

# Well Manufacturing Technologies

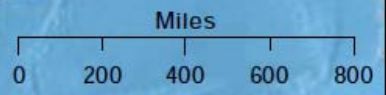
IADC Future Technology Shale Drilling Workshop

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27.1.11

# Current and Prospective North American Shale Gas Plays as of December 2010

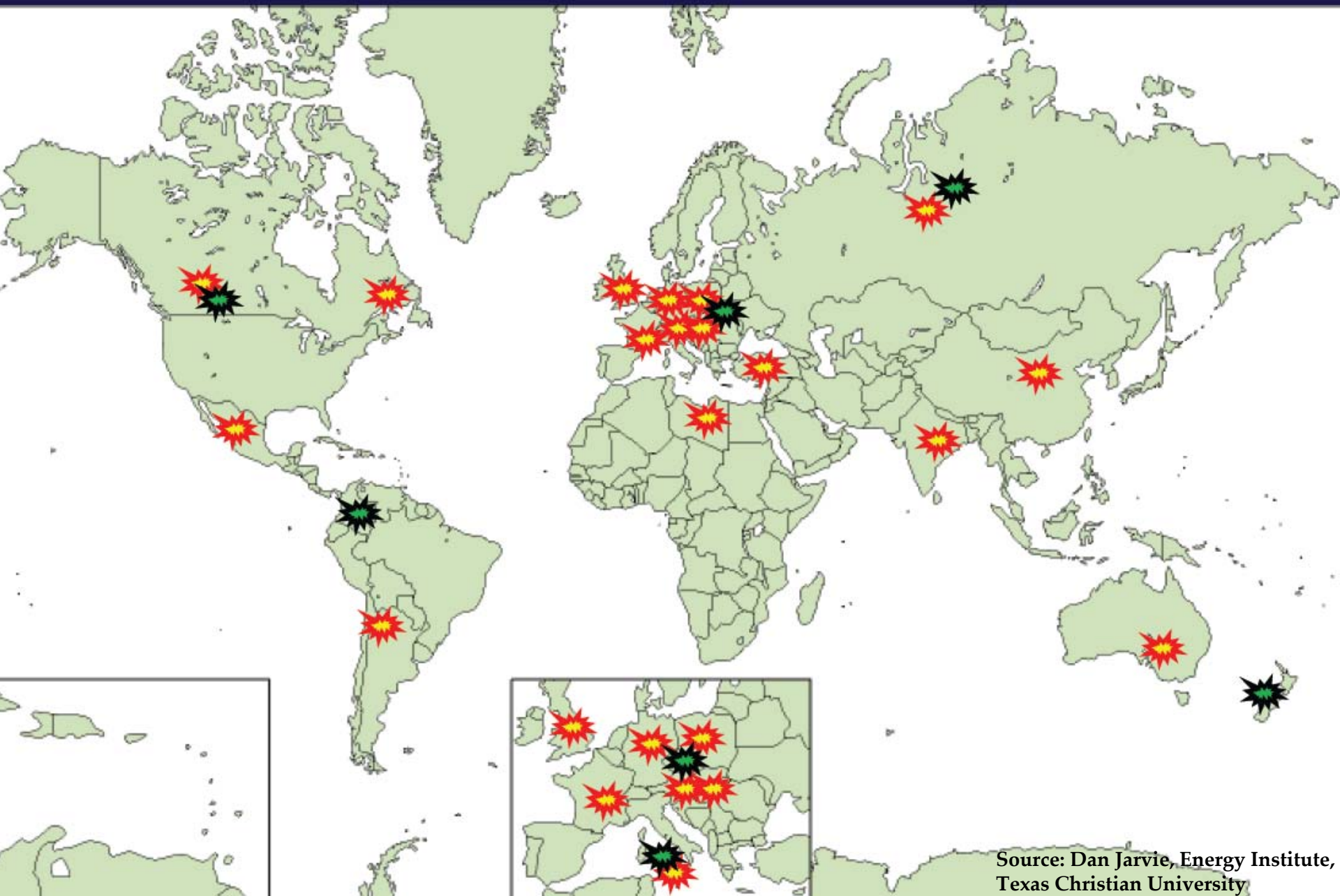


<span style="color: red;">■</span>	<b>Current Shale Gas Plays</b>
<b>Stacked Plays</b>	
<span style="color: red;">▬</span>	Shallowest / Youngest
<span style="color: blue;">▬</span>	Deepest / Oldest
<span style="color: green;">■</span>	<b>Prospective Shale Plays</b>



Source: Energy Information Administration based on data from various published studies.  
 Updated: December 15, 2010

# Global Potential Shale Resource Plays



Source: Dan Jarvie, Energy Institute,  
Texas Christian University

# Economics of Shales

*“The product is not the well. The product is in the well.”*

- Economies of Scale
- Characterized as low-margin and low-risk drilling
- Significant costs associated with completions processes
- Additional challenges in regards to environment in comparison to conventional plays



# Breakdown of Costs

Well Cost Component Distribution

Category	2008				2009				2010
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
Drilling Rigs	38%	34%	35%	29%	30%	29%	31%	32%	32%
Bits	2%	2%	2%	2%	2%	2%	2%	2%	2%
Fluids	6%	6%	6%	5%	5%	5%	5%	5%	5%
OCTG	13%	19%	19%	18%	15%	15%	14%	15%	15%
Stimulation	10%	8%	8%	14%	14%	14%	13%	13%	13%
Cementing	4%	3%	3%	3%	3%	3%	3%	3%	3%
Technical Services	7%	7%	7%	8%	8%	9%	9%	9%	9%
Production Equipment	10%	10%	10%	10%	11%	12%	11%	11%	11%
Completion Rig	3%	2%	2%	2%	2%	2%	2%	2%	2%
Site Access	8%	9%	9%	9%	10%	9%	9%	8%	9%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

- Drilling Rigs & Stimulation account for approximately 45% of total costs

# 3 Styles of Manufacturing

- Craft Producer
  - Uses highly skilled workers and simple but flexible tools to make exactly what the consumer asks for – one item at a time
- Mass Producer
  - Uses a narrowly skilled professionals to design products made by unskilled or semiskilled workers tending expensive, single-purpose machines
- Lean Producer
  - Combines the advantages of craft and mass production, while avoiding the high cost of the craft producer, and then the rigidity of the mass producer

*“Lean” is a process philosophy with three purposes*

- To eliminate wasted time, effort, and material
- To provide customers with make-to-order products
- To reduce cost while improving quality


# Six Sigma Methodology

- A process-improvement methodology that focuses on delivering products at a lower cost, with improved quality and reduced cycle time
- A method for *reducing process variation*
- Also defined as:
  - A measure of process capability
  - A set of tools
  - A disciplined methodology
  - A vision
  - A philosophy
  - A strategy

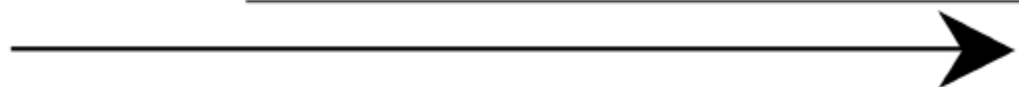
# The Ultimate Combination: Lean Six Sigma

**TABLE 1—OVERALL YIELD AS A FUNCTION OF SIGMA LEVEL AND PROCESS STEPS**

Reducing Process Steps With Lean



Reducing Process Variation With 6  $\sigma$



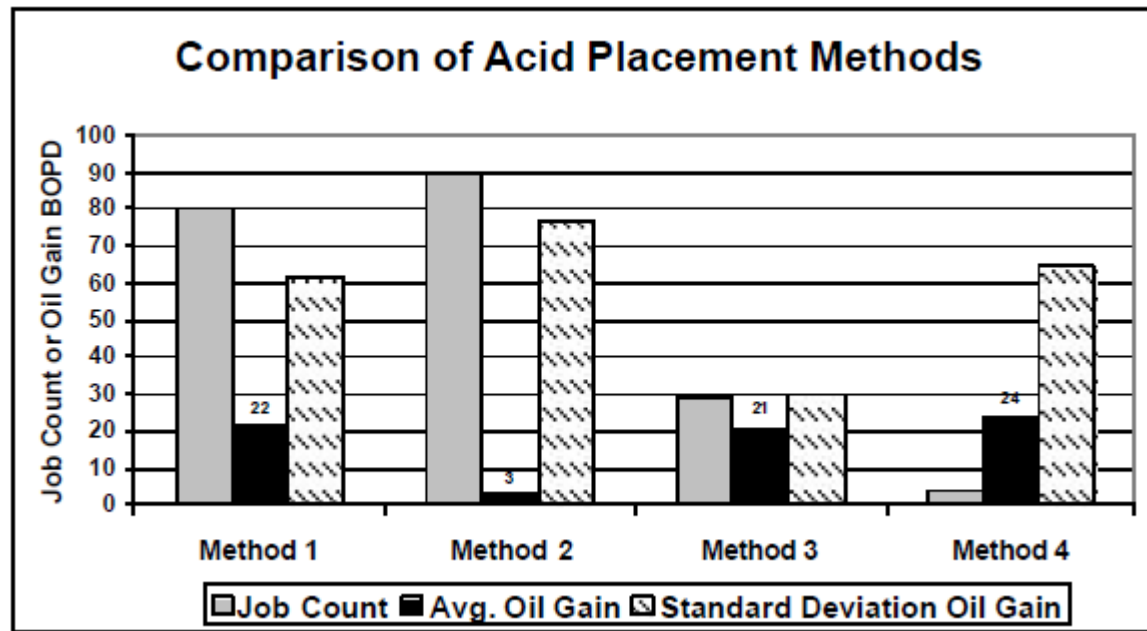
No. of Parts or Process Steps	Sigma Level			
	+/- 3	+/- 4	+/- 5	+/- 6
1	93.32%	99.379%	99.9767%	99.99966%
10	50.1%	94.0%	99.767%	99.997%
100	0.1%	53.6%	97.70%	99.966%
1,000		0.2%	79.2%	99.7%
10,000			9.7%	96.7%
100,000				71.2%
1,000,000				3.3%

# Lean Six Sigma – Well Stimulation Study

- Southeast Asian steam drive oilfield – over 200 acid jobs performed to stimulate oil production
- Lean Six Sigma project conducted using historical statistical data
- Analysis revealed that the process did increase oil production, and on an overall basis met economic hurdles
- Due to high process variability, large percentage of the wells did not produce an economic response that met economic hurdles

# Lean Six Sigma Stimulation Study - Results

- Tests revealed significant differences in gains due to:
  - Area of the field
  - Production interval stimulated
  - Temperature of the well
  - Oil production pre stimulation
  - Method of acid application



# Lean Six Sigma Stimulation Study Results

- Improved economics due to reduced downtime required for well stimulation & amount of acid used
- Detailed process flow diagram created for screening un-profitable jobs
- Project yielded **net benefit of \$1,000,000**

# Apply Lean Six Sigma to Shale Drilling/Completion

- Main Processes in creating a well
  - Rig Set up
  - Drilling – Surface & Intermediate Hole, Production Hole
  - Rig Down
  - Completions
  - Stimulations
  - Tie in to Production
- Think of all inefficiencies and stand-by times involved in each process, as well as between each process

# Apply Lean Six Sigma to Shale Drilling/Completion

- Rig Mobilization
  - “Walking Rigs” , Highly mobile, Assembly line concepts, factory drilling
- Drilling
  - Casing While Drilling
  - Mud Tracer Technology
  - Fit for Purpose Rigs
  - Multi-operational rigs
  - Automated Control Systems
- Completions/Stimulation
  - Monobore completions
  - SOP's (Standard Operating Procedures)
  - Multi-stage liner completions
  - Centralized Water Source/Recycle & Treatment Facility

Most importantly, ensure a smooth, quick transition between operations. Think Integration. Eliminating individual processes leads to increased productivity.