Southwestern Energy®

EPA Natural Gas STAR Production Workshop
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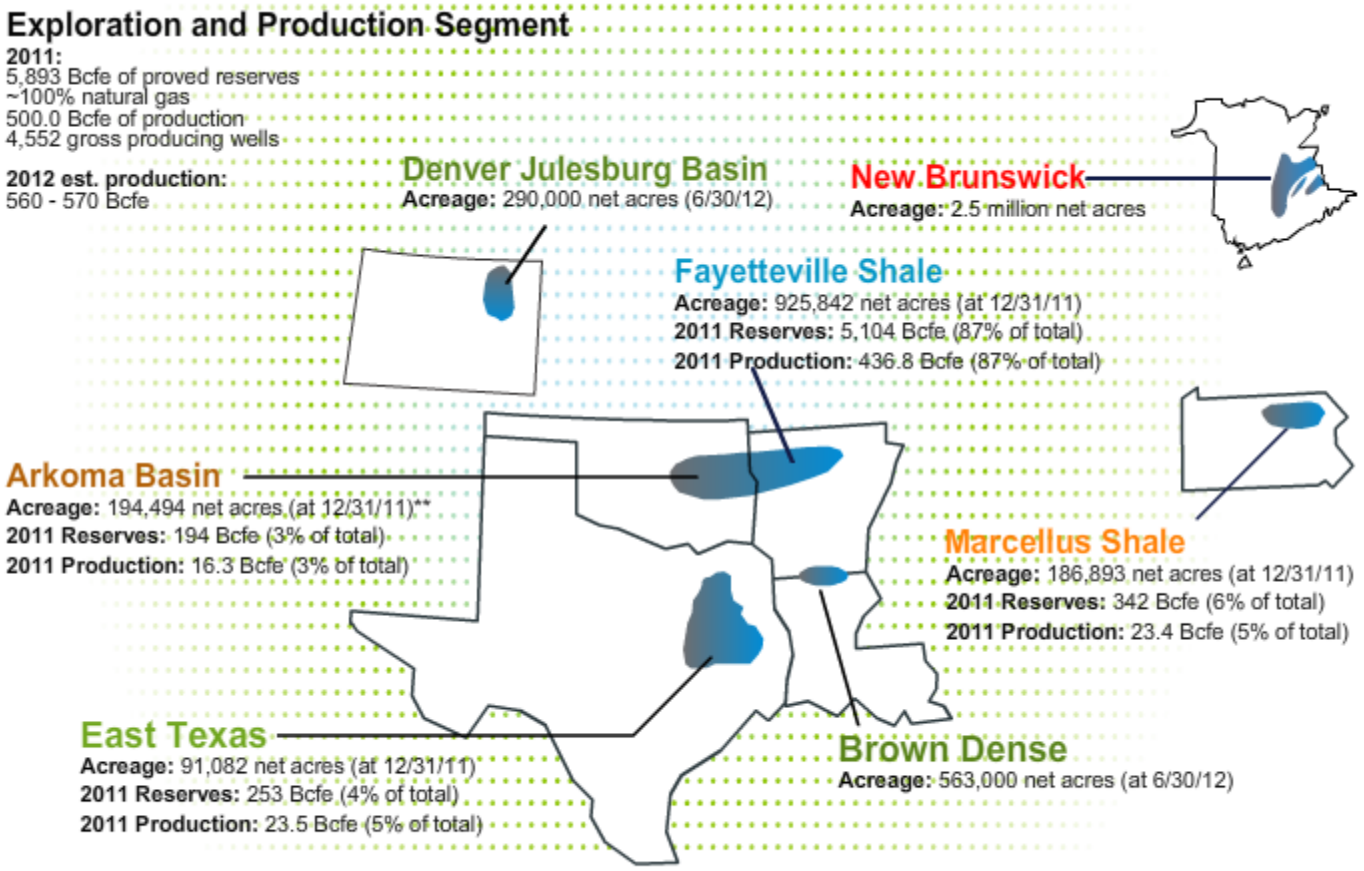
Denver, Colorado

Doug Jordan
Corporate Environmental Programs

Development Solutions
Balancing Environment, Community & Economy
a division of Southwestern Energy

SWN Geographic Areas of Operation



**Conventional Arkoma acreage excludes 125,056 net acres in the conventional Arkoma Basin operating area that are also within the company's Fayetteville Shale focus area.

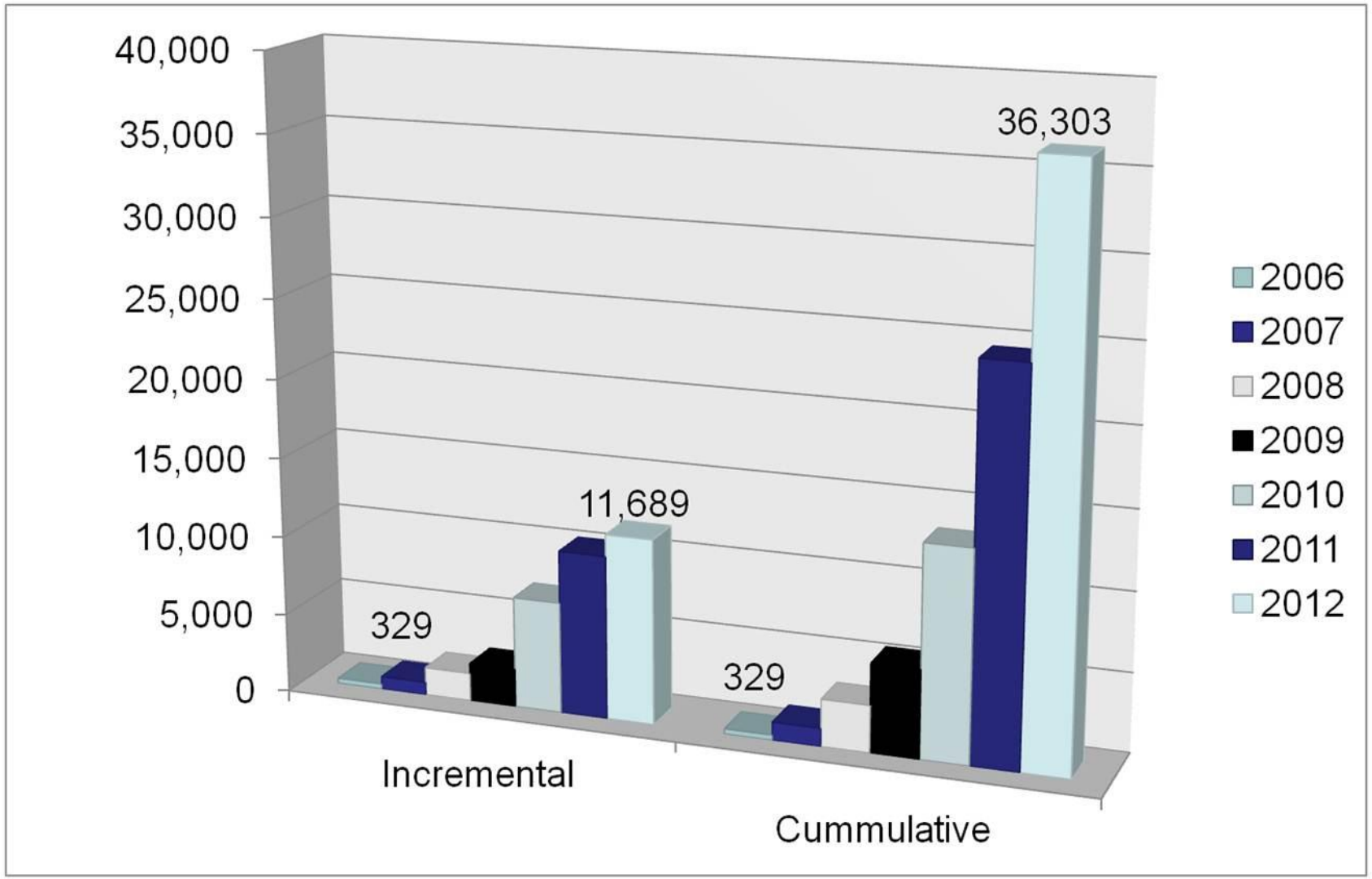
SWN – Vertically Integrated Company

- SEECO
  - Fayetteville and Arkoma (Arkansas)
- Southwestern Energy Production Company
  - Pennsylvania
  - Texas, Louisiana, Oklahoma
  - SWN Drilling Company, Inc.
- SWN E&P Services L.L.C.
  - Desoto Sand L.L.C.
  - SWN Well Services L.L.C.
- SWN Resources Canada Inc.
- Desoto Gathering Company
- Angelina Gathering Company

SWN EPA Natural Gas STAR

- 2006 Initial Reporting Year - 329.266 MMSCF
- 2007 “Rookie of the Year”
- 2011 “Production Partner of the Year”
- 2012 Report
  - 11.689 BCF
  - 36.3 BCF Cumulativ

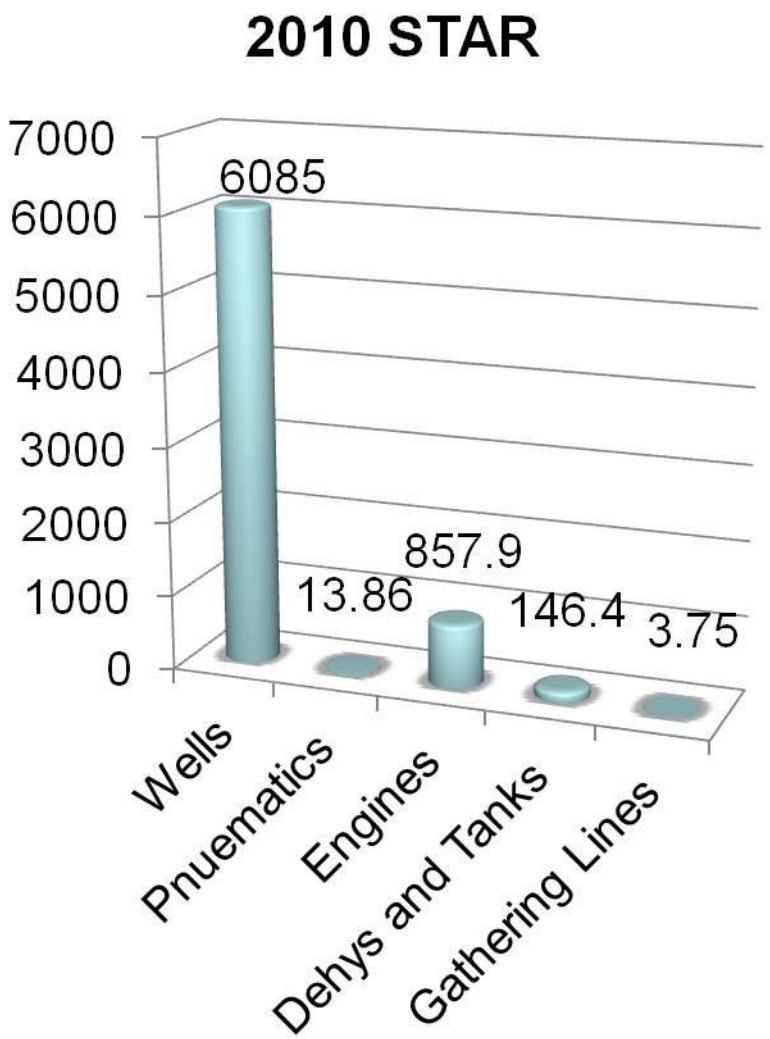
SWN EPA Natural Gas STAR Reductions

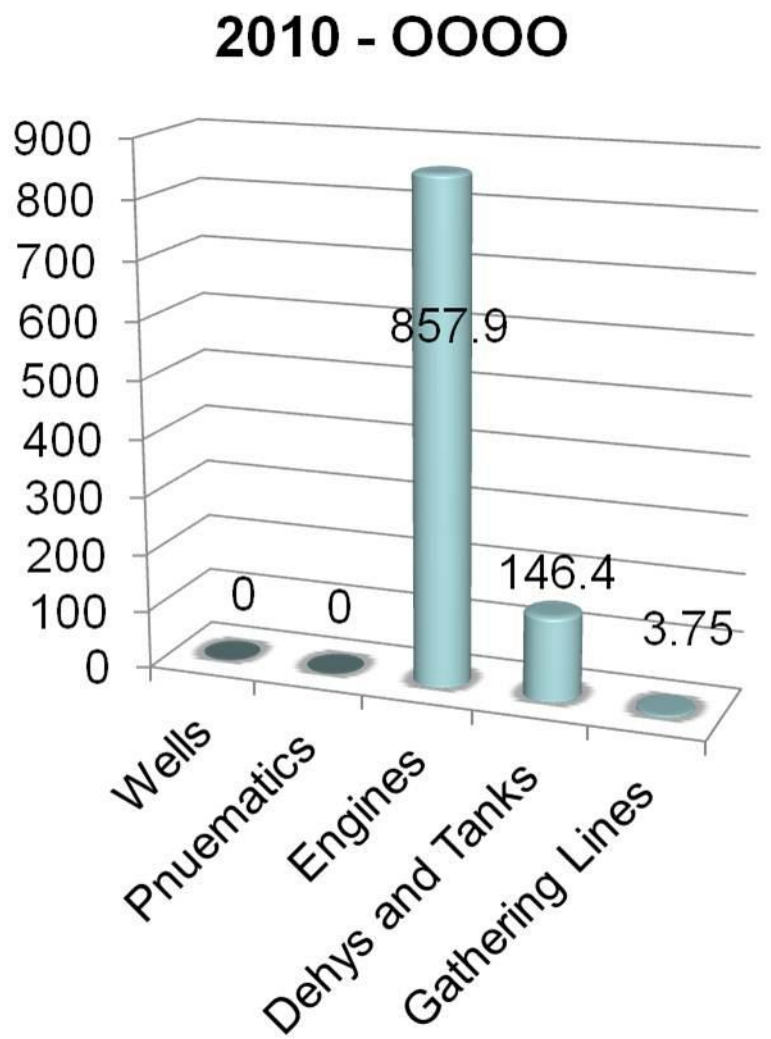


In the Past

- Regulated by OOOO
  - Hydraulically Fractured Gas Well Completion Flowbacks
  - Hydraulically Fractured Gas Well Recompletion Flowbacks
  - **Continuous Bleed** Pneumatic Controllers
  - Oil, Condensate, and Produced Water Storage Tanks
  - Reciprocating Compressor (not at wellpad)

Pre and Post NSPS OOOO





Moving Forward

- Future Opportunities
  - Reciprocating compressors at well pad
  - No bleed pneumatics
  - Solar Powered pumps
  - Thermostat controllers
  - Liquids Unloading
  - Storage Tanks < 6 tpy
  - Gas capture of blowdowns
  - Fleet and vehicle conversions to CNG
  - Diesel/Gas Drill Rigs
  - Diesel/Gas Frac Spreads (Completions pumps)
  - Directed Inspection/Maintenance
  - Fuel cells for power generation (air compressors)

SWN Gas Capture

- Since 2009 - 27.562 BCF recovered by Gas Capture and Green Completions

SWN Gas Capture: History - Background

- **Pre 2010:** Wells vented until tubing flow could be established
- **September 2009**: Study concluded 16 MMCF is vented during an average flowback
- **December 2009**: Completion program changed. Tubing run immediately after frac plug drill out, no casing flowback
- **December 2009**: Flowback scheme "modified" to allow selling gas via the casing/tubing annulus
- **January 2010**: Separators upgraded, allowing for 2000+ bwpd capability, "modified" flowback in full use
- **January 2010**: First "Gas Capture" well was executed
- **April 2010**: Completed 19th full "Gas Capture" operation
- **September 2010:** Completed the 100th full "Gas Capture" operation
- **October Forward:** Expanded "Gas Capture" to recompletions or "Ventless Restoration

SWN “Gas Capture”

SWN Gas Capture - Portable Compressor

- Portable Caterpillar 3406
- 200-300 MCF Gas Compressed
- 8-12 Hours
- Target 2000 psi

SWN Gas Capture -Sand Separator and Sand Box

SWN Gas Capture - Flowback Water to Frac Tank

SWN Gas Capture - Water Recovery/Recycling

SWN Gas Capture - Fat Boy Separators

SWN Gas Capture - Updated Gas Capture Layout

SWN Gas Capture – Fayetteville vs Marcellus

- Fayetteville
  - Low pressure reservoir
    - Need for gas compression/injection
  - Low sales line pressure~65 psia

- Marcellus
  - High pressure reservoir
  - High sale line pressure >500 psi
  - Installing additional compression to lower line pressure

SWN Methane Initiatives

- Natural Gas System Methane Emission Measurements
  - Production Sector
  - Gathering & Processing Sector

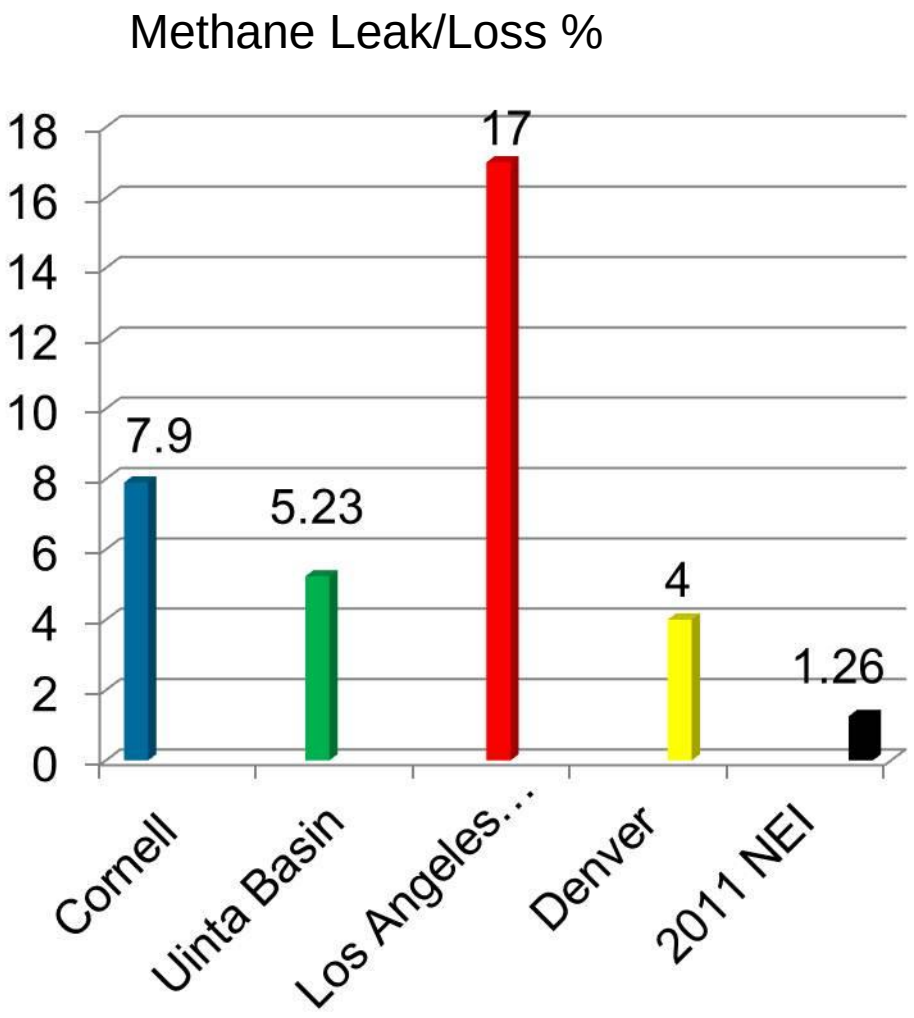
- SWN Leak Detection and Monitoring
  - SWN SMART LDAR
  - Picarro Monitoring Evaluation
  - Methane Monitoring Projects

- SWN Methane Reduction Projects

Natural Gas System Methane Emission Measurements

Why?

- Need for more accurate and factual methane emissions data
  - Limited or no methane emissions measurements for industry
  - Outdated emissions factors (GRI 1996).
  - EPA and NEI estimates vary in order of magnitude due to changes in assumptions
- Better understanding of methane emissions and sources
- Demonstrate that natural gas is natural fuel of choice



“Measurements of Methane Emissions at Natural Gas Production Sites in the United States”

- A Unique Partnership
  - Sponsors were an environmental group and nine natural gas producers Environmental Defense Fund (EDF), Anadarko Petroleum Corporation, BG Group plc, Chevron, Encana Oil & Gas (USA) Inc., Pioneer Natural Resources Company, SWEPI LP (Shell), Southwestern Energy, Talisman Energy USA, and XTO Energy, an ExxonMobil subsidiary
  - Study team Led by University of Texas and including URS and Aerodyne Research
  - Scientific Advisory Panel Six university faculty with expertise in air quality and natural gas production

Production Sector Methane Measurements

- Direct Measurements
  - "Stack" measurements (flowbacks and unloadings)
  - FLIR Camera (observation of leak)
  - HiFlow (measurement of leak)
- Direct Measurement Sources/Activities
  - Completion Flowbacks
  - Production Sites
    - Chemical Pumps
    - Pneumatic Controllers
    - Equipment Leaks (valves, flanges, open ended lines)
  - Liquids Unloadings (limited)
  - Workovers (limited)

UT Study Results – Phase 1

Source	EPA National Inventory	UT Study Observations
Completion Flowbacks	654 Gg CH4	18 Gg CH4
Chemical Pumps	34 Gg CH4	68 Gg CH4
Pneumatic Controllers	355 Gg CH4	580 Gg CH4
Equipment Leaks	172-211 Gg CH4	291 Gg CH4
Measured Sources	1215-1254 Gg CH4	957 Gg CH4
Total Emissions Estimates	2,545 Gg CH4	2300 Gg CH4

Production Sector Study Methane Measurement Summary

- Direct, on-site measurements of methane emissions from gas production operations were made; for some sources (well completions and unloadings) these are the first measurements reported.
- 67% of the hydraulically fractured well completions sampled during the study had equipment in place that reduces methane emissions by 99%. Because of this equipment, methane emissions from well completions are 97% lower than calendar year 2011 national emission estimates, released by EPA in April 2013.
- Emissions from pneumatic devices are 70% higher than current EPA net emissions estimates, and equipment leaks are 50% higher than current EPA net emission estimates; collectively these emissions account for more than 40% of methane net emissions from natural gas production.
- Methane emissions from gas production, from all sources measured in the study, were comparable (957 Gg ± 200 Gg)to the most recent EPA estimates (~1200 Gg).
- The 957 Gg in emissions for completion flowbacks, pneumatics and equipment leaks, coupled with EPA national inventory estimates for other categories, leads to an estimated 2300 Gg of methane emissions from natural gas production (0.42% of gross gas production).

Production Sector Measurement – Project Takeaways

- Project Highlights:
  - Successful collaboration between participants resulting in better understanding of emissions
  - Identified the need for additional studies
  - Identified opportunities for SWN to pursue regarding emission reduction/product recovery
    - Catalyst for SWN LDAR initiative
  - One of the pillars for the foundation of SWN's Methane Leadership Initiative

Production Sector Phase 2 Measurements

- Phase II – Emphasis
  - Pneumatic Controllers
  - Liquids Unloading
- Phase II - Participants
  - University of Texas
  - URS
  - Environmental Defense Fund
  - Anadarko
  - British Gas
  - Chevron
  - Conoco Phillips
  - Encana
  - Pioneer
  - Shell
  - Southwestern Energy
  - Statiol
  - XTO-Exxon

Gathering and Processing Methane Measurement

- Colorado State University
  - Aerodyne
  - Carnegie Melon University
- Environmental Defense Fund
- Anadarko
- Access Midstream
- Williams
- SWN
- Hess
- DCP (data site)

- Tracer Flux Measurements

SWN Leak Detection and Monitoring

SWN SMART LDAR Program

- Company-wide program
  - New wells and compressor stations in Pennsylvania 8/10/2013
  - New wells commencing operation 4th Quarter 2013
  - New and existing wells and compressor stations 2014

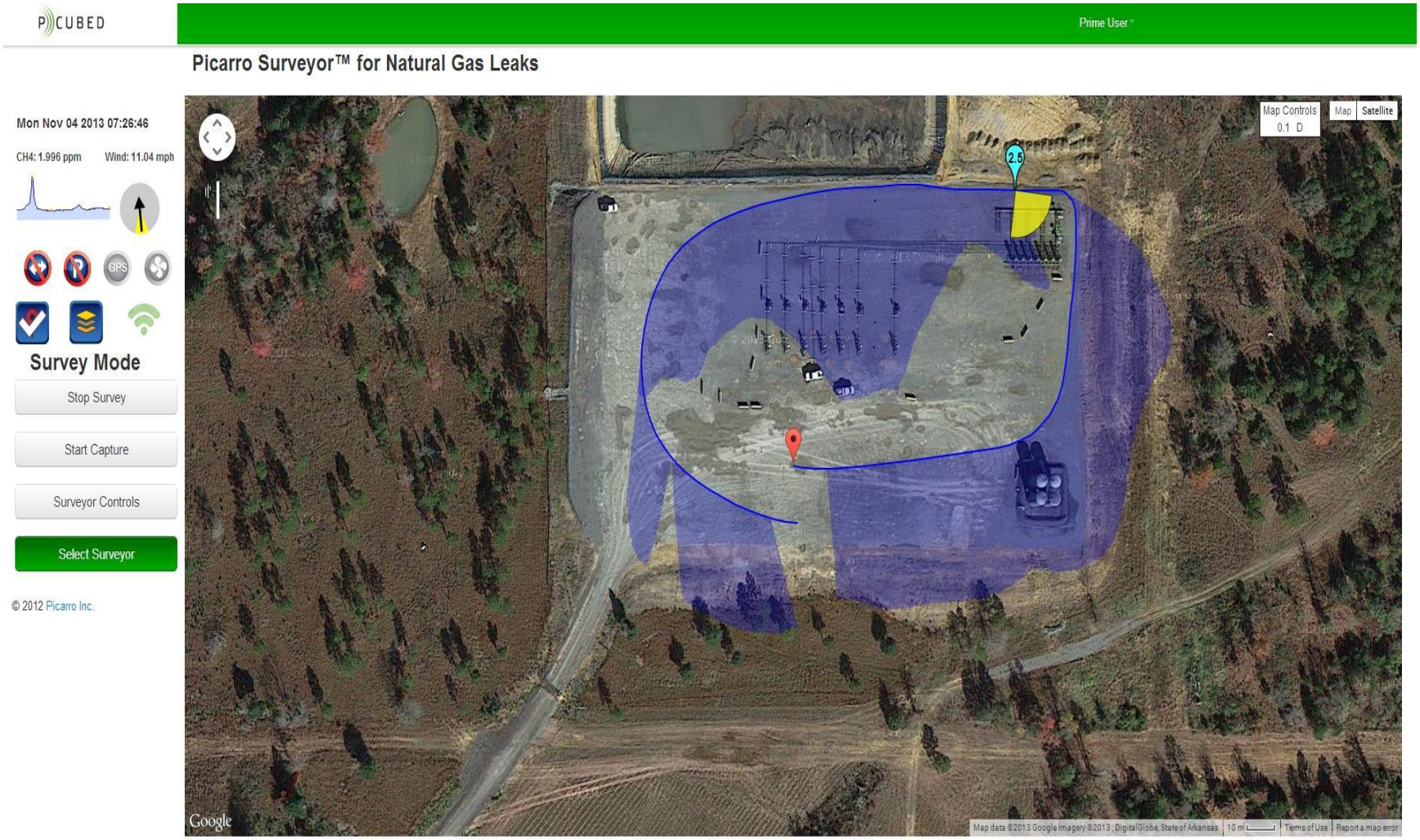
- Identify equipment leaks
  - Annual Survey and confirm leak repair
  - Optical Imaging Camera (e.g. FLIR)
    - Primary targets
      - Valves, connectors, open-ended lines
    - Secondary targets
      - Pneumatic Controllers, Storage Tanks, Compressors
- Leak Repairs
  - Repair leaks ASAP but within 15 days (Delay of Repair exemption)

- Track and trend leaking components

SWN Picarro Evaluation

- SWN project to compare Picarro monitoring with “direct measurement” (FLIR and HiFlow) to assess viability.
- Field measurements conducted November 4-8, 2013 in Fayetteville operations.

SWN Well Example



Picarro Evaluation Summary

1. **Survey ~20 well pads with Picarro Surveyor technology and FLIR camera to determine if the well pads had methane leaks or not**
   - –Surveyed 21 wells pads and 3 drill sites in ~17 hrs
2. **Execute a simulated leak to directly compare the Picarro Scanner and high flow instrument leak measurements**
   - –Picarro Scanner and high flow instrument measurements agree
3. **Quantify the leaks at 5-6 well sites using both the Picarro Scanner technique and high flow instrument operated by Dexter.**
   - –Due to limited road access and wind direction, only 2 well pads were measured with the Scanner technique
   - –Only 1 well pad leak was measured by both the Plume Scanner (59.8 SCFH) and high flow instrument (79.2 SCFH)
   - –We can estimate the leak rates of all pads surveyed using both high flow instrument and Picarro Scanner measurements

Main Results:

- •19% of well pads were *not leaking*
- •77% of leaks rates are less than 10 SCFH (standard cubic feet per hour)
- •Direct comparison with a simulated leak show that Picarro Surveyor agree with Dexter's high flow instrument

Methane Monitoring

SWN Methane Emissions Reduction Projects

- Fuel Cell

SWM Methane Reduction Projects

Pressure Actuated Liquids Unloading

Thermostat Actuated Chemical Addition

SWN Methane/GHG Reduction Projects