Overview of Reduced Emissions Completions (RECs)

Cost-effective practice to recover natural gas and condensate produced during flowback following hydraulic fracture of natural gas wells

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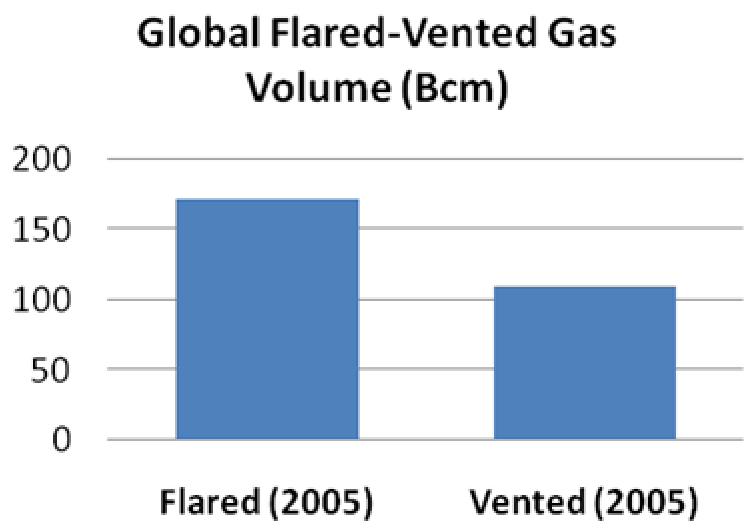
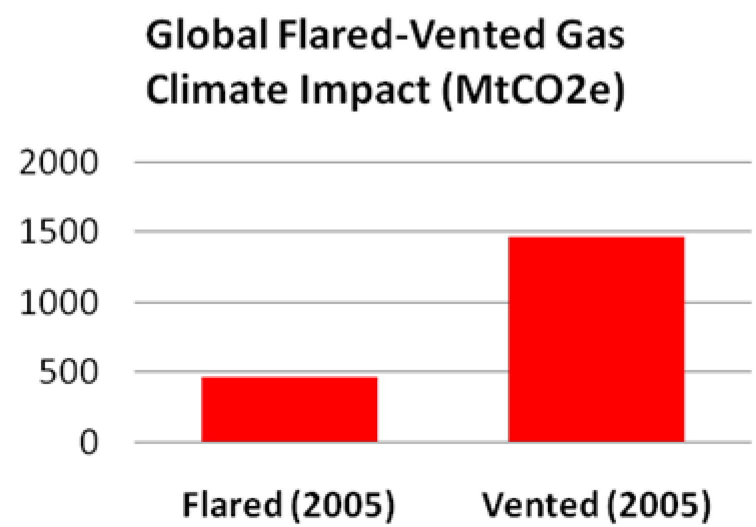
Natural Gas STAR Program

- Started in U.S. in 1993, expanded internationally in 2006
- More than 120 domestic and 14 international partners have
  - Identified over 50 cost effective technologies and practices to reduce methane emissions
  - Reduced methane emissions by 983 Bcf, saving over $3 billion worth of gas

Global Oil and Gas Sector Methane Emissions

- Over 4,000 Bcf of natural gas* lost annually worldwide
  - US$12 to $28 billion lost revenues
  - Over 4% of worldwide net dry gas consumption
- Upstream gas emissions can include volatile organic compounds (VOCs) and hazardous air pollutants (HAPs)
- Climate impact of natural gas venting 300% greater than that of global natural gas flaring

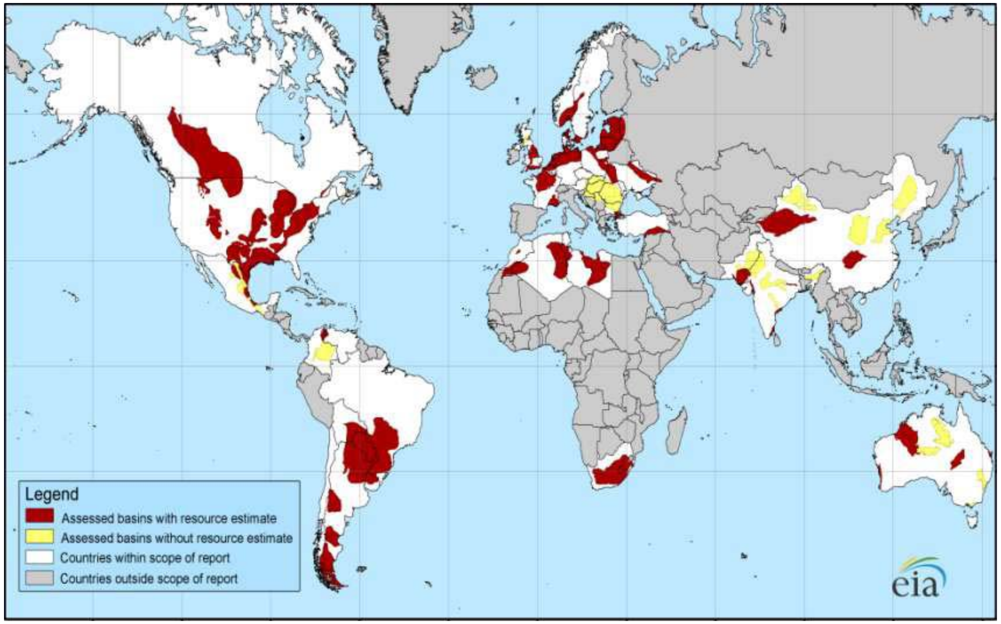




*Methane is the primary component of natural gas

Global Shale Gas Potential

- Energy Information Agency estimates initial shale gas technically recoverable resource (TRR) for 32 countries outside the U.S. is 5,760 Tcf
  - More than six times EIA's 862 Tcf TRR estimate for U.S. shale gas
- Including U.S. shale gas, raises estimated world natural gas TRR by over 40 percent to 6,622 Tcf
- TRR by continent (Tcf)
  – North America (excluding US): 1,069
  – South America: 1,225
  – Europe: 624
  – Africa: 1,042
  – Asia: 1,404
  – Australia: 396

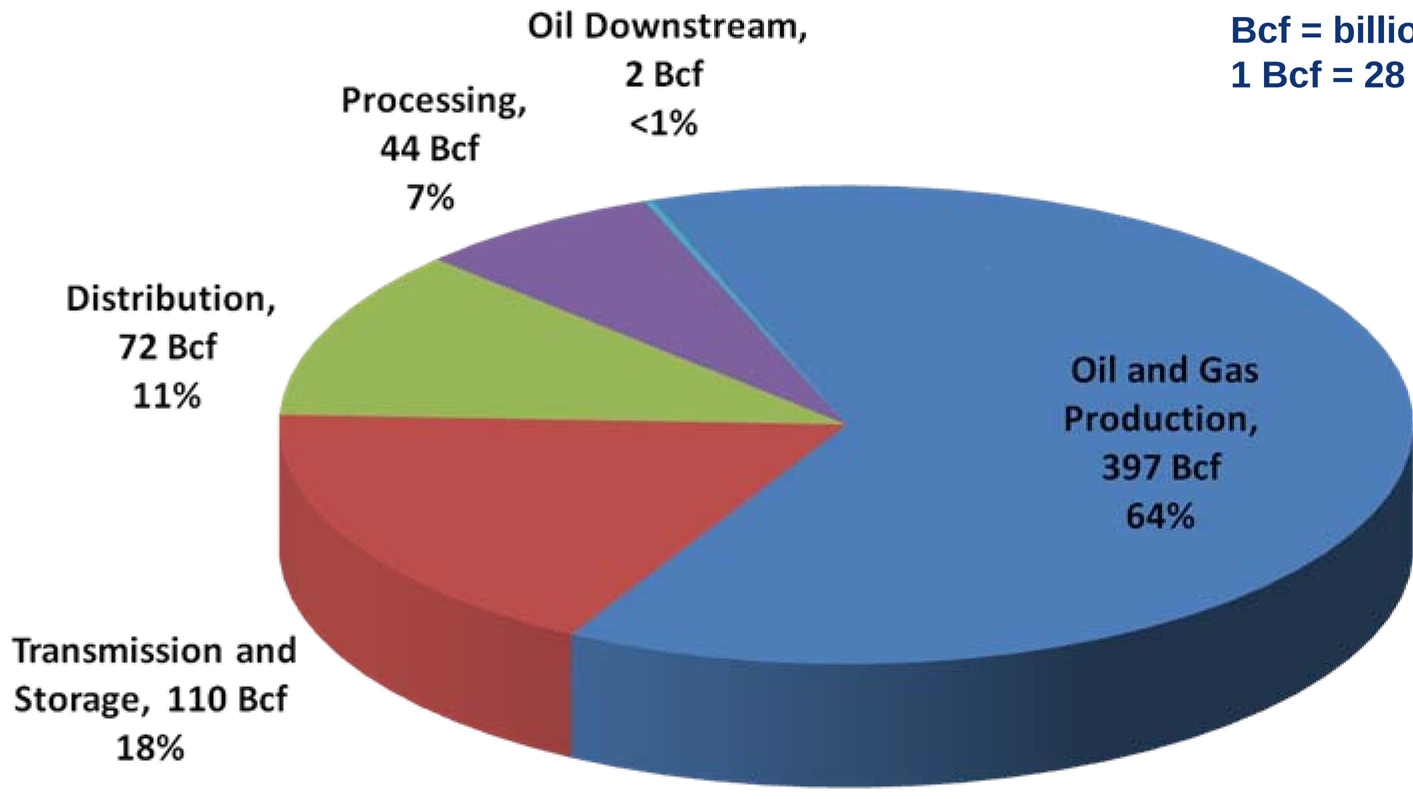


Source: World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States, April 2011 (http://www.eia.gov/analysis/studies/worldshalegas/)

U.S. Oil & Natural Gas System Emissions

2009 U.S. Oil and Gas Industry Methane Emissions (624 Bcf / 252 million tonnes CO_2eq)

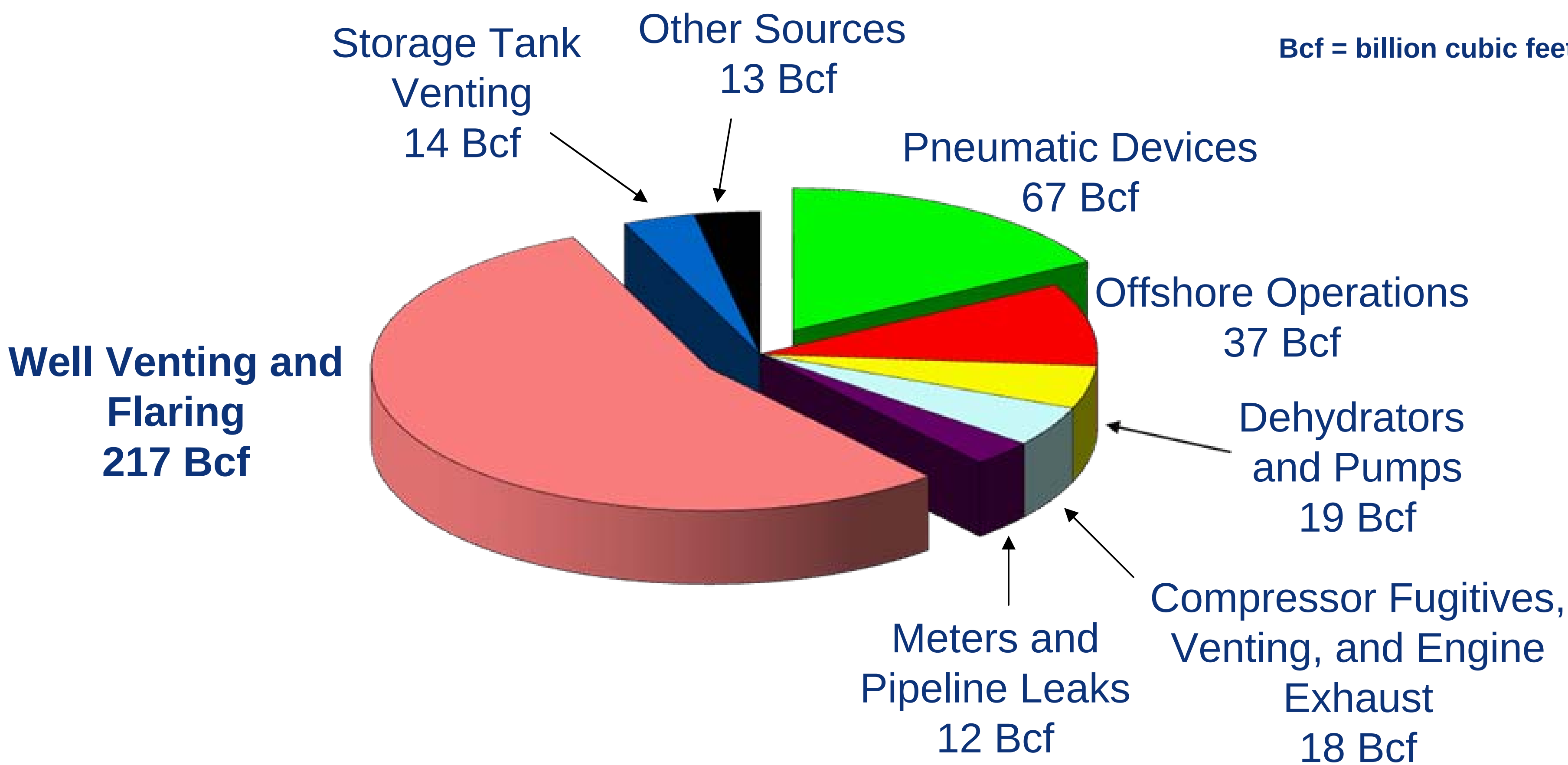
Bcf = billion cubic feet
1 Bcf = 28 Million m^3



EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2009.* April, 2011. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html.

2009 Oil and Natural Gas Production Emissions Sources

2009 Production Sector Methane Emissions (397 Bcf / 160 million tonnes CO_2e)



Source: EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990 – 2009*. April, 2011. Available on the web at: epa.gov/climatechange/emissions/usinventoryreport.html.

Overview of Hydraulic Fracturing

- Gas wells in tight formations, coal beds, and shale may require hydraulic fracture to produce gas
  - For new wells or re-fracturing to stimulate production of existing wells (workovers)
- During completion of the well, flowback of fracturing liquids and proppant (often sand) is necessary to clean out the well bore and formation prior to production
  - High volume of liquid and solids are produced at high pressure to expel sand, cuttings, and hydraulic fracture fluids prior to production
- Hydraulic fracturing video: www.northernoil.com/drilling
  - Video is for oil production but well drilling and hydraulic fracture process similar for gas

Natural Gas Losses during Gas Well Completions and Workovers

- One standard practice is for operators to produce flowback to an open pit or tank to collect sand, cuttings, and fluids for disposal
  - Vent or flare the natural gas
- Typical composition of pollutants in flowback emissions:
  - Primarily methane (CH_4)
  - Substantial amount of VOCs
  - Trace amounts of HAPs

Source: Newfield

Reduced Emission Completions (RECs)

- Practice to recover natural gas and condensate produced during flowback following hydraulic fracture
- Portable equipment brought to well site
  - Separates sand and water
  - Processes gas and condensate for sales
- Route recovered gas through dehydrator and meter to sales line, reducing venting and flaring while increasing gas sales

Portable REC Equipment

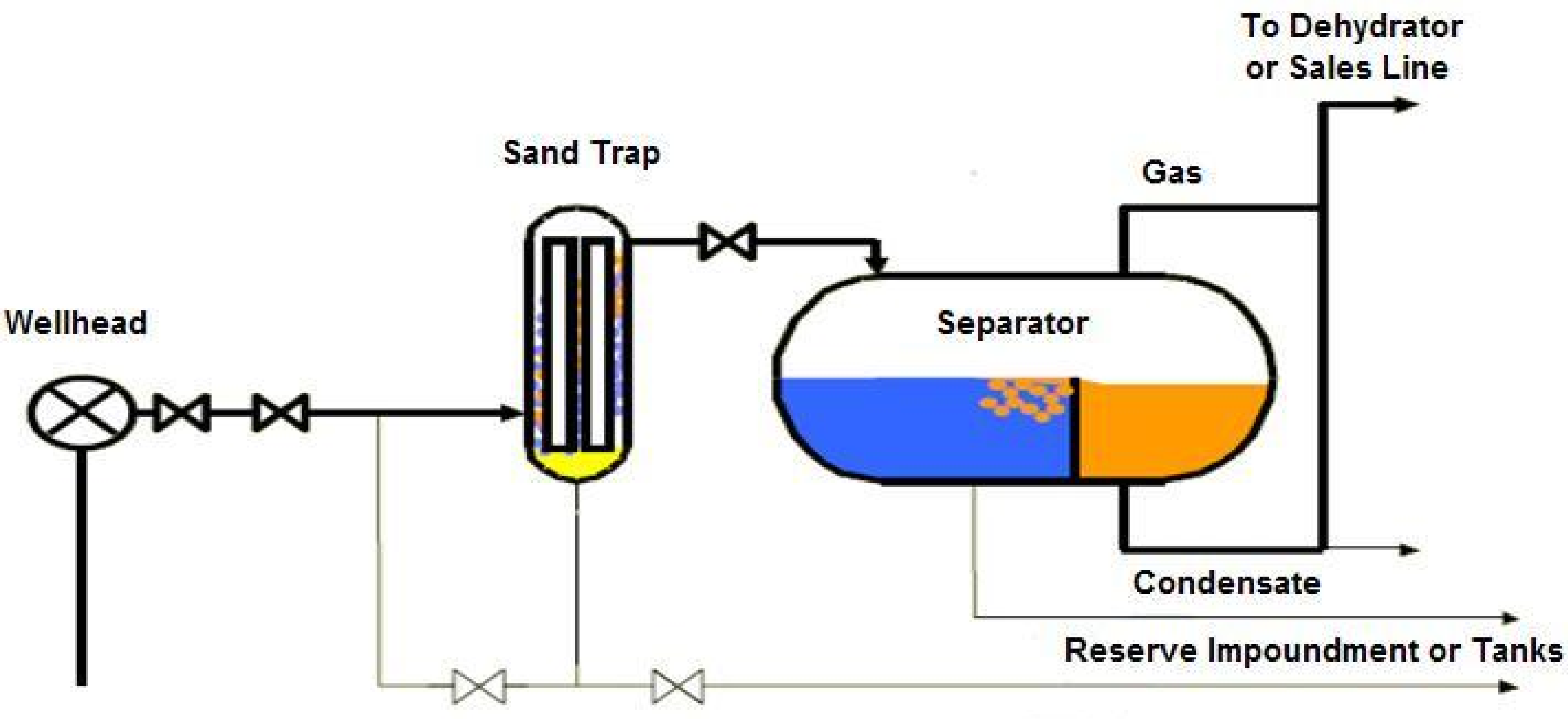
Source: Weatherford

RECs: Equipment

- Skid or trailer mounted portable equipment to capture produced gas during cleanup
  - Sand trap
  - Three-phase separator
- Use portable dehydrator to remove water from the produced gas before it enter sales line

Source: Williams

RECs: Diagram



(for produced fluid, mainly water)

Temporary, Mobile Surface Facilities, Adapted from BP

RECs: Preconditions

- Permanent equipment required on site before cleanup
  - Nearby gathering system / sales line
  - Piping from wellhead to sales line
  - Lease meter
  - Gas quality meets gathering system specification
  - Stock tanks for wells producing significant amounts of condensate
  - Dehydrator (if needed to process gas to pipeline specifications)

RECs: Benefits

- Reduced methane and other air emissions during completions and workovers
- Increase sales revenue from recovered gas and condensate
- Partners report recovering 500 to 2,000 Mcf/day/well
  - Partners also report recovering zero to several hundred bbl/day/well of condensate (which can result in significant additional revenue)
  - Typical well flowback time is 3 to 10 days
- Improved relations with government agencies, public, and neighbors
- Reduced environmental impact
- Reduced disposal costs

Partner Experience Economics

- Noble in Ellis County, Oklahoma
  - RECs on 10 wells using energized fracturing
  - Total cost of $325,000
  - Estimated net profits: $340,000, or $34,000 per well on average
- BP in Green River Basin, Rocky Mountain region
  - RECs on 106 total wells, high and low pressure
  - Capital investment of ~$500,000 per skid (including portable three-phase separators, sand traps, and tanks)
  - Conservative net value of gas saved: $20,000 per well
- A Partner Company (Fort Worth Basin, Texas)
  - RECs on 30 wells
  - Incremental cost of $8,700 per well
  - Conservative net value of gas saved: about $50,000 per well

Related Regulations (1 of 2)

- Review of Clean Air Act New Source Performance Standards (NSPS) and National Emissions Standards for Hazardous Air Pollutants (NESHAP) resulted in a proposed rule, released July 2011, which includes a revised NSPS regulation for smog-forming volatile organic compound (VOC) emissions
- Flowback emissions from completion of fractured gas wells are included in the NSPS proposal; this is the first federal air standard for wells that are hydraulically fractured
- The proposed rule would apply to the more than 25,000 wells that are fractured and refractured each year in the U.S.
  - VOC emissions would be minimized through the use of "green completions," also called "reduced emissions completions"
  - When gas cannot be collected, VOCs would be reduced through pit flaring, unless it is a safety hazard
  - Nearly 95 percent reduction in VOCs emitted from new and modified hydraulically fractured gas well
  - Co-benefit of significant methane reductions

Related Regulations (2 of 2)

- Oil and Gas Systems Greenhouse Gas Reporting Rule, Subpart W
  - Reporting of emissions from the oil and gas sector
  - For hydraulically fractured well completions and workovers, will collect total number of completions and workovers and emissions from these sources as well as the number of wells using Reduced Emission Completion techniques and total gas recovered for sales

- State Regulations
  - Wyoming requires “flareless completions” for wells in Jonah-Pinedale and concentrated development areas
  - Colorado requires sand traps, surge vessels, separators, and tanks as soon as practicable during flowback and cleanout of certain wells

  - EPA is also addressing potential water or other impacts under relevant statutes including Safe Drinking Water Act, Clean Water Act, Resource Conservation and Recovery Act

Water Impacts - Research

- US Congress asked EPA to study relationship between hydraulic fracturing and drinking water resources.
- **Peer-reviewed** study with first results due in late 2012 and final report in 2014.
- **Lifecycle approach**, use of **case studies**, focus on **sources** and **pathways** of potential impacts to water resources.
- **Stakeholder involvement** throughout process.
  - Information request to natural gas service providers
  - Technical workshops to inform study
  - Public and sector-specific meetings

- Topics that are not within the scope of the study include: **air quality, impacts on land and aquatic ecosystems, seismic risks, public safety** and **occupational risks**

In Summary – EPA's Approach

- Responsible development of America's shale gas resources offers important economic, energy security, and environmental benefits
- EPA plays an important role in addressing public concerns, ensuring environmental protection, and in working with federal and state partners to manage the benefits and risks of shale gas production
- The Agency is committed to improving scientific understanding of the potential environmental impacts of shale gas extraction and using tools at hand to address any known concerns
- Through U.S. participation in the Global Methane Initiative, EPA seeks to share lessons learned internationally to promote available, cost-effective methane emission reduction activities related to shale gas development as well as the oil and gas sector as a whole

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http://www.epa.gov/gasstar/

http://www.epa.gov/gasstar/tools/recommended.html