

# Addressing the Challenges Along the Shale Gas Supply Chain

The production of natural gas from shale formations is one of the fastest-growing segments of the U.S. oil and gas industry today. The U.S. Energy Information Administration's *Annual Energy Outlook 2012* reference-case scenario has shale gas production increasing from 5.0 trillion ft<sup>3</sup>/yr (23% of total U.S. dry gas production) in 2010 to 13.6 trillion ft<sup>3</sup>/yr (49% of the total) in 2035.

Whether the gas is obtained from a shale formation or another source, the natural gas supply chain is the same. It encompasses wells, gathering and processing facilities, storage, transportation and distribution pipelines, and ultimately an end user, such as an industrial manufacturing plant or a single-family home. This special section on shale gas spans the supply chain.

To set the stage and provide perspective, the first article deals with the end of the supply chain. William Liss of the Gas Technology Institute (GTI) asks the question posed by the title of a recent International Energy Agency report, *Are We Entering a Golden Age of Gas?* Liss believes that based on the confluence of shale gas resources, hydraulic fracturing, and directional drilling techniques, the answer in the U.S. is an emphatic "yes." He supports this assertion with a look at the supply and demand picture in key

sectors of the economy that rely on natural gas — industrial, power generation, transportation, residential, and commercial — and the transformative role that shale gas is playing.

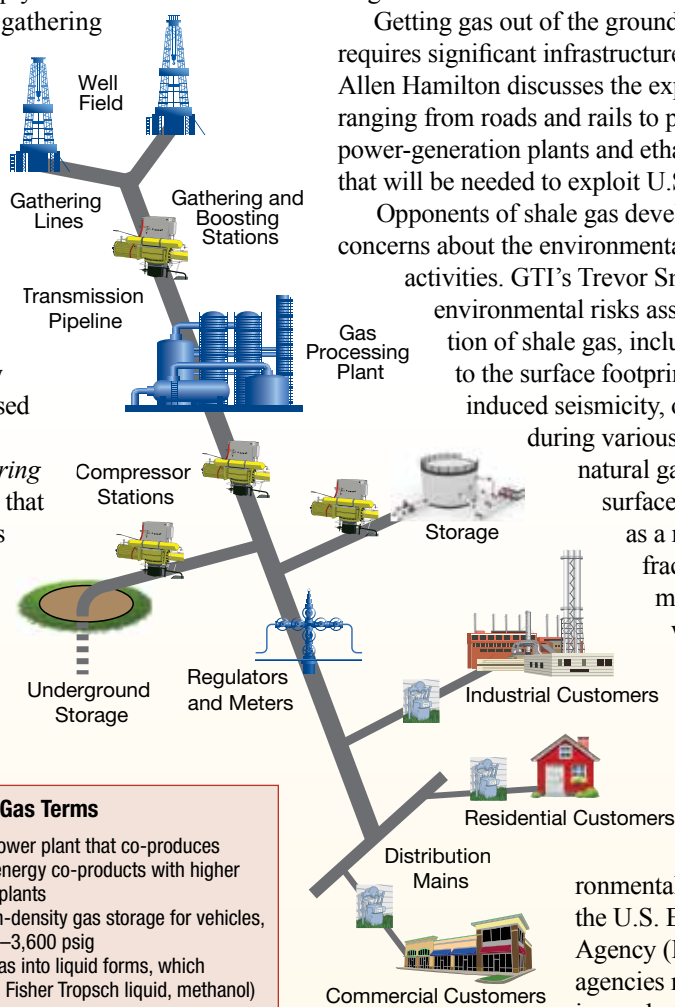
In the second article, Stephen A. Holditch, P.E., of Texas A&M Univ. explains the basics of horizontal drilling, hydraulic fracturing, and fracture fluids. He looks at the state of the art and recent developments, as well as some of the remaining challenges and opportunities, and he provides insight into the economics of shale gas production.

Getting gas out of the ground and to the customer requires significant infrastructure. Jesse Goellner of Booz Allen Hamilton discusses the expansion of assets — ranging from roads and rails to pipelines and seaports to power-generation plants and ethane crackers and more — that will be needed to exploit U.S. shale gas resources.

Opponents of shale gas development have raised concerns about the environmental footprint of these activities. GTI's Trevor Smith explores the potential environmental risks associated with the production of shale gas, including impacts on land due to the surface footprint of the operations and to induced seismicity, on air due to emissions during various activities along the natural gas supply chain, and on surface water and groundwater as a result of water use in the fracturing process and the management of the wastewater generated.

The final article, by Mary Ellen Ternes, an attorney with McAfee & Taft, expands Smith's discussion of environmental footprint. She explains the key environmental statutes under which the U.S. Environmental Protection Agency (EPA) and delegated state agencies regulate hydraulic fracturing and other aspects of shale gas development. She also touches on water sourcing issues such as property rights associated with surface waters and groundwater.

Chemical engineers will be needed to innovate all along the supply chain. These articles provide a glimpse into the challenges and opportunities that lie ahead.



## Glossary of Natural Gas Terms

- CHP** *Combined Heat and Power:* A type of power plant that co-produces power and heat (e.g., steam) or other energy co-products with higher efficiency than power-generation-only plants
- CNG** *Compressed Natural Gas:* Used for high-density gas storage for vehicles, typically at nominal pressures of 3,000–3,600 psig
- GTL** *Gas to Liquids:* Conversion of natural gas into liquid forms, which includes chemical transformation (e.g., Fisher Tropsch liquid, methanol) or phase change to liquefied natural gas
- LNG** *Liquefied Natural Gas:* A cryogenic liquid form of natural gas (at –150°C to –160°C) used for high-density stationary storage and vehicle use
- NGL** *Natural Gas Liquids:* A mixture of light hydrocarbons such as ethane, propane, and butanes that are co-produced and extracted from natural gas
- NGV** *Natural Gas Vehicles:* Vehicles that operate on natural gas (CNG or LNG)

Compiled by William Liss, GTI

CEP