Associated Gas in the Bakken Formation – Attendant Challenges and Opportunities

North Dakota Legislative Council
Energy Development and Transmission Committee Meeting

August 28, 2012

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EERC Energy & Environmental Research Center (EERC)…

Investigating Flare Gas Reductions

- The EERC was funded in May 2011 by the North Dakota Industrial Commission (NDIC), U.S. Department of Energy (DOE), and Continental Resources to investigate alternatives to flaring:
  - Rig power demonstration
  - Associated gas utilization study
- The EERC continues to work with various Bakken partners to explore novel methods to reduce flaring and monetize this otherwise-uncaptured resource.

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Demonstration of Gas-Powered Drilling Operations for Economically Challenged Wellhead Gas

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Drilling Demonstration Overview

- Test dual-fuel operation of a Caterpillar engine at the EERC:
  - Butler Machine supplied Caterpillar 3512 engine.
  - Simulated rich-gas mixture produced with EERC-fabricated gas-metering system.
  - GTI Bi-fuel® system used to manage fuel supply to engine.
  - Monitored engine performance and emissions under varying operating conditions and fuel mixtures.
- Field demonstration of gas-powered drilling operations using rich Bakken gas:
  - Two wells are being drilled using GTI Bi-fuel system fueled with rich wellhead gas.
  - Monitoring engine performance, gaseous and diesel fuel use, and emissions over entire drilling cycle.

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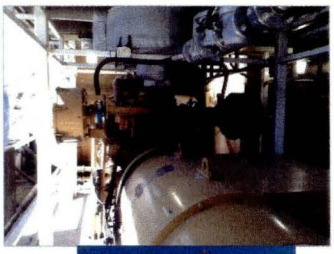
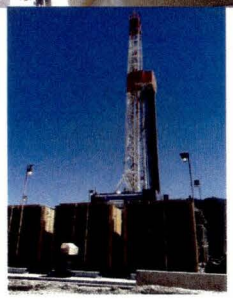
Synthetic Rich-Gas Tests





- Tested dual-fuel operation of a Caterpillar 3512 engine at the EERC:
  - Tests completed June 2012.
  - Tests concluded that diesel replacement rates of greater than 40% can be achieved and that the GTI Bi-fuel system can control fuel use to ensure safe engine operation.
  - Field testing is enabling further assessment of optimized gaseous fuel utilization.

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Field Tests Using Rich Wellhead Gas

- Field demonstration of gas-powered drilling operations using rich Bakken gas:
  - GTI Bi-fuel power system now installed on a two-well pad, Hartman 3-28 and Hartman 4-28H.
  - System performance is being monitored for the duration of the batch drilling operation.
  - Gas supply will come from Hartman 2-28H, approximately 1500 feet east of the test site.

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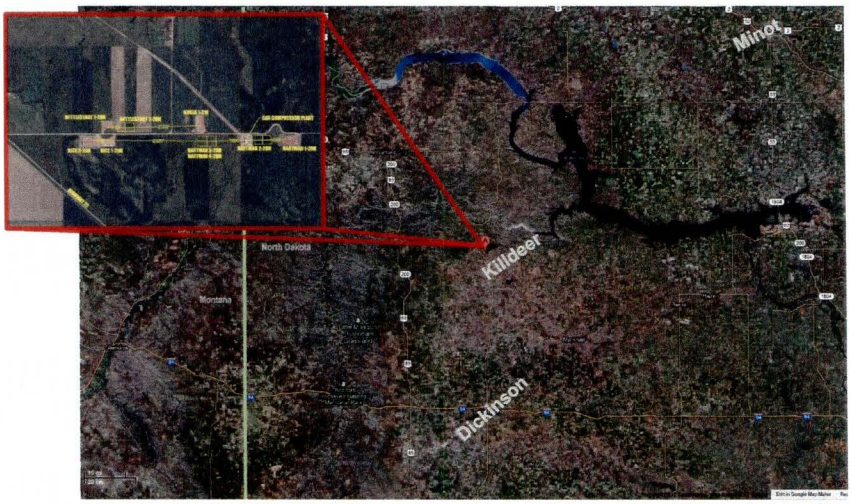
Location of Demonstration Well Site



Images courtesy of Google Maps ®2012

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Project Participation and Funding

- Project partners:
  - Continental Resources
  - GTI-Altronics
  - Butler CAT
  - ECO-AFS
  - NDIC Oil and Gas Research Council (OGRC)
  - U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL)
- Funding Total $1,900,000
  - NDIC OGRC – $750,000
  - DOE NETL – $400,000
  - Continental cost share – $750,000

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Take Home Summary

- Demonstrate efficient and economical use of wellhead gas:
  - Improve economics of drilling operations – $3200–$9600/day diesel cost avoided
  - Reduce gas flaring in the Williston Basin
  - Reduce diesel fuel delivery and associated traffic
- Establish guidelines for rich-gas use in diesel engines:
  - Define diesel replacement ratio that maximizes gas use while preventing engine knock and improving engine emissions
- Prove logistics of rich-gas capture and delivery to drill sites.
- Demonstrate progressive approach to improve efficiency and mitigate impacts of oil and gas production.

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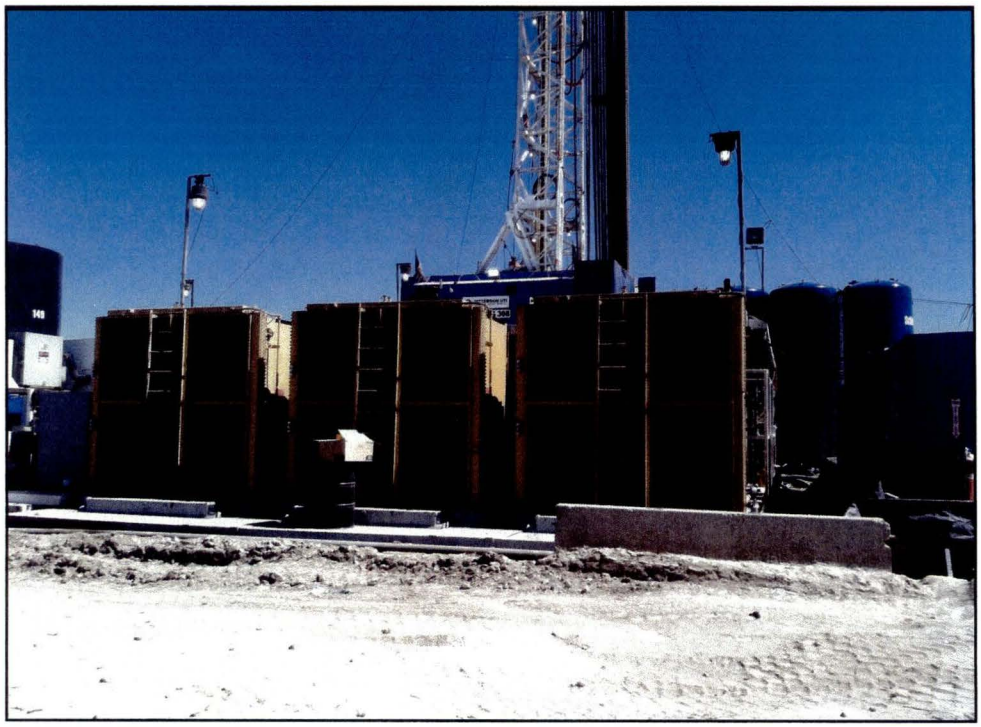

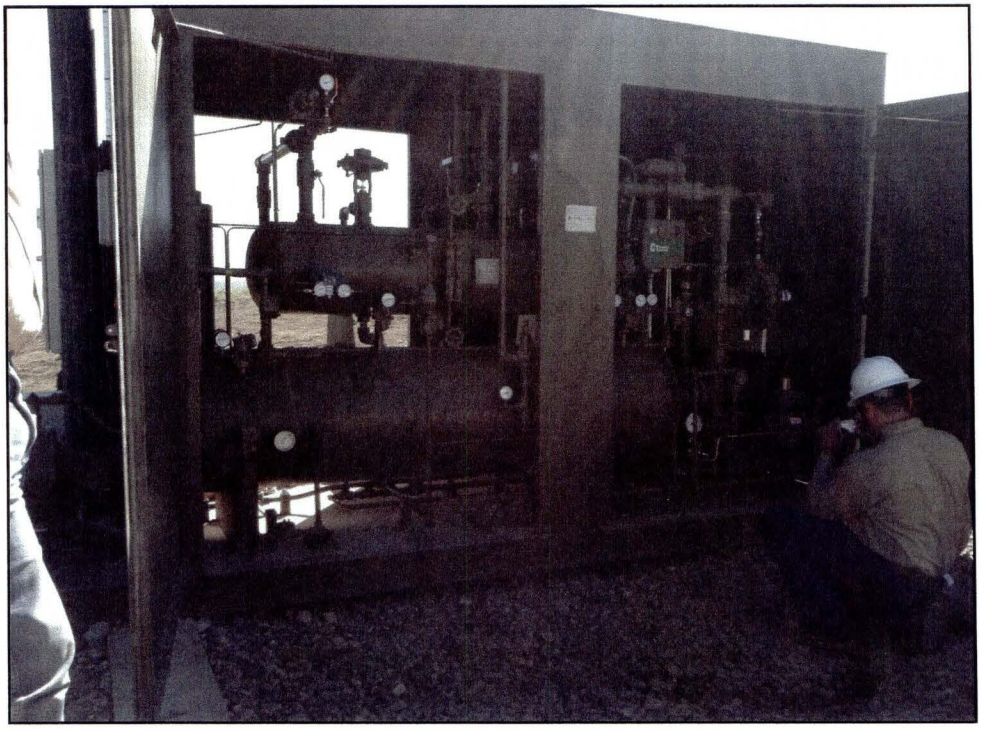

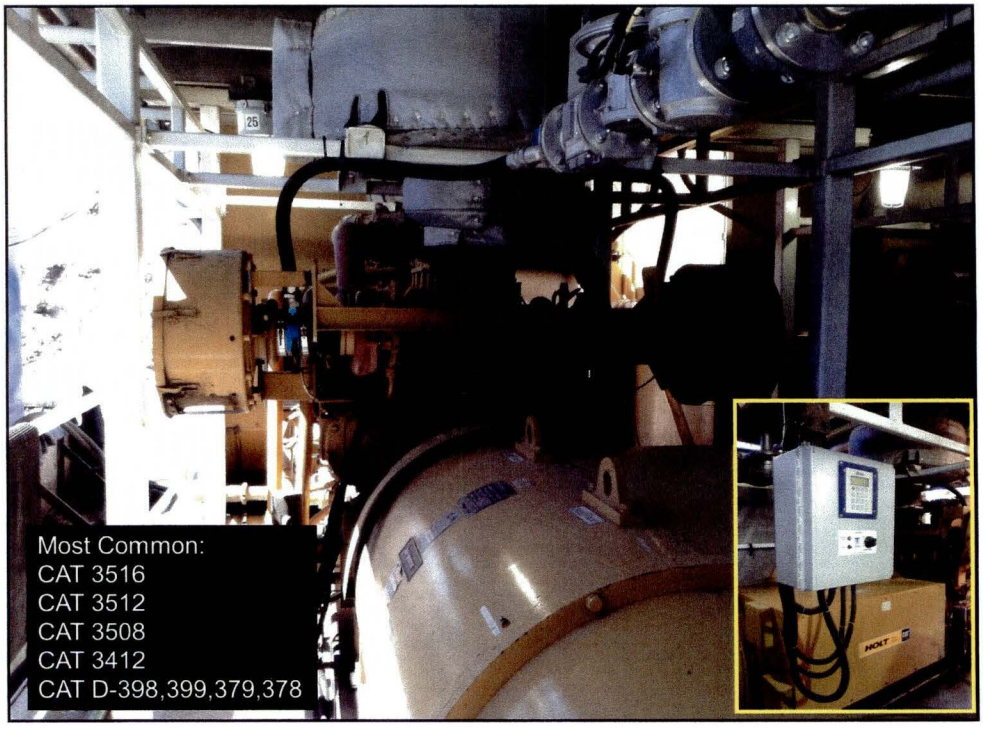
Most Common:
CAT 3516
CAT 3512
CAT 3508
CAT 3412
CAT D-398,399,379,378

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Associated Gas Utilization Study

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Study Goals

- Assess the technical viability of technologies utilizing associated Bakken gas.
- Define economic conditions that would enable commercial deployment both regionally and nationally:
  - Define unutilized gas resource in the Williston Basin.
  - Identify natural gas use options that match quality and quantity of associated gas.
  - Identify distributed-scale gas cleanup technologies.
  - Identify uses tolerant of natural gas liquids (NGLs), moisture, CO_2, and sulfur.
  - Assess economic conditions that could lead to viable opportunity.

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Study Motivations

- Based on a desire to assess/define end uses that:
  - Have favorable economics.
  - Take advantage of small, distributed quantities of gas.
  - Require less gas cleanup than pipeline gas (rich gas).
  - Maximize profitable use of North Dakota associated gas.
  - Maximize revenue extraction from resources.
  - Reduce flared gas.
  - Improve air quality.
  - Ensure good stewardship of resources.
- *Potential uses may fall outside the typical model of gas-gathering, processing, and pipeline infrastructure.*

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Study Methodology

- Resource assessment:
  - Assess quantity and quality of gas produced and not marketed.
- Initial end-use technology evaluation:
  - Identify potentially viable end uses, accommodate gas quantity and quality (distributed scale with regional demand to provide economic advantage).
  - Define high-level business opportunities and questions or data gaps.
- Engagement of technology providers and potential end users:
  - Engage technology providers.
  - Exchange information on enabling technology platforms (e.g., cleanup requirements).
  - Refine and prioritize end-use opportunities.
- Refine end-use technology evaluation.
- Produce first-cut economics for pertinent end uses.

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Study Contents

- Gas resource
  - Overview of gas produced and flared
- CNG/LNG
  - Utilizing associated gas with minimum cleanup in oil field fleets.
- Power
  - Oil field equipment/off-grid, peaking power, firm intermittent power.
- Chemicals
  - Assess applicability of North Dakota-based industry.
  - Natural gas to fertilizer, Fischer–Tropsch (FT) liquids, or alcohols.
- NGLs
  - Ethane – olefins, polyethylene, ethylene glycol.
  - Propane – liquefied petroleum gas (LPG), propylene, polypropylene.
  - Butanes – gasoline additive, butylene, dilbit.
  - Pentanes – gasoline additive, dilbit.
  - Hexanes – gasoline, dilbit.

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Gas Flaring by Location

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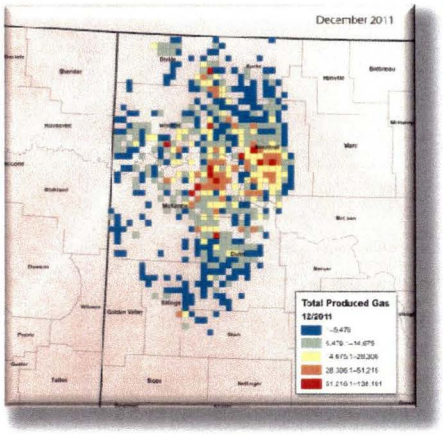
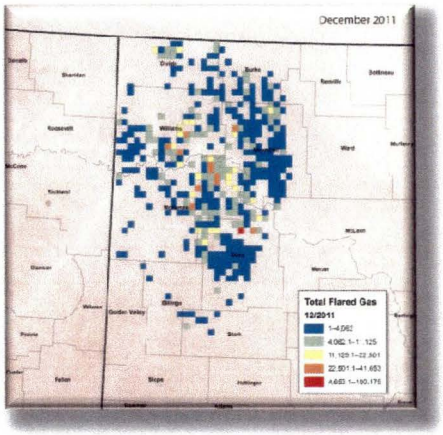


FLARED



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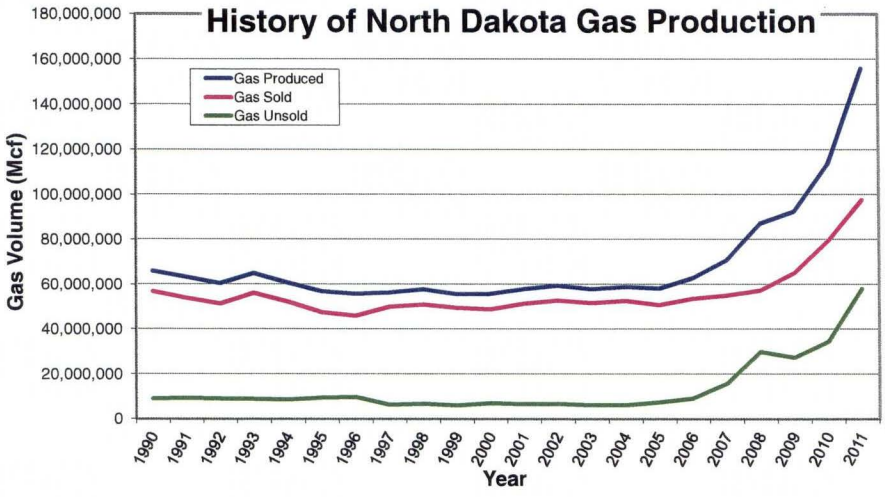
History of North Dakota Gas Flaring



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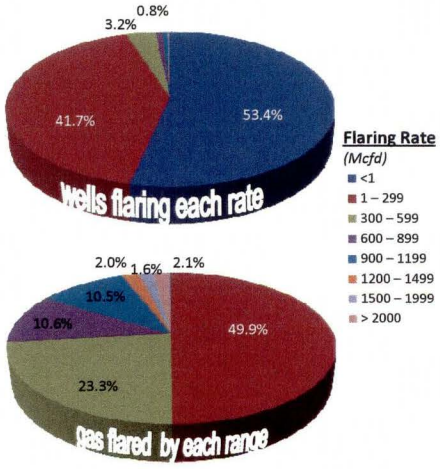
North Dakota Flared Gas Data

Flaring Rate, *Mcfd*	Number of Wells	Total Gas Flared Dec. 2011, *Mcf*
<1	1695	**2331**
1–299	1325	**2,178,842**
300–599	103	**1,017,536**
600–899	26	**463,634**
900–1199	17	**457,220**
1200–1499	4	**87,378**
1500–1999	3	**70,974**
>2000	2	**89,621**
TOTAL	**3175**	**4,367,536**



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Study Results Summary

Technology	Gas Use Range, Mcfd	NGL Removal Requirement	Scalability to Resource	Mobility	Likelihood of Deployment at Small Scale
Power – *Grid Support*	1000-1800	Minimal	Very scalable	Mobile	Very likely
Power – *Local Load*	300-600	Minimal	Very scalable	Mobile	Very likely
CNG	50+	Yes	Scalable	Mobile	Possible
Chemicals	>2000	No	Not scalable	Not mobile	Very unlikely
Fertilizer	300-2000	No	Scalable	Potentially mobile	Possible
Gas-to-Liquids	>2000	No	Scalable	Potentially mobile	Possible

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