



**Building for
the Future**

$$\frac{R^2}{A} \rightarrow V^+$$



SWN Gas Capture Case Study and Methane Emission Initiatives

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Director, Corporate
Environmental Programs

Areas of operation

Exploration & Production Segment

2013

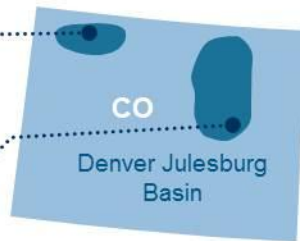
6,976 Bcfe* of proved reserves

657 Bcfe of production

2014 est. production: 740 – 752 Bcfe

Sand Wash Basin

Acreage: 313,000 net acres



Denver Julesburg Basin



New Brunswick

Acreage: 2.5 million net acres

Marcellus Shale

Acreage: 292,446 net acres (at 12/31/13)

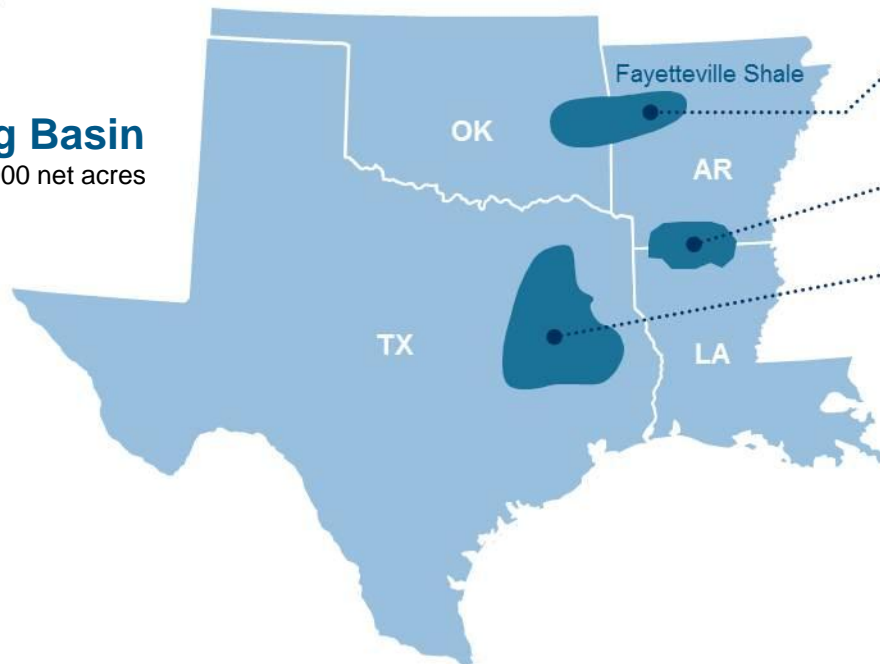
2013 Reserves: 1,963 Bcfe (28% of total)

2013 Production: 151 Bcfe (23% of total)

Marcellus Shale
PA

Denver Julesburg Basin

Acreage: 302,000 net acres



Fayetteville Shale

Fayetteville Shale

Acreage: 905,684 net acres (at 12/31/13)

2013 Reserves: 4,795 Bcfe (69% of total)

2013 Production: 486 Bcfe (74% of total)

Brown Dense Project

Acreage: 459,000 net acres (at 12/31/13)

Ark-La-Tex

Acreage: 152,937 net acres (at 12/31/13)

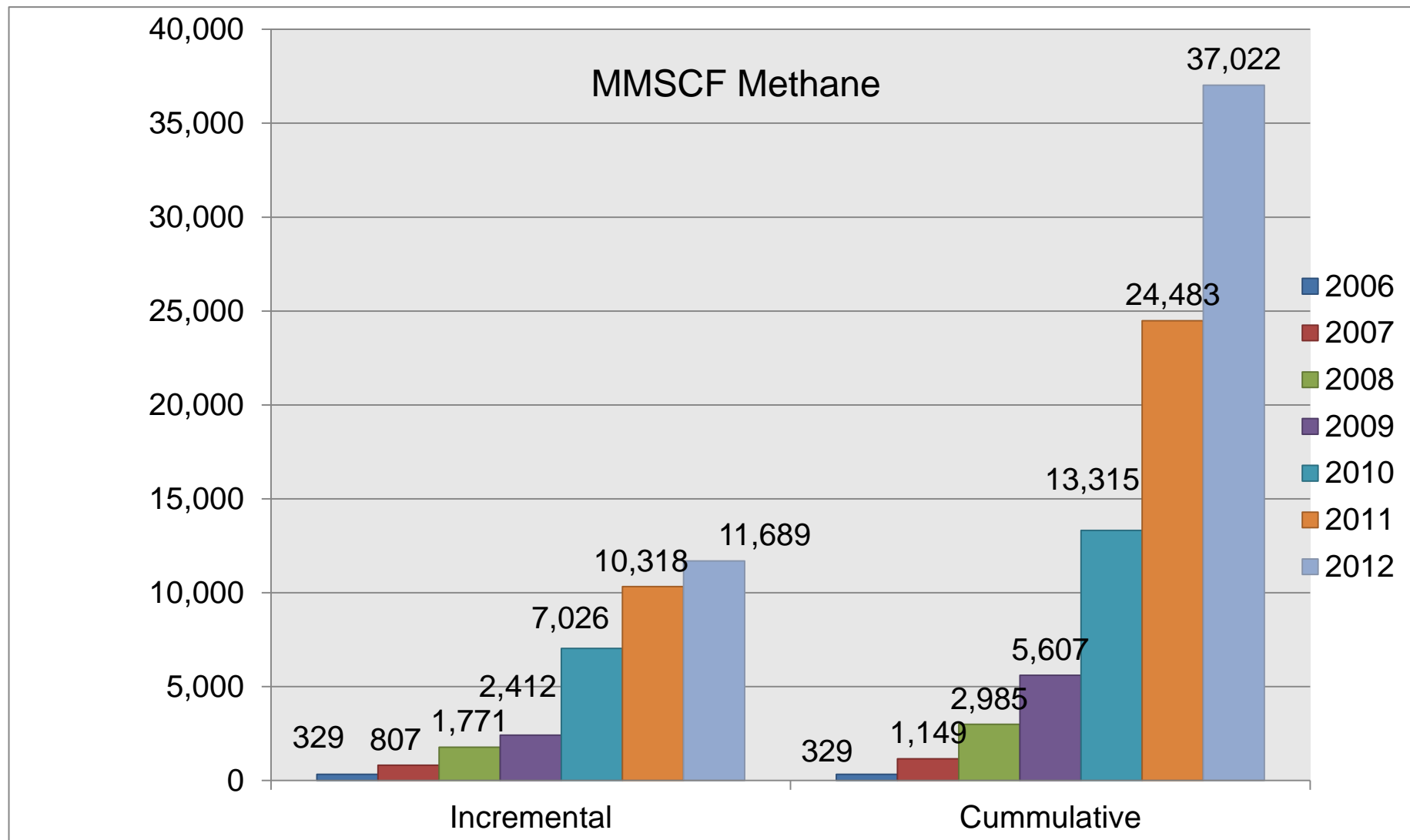
2013 Reserves: 215 Bcfe (3% of total)

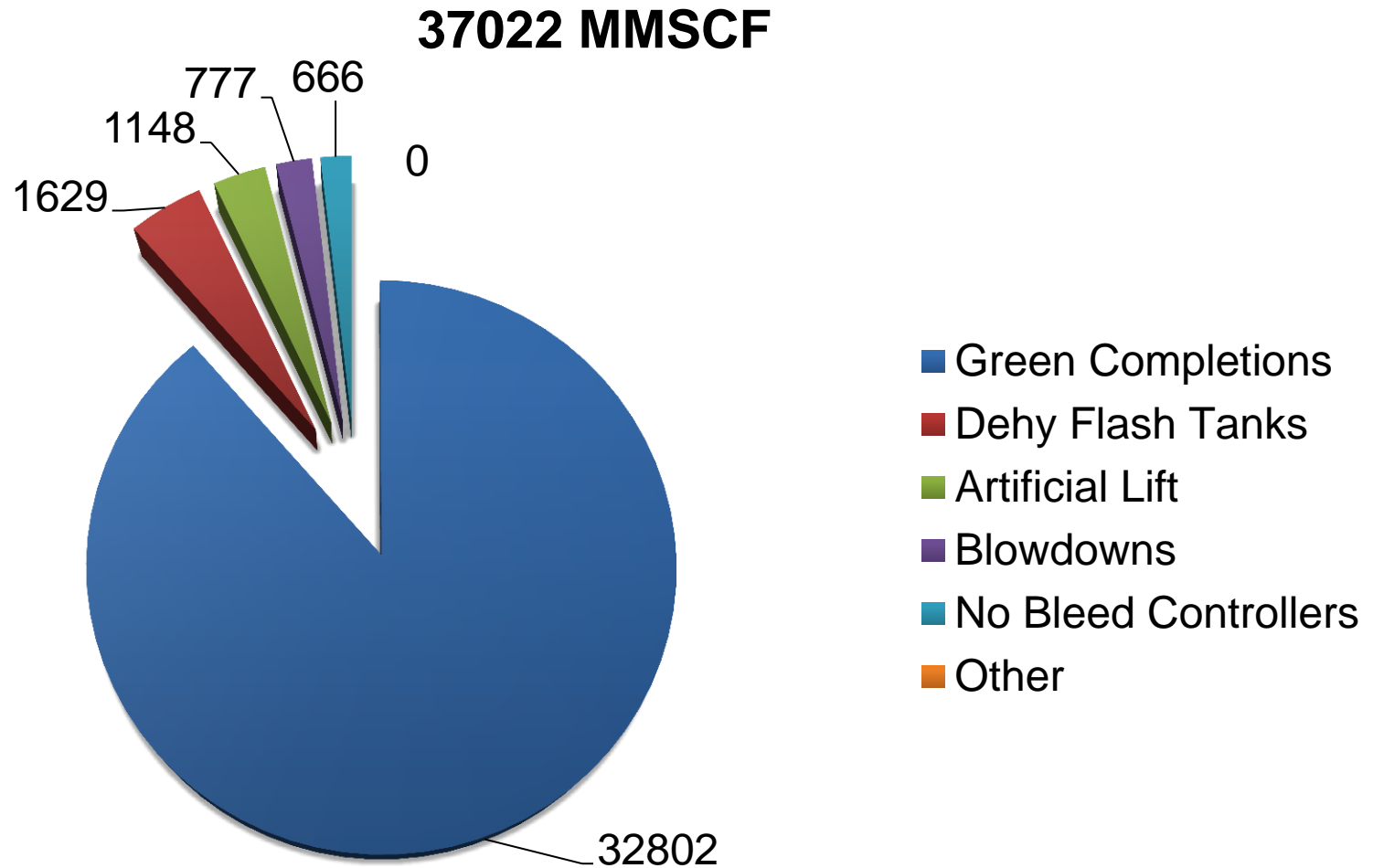
2013 Production: 18 Bcfe (3% of total)

• Bcfe is an equivalent measurement of one billion cubic feet of mixed oil and gas reserves

• ** Arkoma acreage excludes 124,653 net acres in the conventional Arkoma Basin operating area that are also within the company's Fayetteville Shale focus area.

SWN EPA Natural Gas STAR Incremental and Cumulative Methane Reductions





SWN Fayetteville Gas Capture – Case Study



- **Fayetteville Shale Gas**
- **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"

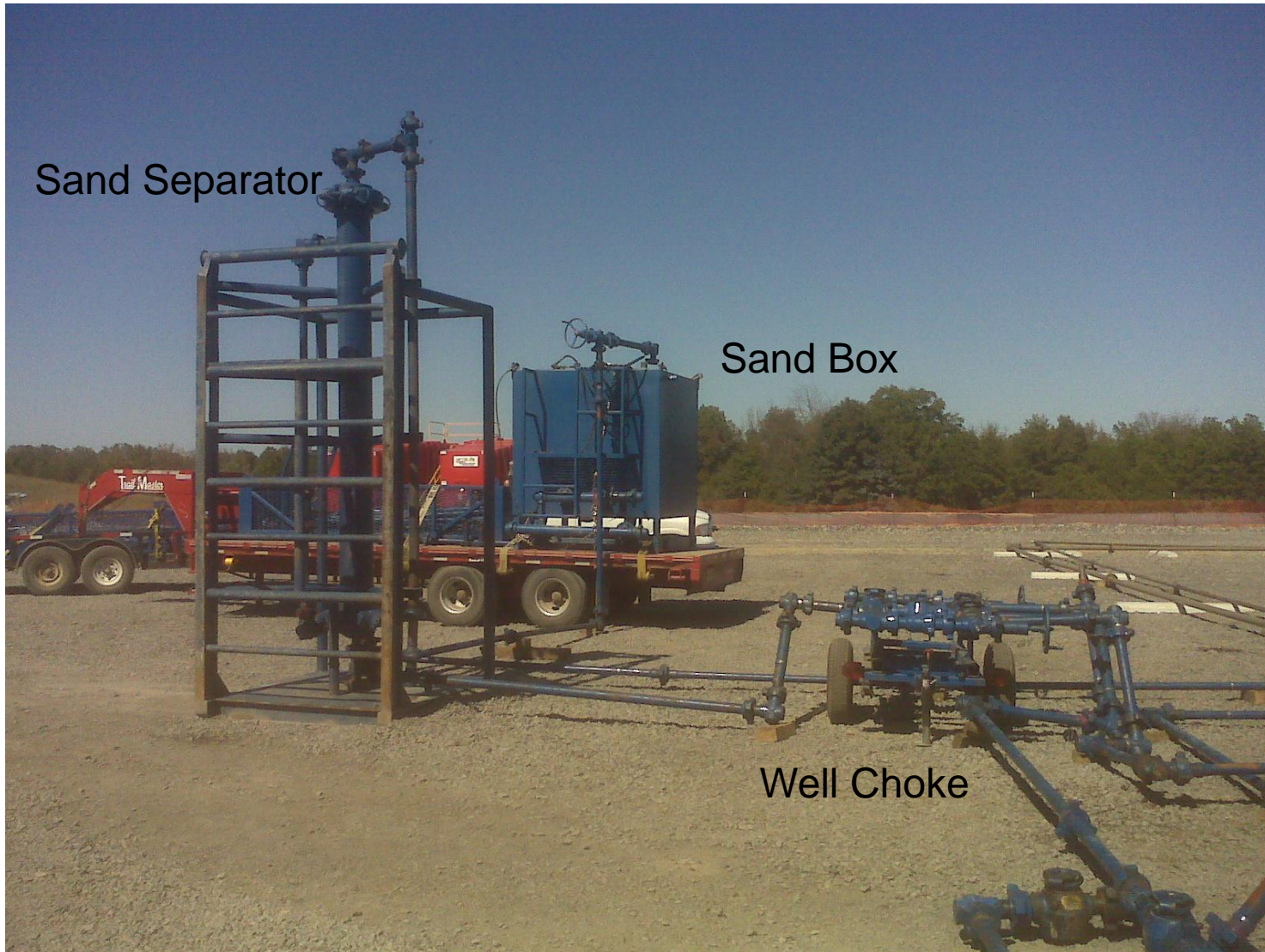


SWN Gas Capture - Portable Compressor



- 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 - Fat Boy Separators



SWN Gas Capture - Flowback Water to Frac Tank



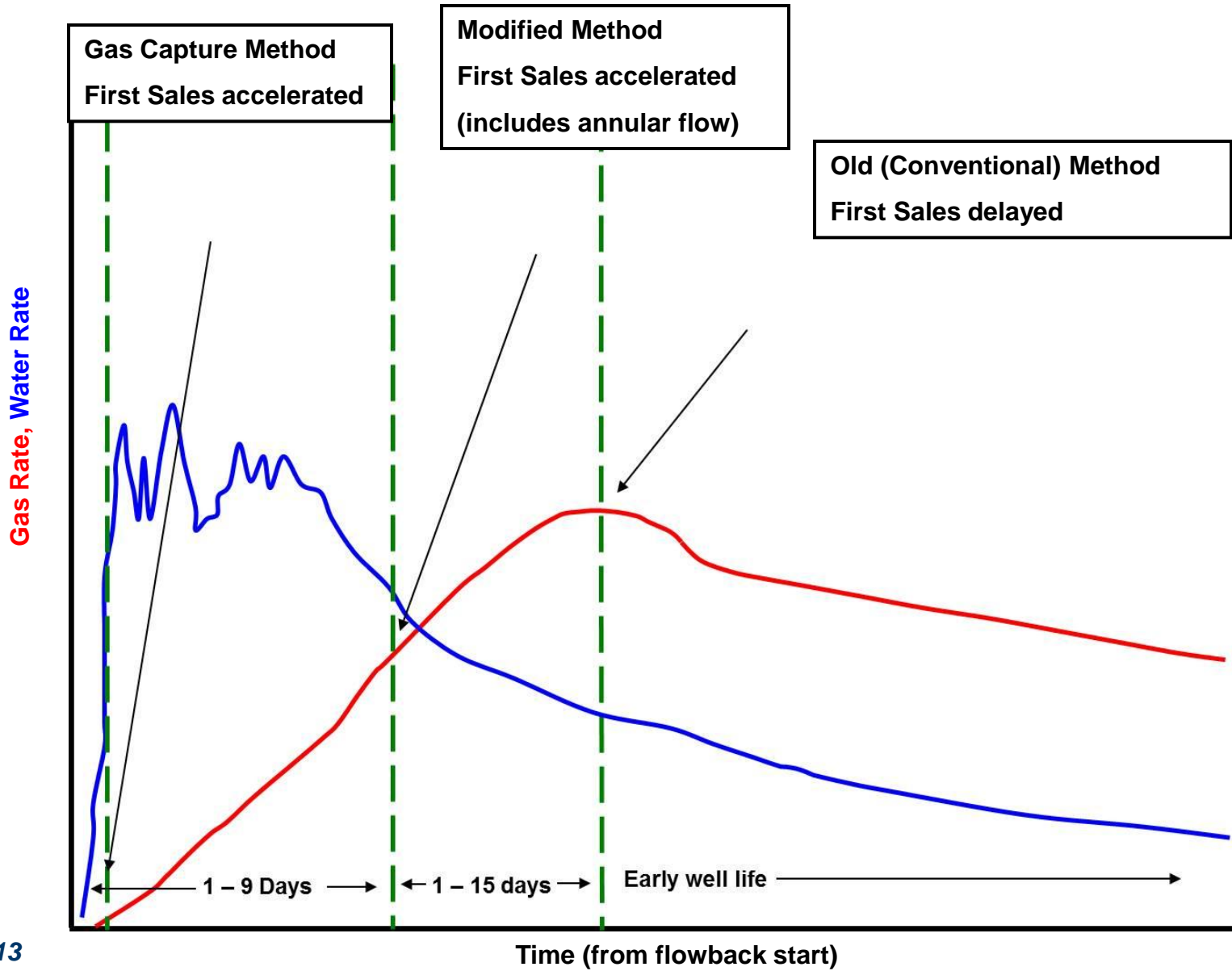
SWN Gas Capture - Water Recovery/Recycling



SWN Gas Capture – Gas Straight to Sales



Flowback Type Curve (Post Drill-Out)



$\frac{R^2}{A} \rightarrow V^+$

SWN Gas Capture – Fayetteville vs Marcellus



- **Fayetteville**

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



- **Marcellus**

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

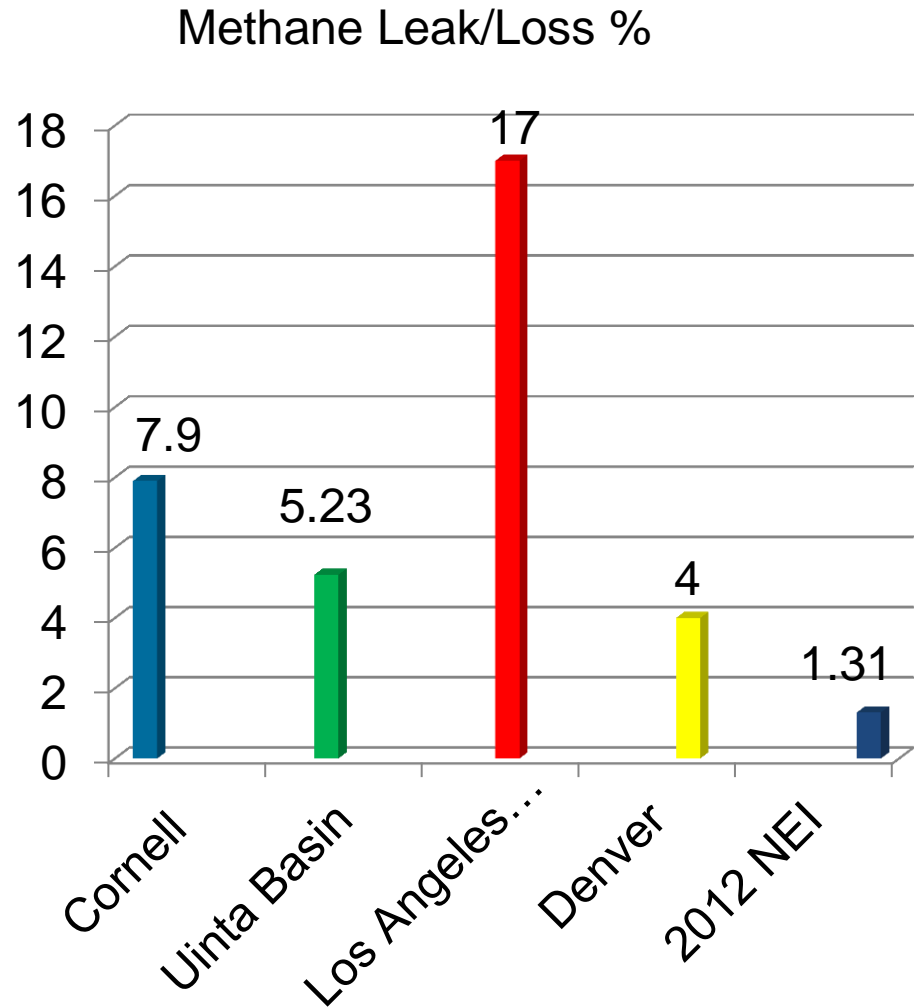
- **32.8 BCF Reported Reductions**

SWN Methane Emission Initiatives



SWN Methane Measurement Study Participation

- 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



Production Methane Measurement Study



$$\frac{R^2}{A} \rightarrow V^+$$

- 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

Gathering and Processing Methane Measurement Study



- EDF “Bottom-Up” series
 - Phase 2 Production Sector
 - Pneumatics and Liquids Unloading
 - Emissions characterized by a “fat-tail” distribution
 - Processing Sector
- EDF “Methane Detectors Challenge”
 - Apache, BG, Hess, Noble and SWN participating with EDF to identify and catalyze next-generation methane monitoring technologies
 - Southwest Research Institute
- DOE/Penn State Marcellus Study
 - Specifically identified in President’s Climate Action Plan. 2 year, \$2 mm project funded by DOE and led by Penn State
 - Currently a top-down study design
 - SWN has been participating in an industry group across the value chain helping with the study design
 - Additional data and financial support may be needed for establishing more accurate measurements
- Joint Institute for Strategic Energy Analysis D-J Reconciliation Study of “top-down” and “bottom-up” methane measurements



- 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



Prime User™

Picarro Surveyor™ for Natural Gas Leaks

Mon Nov 04 2013 07:26:46

CH4: 1.996 ppm Wind: 11.04 mph



Survey Mode

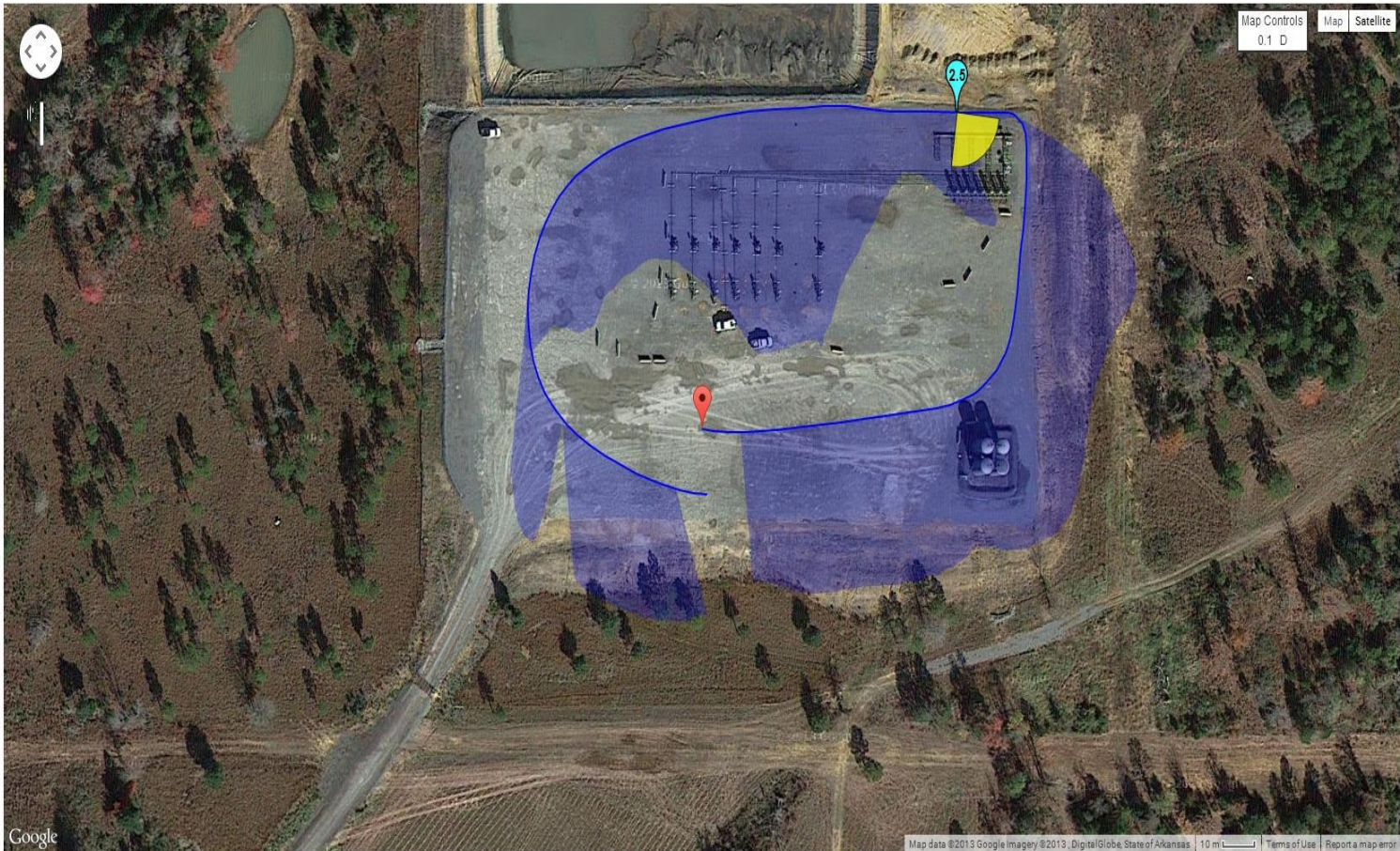
Stop Survey

Start Capture

Surveyor Controls

Select Surveyor

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Google

Map data ©2013 Google Imagery ©2013 DigitalGlobe, State of Arkansas 10 m Terms of Use Report a map error

- 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 well 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 leak 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

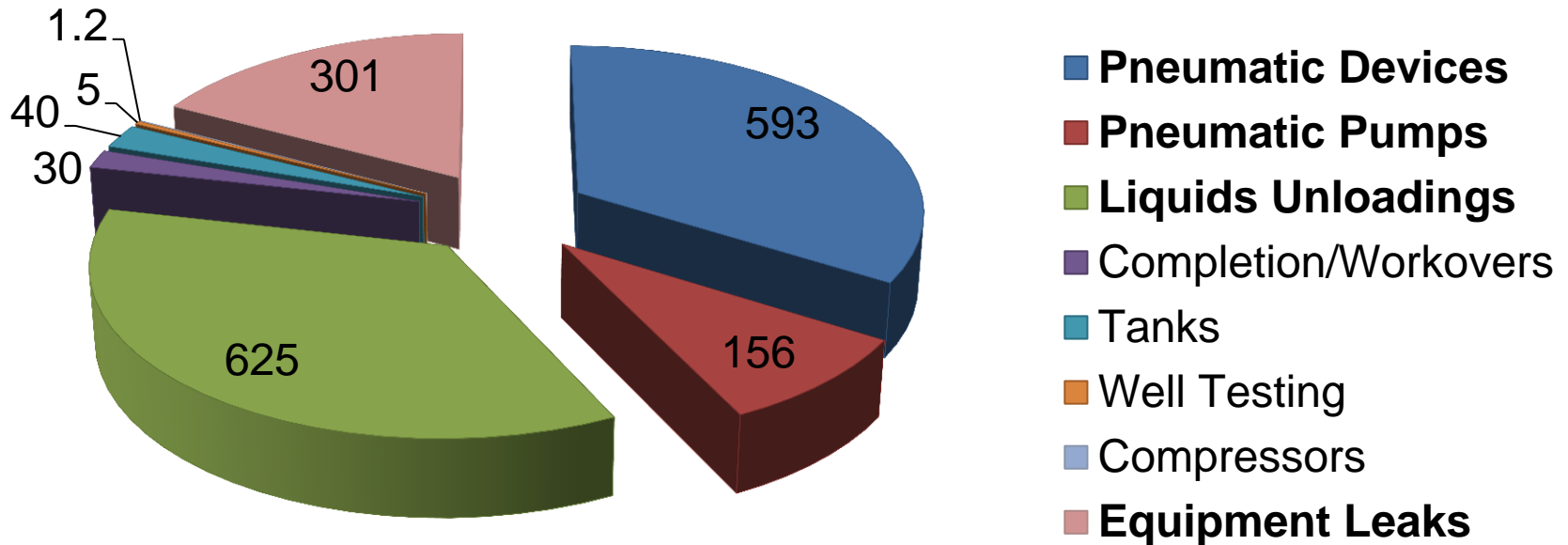
Preliminary Advantages

- Quick measurement time (approximately five minutes, vs. 15-20 minutes per pad for FLIR and high volume samples).
- Ease of data storage.
- Concentrations can be plotted on Google map in real time.
- Low concentration detection level (ppb vs. 10,000 ppm for FLIR)
- High distance detection ability (100 ft vs. 20 ft. for FLIR)
- Ability to visualize what has been “sniffed” on i-Pad.

Preliminary Disadvantages

- Inability to distinguish exact source of leak.
- Requires wind speed between 3.5-20 mph to determine “Flow rate” (scf/hr)
- “Pressurized Releases” may impact measurement accuracy
- Requires mounting a sensor on the front of the vehicle and an anemometer on the roof.
- Not currently accepted by EPA as an acceptable alternative to a standard LDAR method.
- Equipment reliability is unknown.

SWN 2013 Subpart W = 1751 MMSCF





Equipment Leaks Gas Loss and Emissions

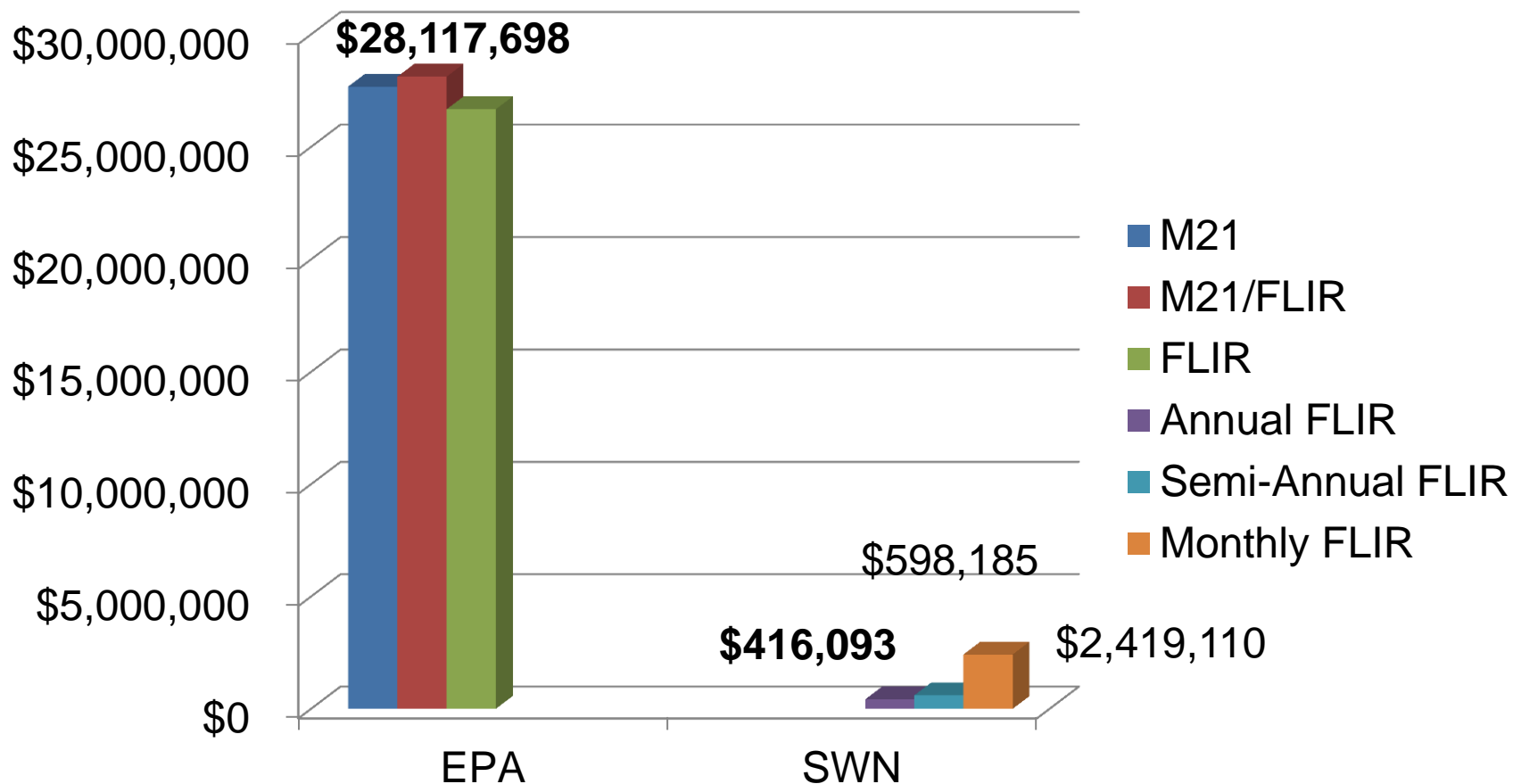
		GHGRR	UT/EDF	OOOO	GHGRR	UT/EDF	OOOO
Region	Wells	MMSCF	MMSCF	MMSCF	TPY	TPY	TPY
Appalachia	71	7.12	2.38	9.1	150.6	48	188.6
E. Texas	408	28.26	13.72	52.1	598.1	74.4	1084
Arkoma	3407	265.29	115	435	5615	2304	9049
Louisiana	4	.15	.14	.5	3.2	2.45	10.6
Totals	3890	301	131	498	6367	2557	10332

GHGMRR is SWN's Subchapter W reported emissions for 2012

UT/EDF uses the national average of 0.064 scf/min/well

OOOO uses the 13.28 tpy estimate for a site with 5 wells

EPA and SWN LDAR Implementation Cost Estimates



- SWN Leak Detection and Repair (LDAR) Program
 - Identify and repair equipment leaks.
 - 6 out of 7 new wells in Pennsylvania identified with leaking components
 - 7 out of 16 well sites observed in UT study identified with leaking components
 - Product recovery, natural resource conservation, environmental stewardship, and safety benefits.
 - Regulatory requirement in Pennsylvania and Colorado, voluntary in other SWN operating areas.
- Phase 1 – Implemented “new well” leak detection program for Fayetteville Shale – 4Q2013.
 - 216 Wells
 - 44 Leaking components
- Phase 2 – Company-wide implementation 2014.

Fuel Cell



SWM Methane Reduction Projects

Pressure Actuated Liquids Unloading



Thermostat Actuated Chemical Addition



RIG 26 gets a perfect retrofit



Scrubber
Although the Caterpillar Dynamic Gas Blending Engine automatically adjusts to changing gas quality, natural gas flows through a scrubber first to remove dirt, water, foreign matter or undesired liquids.

Wellhead
The engine has the capability to run on LNG or CNG. However, we are using natural gas directly from the wellhead. This allows us to keep our wellhead pressure and maintain low-cost gas.

Piping
Installation of piping needed on location to use this system is just one example of SWN teams working together through various integration to make wellhead operations safer and more efficient.

Intake for Natural Gas
Just because the engine runs on natural gas doesn't mean it's short on power. Churning at 1,200 revolutions per minute, the Caterpillar Dynamic Gas Blending Engine produces 550 horsepower running at 60 percent of its power-rated capacity.

Southwestern Energy is proudly one of the first companies to implement a new natural gas powered engine in our drilling operations. We have successfully been using natural gas from the Fayetteville Shale to drill for gas in the Fayetteville Shale since June.


The recently deployed Dynamic Gas Blending Engine from Caterpillar allows us to generate the power we need to run the RIG 26 skid/pumpjack set with a blend of natural gas and diesel, and seamlessly use traditional diesel methods when natural gas isn't available. At its maximum gas utilization, the engine will run on a 70 percent blend of natural gas and 30 percent diesel. This not only reduces our use of diesel, it lowers the amount of air emissions we create during the drilling phase of our operations.

"I think it says something about who we are as a company. It makes a statement that we are so passionate about natural gas as a fuel source, that we are using our own product to power our operations," said Harry Carley, Vice President of SWN Drilling Company. "This is definitely SWN doing the Right Thing."

The longer we continue to utilize this technology, it will also provide significant cost savings. We are expecting a five month payback on the investment, and if you look at the current direct-cost comparison of using the two fuels, we are currently saving approximately \$2,000 per day.


6 CONNECTION JUNE 2015

ROCKET RIG⁺



SWN
Southwestern Energy®

- Rated hoisting capacity of 800k lbs with full 600k lbs setback
- Highly mobile design featuring ground level assembly
- Drill floor and mast elevated simultaneously
- Multi-axis rig walker system with 2.4 MM lbs lift capacity
- Well to well skid function with full rated setback



$$\frac{R^2}{A} \rightarrow V^+$$

- Future Opportunities

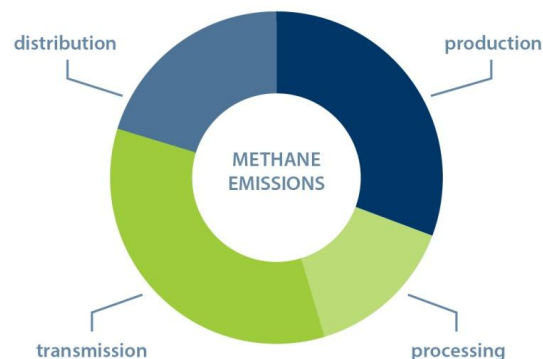
- No bleed pneumatics
- Solar Powered pumps
- Thermostat controllers
- Liquids Unloading
- Storage Tanks < 6 tpy
- Gas capture of blowdowns
- Diesel/Gas Drill Rigs
- Diesel/Gas Frac Spreads (Completions pumps)
- Directed Inspection/Maintenance
- Fuel cells for power generation (air compressors)
- Reciprocating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





OUR GOAL

Enhance the energy delivery efficiency of the natural gas supply chain by limiting energy waste and by achieving a methane “leak/loss rate” of no more than one percent.





Where is the Platinum Program?