maintenance

- **Traffic and route planning.**
  - Continued emphasis on driver quality and training.
  - Expanded use of “no activity” times and zones.

- **Setback limits will tend to increase**
  - Beware of unintended consequences.
  - Allow flexibility in implementation.

- **Operator public outreach and engagement will improve.**
  - More transparency and regular discussion.
Conclusions

- Unequivocal commitment to safety.
  - One is too many.
  - A year from now....

- Environmental aspects will continue to benefit from continuing technology and regulatory improvements.

- Public engagement processes improving.
  - More transparency = more trust
Questions

“This just isn’t doing it for me. Could we go back to using the crystal ball?”