Adapting Low Environmental Impact Technologies from Oil & Gas Development

CONFERENCE

SMU

Geothermal Energy and Waste Heat to Power: Utilizing Oil and Gas Plays

David B. Burnett

Department of Petroleum Engineering GPRI

Texas A&M University

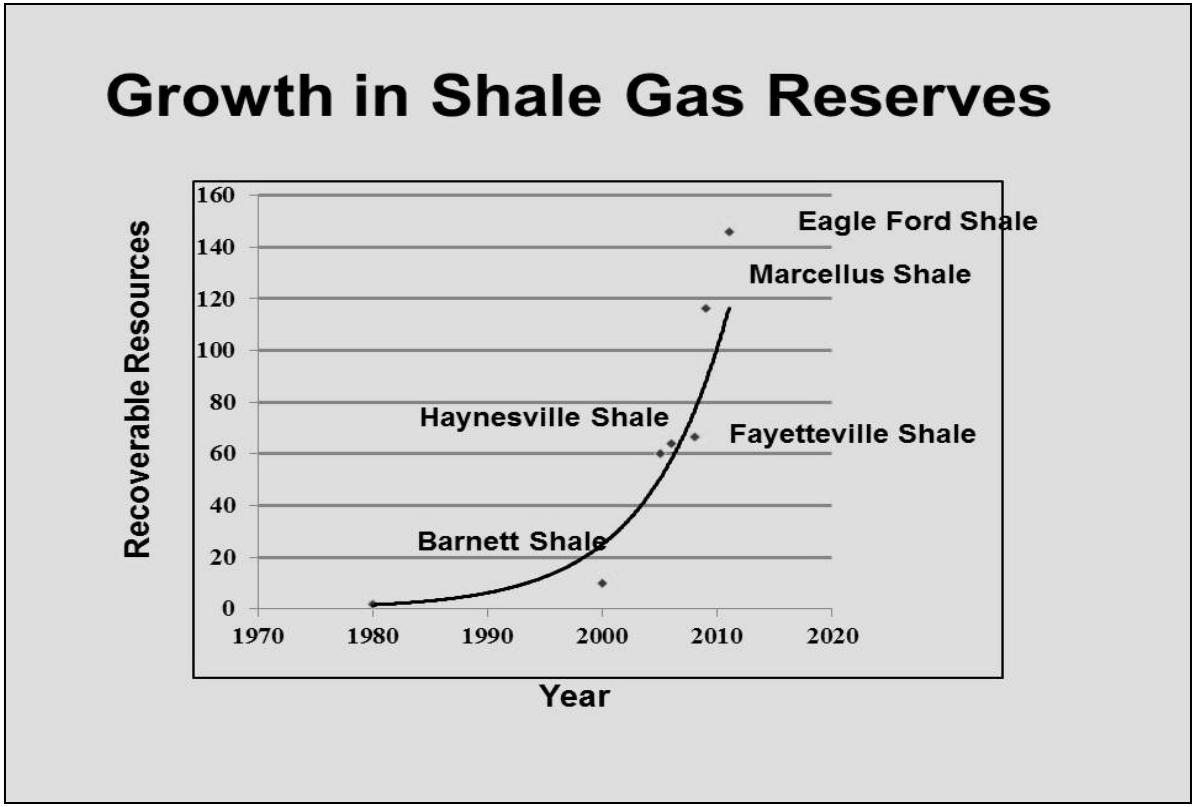
March 2013

Harold Vance Department of PETROLEUM ENGINEERING TEXAS A&M UNIVERSITY

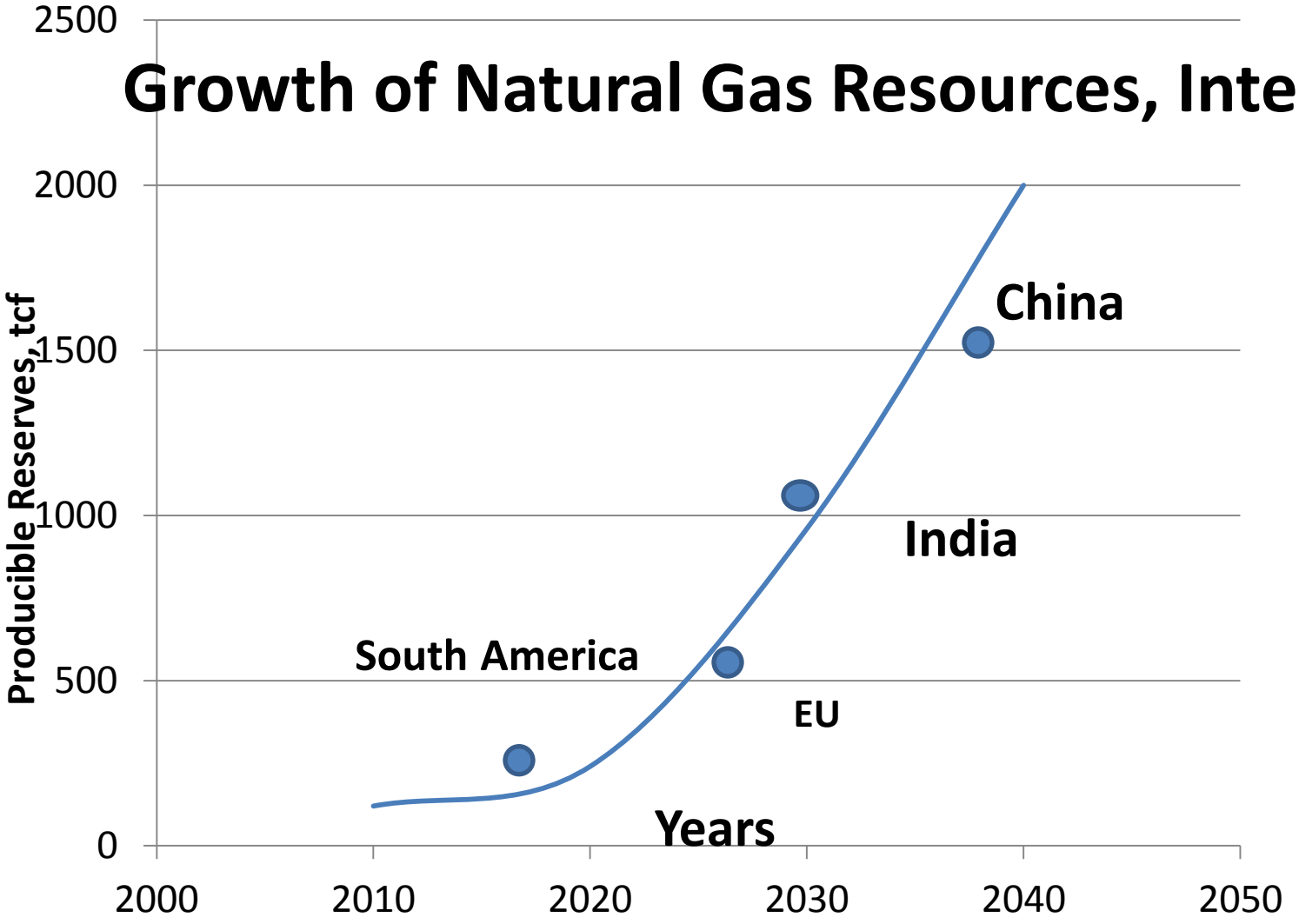
GPRI

How Innovation is Saving America

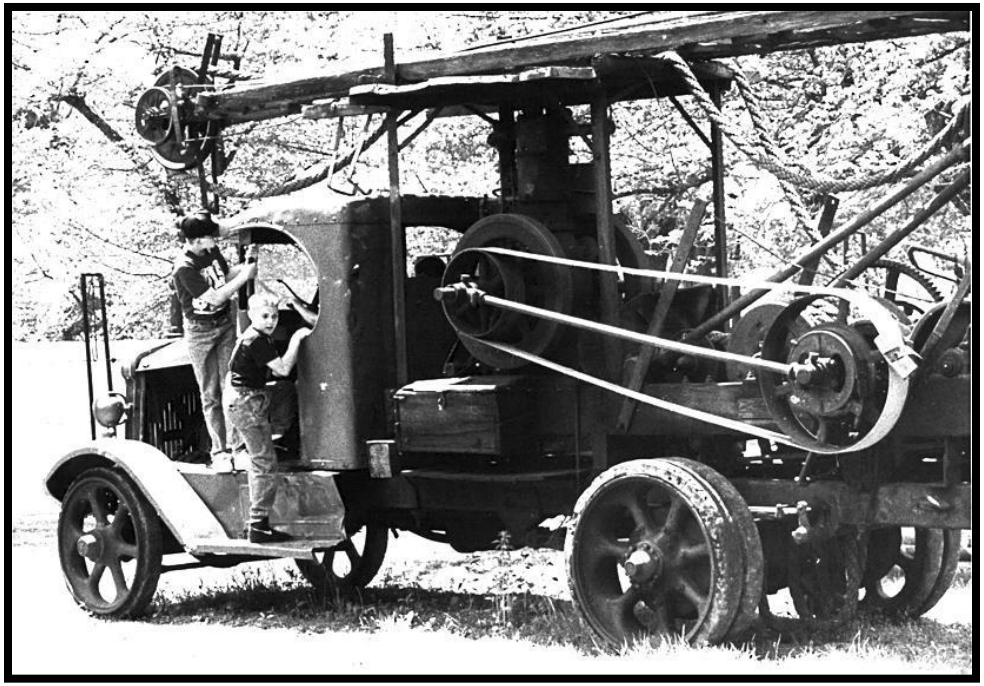
EFD



There is Plenty of Energy Available from Natural Gas – a 200 Year Supply

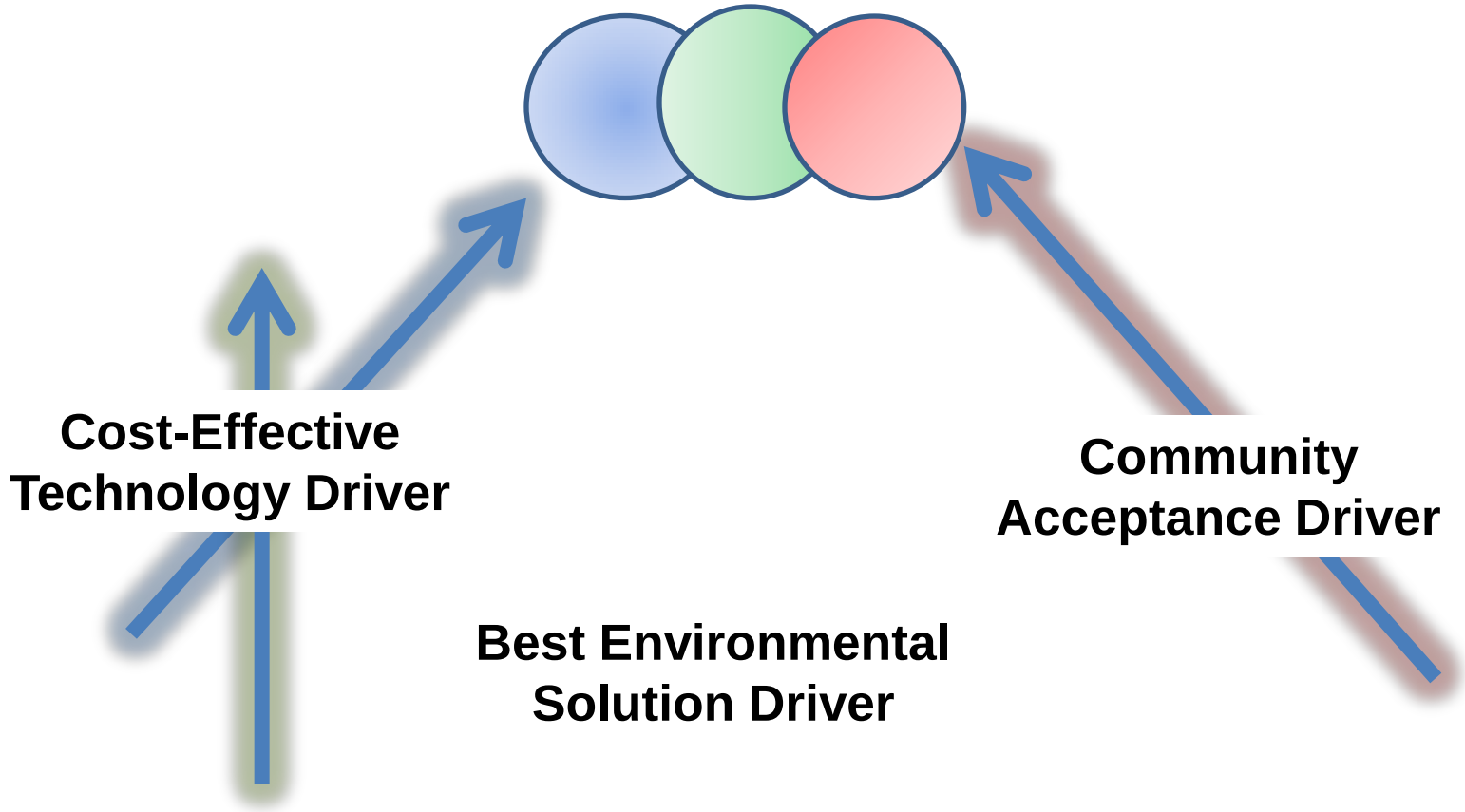

Growth of Natural Gas Resources, International
Producible Reserves, tcf
2500
2000
1500
1000
500
0
2000
2010
2020
2030
2040
2050
China
India
EU
South America
Years

How Innovative Are We?



The gas shale development boom is the biggest thing to happen to the O&G industry since the invention of the rotary drilling rig.

Innovation Needed in More Than "Just" Engineering



Environmental Performance

An Energy Company's License to Operate

Technology is available, but it will be the environmental issues and society's acceptance that slow the development of shale gas resources

The Environmentally Friendly Drilling Systems Program

Demonstrating innovative technologies that reduce environmental footprints

www.efdsystems.org

www.efd-tip.org

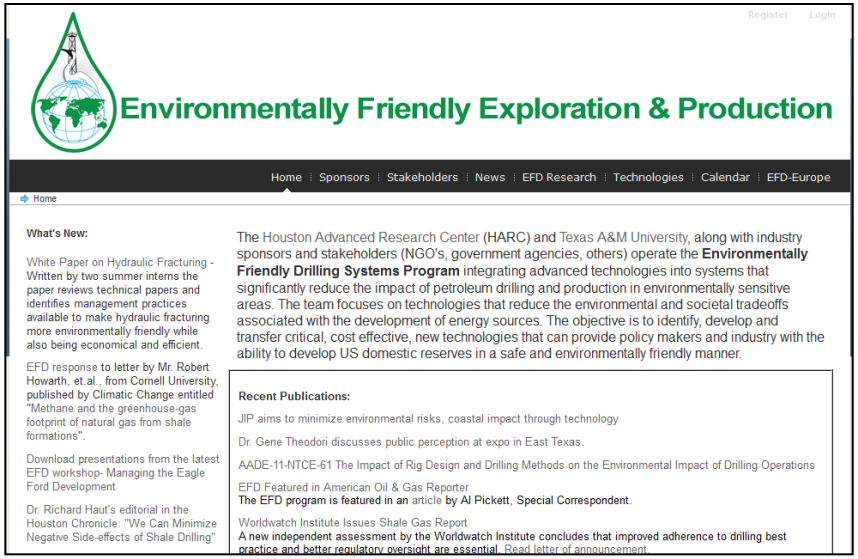
Working to Reduce Impacts

For more Info see:

http://www.oilandgasbmps.org/resources/fracing.ph

http://www.strongerinc.org/p

http://www.efdsystems.org



EFD Program History

- Formed Team in 2005 (6 years)
- Texas A&M University took lead to obtain U.S. Department of Energy Funding
- Formed Joint Industry Partnership to guide and co-fund program
- Engaged Environmental Organizations
- Phase 2 led by HARC with RPSEA funding
- Formed University/National Lab Alliance
- Initiated International outreach program including EFD-EU
- Phase 3, Technology Integration Program co-funded by RPSEA & Industry
- Initiated complementary program funded by U.S. Coastal Impact Assistance Program (CIAP) managed by the Texas General Land Office

The EFD Team

Co-funded by RPSEA, U.S. Fish & Wildlife, Industry, Environmental Organizations


DON'T
FRACK
YOUR
MOTHER!


HIDE YO KIDS
HIDE YO WIFE
Cause they
FRACKING!


I PREFERE
MY WATER
WITHOUT
CHEMICAL
You CAN'T
DRINK GAS
FRACKING


DONT FRAC UP OUR WATER
CHEMICALS USED / 5000 GALLONS PER WELL
BENZENE → CARCINOGEN
TOLUENE → CENTRAL NERVOUS SYSTEM DEPRESSANT
XYLENE → NEUROTOXIN

Environmental Performance

Do you think Geothermal Energy will Avoid the Pushback that Hydraulic Fracturing Has Caused?

Better Think Again!

Geothermal Protestors in Hawaii

Water – The Solution

- This technology is mobile, works in remote settings and is dependable
- Acceptable to regulatory agencies
- Turns unusable water into usable water
- Affordable

More water for communities and agriculture!

GPRI Mobile Water Re-use Lab

Mobile Test Unit for Advanced Membrane Testing

Interior of unit, set up for membrane modules

SPE 158396 PP
New York Field Trial of Ultra-High Salinity Brine Pre-treatment: Texas A&M Environmentally Friendly Drilling Technology for the Marcellus Shale

Field Frac Brine after Three Weeks

Treated **Un-Treated**

Emissions Reduction in Energy Production

How Rare is Clean Air?

- Urban Issues
  - Non-attainment
  - Permit levels
- Emissions of Concern
  - NOx and VOC's
    - Ozone
    - Cold-formed Ozone
  - Greenhouse Gases
- Green Completion Technologies
- Regulations/Policies
  - Clean Air Act
  - Greenhouse Gas Issues

The EPA estimates that atmospheric emissions of approximately 250 mscf/yr or 100 metric tons of CO_2 equivalent (CO_2e) of methane per year could be avoided for each high-bleed controller converted.

NOx Air Emissions Studies

Develop guidelines concerning the measurement of oxides of nitrogen (NOx) for a drilling site and work with operating company personnel to plan an investigation at a location.

Deliverables

- Plans for an emissions study.
- Guidelines for emissions reduction of large engines.

NOx Reduction Technologies

Exhaust Gas Recirculation (EGR)

- Send up to 30% of the exhaust back into the engine
- Many different options with varying results, broadly applicable
- Limitations: Durability
- 30% to 40% reduction in NOx

Selective Catalytic Reduction (SCR)

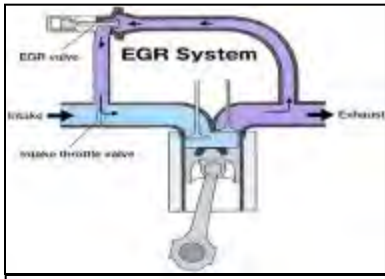
- Requires ammonia to be injected into the exhaust stream
- 3 different technologies functional in different temperature ranges
- Limitations: Requires urea, temperature dependence
- 65% to 90% reduction in NOx

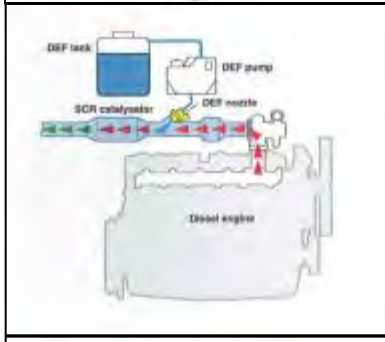
Lean NOx Catalyst (LNC)

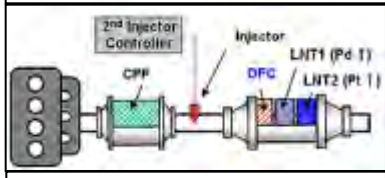
- Requires fuel to be injected into the exhaust stream
- Requires at least 260°C for at least 25% of the time
- Limitations: Sulfur sensitive, temperature dependent
- 10% to 50% reduction in NOx

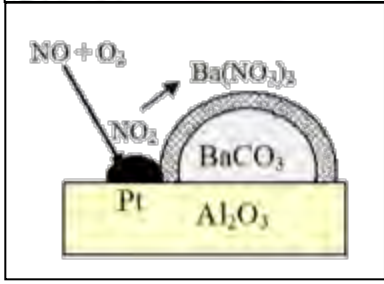
Lean NOx Trap (LNT)

- Chemically absorbs NOx onto a special catalyst
- At set intervals (~60-90 seconds), fuel is injected into the LNT to react with the stored NOx
- Limitations: Requires tight integration with engine management system
- 50% to 80% reduction in NOx









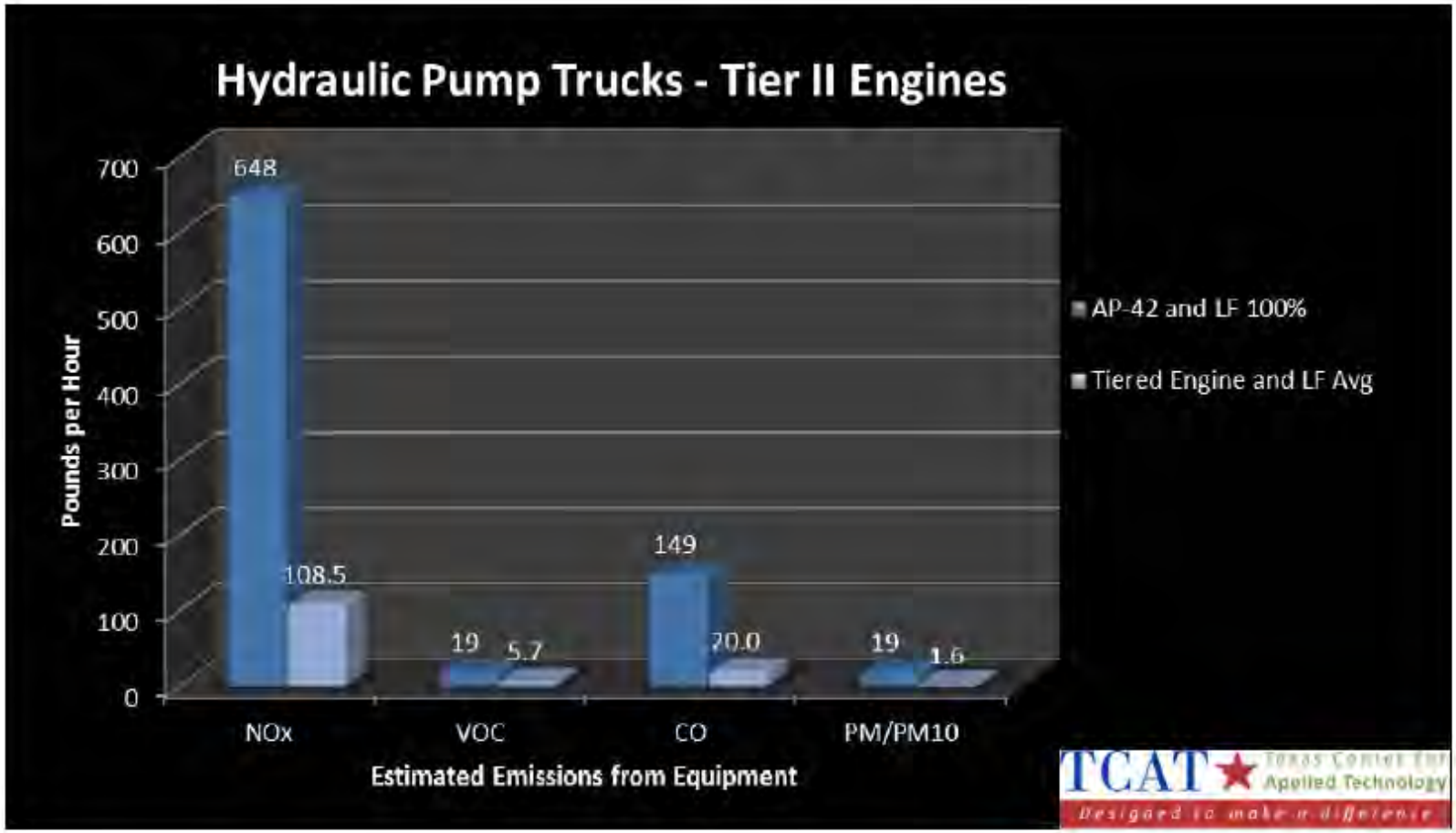
Air Emissions Inventory

Hydraulic Fracturing in the Eagle Ford

How much NOx?

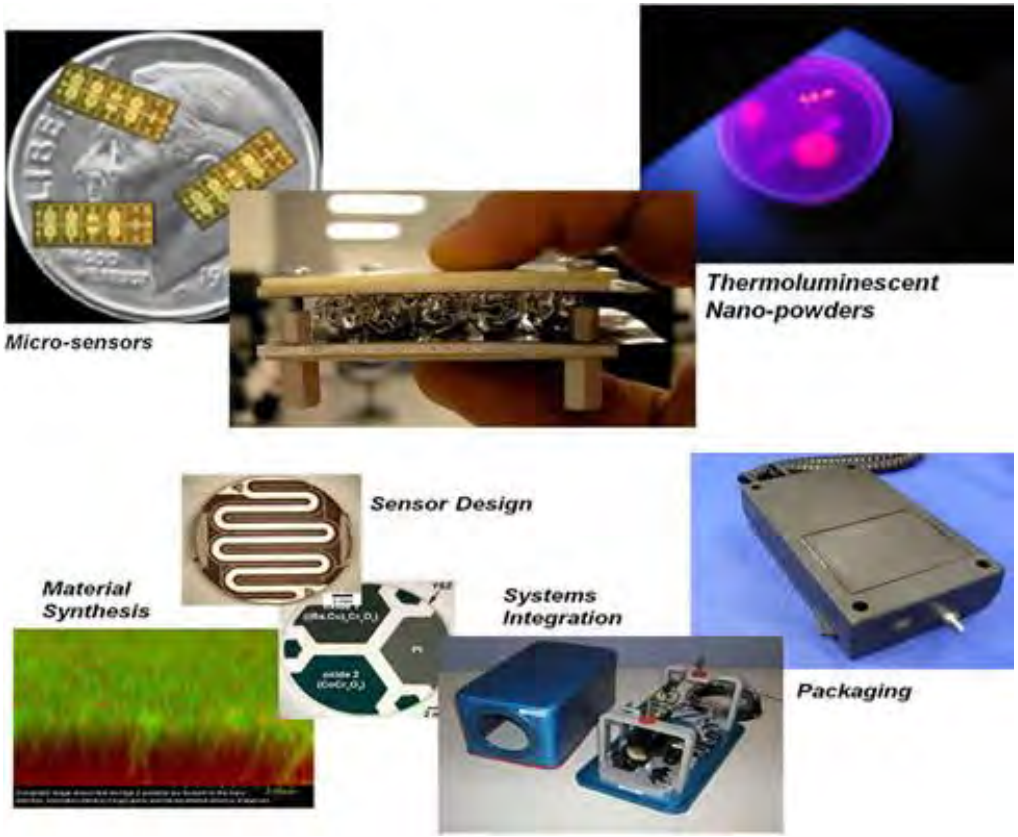
FRAC PROCESS EQUIPMENT				
Equipment	**Make/Model**	**Fuel**	**Size**	**Number**
Light Carts	TEREX RL4000	Diesel	13.6 hp	6
Frac Water Pump Engine	Cornell 18F8A Pumps w/Engine-John Deere 6090HF485B	Diesel	384 hp	5
Sand Trucks (Trailer/High Rate Feeder)	APPCO FS-40/Schlumberger SSF-353 Deck Engine	Diesel	78 hp	3
Sand Truck (Cab)	UNKNOWN	Diesel		
Water Tanks (Trailers)	NOT AN EMISSION SOURCE	N/A	N/A	5
Water Tanks (Cab)	UNKNOWN	Diesel		4
Blow Out Control System Engine	Engine - Hatz Diesel-8HZXL.667V83	Diesel	9.4 kW	1
Blow Out Control System Engine	Engine - Hatz Diesel-7HZXL.667V83	Diesel	9.4 kW	1
Telehandler (Forklift)	GRADALL - 534D9-45 w/Engine - John Deere 4045TF275B	Diesel	110 hp	1
Generator (small) -(on fire control trailer)	TITAN 8500 High Performance	Diesel	8500 kW	1
Bulldozer	Angus-Palm TR95 w/Engine-John Deere 4045TF270B	Diesel	99 hp	1
Backhoe	Caterpillar 420D	Diesel	88 hp	1
High Pressure Water Cannon	Twin Disc 1G4539 Model SP211HP3	Diesel		1
Generator - Mobile Office	Terex T70C	Diesel	91 hp	1
Generator - Cooling Room	ATLAS COPCO - Model QAS25	Diesel	29.6 hp	1
Vehicles				
Pump Trucks - Operating Engine	SPF343 - Engine-Caterpillar 3512B	Diesel	2250 hp??	12
Pump Trucks - Cab Engine	Peterbilt	Diesel		
Perf & Plug Truck - Cab Engine	Freightliner Columbia	Diesel		
Perf & Plug Truck - Operating Engine	Caterpillar - 3512B	Diesel	4423 hp	2
Mobile Command Center	SMT 503 Mobile Monitoring Unit/Caterpillar 3176	Diesel	210 hp	1
Crane (small)		Diesel		1
Crane (large) - Operating Engine	ATC3200	Diesel	517 hp	1
Crane (large) - Cab Engine		Diesel		
Large Pickup		Gasoline	250 hp	6
Medium Pickup		Gasoline	350 hp	6
Small Pickup		Gasoline	400 hp	6
Work Truck - GMC	GMC C5500			2
Crew Van	Ford E350	Gasoline	255 hp	1
Cab - 18 Wheeler	Peterbilt	Diesel		3
PRODUCTION PROCESS EQUIPMENT				
Vehicle/Equipment	**Make/Model**	**Fuel**		**Number**
High Pressure Separators		N/A		2
Low Pressure Separators		N/A		2
Condensate Tanks		N/A		8
Test Separator				

Comparison of AP-42 Emission Factors and 100% Load Factor with Tiered Engine Emission Factors and Actual



Air Monitoring Technologies

ORNL Micro-Sensors



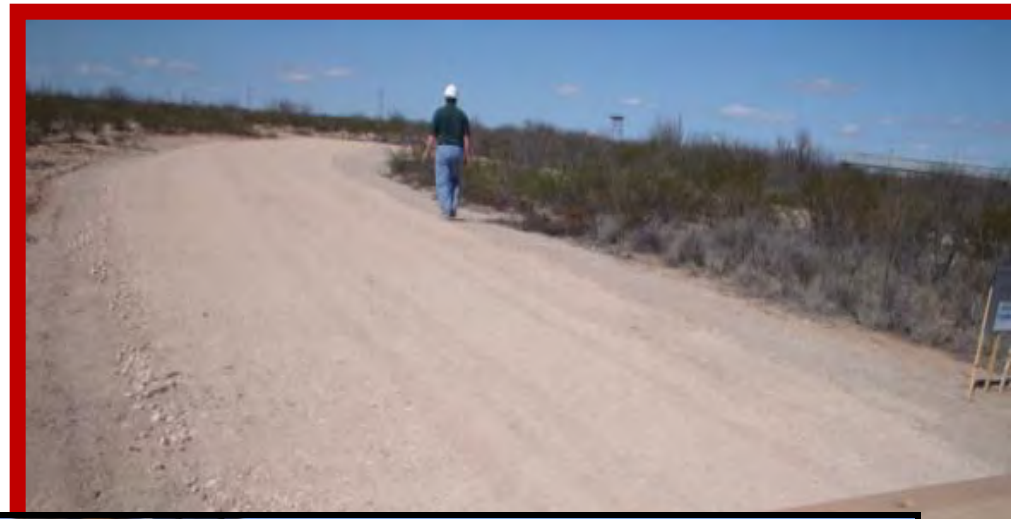
NETL Helicopter

- Can carry 12 lb payload

Reducing Energy Production's Surface Footprint

EFD Projects: Land Use

- Solid Waste Management.
- The University Disappearing Roads Competition.
- RPSEA Low Impact Roads: Storey Ranch
- Risk Based Assessment of EFD Systems.
- Analytical Services Roundtable.
- Land Use Site Selection Information Tool (LUSSIT)



Acknowledging the Role of the Public in Energy Development: Local

Stakeholder Engagement is Important!

Stakeholders are all those who are affected, interested in or have the capacity to influence a project.

Academia

- Texas A&M University College Station
- Texas A&M University Kingsville
- University of New Hampshire
- UT Medical Center
- Mississippi State University
- Sam Houston State
- University of South Alabama
- John Hopkins University
- University of Arizona
- University of Texas
- University of Houston

Environmental Organizations

- Natural Resources Defense Council
- Environmental Defense Fund
- The Nature Conservancy
- Conservation International
- Mercer Arboretum
- Bureau of Applied Anthropology/Arizona
- Clinton Climate Initiative
- Rocky Mountain Clean Air
- McFaddin Ranch

Industry

- API
- Ballard Exploration
- BP
- Shell
- Chevron
- StatoilHydro
- ConocoPhillips
- Devon
- King Exploration
- Halliburton
- Huisman
- National Oil Well – Varco
- MI Swaco
- TerraPlatform
- T. Baker Smith
- Weatherford
- Derrick Equipment
- Composite Mats
- Ecology and Environmental Inc.
- PTTC
- IADC

State/Federal Agencies

- US Department of Energy
- Bureau of Land Management
- US Park Service
- Texas Railroad Commission
- Texas General Land Office
- Texas Dept. of Agriculture
- Texas Dept. of Transportation
- US Minerals Management Services
- Texas Parks & Wildlife
- Texas Water Board
- Texas Commission on Env. Quality
- US Environmental Protection Agency
- US Fish and Wildlife
- Argonne National Laboratory
- Big Thicket Preserve
- Idaho National Laboratory

Source:Connor Development Services Ltd

Findings indicate that public will accept and support responsible development

However, the public ***will not accept:***
excessive traffic, dust, noise,
pollution of the land and water,
destroying public roads;
poor choices in well sites, roads,
compressor stations,
tank batteries, drilling locations;
and "visitors" who do not
respect their community.

Failure to adequately inform and engage all stakeholders results in poor public perception of the oil and gas industry;

…and because a small percentage of companies do not practice proper environmental safeguards in their operations, the "license to operate" is thus compromised.

Tradeoff Scorecard Development

EFD Facts

Project:
Location:
Ecosystem:

	Max	Score
AIR	10	0
WATER	15	0
SITE	15	0
WASTE MANAGEMENT	20	0
BIODIVERSITY/HABITAT	20	0
SOCIETAL	20	0
	100	0

Environmentally Friendly Drilling Scorecard

Project:
Location:
Ecosystem: Semi-Arid
Date:

0 Points Achieved — Possible Points: 100

★ 55 - 64 points ★★ 65 - 74 points ★★★ 75 - 84 points ★★★★ 85 - 94 points ★★★★★ 95 - 100 points

	Air	Possible Points: 10	
	Prerq 1	Compliance w/Air Quality Regs	
0	Credit 1	Contractual Obligations for Logistics	2
0	Credit 2	Site Emissions	2
0	Credit 3	Dust Suppression	2
0	Credit 4	Clean Power	3
0	Credit 5	Green Completions	1

	Water	Possible Points: 20	
	Prerq 1	Stormwater Management Plan	
	Prerq 2	Integrity Testing of Surface Casing	
0	Credit 1	Water Management Plan	9
0	Credit 2	Setbacks from Streams/Sources	4
0	Credit 3	Mitigation Measures/Protect Waters	4
0	Credit 4	Reduce Water Usage	2
0	Credit 5	Reuse of Water/Fluids	1

	Site	Possible Points: 20	
	Prerq 1	Regulatory Compliance	
	Prerq 2	Erosion & Sedimentation Control	
0	Credit 1	Pre-Existing Site	2
0	Credit 2	Pad Drilling	2
0	Credit 3	Protect and Restore Habitat	2
0	Credit 4	Contractor Guidelines	2
0	Credit 5	Site Restoration Plan	2
0	Credit 6	Well Design Considerations	2
0	Credit 7	Living Quarters and People	2
0	Credit 8	Organic Materials	1
0	Credit 9	Pre-Plan for Production	2
0	Credit 10	Match Site/Access to Topgraphy	1
0	Credit 11	Logistics Plan - Offsite Storage	1
0	Credit 12	Planting of Native Vegetation	1

	Waste Management	Possible Points: 20	
	Prerq 1	Waste Management Plan	
	Prerq 2	Pit Design Pre-site Assessment	
0	Credit 1	Drilling Fluid Handling System	6
0	Credit 2	Lubricants, Fluids, Bulk Materials	5
0	Credit 4	Spill Prevention System	3
0	Credit 5	Cuttings Reuse	3
0	Credit 6	Cuttings Reinjection	3

	Biodiversity/Habitat	Possible Points: 15	
	Prerq 1	Species Protection	
	Prerq 2	Habitat Protection/Enhancement	
	Prerq 3	Regulatory Requirements	
0	Credit 1	Restoration/Interim Reclamation	4
0	Credit 2	Reduction of Surface Disturbance	3
0	Credit 3	Erosion Prevention	2
0	Credit 4	Voluntary Offsite Mitigation	1
0	Credit 5	Invasive Species Prevention	1
0	Credit 6	Reintroduction of Species, Habitat	1
0	Credit 7	Avoidance of High Value Areas	1
0	Credit 8	Wildlife and Habitat	2

	Societal	Possible Points: 15	
	Prerq 1	Regulatory Compliance	
	Prerq 2	Communication Plan	
0	Credit 1	Public Outreach	3
0	Credit 2	Noise and Lighting Control	2
0	Credit 3	Training of Local First Responders	2
0	Credit 4	Air Quality Monitors	2
0	Credit 5	Emergency Response Plan	2
0	Credit 6	Dispute Resolution Plan	1
0	Credit 7	Surface Use Plan	2
0	Credit 8	Unintended Consequences Program	1

EFD Facts

Project:
Location:
Ecosystem:

	Max	Score
AIR	10	0
WATER	20	0
SITE	20	0
WASTE MANAGEMENT	20	0
BIODIVERSITY/HABITAT	15	0
SOCIETAL	15	0
	100	0

Next Phase

Technology Integration Program

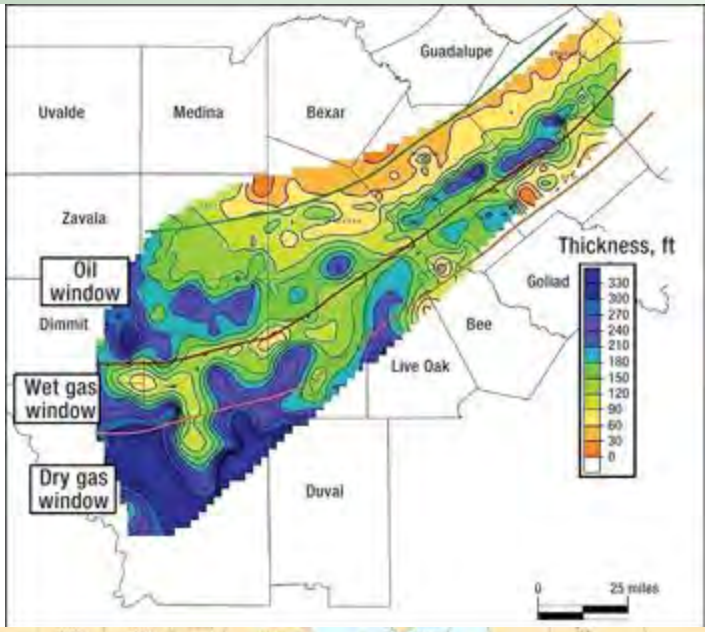
Integrated approach for applying new technologies

Description

- **Field Tests in the Eagle Ford, other shales**
- **Web sites for virtual gas developments**
- **Outreach/Technology Transfer**

Goals

- **Speed commercial development**
- **Create organizational structure to facilitate field deployment**
- **Perform field trials**
- **Document and transfer results**
- **Emphasis on reduced costs and improved performance**
- **Safety improvements of low impact technologies**



Best Management Practices - Sustainability

The third item identified is to develop a set of best management practices (BMP) that can be use for operations, employees and, importantly, for their subcontractors.

- EFD has invested in the development of a Rocky Mountain regional BMP project at the University of Colorado Natural Resources Law School
- Initiated another effort in the Eastern U.S. Marcellus and Utica Play region.
- All documents will be web-based and publicly available. These BMPs could be adapted by any company.

www.oilandgasbmps.org

WWW.efd-aas.org

Summary

- Public Perception can Make or Break a Project
- Technologies are available to ***reduce emissions (water and air)*** and new technologies are being developed and tested. Reduction in surface impact should be a paramount research target
- **EFD Program** – Should be Carried over into EGS Planning and Operations

Contacts

Rich Haut
Houston Advanced Research Center
rhaut@harc.edu
(281) 364-6093

Tom Williams
twilliams@afsolutionsinc.com
(713) 201-3866

Dave Burnett
Texas A&M University
burnett@pe.tamu.edu
(979) 845-2274

Gene Theodori
Sam Houston State University
glt002@shsu.edu
(936) 294-4143

Gerhard Thonhauser
University of Leoben
gerhard.thonhauser@unileoben.ac.at
+43 (664) 2110 656

Jim Slutz
Global Energy Strategies LLC
jslutz@globalenergystrategies.net
(202) 436-4410

Harold Vance Department of PETROLEUM ENGINEERING TEXAS A&M UNIVERSITY