Technological advances have changed virtually every aspect of our lives. Whether we embrace them or despise them, we are surrounded by high-tech devices that help us communicate, navigate, translate...even recreate.

Energy consumers have also benefited from new technology. Improvements in energy efficient appliances enable us to use less energy and lower our costs. New developments in power generation, from highly efficient, combined-cycle natural gas turbines to advanced solar and wind technologies, mean we can produce power while reducing our environmental footprint.

But a less heralded revolution in drilling technology has changed our energy world dramatically in just the past few years. Refined drilling equipment and new drilling techniques can now extract natural gas from vast shale formations thousands of feet underground. As this technology has become more cost-effective, it has unlocked access to vast North American natural gas resources – now estimated at well over 100 years’ supply.

As an integral part of the continental natural gas market, Pacific Northwest energy consumers are benefiting from this extraordinary market transformation. Just a few years ago we were looking for ways to access more natural gas to balance our rapidly growing energy demand. Today, abundant shale gas potential creates a new set of opportunities and challenges: How do we put this clean-burning resource to its most efficient use? How do we manage the environmental issues related to developing unconventional gas fields, particularly in communities unfamiliar with drilling? What are the repercussions for infrastructure, including pipelines and storage?

Even with new issues to address, the new abundance provides tremendous opportunities for the region and North America. The advantage of plentiful North American sources of natural gas supply puts us in the driver’s seat to manage our own energy destiny. It allows us to rely less on foreign oil – and on Gulf Coast resources prone to hurricane disruptions. And the timing couldn’t be better: as new energy policies seek to move us away from certain polluting energy resources and encourage the use of cleaner burning and renewable resources, natural gas is already serving a growing role directly heating homes and businesses, generating electricity and fueling vehicles.

This white paper explores where our natural gas supply comes from, how technology has boosted our domestic supply and how the industry is managing challenges posed by new drilling techniques. It also discusses strategies to optimize production and the use of this valuable resource.
THE CHANGING NATURAL GAS SUPPLY PICTURE

North America’s natural gas needs are met almost entirely by its own production. In 2008, 72 percent of the continent’s natural gas supply was produced in the U.S., 21 percent in Canada and 6 percent in Mexico. Less than 1 percent of the natural gas used in North America came from imported liquefied natural gas (LNG).¹

Pacific Northwest energy consumers have long benefited from their proximity between two prolific natural gas producing areas: the Western Canada Sedimentary Basin (WCSB) and the U.S. Rockies (primarily in Colorado, Utah and Wyoming). More than one third of all natural gas produced in North America – more than 26 billion cubic feet per day (Bcf/d)² in 2008 – comes from these two regions. More than half the natural gas consumed in the region comes from the WCSB and the rest from the Rockies.

Until recently, most of our regional and continental supply came from conventional sources that are now maturing and producing less gas (see box). The expense and complexity of developing new conventional sources (such as Alaska’s North Slope) and unconventional sources seemed to preclude them as quick or wide-scale solutions, so we were resigned to declining continental supply. All that has changed in the past few years. The convergence of higher natural gas prices and enhancements of drilling technologies made many unconventional natural gas plays economically viable and producers lost no time getting rigs in place. Already, shale plays are producing about 10 percent of North America’s natural gas supply.¹ Looking forward, shale gas is expected to make up 50 percent of U.S. and Canadian combined production by 2020, up from 16 percent in 2009.³ Unconventional gas development in the U.S. alone could make up 56 percent of U.S. supply by 2030, led by increases in shale gas production.⁴

Conventional vs. Unconventional Resources

Conventional natural gas is contained in sandstone or limestone formations that store the gas in interconnected pore spaces, much like a sponge, allowing easy flow to the wellbore. These reservoirs can be developed with traditional vertical wells, which can often recover 80-95 percent of existing gas. Conventional gas accumulations tend to be distributed over a much larger area and generally require “well stimulation” (usually with high-pressure water) to be economically productive. Recovery factors are typically 20-30 percent.

By contrast, unconventional natural gas is contained in formations with very poorly connected pores, typically made up of “tight” sandstone, coal beds, or shale. Unconventional gas accumulations tend to be distributed over a much larger area and generally require “well stimulation” (usually with high-pressure water) to be economically productive. Recovery factors are typically 20-30 percent.

Our Natural Gas Supply Yesterday, Today and Tomorrow

Productive Capacity in the U.S. and Canada

Supply Potential at $6.50 NYMEX

Supply Can Grow Substantially while Maintaining Affordability for Consumers

![Bar chart showing actual and projected natural gas production from 2000 to 2020.](chart.png)

- Actual natural gas production
- Projected natural gas production
- Shale gas becomes more than 10% in 2009 to 50% by 2020

Source: Encana, IHS Energy

Natural gas produced from shale is a prolific, affordable and increasingly important part of North American consumers’ supply. Source: Encana, IHS Energy.

HOW MUCH GAS? AND WHERE IS IT?

The Potential Gas Committee (PGC, Colorado School of Mines), which evaluates the U.S. gas resource biennially, estimates a total technically recoverable natural gas resource of over 2,000 Tcf in the U.S. as of year-end 2008. That number is 77 percent higher than the resource assessment in 1990. Of the 2,000 Tcf of natural gas, 600 Tcf or about 30 percent is attributed to shale gas development alone. Just five years earlier, the shale resource was estimated at 35 Tcf.⁵ Overall, U.S. natural gas deposits are more widespread and larger than U.S. coal deposits.⁶

In Canada, an estimated 700-1,300 Tcf of marketable (similar to the PGC’s “technically recoverable”) natural gas exists – double to quadruple previous estimates – of which between 128 and 343 Tcf could come from shale.⁴ In total, the two nations’ natural gas resource equals more than 100 years’ supply at North America’s current consumption rate.

This is great news for natural gas consumers, including those in the Pacific Northwest. Much of this unconventional growth is occurring in the two production areas serving our region. In the Rockies, the estimate of technically recoverable gas grew 60 percent between 2006 and 2008, according to the PGC. In addition, more than half of Canada’s potential shale supplies are located in the WCSB in British Columbia (BC). There is also growing gas production from other unconventional sources, such as coal beds and tight sands, in both areas. Overall, total annual natural gas production serving the region (and other markets) could approach or exceed 30 Bcf/d by 2019 (up from 26 Bcf/d currently).

² EIA; Statistics Canada – dry natural gas production through 2008. StatCan data adjusted from Terajoules to Dekatherms then to Bcf using a heat rate of 1030 Btu/cubic foot.
³ The Natural Gas Economy, presentation by Encana Corp. at the WEI Energy Management Meeting, May 6, 2010.
⁶ Canadian Society for Unconventional Gas (CSUG), www.CSUG.ca.
The advantages of growing continental natural gas supplies are many. Because production has risen faster than recent demand, consumers are currently benefiting from moderated prices. Prices could move higher as the economy improves and the market establishes a new supply/demand balance, but increased production capacity should limit prices to levels lower than those being projected only a couple of years ago. In addition, because most natural gas consumed in North America is produced here, natural gas prices are insulated from political instability and other uncertainties affecting international energy markets like oil. And finally, this new-found abundance gives us the ability and flexibility to match demand growth spurred by state/provincial and federal energy policies. As these policies establish renewable energy goals and greenhouse gas (GHG) emission standards, they are encouraging the use of more natural gas – the cleanest-burning fossil fuel – for direct heating, power generation and transportation (primarily fleet vehicles).

A CLOSER LOOK

NEW EXTRACTION TECHNIQUES COAX ELUSIVE GAS TO SURFACE

Natural gas producers have literally taken a new direction for extracting natural gas. Besides drilling down, they are now drilling sideways. While the concept is simple, the technology enabling it took millions of dollars to develop and years to refine.

Turning a drill bit from a vertical to a horizontal trajectory allows one surface well to access gas over a large geographic area. Combined with hydraulic fracturing, which frees the gas molecules to flow to the surface, this drilling technique can efficiently and economically produce natural gas from areas once considered uneconomic. For example, four to eight horizontal wells drilled from a single well pad can access the same reservoir volume as 16 vertical wells (on 16 separate pads). This not only reduces the number of well pads, but also the need for access roads, pipeline routes, and production facilities – minimizing surface disturbance, impacts to habitat and the public, and the overall environmental footprint by up to 90 percent.8

Developing a horizontal well starts out like a vertical well, including the installation of multiple steel casings, each cemented in place, to isolate the gas reservoir from freshwater aquifers and other subsurface features. When drilling reaches a predetermined depth, the drill is turned and horizontal drilling begins. The direction and length of the drill path is determined based on known natural fracture trends in the geological area; horizontal runs of a mile or more are not unusual.

Once drilling is completed, operators prepare to stimulate the well and bring the gas to the surface.

That's where hydraulic fracturing comes in. By pumping high-pressure fluid into the shale, cracks or fractures are created in the rock formation, enabling the natural gas to flow out. (Fracture fluids are about 99.5 percent water mixed with 0.5 percent additives such as friction reducers and corrosion inhibitors, along with sand, which helps to “prop” open the cracks.) This process is usually done in multiple stages from one wellbore, dramatically improving the economics of the well. Micro-seismic imaging allows operators to visualize where fractures are occurring.

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How much this combination of horizontal drilling and hydraulic fracturing has revolutionized the industry can be seen in the numbers. Until the last few years, drilling rigs in operation (rig counts) served as a reasonable proxy for production, with gas volumes correlated to increases or decreases in the number of working rigs. Average weekly rig counts during 2009, however, were half that of 2008 — about 1,000 total drilling rigs operating compared to 2,000 rigs at the 2008 peak — but domestic production actually grew in 2009 over 2008. This is because the new drilling fleet — of which 62 percent are now horizontal rigs – is more efficient. Simply put, a horizontal rig produces significantly more natural gas today than a conventional vertical rig did just a few years ago.

OTHER FUTURE SOURCES OF NATURAL GAS SUPPLY

Besides shale gas, our continental natural gas supply is also being boosted by production from coal beds and tight sands. Together these sources could eventually provide more than 300 Tcf in natural gas. However, understanding incremental sources of new gas supply is not just a matter of looking at unconventional gas development. Other future sources include:

Frontier gas supplies – The Mackenzie River Delta (Canada) and the Alaska North Slope contain some 9 and 35 Tcf in reserves, respectively. This would make frontier gas the second largest provider of incremental supply, behind only shale gas. Pipelines have been proposed that could bring this gas to the lower 48 within the next decade.

Offshore resources – An estimated 420 Tcf of natural gas sits immediately offshore in the U.S., and another 43 Tcf off the BC coast.

LNG – Proven natural gas reserves around the globe approach 4,000 Tcf. Currently, LNG imports serve about 1 percent of North America’s natural gas requirements. The future role of LNG will depend on domestic and global energy market dynamics and natural gas prices, but our ability to import gas (and store it; see box) provides valuable flexibility to serve demand with the most cost-effective supply should we experience unforeseen changes in our domestic supply.

Biogas – Whether from human or animal waste, landfills or dairy farms, biogas is used in various applications around the world, including as a fuel source for electricity generation or transportation. According to the Gas Technology Institute (GTI), natural gas from the 9 million dairy cattle in the U.S. alone could potentially produce sufficient methane to meet 1 percent of total U.S. consumption of natural gas. And capturing this “fugitive” methane removes it from the environment — a two-for-one benefit.

Regulations Keep Close Tabs on Drilling

In the U.S., a series of federal laws governs most environmental aspects of shale gas development. For example, the Clean Water Act (CWA) regulates surface water discharges from shale gas drilling, as well as stormwater on land. The Safe Drinking Water Act (SDWA) regulates the underground injection of fluids from shale gas activities. The Clean Air Act (CAA) limits air emissions from all equipment. And the National Environmental Policy Act (NEPA) requires that exploration and production be thoroughly analyzed for environmental impacts.

By statute, states may adopt their own standards; however, these must be at least as protective as the federal standards they replace, and may even be more protective in order to address local conditions. Once these state programs are approved by the relevant federal agency (usually the EPA), the state then has primacy jurisdiction. — DOE10

MANAGING OPPORTUNITIES AND CHALLENGES

Along with the good news of shale gas potential comes responsibility for producing the gas in a environmentally responsible manner. Hydraulically fracturing wells is a water-intensive procedure that requires careful water management and groundwater protection. This process is successfully accomplished every day by operators, under stringent oversight by regulators. Natural gas production is subject to federal, state and local regulations that cover everything from initial permits to well construction to water disposal. Developers are required to provide analyses of how a proposed well will affect all natural resources, including soil, water, plants and wildlife, as well as public safety.

Still, the recent rapid expansion of unconventional gas drilling, particularly in communities not familiar with larger-scale oil or gas development, has understandably heightened local concerns. These include:

Aquifer protection: Natural gas producers are mandated by law to protect freshwater aquifers from potential contamination. Among the many steel casings installed at a well site is a cemented “surface casing” that extends far below the base of the local ground water aquifer, protecting it from any production fluids or gas produced through the bore hole. The aquifer is naturally separated from the gas reservoir itself by thousands of feet and millions of tons of impermeable rock.

Most additives contained in fracture fluids, including sodium (and) potassium chloride and diluted acids, present low to very low risks to human health and the environment. — Ground Water Protection Council (GWPC)

Disposal of “frac” fluids: While fracture fluids are primarily water mixed with a small amount of additives — many used in household products — they are nonetheless kept separate from surface water and aquifers per regulatory requirements. Recovered frac fluids are collected and then managed as required by the well operator’s permit: typically they are recycled for the next frac job or injected into saltwater aquifers far underground. But it is important to put this into context. Every year the onshore U.S. oil industry safely disposes of some 18 billion barrels of produced water. By comparison, a high-volume shale fracturing operation may return some 50,000 barrels of fracture fluid and water to the surface.11

10 U.S. DOE, State Oil and Natural Gas Regulations Designed to Protect Water Resources, May 2009, produced in collaboration with the Ground Water Protection Council (GWPC).
11 The Future of Natural Gas, Massachusetts Institute of Technology (MIT), 2010.
### Typical Composition of Fracture Fluid

- **Water and Sand: 99.5%**
- **Other: 0.5%**
  - Acid
  - Friction Reducer
  - Surfactant
  - Gelling Agent
  - Scale Inhibitor
  - pH Adjusting Agent
  - Breaker
  - Crosslinker
  - Iron Control
  - Corrosion Inhibitor
  - Antibacterial Agent
  - Clay Stabilizer

With over 20,000 shale wells drilled in the last 10 years, the environmental record of shale gas development is for the most part a good one.”

— MIT study, The Future of Natural Gas, 2010

Local water supply use: Fracturing a horizontal shale gas well can require 2 to 4 million gallons of water, depending on the basin and formation characteristics. While these volumes may seem large, they represent less than one percent of total water use in each shale gas area. Put in context, these volumes are also small compared to some other energy-related water uses, notably electric power generation. In addition, producers closely coordinate withdrawals with local water officials to ensure a balance between drilling needs and existing water demands.

Beyond regulatory requirements, however, the natural gas industry understands that addressing public concerns is an integral part of every drilling project. Producers have responsibility to educate the community about the drilling process and potential impacts, to strictly manage those impacts and to maintain transparency.

### NWGA’s Policy Recommendations

Besides market dynamics, public policy can substantially affect natural gas supply. In particular, emerging energy policies that address GHG emissions and regulations that may be developed in response to new drilling techniques could have far-reaching impacts on access to, restrictions on and use of natural gas in the future.

EPA’s Office of Research and Development (ORD), for example, is currently conducting a study on the relationship between hydraulic fracturing and drinking water. Despite numerous protections in place, EPA wants to be sure it has identified all potential risks of the now commonly used procedure. Initial study results are expected in late 2012.

To ensure we can continue to benefit from abundant unconventional gas supplies, and to optimize how we use this valuable resource, we encourage policymakers and regulators to consider the following:

**Ensure access to natural gas supplies, particularly new unconventional resources.** New policies should effectively address barriers that impede infrastructure expansion and construction (e.g., permitting delays, redundant oversight) while strengthening and clarifying environmental regulations and accountability – to encourage appropriate development of new natural gas resources.

**Treat competing fuels fairly.** New GHG emission-control policies should treat energy sources fairly, consistent with their contributions and economic impact; e.g. they should create a level playing field. Otherwise these policies risk skewing the marketplace and diverting consumers to less efficient, more costly and more polluting energy sources.

**Encourage the right fuel for the right use.** Recognizing that some energy sources are more efficient for some purposes than others, new energy policies should guide consumers to make the right choices. Providing consumer incentives to upgrade appliances and equipment, for example, will work only if these incentives accurately reflect efficiency differences between fuel types.

**Fund more research and development (R&D).** Policymakers should encourage more collaborative R&D to refine new drilling technology (e.g., reduce water used in fracturing, develop cost-effective water-recycling technology, determine better reservoir models); to explore and develop carbon-capture and sequestration methods; and to improve or enable access to other unconventional natural gas forms – from renewable biogas to methane hydrates (ice-trapped methane, a potentially huge source of natural gas found along the ocean floor or in arctic permafrost).
CONCLUSION

What a difference a few years can make.

Consumers in the Pacific Northwest and across North America have entered a new era of more plentiful natural gas. This has already produced tangible benefits. Prices are much lower today than in 2008. In addition, the added diversity of supply means we are increasingly insulated from seasonal disruptions like hurricanes. Five years ago, when Hurricane Katrina disrupted natural gas production in that region, the Gulf was providing nearly one quarter of U.S. supply. Now, it is producing only 12 percent. Shale gas production is providing the difference.

Besides more favorable prices and supply security, the new abundance also means the natural gas industry can participate fully in achieving our regional and continental environmental goals. In a carbon-constrained world, the role of natural gas will only grow. And now we have the resources to back that up.

For the Pacific Northwest, the new market dynamics don’t change where our supply comes from – the WCSB and Rockies – but the source will be increasingly unconventional. And the development of large shale plays in the East and South may mean we will now compete less for WCSB and Rockies’ production, which has been increasingly headed to other regions.

While shale gas is our champion now and for the foreseeable future, the strength of our natural gas supply remains in its diversity. Continued security and reliability is only possible by optimizing access to all our resources, including onshore and offshore, conventional and unconventional, and imported. It will require that we maintain and add infrastructure, both pipelines and storage, as required to keep the gas flowing. And it will depend on effective policies and regulatory measures that protect all interests in securing a stronger domestic energy future.

This White Paper was published by the Northwest Gas Association (NWGA) to provide the public, policy makers, opinion leaders and the media with accurate and timely information about natural gas supply in the region and across the continent. NWGA members include six natural gas utilities serving communities in Oregon, Washington, Idaho and British Columbia, and three interstate pipelines that move natural gas from supply basins into and through the region. NWGA members deliver or distribute all the natural gas consumed in the Pacific Northwest. For more information, contact us or visit our website at www.nwga.org.

NWGA RESOURCES

WEBSITE AND SOCIAL MEDIA
The NWGA website provides visitors with access to our various white papers and studies, as well as industry news, articles, and basic information on natural gas. Visitors have the opportunity to express their opinions and provide feedback to our blog and poll. Our website is located at www.nwga.org. You can also find us on various social media platforms providing current Pacific Northwest natural gas industry information. Look for us on Facebook, LinkedIn and follow us on Twitter (@Meg_at_NWGA).

PRESENTATIONS
NWGA provides presentations on the natural gas industry to interested groups throughout the Pacific Northwest. The most common presentation requested is our Northwest Gas Outlook presentation; however, presentations tailored to fit your needs are available. To schedule a presentation contact the NWGA office at 503.344.6637 or info@nwga.org.

ANNUAL CONFERENCE
NWGA partners with Northwest Industrial Gas Users each year to bring an annual energy conference to the Pacific Northwest. The conference showcases top-notch speakers from the energy industry including regional experts, energy policy leaders and key decision-makers, and focuses on current energy industry issues. The energy conference is held in early June in Portland, Oregon. For more information, go to the NWGA website or contact us at info@nwga.org.

ANNUAL NORTHWEST GAS OUTLOOK
The NWGA annually produces a comprehensive study about natural gas demand, supply and capacity serving the Pacific Northwest. The study is unique in that it represents a consensus view of the Northwest natural gas market developed by industry participants serving the region.