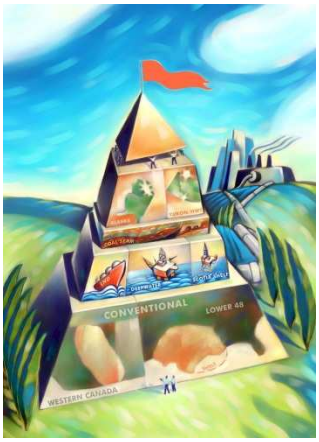


**Schedule "B"**

# Natural Gas Supply and Demand Forecast to 2046

## North America and Canada

**Prepared for:**

**Woodfibre LNG Export Pte. Ltd.**

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Supply and Supply Cost

**APEGA Permit P08121**

*Calgary, Alberta*

**July 22, 2013**

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# NATURAL GAS SUPPLY AND DEMAND FORECAST TO 2046

## TABLE OF CONTENTS

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# 1. INTRODUCTION

**Woodfibre LNG Export Pte. Ltd.** ("Woodfibre LNG Export", or "Project") **or its nominee** has applied to the National Energy Board for a licence to export up to 2.1 million tonnes per annum of liquefied natural gas ("LNG")[1] for a period of 25 years starting between 2016 and 2021. Natural gas will be liquefied at the proposed LNG terminal to be located near Squamish, British Columbia and transported from there by LNG carriers to markets primarily in the Asia-Pacific region. **Woodfibre LNG Export Pte. Ltd.** retained Ziff Energy Group ("Ziff Energy") to provide an independent assessment of North American, Canadian, and Western Canadian natural gas supply, demand, flows, and costs, and to draw conclusions regarding the balance of supply and demand for the period 2016-2046 within which the applied-for export would take place. This report presents summary findings on gas supply, demand, and market dynamics through 2046, and draws related conclusions. The work is extracted from Ziff Energy Group's detailed proprietary sectorial and regional demand analyses, basin-by-basin gas supply work, full-cycle cost studies, and understanding of changing continental gas flows.

# 2. SUMMARY

## 2.1 Gas Resources

Ziff Energy's evaluation of North American and Canadian gas resources shows there is productive potential far exceeding projected gas demand over the forecast period. North America has 2,559 Tcf (2,700 EJ) of remaining resources as of January 1, 2013. Canada has 593 Tcf (626 EJ) of remaining gas resource of which 90% is to be found in Western Canada (535 Tcf, 564 EJ).

## 2.2 Gas Supply

Ziff Energy forecasts North American supply of natural gas to grow to 123 Bcf/d (130 PJ/d) in 2046 from 80 Bcf/d (84 PJ/d) in 2012. After 2020, Shale Gas is expected to be the main type of gas produced in North America. Canadian supply is forecast to grow to 20 Bcf/d (21 PJ/d) in 2046 from 13 Bcf/d (14 PJ/d) in 2012. Ziff Energy assumes natural gas prices rise in line with full-cycle producer costs (including a 15% before tax rate of return). If gas prices are below full-cycle producer costs, gas-directed drilling levels are expected to decline, decreasing gas supply, which would lead to higher gas prices.

## 2.3 Gas Demand

Ziff Energy forecasts North American demand[2] (including LNG export) for natural gas to increase 41 Bcf/d (43 PJ/d) to 120 Bcf/d (126 PJ/d) by 2046 from 79 Bcf/d[3] (83 PJ/d)[4] in 2013, an average annual growth rate of 1.3%/year. Within that total, Canadian gas demand (currently 8.7 Bcf/d (9.2 PJ/d)) is expected to grow at a rate of 2.5% per year driven principally by a switch away from

[1] approximate natural gas equivalent of 0.3 Bcf/d at the liquefaction plant inlet
[2] does not include 3 Bcf/d (3 PJ/d) of natural gas exports to Mexico from the U.S.
[3] Ziff Energy has treated LNG export volumes as an out-flow from North America
[4] 1 Bcf/d = 1.05 PJ/d, National Energy Board website (Statistics / Energy Conversion Tables)

coal-fired power generation, increased gas requirements for growing Oil Sands bitumen production and growth in Liquefied Natural Gas (LNG) exports. Canadian gas demand as a share of overall North American demand will grow to 17% by 2046, from 11% in 2013. During the forecast period, demand in the U.S. will grow 1.2% per year driven by strong growth (2.4 % per year) in the gas-fired power generation sector. Included in North American gas demand are LNG exports of 8.9 Bcf/d (9.4 PJ/d) in 2046 of which 4.9 Bcf/d (5.2 PJ/d) are from Canada.[5]

Ziff Energy's forecast is predicated on annual North American GDP growth of 2.2% over the forecast period. Government policies, such as putting a price on carbon emissions, will tend to increase gas demand (natural gas emits about half the carbon emissions of coal).

## 2.4 Supply / Demand Balance

The North American gas market is comprised of a large numbers of competing buyers and sellers with a multitude of purchase and sale instruments. Energy pricing is transparent and facilitated by electronic trading systems, a vigorous futures market, and various financial instruments. Natural gas markets in North America are expected to continue to function in a rational manner during the forecast period and will continue to provide appropriate market signals for development of resources to meet Canadian domestic and export demand.

Low cost sources of gas supply are growing, mainly from Unconventional Gas plays, some of which are located near major market centers. The North American gas supply system is characterized by a sophisticated network of transmission and storage infrastructure. Imports of gas from the U.S. into Eastern Canada via Dawn and Niagara are displacing some gas delivered previously via the TransCanada PipeLines Limited (TransCanada) Mainline system from Western Canada. This trend is expected to continue. Gas buyers will continue to be incented to minimize delivered gas costs in a functioning North American natural gas market. Ziff Energy expects supplies of North American gas will be available to meet demand for all Canadian and North American sectors over the forecast period. Over the forecast period, Western Canadian supply will be available for Canadian and export markets, and, given a competitive market, will preferentially flow to the markets providing highest netbacks.

Ziff Energy expects new North American gas supplies, principally from Shale Gas and other Unconventional Gas plays to more than offset declines in Conventional Gas. The market, including large LNG exports, will therefore balance. Gas from new and expanding gas supply basins will alter North American gas flows. Western Canadian demand is increasing, providing economic incentive for Western Canadian producers to sell locally and minimize transportation costs. Therefore, the Western Canada region will likely be well-supplied over the forecast period with adequate supply for LNG exports which are expected to reach 4.9 Bcf/d (5.2 PJ/d) by 2046.

[5] Ziff Energy considers there is gas resource potential available for higher levels of North American LNG export than indicated here; Ziff Energy are considering NEB approved exports with the addition of Woodfibre LNG Export Project volumes (assumptions shown in Section 8.5)

# 3. BASIN COMPETITIVE FACTORS

## 3.1 Competition with U.S. Gas in Traditional Markets

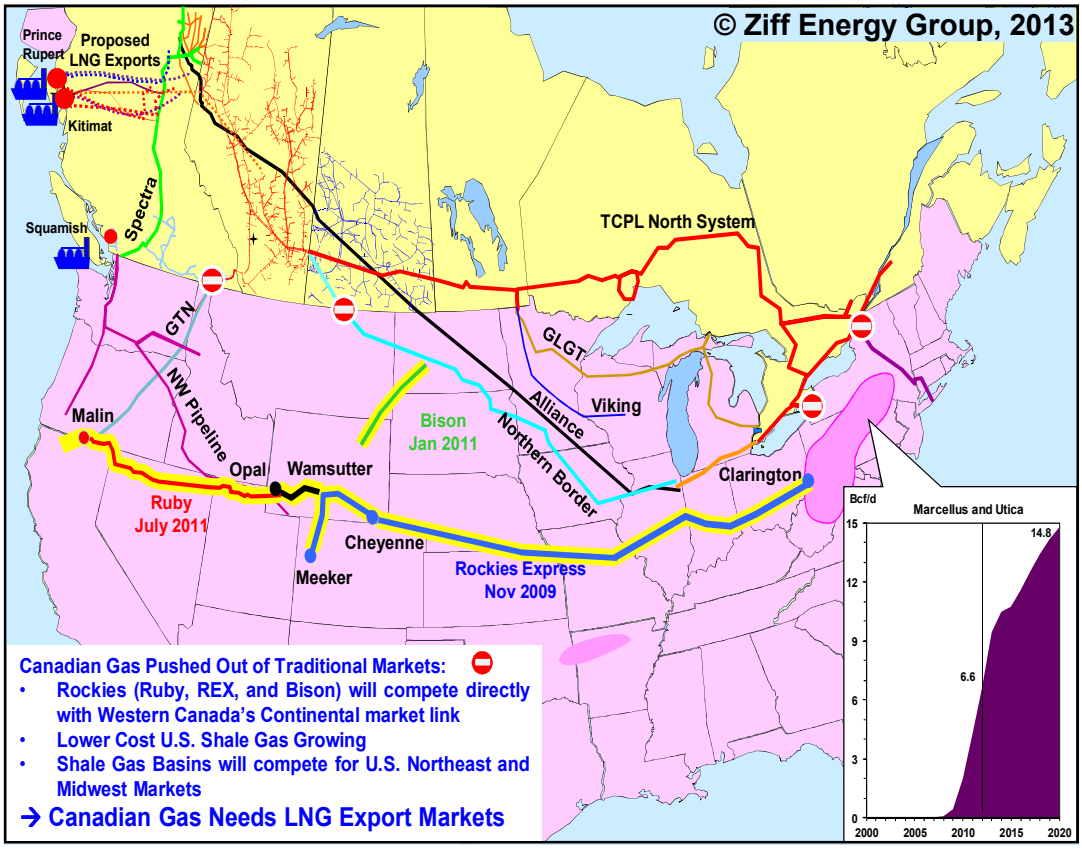
Western Canada natural gas faces growing competition from United States Lower 48 (U.S. L48) gas in traditional markets. The advent of new pipeline capacity from the U.S. Rockies[6] over the last decade has pushed back Canadian gas into the Western Canada Sedimentary Basin (WCSB), driving down prices and resulting in lower levels of gas-focused upstream activity. The Rockies Express Pipeline built in 2009 delivers U.S. Rockies gas into the U.S. Midwest and Northeast markets, displacing higher cost Canadian gas in these markets. The Bison Pipeline, connected in 2011, delivers Rockies gas into Northern Border Pipeline and could back out up to 400 MMcf/d of Canadian gas destined for U.S. Midwest markets. The Ruby pipeline, which delivers Rockies gas from the Opal, Wyoming Hub, to Malin, Oregon, could back out up to 700 MMcf/d of WCSB gas from this traditional Canadian market (California). Low cost supply from the Marcellus Shale Gas play in the U.S. Northeast is now pushing into Eastern Canadian markets at Niagara via a reversal of Tennessee Pipeline. Spectra, DTE, and Enbridge have proposed the greenfield Nexus pipeline[7] to connect Utica gas from Ohio through the Vector pipeline into Ontario at Dawn.

Low cost Shale Gas supply and Associated Gas from the Utica and other North American Tight Oil plays are altering North American gas flows and causing a major re-configuration of pipeline infrastructure. Currently, high tolls on the TransCanada Mainline cause the delivered cost of WCSB gas in traditional Ontario and Quebec markets to be less competitive with U.S. L48 gas delivered to the Dawn, Ontario Hub. Ziff Energy expects that transportation costs on other ex-WCSB pipelines will be too high for continued export of Canadian gas to traditional markets in the U.S. Lower 48 and eastern Canada. This trend will continue[8] as supply in low cost U.S. L48 gas basins continues to grow over the forecast period.

[6] Rockies Express (November 2009), Bison (January 2011), and Ruby (July 2011)
[7] size of Nexus pipeline is being discussed at 30 or 36 inches diameter, the pipeline could deliver up to 2 Bcf/d
[8] Ziff Energy expects some Western Canada gas supply will continue to be delivered to the Dawn Hub throughout the forecast period

Figure 1 shows decreasing relevance of Canadian natural gas in the North American market as a result of increasing Marcellus and Utica Shale Gas and other U.S. L48 supply pushing into eastern Canada and northeast U.S. markets, and new pipelines from the U.S. Rockies bringing increased competition in the U.S. Northeast, Midwest, and California markets.

**Figure 1**
**North American Competition for WCSB Gas**

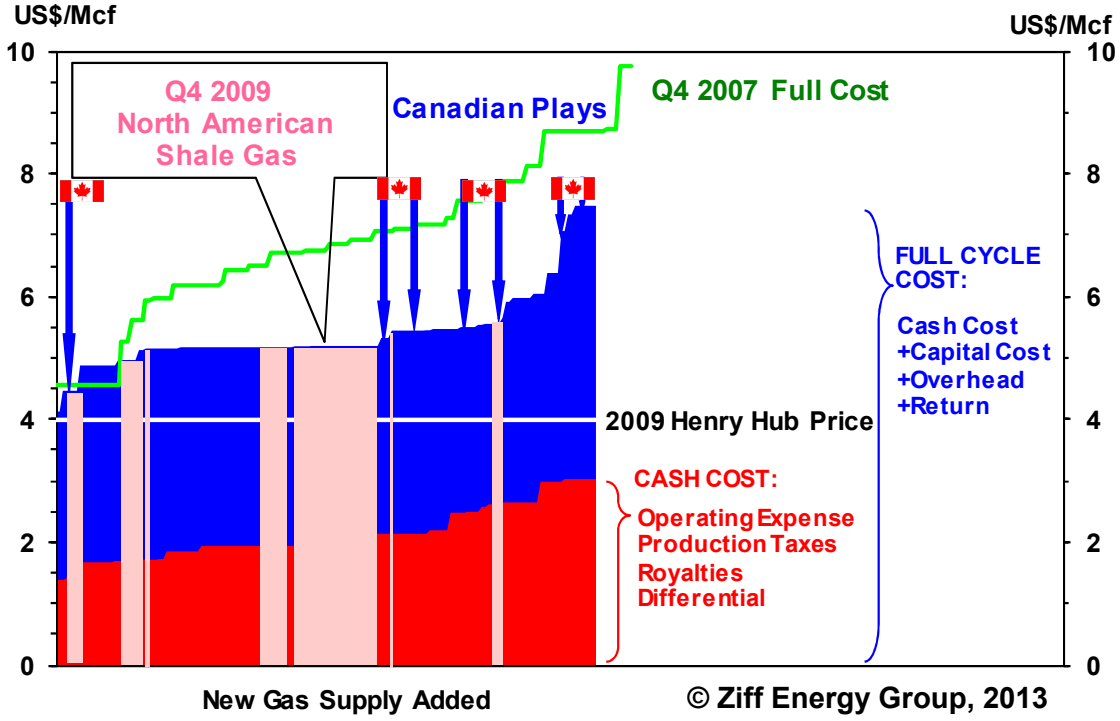


## 3.2 North American and Western Canada Full Cycle Gas Costs

Full-cycle costs for natural gas vary markedly by basin, within a basin, by play, and by producer. High cost Conventional gas supply is being squeezed out by supply from lower cost Shale Gas and Tight Gas plays. This phenomenon accelerated after 2006 as a land rush in Shale Gas prone areas resulted in drilling activity centered on holding lands by production (HBP) even in the face of declining gas prices. Much of the drop in full-cycle costs is due to lower royalties payable on lower gas prices and lower Finding and Development (F&D) costs of more productive unconventional wells. Canadian full-cycle costs are primarily at the high end of the North American cost curve. Thus, Western Canadian gas is being squeezed out of its traditional markets in the U.S. and Eastern Canada and new export markets are required to realize the productive potential of Western Canada. Some Canadian plays, such as the Montney and Horn River, are lower cost than the Western Canada average and production can be expected to increase in these areas over the forecast period. Production from higher cost conventional areas of Western Canada will continue to decline.

Figure 2 shows a summary of full-cycle cost[9] for new gas supply with Western Canadian plays highlighted by blue arrows.

**Figure 2**
**North American Full Cycle New Gas Cost**




[9] based on Ziff Energy's Economic Ranking of North America Gas Basins, spring 2008 and Economic Ranking of Gas Basins, issued April 2010: Q4 2007 full cycle costs averaged US$7.20/Mcf, dropping to US$5.45/Mcf in Q4 2009

## 3.3 Impact of Competition and High Full Cycle Costs on Basin Activity and Production

Competition from U.S. L48 gas in Canada's traditional natural gas markets and high full-cycle costs have led to declining gas-focused exploration and development activity in the Western Canada Sedimentary Basin. Investment levels are expected to remain low until gas prices rise to cover full-cycle costs.

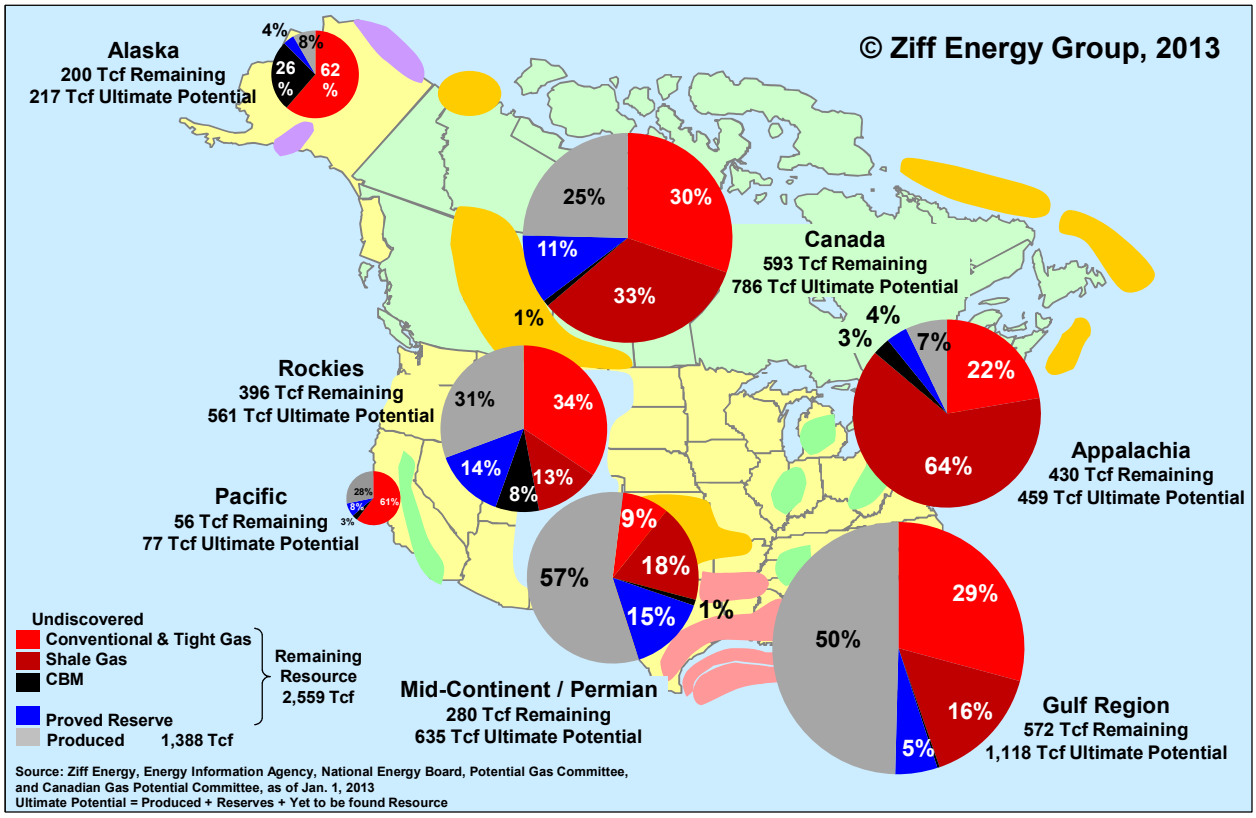
Western Canada gas production is located far from major North American population centers. The costs of pipeline infrastructure and the associated tolls are competitive disadvantages relative to natural gas produced in areas more proximate to major markets. Gas producers in the Marcellus Shale Gas region and emerging Utica Shale Gas play in the Northeastern United States have a much shorter distance to transport their low cost gas to premium markets versus Western Canada gas producers, providing a higher netback, better investment returns, and more money directed to drilling, infrastructure, and development. Western Canadian gas producers are disadvantaged due to distance from markets.

# 4. GAS RESOURCES

## 4.1 North America Gas Ultimate Potential Resource

The ultimate potential resource is the total amount of gas that can be produced, including production to date, discovered reserves or resources, and undiscovered potential resources, without assessing economic viability. Ziff Energy considers that North American natural gas resources are prolific and well able to meet consumers' energy requirements at fair market prices over the forecast period. Figure 3 shows Ziff Energy's assessment of the ultimate potential natural gas resource[10] of North America by region, 3,947 Tcf (4,164 EJ)[11]. The size of each pie is proportional to the gas endowment of each region as of January 1, 2013. North America has 2,559 Tcf (2,700 EJ) of remaining resource of which more than 350 Tcf (369 EJ) is proven.

**Figure 3**
**North American Natural Gas Resources**




[10] undiscovered potential resources are estimates of technically recoverable raw gas based on existing or anticipated technology as reported by the Potential Gas Committee, the Canadian Gas Potential Committee, the National Energy Board of Canada, and Ziff Energy resource and production models; cumulative production and reserves are dry, recoverable gas as reported by the Energy Information Agency (U.S.) and Canadian Regulators

[11] while the North Central region of the U.S. is not shown on the map in Figure 3, the total resources include the region's 47 Tcf of Ultimate Potential and 32 Tcf remaining

In general, there is uncertainty with respect to undiscovered resource estimates:

- evaluations are generally not comprehensive, nor is a consistent methodology used
- estimates for developing plays[12] or unproven concepts are speculative – Shale Gas resources are substantial and may differ from current estimates
- undiscovered resource can increase with improved technologies[13] which enhance existing plays or make other plays technically viable.

Supply responds to changes in demand, while ultimate potential should not – it is an estimate of the original gas resource which existed before production started, based on current information, and not limited by demand or economics. While ultimate potential resource estimates are not gas supply, they can provide an indication of an upper limit to potential supply with today's knowledge and expected technological improvement. For example, estimates of Conventional Gas ultimate potential grew as knowledge of the conventional basins increased; for the last 20 years, the estimate has not changed significantly. The recent surge in Unconventional Gas production, triggered by the technology combination of horizontal drilling and multistage fracturing, may continue for some time to come and the ultimate potential may also grow – production is just starting from the Utica Shale Gas play, increasing the Shale Gas ultimate potential resource. Note that:

- resource development requires skilled labour, investment, and adequately priced gas markets to give producers a reasonable rate of return on their investments
- producers will commit to the development of additional gas resources as they become economic, including gas discoveries which are distant from the North American natural gas pipeline grid.

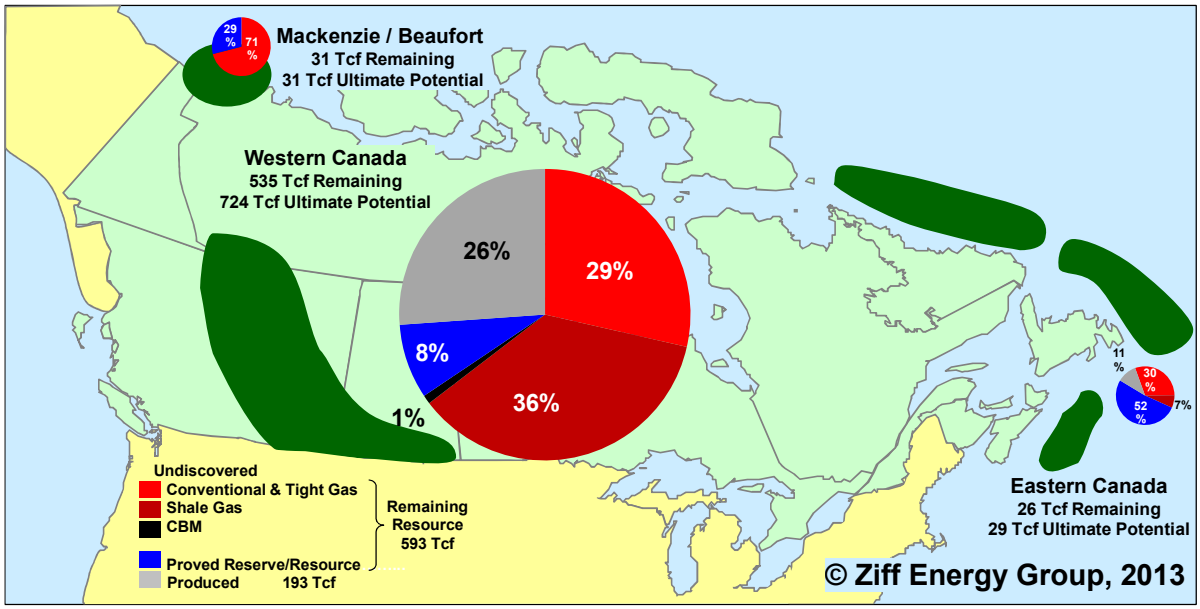
[12] a play is a group of many drilling opportunities which have similar geological characteristics, such as the Horn River Basin Shale Gas play

[13] the innovation of horizontal drilling and multistage hydraulic fracturing has dramatically increased resource across North America by adding Shale Gas and other plays to the Ultimate Potential

## 4.2 Canadian Gas Resource

Canada has 593 Tcf (626 EJ)[14] of remaining gas resource of which 90% is in Western Canada. Connecting gas resources outside of Western Canada is generally not viable due to the high cost of developing and transporting these resources to market and the availability of lower cost gas resources already connected to North American markets. Figure 4 is a map of Canadian basins showing gas resource estimates for major basins. In addition to these basins, other areas and plays have potential gas resource, such as offshore Newfoundland Associated Gas, Maritime Shale Gas, Quebec Shale Gas, B.C. Interior and Offshore Basins, Arctic Islands, and Mackenzie Valley Canol Shale. These have not been included because they are speculative, unproven, or so far from any transport system that they are unlikely to contribute to supply in the foreseeable future[15].

**Figure 4**
**Canadian Natural Gas Resources**




Source: Ziff Energy, National Energy Board, and Canadian Gas Potential Committee; as of Jan. 1, 2013
Ultimate Potential = Produced + Reserves + Yet to be found Resource

## 4.3 Western Canadian Gas Resource

Figure 5 illustrates the 724 Tcf (764 EJ) of Ultimate Potential Gas Resource[16] by gas resource type. As of January 1, 2013, Western Canada has produced 26% (189 Tcf, 199 EJ) of the Ultimate Potential with 535 Tcf (564 EJ) remaining. By 2046, remaining recoverable resources will have declined to 298 Tcf (314 EJ) with a total of 427 Tcf (450 EJ) produced. Conventional Gas in

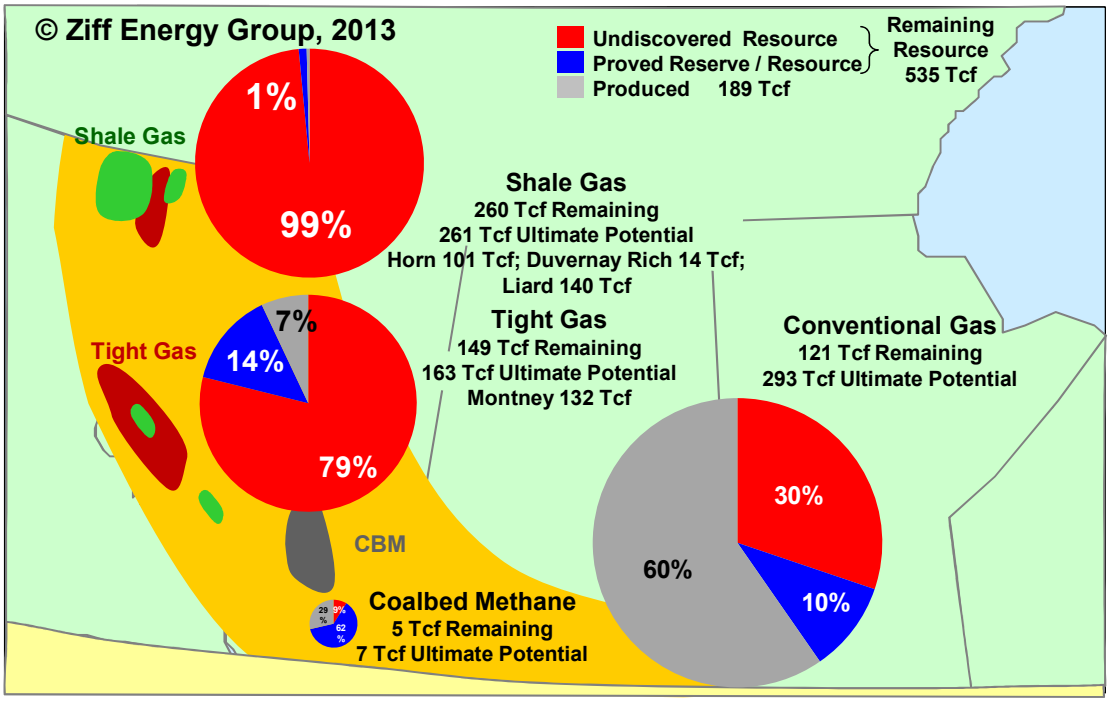
[14] while the Ontario gas resource is not shown on the map in Figure 4, the total resources include the province's 2 Tcf of Ultimate Potential and 1 Tcf remaining
[15] these basins contain more than 50 Tcf of gas resource potential; in general basins that contain gas associated with oil or natural gas liquids production may be connected sooner
[16] sources: Ziff Energy, National Energy Board, Canadian Gas Potential Committee, B.C. Ministry of Energy, Mines, and Petroleum Resources, and the Alberta Energy Resources Conservation Board

Western Canada is high cost and production is falling as producers concentrate on lower cost unconventional sources and liquids rich gas.

Over the last year, Ziff Energy has created preliminary estimates of the technically recoverable ultimate potential of the Montney, Horn River, Liard, and Duvernay plays. These new and developing plays demonstrate the trend in discovering new gas resource in Canada. Resource estimates of Western Canadian gas are as follows:

- Shale Gas: 261 Tcf (275 EJ) – 36% of the ultimate potential; almost all is in the Horn River and Liard Basins. Apache recently announced a 21 MMcf/d Shale Gas well in the Liard Basin of Western Canada – a westward extension of the Horn River Basin. Ziff Energy estimates the Shale Gas potential of this basin could exceed 140 Tcf. In the Duvernay Shale, 14 Tcf of gas could exist in the liquids rich portion of the play; no resource estimate has been included for the dry and Associated Gas areas of the play
- Tight Gas 163 Tcf (172 EJ) – 23% of the ultimate potential; more than three quarters is in the Montney
- Conventional and Associated Gas: 293 Tcf (309 EJ) – 40% of the ultimate potential
- Coalbed Methane (CBM): 7 Tcf (7 EJ) – 1% of the ultimate potential. While the theoretical gas-in-place is more than 500 Tcf, Ziff Energy expects only small quantities of this high cost gas will be produced.

**Figure 5**
**Western Canada Gas Resources**




Source: Ziff Energy, National Energy Board, and Canadian Gas Potential Committee, as of Jan. 1, 2013
Ultimate Potential = Produced + Reserves + Yet to be found Resource

## 4.4 Northern Gas

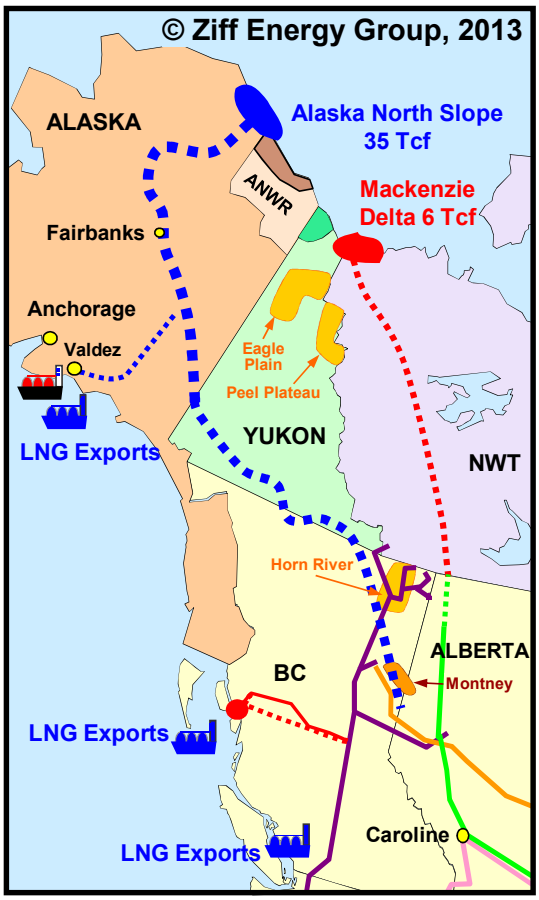
### Northern Gas as Supply Source for North America

Northern Gas is among the most costly potential gas supply sources for North America due to the remote location of the supply and the prohibitive cost to connect to market. Northern Gas is more costly on a full-cycle basis than most Unconventional Gas. Ziff Energy believes the gas resource base available to North American consumers is robust and sufficient to back Northern Gas out of the North American grid for many years, perhaps decades.

### Alaska

Alaska gas reserves of 35 Tcf could be produced at 4 Bcf/d. While the initial commercial plan was to deliver the gas to Western Canada via a 2,760 km, 48 inch diameter pipeline, costing over $40 Billion[17], the current LNG Option is being explored more thoroughly with project estimates for a 3 Bcf/d pipeline to Valdez of $20-26 Billion[18]. Alaska currently produces gas associated with oil production on the North Slope, though most of the gas is re-injected to enhance oil recovery.

**Figure 6**
**Northern Gas**




### Mackenzie Delta and Other Northern Potential

The Mackenzie Valley Pipeline proposal is designed to transport 0.8 to 1.2 Bcf/d (0.8 to 1.3 PJ/d) of gas through a new $8 Billion, 1,225 km pipeline to northern Alberta. Another $8 Billion would be needed for field development. These high costs have made this project uncompetitive with cheaper Canadian and U.S. L48 supply.

The Yukon region requires further gas exploration and commercial discoveries to better assess its potential as a gas supply source.

Figure 6 illustrates the location of the Alaska resource, the Mackenzie Delta, Eagle Plain, and Peel Plateau basins along with potential transport routes. While exploration is taking place in the central Mackenzie Valley (Canol Shale Oil play), Ziff Energy does not believe this will lead to gas production delivered into the Canadian pipeline system in the forecast period due to large, low-cost resources available in the Western Canada Sedimentary Basin (WCSB) and U.S. L48.

[17] TransCanada Pipeline's Open Season Plan filed with FERC, January 2010, estimated the project cost at US$32 to $41 Billion. BP and ConocoPhillips proposed the competing Denali Pipeline project. The open seasons for both projects failed to achieve the necessary commitments to proceed

[18] January 29, 2010 TransCanada media release relating to a 800 mile pipeline to Valdez, Gas Treatment plant, and 58 miles of facilities to connect Point Thomson field. Additional liquefaction facilities would be required

# 5. COST OF GAS

## 5.1 Factors Affecting Supply Costs

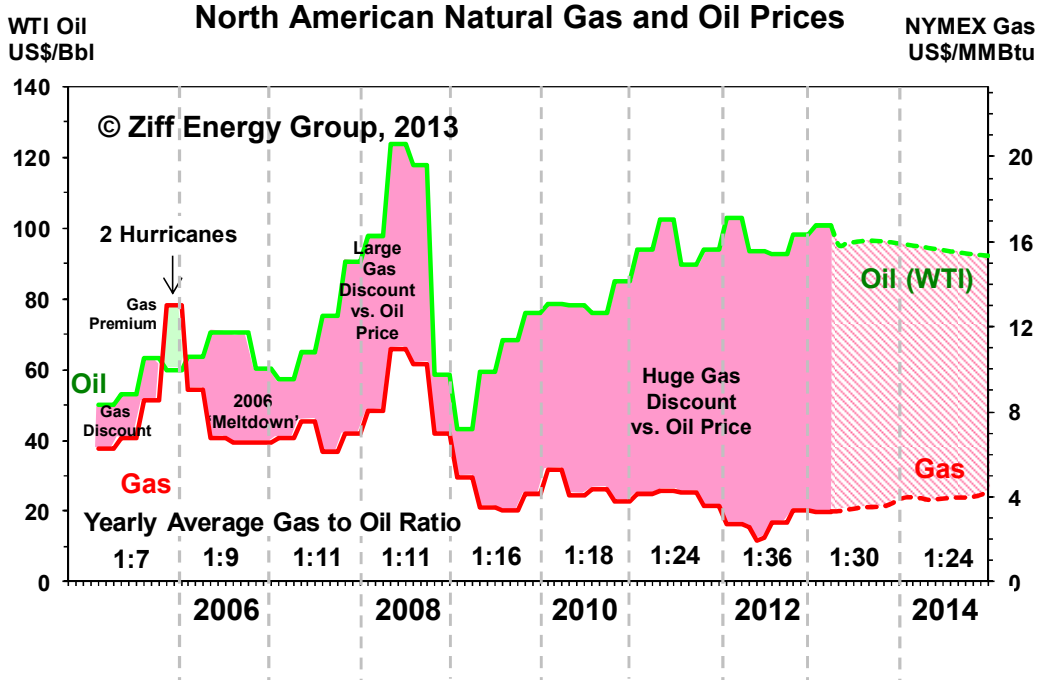
Many factors influence natural gas supply costs. Recent advances in technology (particularly horizontal wells with multistage completions), improved reservoir knowledge, and the high number of gas wells drilled in a small set of plays create "gas factories", where standardized programs and continuous improvement leads to lower costs. Should drilling equipment or experienced staff become scarce in boom times, increased costs and project delays may occur.

Development of Shale Gas has had a profound impact on gas supply costs. Figure 7 illustrates that during the period leading to mid-2008, gas drilling was constrained leading to high full cycle costs and gas prices; over two-thirds of 1,500 gas rigs working in the U.S. at that time were drilling vertical wells with little resulting production growth due to declining new gas well productivity. Since the surge of low cost Shale Gas production in late 2008 - early 2009, as few as 350 gas rigs have been operating in the U.S., over two-thirds drilling horizontal wells and generating high gas production growth – 31% over 6 years. In 2013, the U.S. gas rig count dropped below 350, and production has not declined.

### Natural Gas Price versus Liquids and Oil Prices

Figure 7 shows the gap between North American gas and oil prices on an energy equivalent basis. This value differential is currently leading producers to concentrate on oil plays, or liquids rich gas plays where the liquids make a large contribution to producer revenues[19]. In oil, liquids rich, and condensate gas plays, gas can be considered as having little value at current prices.

**Figure 7**
**North American Natural Gas and Oil Prices**




[19] Natural Gas Liquids (NGLs) such as propane, butane, and pentane, together with condensates have product prices that that are influenced by oil price; overall drilling economics are driven largely by oil prices

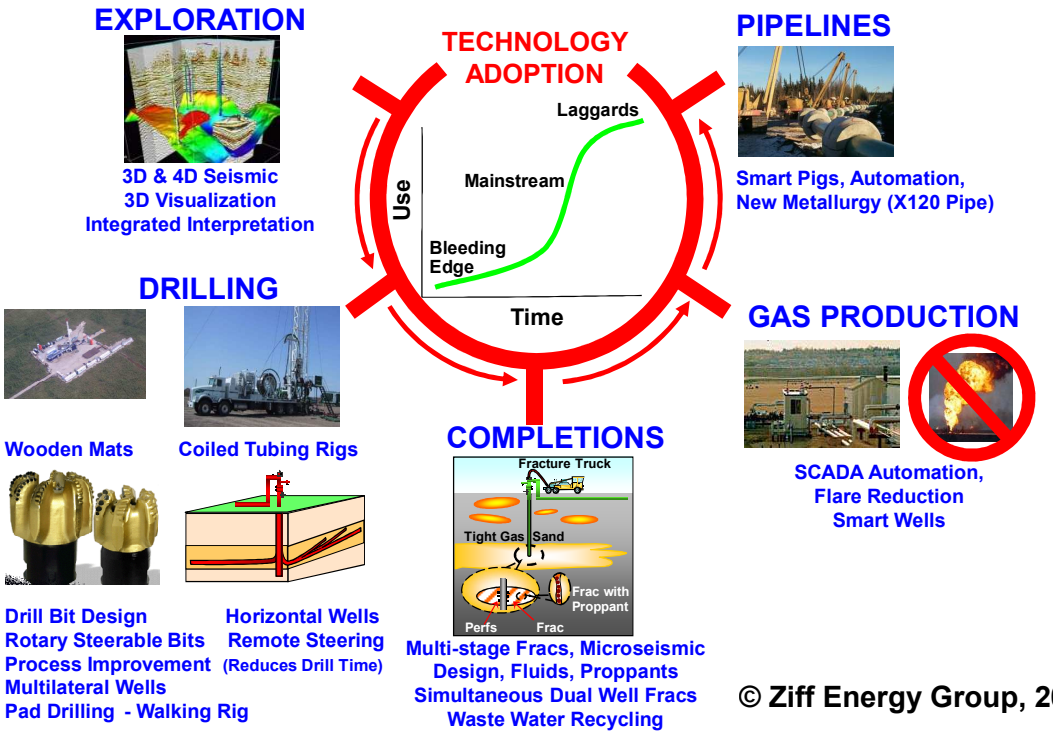
## Technology

The combination of drilling horizontal wells and completing them with multistage hydraulic fracturing[20] is the most important change in technology in several decades, opening up a new class of global plays – Shale Gas. This has led to a surge in lower cost gas production across North America, rendering most new Conventional Gas uncompetitive. This technology combination has also been successfully applied to other play types, such as Tight Gas and Tight Oil. Lower costs are primarily the result of:

- longer horizontal wells with more hydraulic fracture stages. While well costs are typically increased, higher gas recovery reduces unit Finding and Development costs
- a single drilling pad for multiple wells reduces the environmental footprint and allows rigs to be skidded from one well to the next, reducing access and rig move costs.

Figure 8 provides a summary of new technologies that industry has adapted. Ongoing use of 3D and 4D seismic help reduce dry wells and increase production through better well location. Where ground conditions are soft, rig mats lengthen the drilling season thereby lowering costs. Optimised drilling and completion programs reduce drilling time and cost, and increase gas resource produced. Collectively, operators have proven these new technologies and gas supply can be quickly increased. Ziff Energy assumes continued technology evolution in resource assessments, resource cost curve, and production outlooks. No new, step change technology, has been included in this analysis.

**Figure 8**
**Technology Changes**

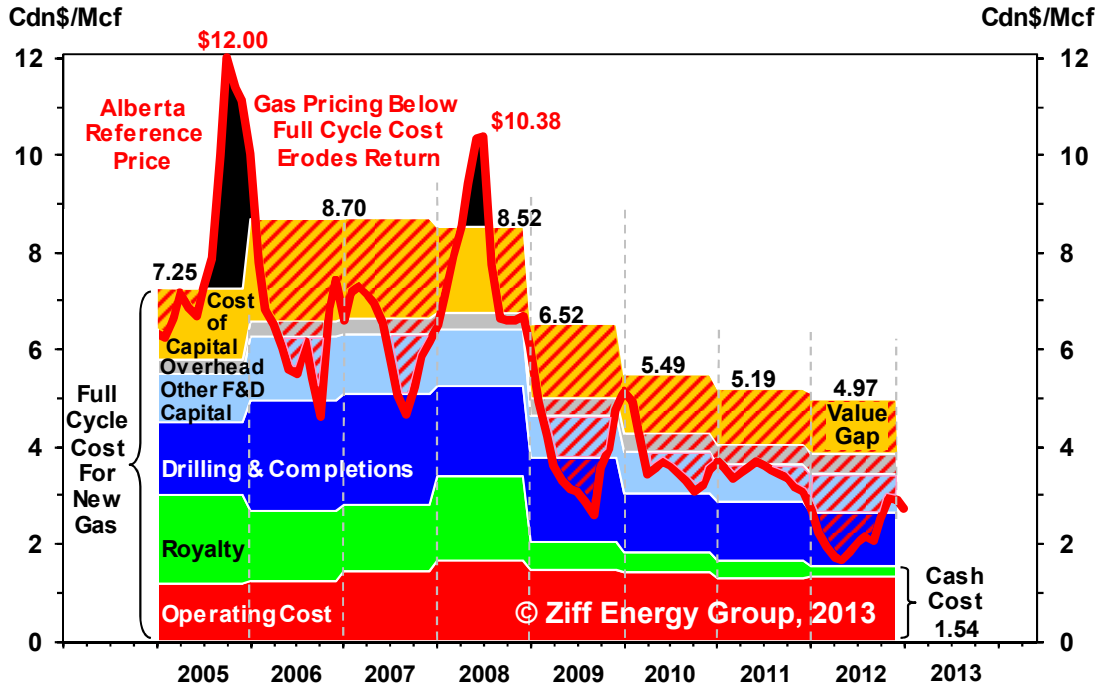



[20] success of hydraulic fracturing requires cracking and "propping" open rock to allow trapped oil and gas to flow to the well bore

## 5.2 Western Canada Full Cycle New Gas Costs

In Western Canada, gas sources range from shallow to deep; to remote and hard-to-access Foothills; from Conventional to Unconventional Gas – CBM (dry and wet), Tight Gas, and Shale Gas. Figure 9 shows the full-cycle cost components[21], the natural gas price in Alberta, periods when the price was higher than cost (black area), and the longer periods when it has been lower than full cycle cost (hatched area) for new gas added between 2005 and 2012.

**Figure 9**
**Full Cycle New Gas Cost**




Source: Ziff Energy - 2012 F&D Cost Study; 2012 Improving Field Performance Study

The cost components do not reflect any uplift in gas price for Natural Gas Liquids which may be entrained in the produced gas stream. For example, gas from the liquids rich portion of the Montney in Alberta can have an incremental value of $2.05/Mcf[22] making those prospects economic at a gas price of $3/Mcf. Each gas type has different challenges and cost structures. For example, unconventional Gas resources are essential to offset Conventional Gas declines and for market growth; the higher cost of deeper gas wells is generally offset by larger reserves per well.

[21] solid colours in Figure 9 represent each of the cost components for new gas supply. F&D costs are divided into drill only cost (drill, complete, and tie-in) and other F&D capital (spending on land, processing plants, and seismic); this definition is consistent with producers' capital spending and budget processes, it is not based on tax treatment of the cost components, some of which are capitalised and others expensed

[22] assuming a yield of 60 Bbls/MMcf, incremental operating costs of $0.30/Mcf, and a royalty of 35% on the liquids

## 5.3 Unconventional Gas Resource Cost

Until 2007, the upstream North American natural gas industry was on a supply treadmill, drilling more and more wells with lower initial production and smaller estimated ultimate recoveries (EURs). Industry was working flat out to meet gas demand and gas prices were rising. LNG importers invested in new LNG re-gasification plants to meet the expected gas supply shortfall. This supply constrained environment was overcome by the surge of Shale Gas production enabled by the combination of horizontal drilling with multi-stage hydraulic fracturing. The Shale Gas plays have added low cost resources, increased North American gas production, and backed out LNG imports.

The average full-cycle costs for developing the primary North American Shale and Tight Gas plays are instrumental in setting long term natural gas prices in North America. Over the period covered by this report, most of these plays are expected to mature with costs rising somewhat as development continues beyond core areas to wells with smaller EURs. In addition to these plays, there are other North American Gas Resources available, such as higher cost Conventional Gas and Coalbed Methane.

## 5.4 Full Cycle Gas Cost Components

### Data Sources

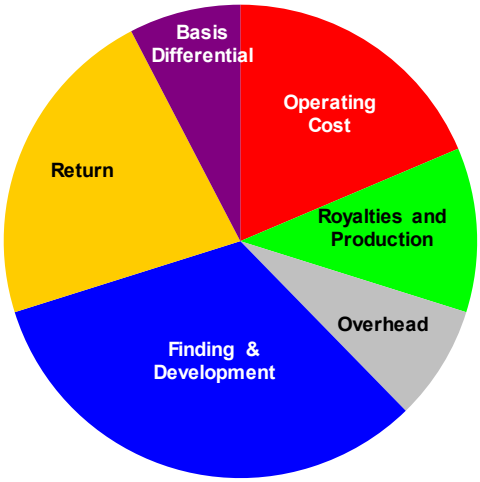
Ziff Energy has completed two studies detailing the full-cycle cost of new natural gas production using an 'apples to apples' comparison of natural gas costs within North America.

### Cost Components

Figure 10 presents gas cost components used:

- **Basis Differential** between the gas price at the point of sale and Henry Hub, so that the different costs may be compared on a consistent basis
- **Return** (cost of capital) a cost equivalent for a producer to earn a 15% before income tax rate of return on capital spending (F&D costs)
- **Overhead** includes all general and administrative expenditures (head office)
- **F&D** capital costs, including dry holes, divided by the estimated ultimate recovery
- **Royalties and Production Taxes**, fluctuate closely with natural gas prices
- Field **Operating Cost** (lifting costs) to the point of gas sale in the basin.

**Figure 10**
**Gas Cost Components**



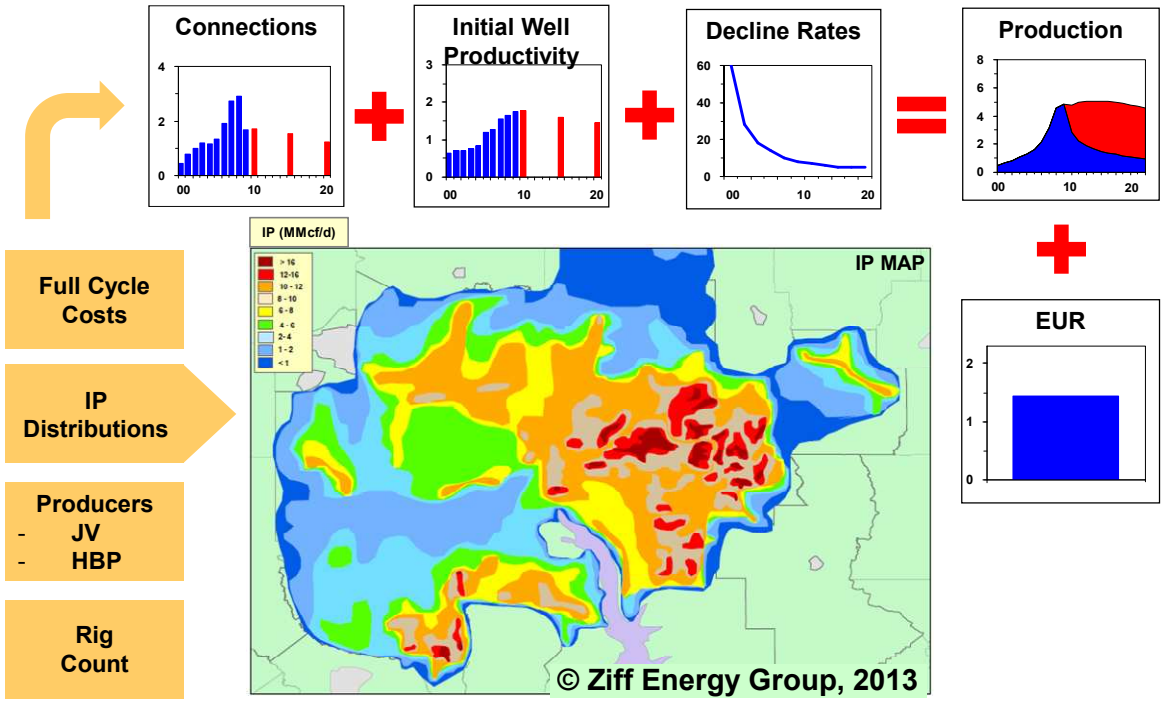
# 6. GAS SUPPLY FORECASTS TO 2046

This section provides Ziff Energy's North American natural gas supply forecast. The past decade has ushered in dramatic changes in North American natural gas production and supply. Game-changing technological advancements have led to rapidly increasing Shale Gas production. Unconventional gas, which includes Shale Gas, Tight Gas, and CBM, has grown to half of North American gas supply. Continuous improvement, knowledge transfer, and best operating practices have helped to reduce full-cycle costs and establish these strong growth rates. Ten of twelve U.S. onshore giant gas fields were discovered or rediscovered in the 1990s, and the list of giant Unconventional Gas fields is growing with the exploration and development of Shale Gas. Since 2008, the growth of L48 Unconventional Gas supply[23] has negated large scale LNG imports and is now backing out Canadian gas from its traditional U.S. and Eastern Canadian markets.

## 6.1 Supply Forecast Methodology

Ziff Energy models each significant gas producing basin in North America for its production forecast and examines major gas types, including Shale Gas, Tight Gas, Coalbed Methane (CBM), Conventional Gas, and gas from oil (Solution Gas or Associated Gas). Figure 11 shows the inputs to and outputs from Ziff Energy's spreadsheet production models. Ziff Energy does not model production by company, thus, a company may have access to gas supply from their lands that would not necessarily be available to the market in general.

**Figure 11**
**Gas Production Forecast Methodology**




[23] U.S. Lower 48 gas production has increased by almost 30% since 2008 with potential to grow much higher

### Basin and Play Models

Ziff Energy maintains proprietary gas production spreadsheet models for each major gas basin[24] and key gas types in North America which use key input parameters[25] to forecast the annual average gas production for each supply source to 2046. Gas production histories in the models come from commercial and public databases.

#### Gas Wells, New Well IP, EUR, and Decline Rates

The number of gas wells connected each year is based on the economic attractiveness of the gas basin or play, gas well density, recent trends, gas reserves, and resource potential (where reliable data exist), and availability of equipment. Where there are equipment restrictions or limited access to markets, drilling is deferred. New gas well initial productivity (IP) and EUR per gas well are projected from recent trends, basin or play maturity, and considering the potential for near-term technological improvements. Gas well decline rates are estimated from recent trends, or calculated from a type well model using IP and EUR. The decline rates are applied to new wells and to existing wells with consideration to the age of the well. The models generate a raw gas production forecast, which is converted to sales gas using shrinkage factors calculated from public sources and previous Ziff Energy analyses. Minor gas basin production is modeled using recent historical production trends, economic attractiveness, and gas resource potential.

Regional drilling and completion activity, the key variable in gas production, rises and falls over time depending on: new well full-cycle gas supply costs relative to costs in other plays and expected natural gas prices; natural gas liquids content which boost play economics; government drilling and production incentives and disincentives; play maturity; the need to validate recent leases through drilling; joint venture agreements which drive drilling; and availability of cash flow.

## 6.2 Supply Assumptions

The Ziff Energy supply forecasts use the following general and gas type assumptions:

### General Assumptions

#### Gas Price

Ziff Energy assumes gas prices will increase to recover full-cycle producer costs. The marginal gas required to balance supply and demand will generally set gas prices. Over the last few months, gas prices at Henry Hub, the key North American reference pricing market, have been below producers' full-cycle costs for new gas supply in many plays, while in Western Canada, the new gas production

[24] Western Canada (includes Montney Tight Gas & Horn River Shale Gas); Green River (Tight Gas); Powder (CBM); Piceance (Tight Gas); Uinta (Tight Gas); San Juan (CBM & Tight Gas); Permian; Fort Worth (Barnett Shale); Gulf of Mexico Coast (includes South Texas Tight Gas and Eagle Ford Shale Gas), Shelf, and Deep Water; East Texas-North Louisiana (includes Tight Gas and Haynesville Shale Gas); Anadarko; Arkoma (Fayetteville and Woodward Shale Gas); Appalachia (includes Marcellus Shale Gas); Northern Gas (Alaska and Mackenzie Delta) and Canadian East Coast

[25] number of gas wells connected each year; new gas well initial productivity; expected ultimate recovery; gas well decline rates

cost has been higher than the gas price over the last five years. If producers do not recover their full-cycle costs, it is expected they will reduce gas-directed drilling, or shift capital to lower cost gas plays. This ensures the lowest cost supply is connected and available to consumers.

### Play Maturity

For immature plays, IPs and EURs tend to increase as the play develops, resulting in lower costs. Mature plays have falling IPs and EURs and rising costs as most of the better locations have been drilled.

### Infrastructure

This includes gas gathering systems, processing plants, and major transportation pipelines. Infrastructure is expected to be built within a reasonable period of time to provide access to the North American market; where infrastructure is inadequate, production is deferred by delaying drilling and completions.

### Government Policies

These tend to reduce gas supply[26]. Examples are drilling moratoriums in the U.S. Rockies, offshore Florida/California, and offshore British Columbia, Canada. Political and environmental factors that may favourably influence gas demand include legislation targeting competitive fuels with higher carbon emissions such as coal and residual fuel oil. Factors that may have an unfavourable influence on gas supply include concerns over potable water supplies which have prompted regulatory review and investigation in some jurisdictions. Ziff Energy believes workable solutions will be found which balance legislators' concerns for constituents' safety and well-being with producers' ability to employ hydraulic fracturing technology in a safe and reliable manner.

### Basin and Play Models

Uses assumptions (for the parameters listed above) based on Ziff Energy's analyses of historic production and expectations based on cost, basin, and play research. For example, Ziff Energy's Western Canada gas supply forecast uses the following assumptions:

- while gas well connections peaked at over 18,000/year in 2006, new gas well completions will be less than a quarter of this by 2046
- more high-productivity horizontal wells and fewer low productivity vertical wells are expected to be drilled
- application of horizontal drilling will result in prospect high-grading and fewer wells drilled
- new gas well productivity and EUR will continue to increase in the short to medium term, then decline in the long term.

[26] royalty reductions and drilling incentives can incent drilling and increase gas supply

## Equipment, Services, People, and Financing

Available Western Canadian gas resources are more than adequate to provide gas for LNG exports. In generating the gas supply forecasts, Ziff Energy assumed no constraints on availability of suitable drilling rigs and service equipment, skilled and experienced people, and financing. A Western Canada gas production shortfall[27] could develop if all the proposed Canadian LNG export plants are commissioned as announced. A large number of deep, complex gas wells would need to be drilled in a short time frame. The rig fleet capable of drilling these very deep wells would likely have to be quadrupled. In addition to replacing retiring baby boomers, thousands of skilled and experienced workers will be needed to staff the new rigs, pressure pumping units, and to provide services. Upstream and LNG facility related activity could lead to inflation pressures, similar to those seen in Australia during their LNG boom and during the Oil Sands boom in Alberta in the middle of the last decade.

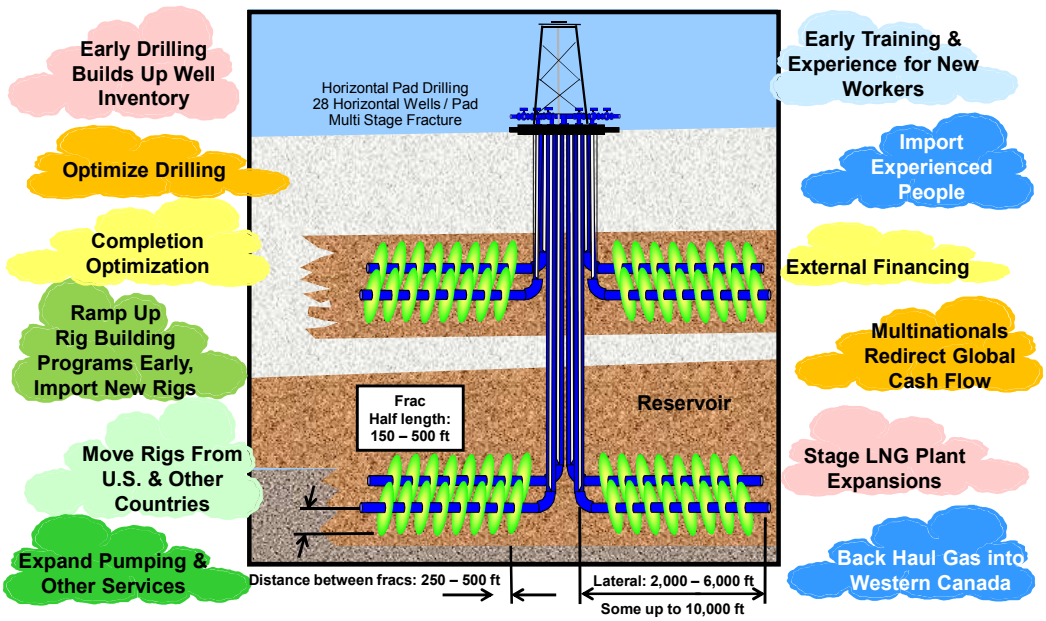
Timely regulatory approvals and investment decisions would provide sufficient lead time to expand the construction, and potential importation of specialized rigs required in Western Canadian Shale Gas plays. There will also be a ramp up in requirements for pumping units, sand for Proppant, water required in the hydraulic fracturing process, and related manpower.

As producers move from the evaluation to development stage in Western Canada Sedimentary Basin (WCSB) Unconventional Shale and Tight Gas plays, optimizing drilling and completion techniques, including horizontal laterals, spacing between wells, and fracture stages, will maximize economic gas recovery. Geological and geophysical (seismic) reservoir mapping and the use of micro-seismic will lead to continuous improvement in developing and enhancing the ultimate recovery of gas resources. Ziff Energy has incorporated efficiency improvements in its gas supply forecast.

Figure 12 illustrates some of the tools available to connect natural gas resource to meet LNG liquefaction demand.

[27] with timely approvals and Final Investment Decisions (FID) taken by proponents, a significant amount of up-front work can be done to pre-drill wells and build necessary infrastructure so gas is connected and available to LNG liquefiers when the LNG trains come online

**Figure 12**
**Ramping Up Western Canada Supply**






## Gas Type Assumptions

### Shale Gas

Shale is both the source rock and reservoir; gas is held in the shale in free (in porosity) and adsorbed states. The Shale Gas plays are immature and relatively low cost. Shales have extremely low permeability[28]. The commercial Shale Gas success is due to a combination of horizontal drilling and multi-stage fracture completions along with rising gas prices from 2000 to 2008. The seven main initial Shale Gas plays in North America: Barnett, Fayetteville, Woodford, Haynesville, Marcellus, Horn River, and Eagle Ford, are each in a different stage of development. Without LNG liquefaction projects, development of some Shale Gas resource will be slower.

There are a number of emerging and unknown future plays that will likely add to production. Ziff Energy models this potential production by adding one new play in the U.S. every 2 to 3 years with peak production up to 3 Bcf/d (3.2 PJ/d). Some of this gas could come from new Shale Gas plays, such as the Niobrara in the Piceance Basin and expansion of existing Shale Gas plays.

### Tight Gas

Gas produced from sand and carbonate reservoirs with very low permeability and that needs hydraulic fracturing for wells to be commercial is deemed to be Tight Gas. It was originally defined and developed in response to stimulus provided by U.S. tax incentives in the 1980s. Most Tight Gas

[28] ability of gas to flow through reservoir rock

is produced in the U.S. Rockies region, South Texas, East Texas-North Louisiana, Anadarko, and Western Canadian basins. Gas production growth in the U.S. Rockies will slow as gas well spacing in the most productive, older fields has shrunk to as low as 5 acres from 640 acres spacing leaving little room for more wells. New fields have relatively low initial productivities and will struggle to offset declines from existing fields though Ziff Energy believes low cost growth opportunities exist in East Texas - North Louisiana (Cotton Valley, Bossier, James Lime, and other plays), and Western Canada (Montney and other Deep Basin plays) will emerge.

### CBM

Gas produced from coal seams, where the gas is held in both free (in fractures and porosity) and adsorbed states (on the surface of the organic matter) is referred to as Coalbed Methane (CBM) gas. Development started in the early 1980s, spurred by U.S. tax incentives and production is past its peak due to high cost and generally low productivity.

### Conventional Gas

Gas from reservoirs with greater permeability has been developed since the late 19$^{th}$ century. Most Conventional Gas plays are mature, higher cost, and have passed their peak production. Reserves per well are small, resulting in high costs. Before the advent of Shale Gas, a record level of drilling activity was required to maintain gas production levels in North America. Aggregate gas production has been in decline for over a decade. For example, the U.S. Gulf of Mexico region, the former work horse of North American gas production, is declining mainly due to the sharp fall in gas production on the Gulf of Mexico shallow-water Shelf. Some old, mature plays are experiencing a new lease on life as producers apply new and evolving technologies, sometimes with spectacular results, such as the Granite Wash in the U.S. Anadarko Basin. Ziff Energy assumes the production declines will continue, though at a moderated pace as improved technologies (horizontal wells, multistage fractures) enhance play economics.

### Northern Gas

Natural gas from northern Alaska and the northern Canadian Mackenzie Delta is not connected to the North American gas pipeline grid. Due to the high proposed transportation costs, Ziff Energy does not expect any Northern Gas to flow into the North American market over the forecast period.

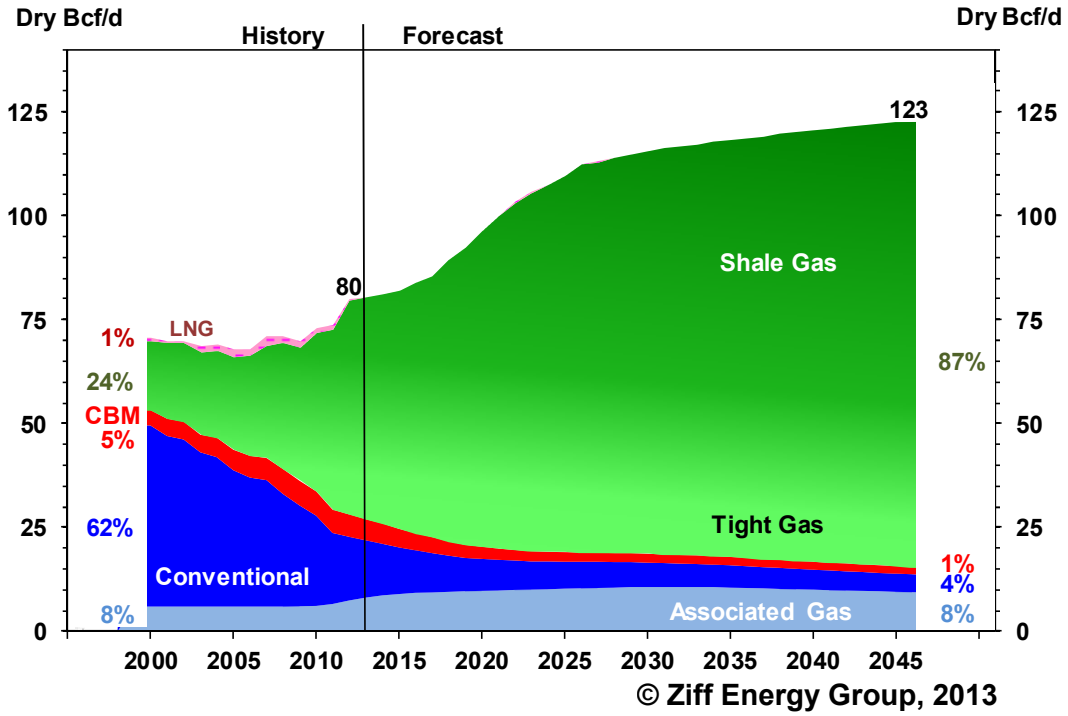
### Liquefied Natural Gas (LNG) Imports

LNG imports into North America after 2012 will decline to 0.3 Bcf/d from a peak over 4 Bcf/d. North America has over a dozen LNG regasification import terminals with a capacity of 19.3 Bcf/d (20.3 PJ/d) operating at a less than 2% utilization and are potentially operational to import LNG should a need arise, though several are being repurposed for exports. Overall, North America LNG imports delivered directly into demand centers will not be significant over the forecast period.

## 6.3 North American Gas Supply Forecast

Ziff Energy forecasts total North America sales gas supply to grow to 123 Bcf/d (130 PJ/d) in 2046 from 80 Bcf/d (84 PJ/d) in 2012. Figure 13 summarizes Ziff Energy's supply forecast by gas type.

**Figure 13**
**North American Gas Supply to 2046**




### Unconventional Gas

By 2046, Unconventional Gas grows to 88% of the supply mix, consisting of:

- **Shale Gas** (including new plays): grows to 68 Bcf/d (72 PJ/d) in 2046 from almost zero at the start of this century, to over half of the North America gas supply mix. Production is from the seven main Shale Gas plays and new plays
- **Tight Gas**: grows to 40 Bcf/d (42 PJ/d) in 2046 from 21 Bcf/d (22 PJ/d) in 2012. Additional gas is being developed in East Texas-North Louisiana and Western Canada though it may be partially offset by declines in the maturing U.S. Rockies. After 30 years of growth in this series of plays, Ziff Energy believes that production will peak in 2040 then slowly decline to the end of the forecast period
- **Coalbed Methane (CBM)**: declines to 2 Bcf/d (2 PJ/d) in 2046 (1% of the supply mix) from 5 Bcf/d (5.3 PJ/d) in 2012. This high cost production will continue to fall as few new wells will be drilled, failing to offset declines from existing wells.

### Conventional Gas

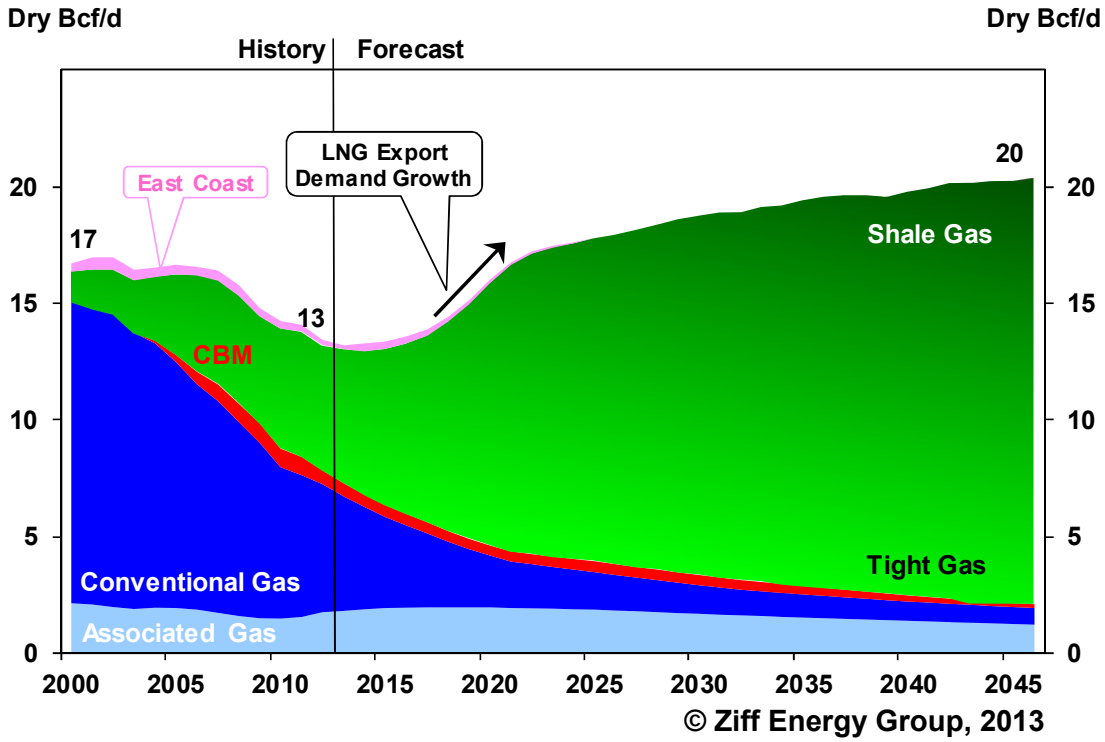
By 2046, Conventional Gas declines to 12% of the supply mix, consisting of:

- Gas from Conventional Gas plays declines to 4 Bcf/d (4 PJ/d) in 2046 from 15 Bcf/d (16 PJ/d) in 2012 primarily due to traditional natural gas basins maturity and high full-cycle costs, which leads producers to divert capital to more profitable Shale Gas. Figure 13 shows declines of the last decade are expected to continue before moderating after 2020
- **Associated Gas**[29] (gas from oil wells): production grows due to Tight Oil drilling to 11 Bcf/d (12 PJ/d), 9 % of gas supply in 2030, up from 7 Bcf/d (7 PJ/d) in 2012, then declines to 9 Bcf/d (10 PJ/d) in 2046.

## 6.4 Canadian Gas Supply Forecast

Ziff Energy's forecast is for total Canadian gas production to grow to 20 Bcf/d (21 PJ/d) in 2046 from 13 Bcf/d (14 PJ/d) in 2012 as new gas supplies offset declines of higher cost Conventional Gas. Western Canada was the source of 98% of Canadian gas supply in 2012. Figure 14 provides summary results of Ziff Energy's production forecast for Western Canada by gas type.

**Figure 14**
**Canadian Gas Production to 2046**




[29] also known as Solution Gas

Western Canada production is currently constrained by market and competitive factors which have resulted in a low gas price. The limitation to production growth is lack of access to markets priced at levels sufficient for producer full-cycle cost recovery and investment – there is more resource available for production in Western Canada. The upswing in Western Canada production from 2019 reflects new market outlets resulting from LNG projects including Woodfibre LNG Export Project volumes. Ziff Energy believes the gas resource available in Western Canada could support more LNG liquefaction and exports over time.

## Unconventional Gas

By 2046, Canadian Unconventional Gas grows to more than 90% of the supply mix from 45% in 2012:

- **Shale and Tight Gas:** including supply from the Montney, Duvernay, Horn River, Liard, and other plays[30], grows to 18 Bcf/d (19 PJ/d) by 2046
- **CBM:** declines to less than 0.2 Bcf/d (0.2 PJ/d) in 2046 due to increasing maturity of Horseshoe Canyon CBM and the high cost of CBM – the wet Mannville coals are generally uneconomic.

## Conventional Gas

Western Canada Conventional Gas peaked before 2000 and is expected to decline to 3 % (0.7 Bcf/d, 0.7 PJ/d) of the supply mix in 2046 from 42% in 2012, due mostly to increasing play maturity and high costs, which lead producers to focus on lower cost, liquids rich unconventional gas. New Western Canadian Conventional Gas[31] is some of the most costly in North America on a full-cycle cost basis.

Associated Gas (gas from oil wells): production grows this decade due to Tight Oil drilling in Western Canadian[32] to a peak of 2.0 Bcf/d (2.1 PJ/d) in 2020, then declines to 1.2 Bcf/d (1.3 PJ/d) 6 % of gas supply in 2046, from 1.7 Bcf/d (1.8 PJ/d) in 2012.

## Other Canadian Basins

The Offshore Canadian East Coast is not a significant source of long term gas supply – Sable Island production is declining and will likely reach the end of its economic life before the end of this decade. The Deep Panuke mobile production module has been plagued with commissioning problems, though it may start production by 2014.

## LNG Exports

LNG Exports are modelled in the demand section; the supply for these exports is included in this forecast. No material LNG imports[33] are modelled for the forecast period.

[30] no Shale Gas from other plays, such as Quebec, has been included in this forecast although resource potential exists
[31] includes production from Sable Island and the new development at Deep Panuke Nova Scotia
[32] Grand Banks gas is believed to be too expensive to bring into the North American market
[33] Canada has one LNG regasification terminal at Saint John, New Brunswick

# 7. GAS DEMAND FORECASTS TO 2046

## 7.1 Demand Methodology

Ziff Energy's North America[34] and Canadian gas demand forecast methodology is based on an assessment of five consumption sectors and the expected rates of growth within each. A brief description of each sector and the forecast methodology used is provided below:

**Industrial Sector (29% of current overall market):** includes gas consumed by the manufacturing, construction, mining, refining, Oil Sands, and petrochemical industries. Ziff Energy has also included North American LNG exports in the industrial sector. Natural gas used for combined heat and power (CHP) generation for manufacturing processes is also included[35]. The industrial sector is the most price sensitive and, therefore, the most elastic demand sector. In the Western Canada industrial sector, natural gas is used to produce bitumen from the Oil Sands by: producing steam (injected into oil reservoirs); generating electricity; upgrading bitumen to synthetic crude oil; and for process heat.

**Gas for Power Generation Sector (33% of current overall market):** includes gas consumed by natural gas fired power stations and gas fired CHP units used to produce electricity directly marketed into the North America power grid. Ziff Energy forecasts overall power generation based on growth factors such as GDP, residential/commercial power markets, demand side management, and industrial demand for power. A regional analysis of the North American power generation inventory is performed and assumptions of potential capacity changes are made for gas, oil, coal, nuclear, hydro, renewable, and other power sources. Natural gas for gas-fired generation tends to be more expensive on a marginal basis[36] relative to coal, nuclear, hydro, and other power sources. Therefore, once capacity and load factors for non-gas fired stations are analyzed, the amount of gas-fired generation required to meet overall power growth is calculated. Gas required for power generation is then calculated based on expected changes to average heat rates (Btu/kWh).

**Residential Sector (18% of current overall market):** includes gas consumed by private households (houses, apartments, and condominiums) for heating and domestic purposes.

**Commercial Sector (13% of current overall market):** consists of gas used by non-industrial and non-residential consumers, such as, schools, hospitals, business, office structures, and motor vehicles.

The residential and commercial sectors' demand forecasts are developed by taking into account the main purpose of the gas consumed by these sectors, namely, space heating, and forecasts of regional gas customer count. Normalized values are used in the forecast methodology to account for the effects of weather on consumption patterns. In the U.S., Heating Degree-Day (HDD) data is based on 65°F (18°C), sourced from National Climatic Data Centre, and adjusted for the North American population. Canadian HDD data is based on 65°F (18°C), sourced from Environment Canada's daily

[34] gas exported to Mexico is not including in North American demand and is discussed in Section 8 of this report
[35] power used on site is included in the Industrial sector; electricity (MWh) marketed to the grid is included in the Power Generation sector
[36] however, gas-fired generation has lower capital costs and can be put in-service faster than coal (2-3 year advantage) and Nuclear (7-8 year advantage)

mean temperature, and adjusted for the North American population. Regional gas customer counts are analyzed and then forecast for regional population growth, market penetration for natural gas, and combined with efficiency gains in normalized consumption patterns. Ziff Energy is then able to forecast overall normalized demand as follows:

forecasted overall customer count * normalized HDD * normalized consumption (Mcf per customer per HDD)

**Pipe and Lease Sector (7% of current overall market):** consists of gas consumed during the production and transmission of natural gas to end-use markets. Ziff Energy forecasts pipeline and lease sector gas demand based on changes in North American supply and takes into account efficiency gains from optimized new builds and replacement of aging infrastructure.

## 7.2 Demand Assumptions

**Gas Price Effect on Industrial Demand:** the industrial sector is responsive to changes in natural gas pricing and is adjusted regionally based on its historical price - industrial demand response. Intensive users of gas, such as fertilizer manufacturers (around 85% of input cost is natural gas) will be more directly impacted than less gas intensive manufacturers such as food manufacturers. Gas demand for residential and commercial sectors is not historically impacted by gas prices. In the last decade, gas demand for power generation has increased in spite of increased gas prices. Recent low gas prices have seen coal to gas switching; however, Ziff Energy believes that longer-term gas prices will exceed coal prices on an MMBtu basis and continue to rise beyond that.

**Oil Sands:** Ziff Energy's forecast of gas used in Oil Sands for growing bitumen production incorporates the following key assumptions: oil pricing to allow Oil Sands projects to recover full-cycle costs; a 90% load factor; one to five years delay for all new projects; Oil Sands production is risked 10 to 90% by regulatory status,[37] demand includes gas for electrical generation, upgrading; 47% of Oil Sands bitumen is upgraded in Alberta,[38] "off-gas" produced in upgrading and In-situ operations is used as fuel, reducing the natural gas required.[39]

**Gas Pricing:** Ziff Energy has assumed that natural gas prices in North America will recover producer average full-cycle costs. Ziff Energy believes that the North American gas market will continue to operate in a rational and integrated manner. Consumers will continue to source supply based on least cost sources, transporters will continue to assess opportunities to invest in infrastructure based on the relative risk of supply-demand fundamentals, and producers will allocate capital to projects which most enhance shareholder value. Gas pricing differentials will continue to price these variables in an open, transparent, and liquid manner.

**Electrical Power**: Ziff Energy assumes carbon emissions from coal stations remain static throughout the forecast period. Uncertain future carbon costs will likely stall growth in carbon intensive fuels, such as coal, and favour gas. More specifically, Ziff Energy assumptions used in the electric power demand forecast are: GDP growth of 2.2% per year leads to power sector growth of 1.1% per year;

[37] projects advanced in the regulatory process are more likely to proceed
[38] based on EUB ST98-2011, which forecasts 47% of bitumen produced is upgraded in Alberta from 2011-2020
[39] off-gas available as fuel for Oil Sands operations may be reduced by proposed off gas processing plants which remove NGL's and shrink the off-gas stream, though this has not been considered in Ziff Energy's forecast

nuclear capacity will begin to increase post-2017 as new stations come online[40], with constraints in availability of equipment, and skilled manpower; coal-fired power generation has some capacity expansion – load-factors creep upward as cleaner coal technology is put into service replacing some aging stations; gas-fired generation is the marginal source of power supply until nuclear capacity can be expanded.

**Customer Counts:** historically, residential and commercial customer count growth averages 1.4% per year. Ziff Energy assumes lower future market penetration growth, more conservative economic growth, and forecasts a lower long-term growth rate of 0.9%.

**Normalized Consumption** (Mcf per customer per HDD): the residential and commercial sectors are most influenced by weather. Ziff Energy assumes normalized weather (average of the previous ten years) will occur over the forecast period. Residential and commercial normalized consumption historically declines 0.8% per year per residential-commercial unit. Ziff Energy assumes consumers make efficiency gains at a slower pace, as the most efficient conservation investments have been made, and forecasts a lower long-term rate of improvement of 0.4% per year.

**GDP**: Since 2000, real GDP growth has averaged 1.8% per year in the U.S. and 2.0% in Canada. The U.S. Federal Reserve's current expectation[41] for longer run real GDP growth is 2.3-2.6% per year. Bank of Canada[42] expects the Canadian real GDP to average 2.3% over the 2013-2015 period. Ziff Energy's expectation is for real GDP to average 2.2% per year throughout the forecast period.

**Government Policies**: Ziff Energy assumes there will be some implementation of policies to reduce carbon emissions resulting in some replacement of coal-fired power generation with gas-fired generation and nuclear power over the forecast period. Ontario coal-fired power plants are expected to be decommissioned by 2014 and other Canadian coal-fired power plants are expected to be decommissioned after a 45 year "economic life" and replaced with a combination of gas, nuclear, hydro, and renewable sources.

[40] February 9, 2012 United States Nuclear Regulatory Commission (NRC) approved Vogtle units 3 and 4 Combined Construction and Operating License (COL). Southern Company has started construction and expects Unit 3 to begin operating in 2016 and Unit 4 in 2017; however, Ziff Energy is forecasting some delays

[41] December 11-12, 2012 Minutes of the Federal Open Market Committee – *Table 1 Economic projections of Federal Reserve Governors and Reserve Bank presidents, December 2012*

[42] Monetary Policy Report - April 2013

## 7.3 North American Gas Demand Forecast

This section describes Ziff Energy's North American demand forecast assessment by sector, ordered based on current market share.

**Gas for Electrical Generation:** sector demand increases to 47.5 Bcf/d (50.1 PJ/d) in 2046 from 25.9 Bcf/d (27.3 PJ/d) in 2013, at 1.9% per year to comprise 40% of total demand in 2046. Overall power growth is driven by economic activity and grows at a rate of 1.1% per year during the forecast period. From 2000 to 2012, the gas burn for electrical generation grew at a rate of 5% per year; Ziff Energy believes gas-fired generation will continue to grow.

**Industrial Sector:** demand grows to 37.3 Bcf/d (39.3 PJ/d) in 2046 from 22.9 Bcf/d (24.2 PJ/d) in 2013, at 1.5% per year to become 31% of total demand in 2046. Included in 2046 industrial demand are 8.9 Bcf/d[43] (9.4 PJ/d) of LNG exports from North America, including 4.0 Bcf/d (4.2 PJ/d) from the U.S. Gulf Coast. Ziff Energy expects growth from non-Oil Sands and LNG export industrial sectors at 0.3%/year as traditional industrials[44] continue to work to become more energy efficient.

**Residential:** sector demand increases to 15.3 Bcf/d (16.2 PJ/d) from 14.5 Bcf/d (15.3 PJ/d), at 0.2% per year to become 13% of total demand in 2046. Ziff Energy's forecast customer count growth rate of 0.8% per year reflects lower future market penetration and more conservative economic growth. Ziff Energy believes that normalized gas consumption per customer will continue to decline; however, at a lower rate of 0.6% per year as the easy conservation measures have been implemented.

**Commercial:** sector demand increases to 11.3 Bcf/d (12.0 PJ/d) from 9.9 Bcf/d (10.5 PJ/d), at 0.4% per year to become 10% of total demand in 2046. Ziff Energy's forecast growth reflects lower future market penetration and more conservative economic growth. Ziff Energy believes that normalized gas consumption per customer will continue to decline, though at a lower rate of 0.4% per year as the easy conservation measures have been taken.

**Lease and Pipeline Fuel:** demand grows to 5.3 Bcf/d (5.6 PJ/d) from 5.2 Bcf/d (5.5 PJ/d) to become 4% of total demand in 2046. Improving fuel efficiency in this sector should keep overall fuel use at modest levels.

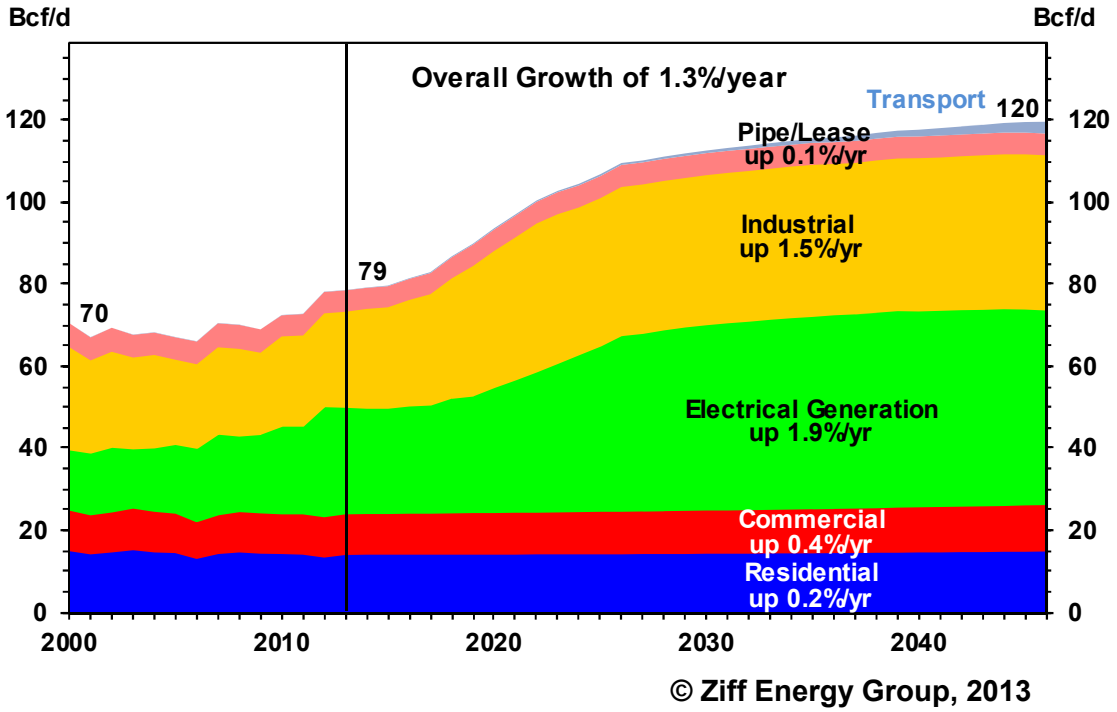
**Transport:** demand grows to 2.9 Bcf/d (3.0 PJ/d) from 0.1 Bcf/d (0.1 PJ/d) to become 2% of total demand in 2046. Ziff Energy believes initial growth will be driven by the least fuel efficient vehicle sectors such as: tractor trailers, city buses, and refuse transporters.

[43] Section 8.5 illustrates Ziff Energy forecast for LNG exports

[44] February 12, 2013, Andrew N. Liveris, Chairman and Chief Executive Officer, The Dow Chemical Company "Our manufacturing energy intensity, measured in British thermal units (BTUs) per pound of product, has improved more than 40% since 1990"

Figure 15 illustrates Ziff Energy's forecast for total North American gas demand which grows at a rate of 1.3% per year to 2046, increasing to 120 Bcf/d (126 PJ/d) at the end of the forecast period from 79 Bcf/d (83 PJ/d) in 2013. Exports to Mexico grow to 3 Bcf/d in 2046 (Section 8.4 of this report) and are not included in neither these volumes, nor in Figure 15.

**Figure 15**
**North America Demand Overview**




## 7.4 Canadian Gas Demand Forecast

This section provides Ziff Energy's Canadian natural gas demand forecast by sector. Major differences from the North American demand forecast are discussed.

**Industrial Sector:** demand grows to 11.2 Bcf/d (11.9 PJ/d) in 2046 from 3.4 Bcf/d (3.6 PJ/d) in 2013, at 3.7% per year, to comprise 56% of total demand in 2046. Included in 2046 industrial demand are 4.9 Bcf/d (5.2 PJ/d) of LNG exports. Non-Oil Sands/non-LNG export industrial demand in Canada is expected to increase to 2.0 Bcf/d (2.1 PJ/d) from 1.9 Bcf/d (2.0 PJ/d).

**Gas for Electrical Generation:** demand increases to 4.1 Bcf/d (4.4 PJ/d) from 1.6 Bcf/d (1.7 PJ/d), at 2.9% per year, to comprise 21% of total demand in 2046. Ziff Energy's forecasted growth rate for overall power generation from 2013-2035 is 1.0% per year, which compares closely to the NEB's[45] 0.9% per year growth rate during the same period.

**Residential:** sector demand increases to 1.9 Bcf/d (2.0 PJ/d) from 1.7 Bcf/d (1.8 PJ/d), at 0.3% per year to comprise 9% of total demand in 2046. As discussed previously (assumptions for customer

[45] "Canada's Energy Future: Energy Supply And Demand Projections To 2035", November 2011 – Reference Case

count and normalized consumption), Ziff Energy has chosen conservative parameters to calculate overall residential growth for Canada. Ziff Energy's forecasted growth rate from 2013-2035 of 0.3% per year is slightly lower than the 0.8% per year rate calculated in the NEB's 2011 reference case.

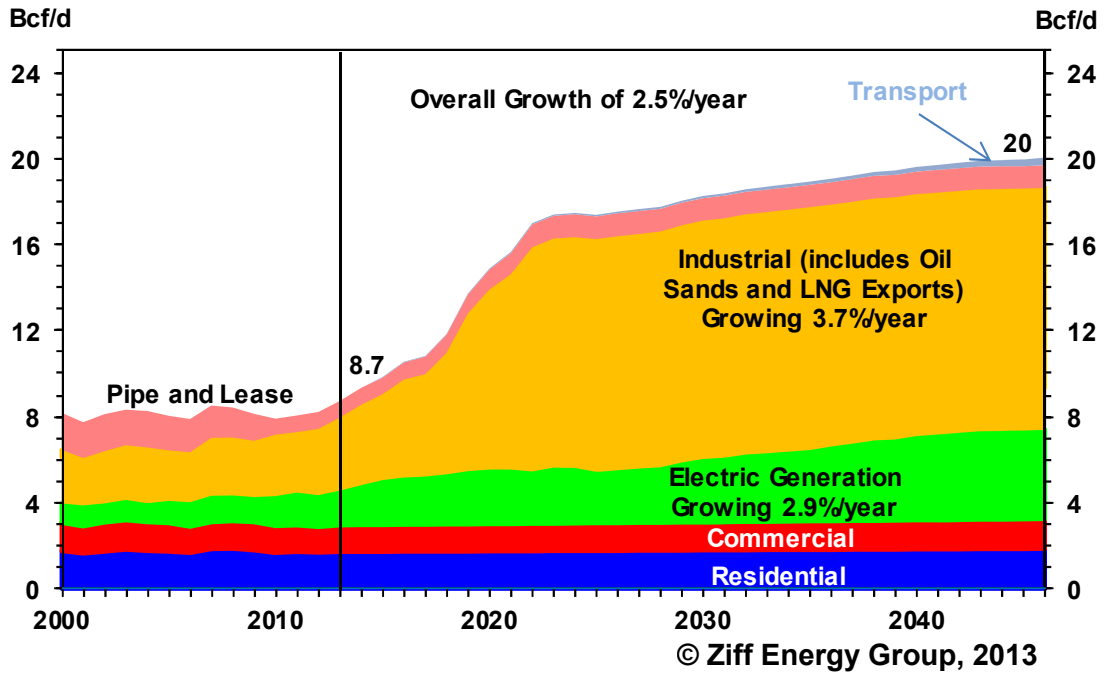
**Commercial:** sector demand increases to 1.4 Bcf/d (1.5 PJ/d) from 1.2 Bcf/d (1.3 PJ/d), at 0.3% per year to comprise 7% of total demand in 2046. Ziff Energy has modeled conservative parameters for customer count growth and normalized consumption based on more tempered economic growth and a decline in the rate of efficiency gains outlined in the assumptions section of this Report.

**Lease and Pipeline Fuel:** demand increases to 1.1 Bcf/d (1.1 PJ/d) from 0.8 Bcf/d (0.8 PJ/d), at 1.0% per year to become 5% of total demand in 2046. Increasing Canadian gas production should increase this sector's fuel use over 2013-2046.

**Transport:** demand grows to 0.3 Bcf/d (0.3 PJ/d) of Canadian demand in 2046 from less than 0.1 Bcf/d (0.1 PJ/d). Heavy trucking fueled by LNG will lead near term growth.

Figure 16 illustrates Ziff Energy's forecast of Canadian gas demand, which grows at a rate of 2.5% per year to 2046, increasing to 20 Bcf/d (21 PJ/d) at the end of the forecast period from 8.7 Bcf/d (9.2 PJ/d) in 2013. Canadian gas demand is currently 11% of the overall North America market; Ziff Energy is forecasting Canadian market share will grow to 17 % by 2046.

**Figure 16**
**Canadian Demand Overview**



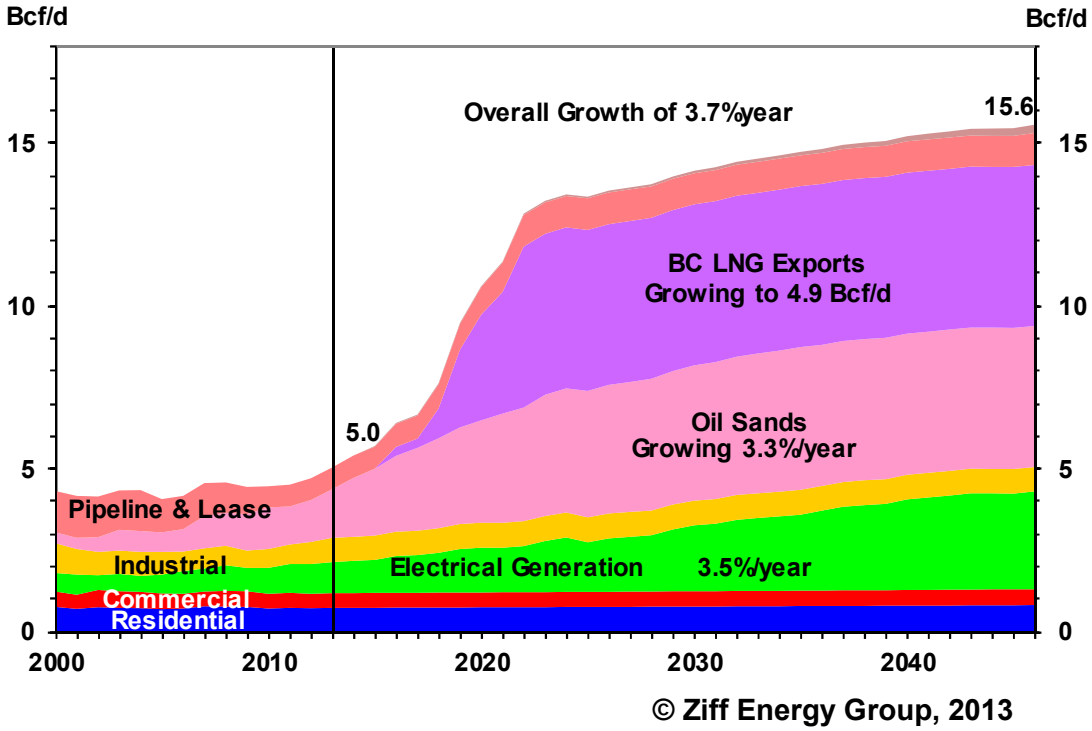
## 7.5 Western Canada Gas Demand Forecast

Figure 17 illustrates Ziff Energy's forecast for Western Canada[46] gas demand to 2046, growing to 15.6 Bcf/d (16.4 PJ/d) from 5.0 Bcf/d (5.3 PJ/d) in 2013. For Western Canada, Ziff Energy has further delineated industrial sector demand to show specifically:

- LNG exports from the West Coast of Canada at 4.9 Bcf/d[47] (5.2 PJ/d) in 2046
- Oil Sands requirements for natural gas growing to 4.3 Bcf/d (4.6 PJ/d) in 2046.

Another growing demand sector is gas required for electrical generation, which is expected to increase 3.5%/year. Alberta and Saskatchewan will increase gas-fired power capacity to meet proposed Environment Canada performance standard for power emission regulations.

**Figure 17**
**Western Canada Demand Overview**




[46] Western Canada includes British Columbia, Alberta, and Saskatchewan
[47] Ziff Energy has assumed 0.3 Bcf/d of LNG exports from the Woodfibre LNG Export Project and 4.6 Bcf/d from other Canadian West Coast facilities; Ziff Energy considers there is gas resource potential available for higher levels of North American LNG export than indicated here

# 8. NATURAL GAS SUPPLY / DEMAND BALANCE

This section reviews current and expected natural gas market dynamics, the impact these have on the interaction between gas supply and demand, and the resulting regional natural gas flows.

## 8.1 Competition for Canada Export Market Share

Figure 1, shown earlier in the report, illustrates the increased competition for Canadian natural gas exports. Throughout the 1990s, Western Canada pipeline exit capacity was expanded to the U.S. Pacific Coast, Midwest, and Northeast (to over 15 Bcf/d) and gas storage infrastructure was enhanced (withdrawal capacity now 7 Bcf/d). This connectivity provided North American gas markets with a valuable continental link giving consumers security of supply tools to mitigate seasonal energy supply disruptions such as low snow pack in the Pacific Northwest (affecting hydro-electric generation) and Gulf of Mexico hurricanes cutting gas supply.

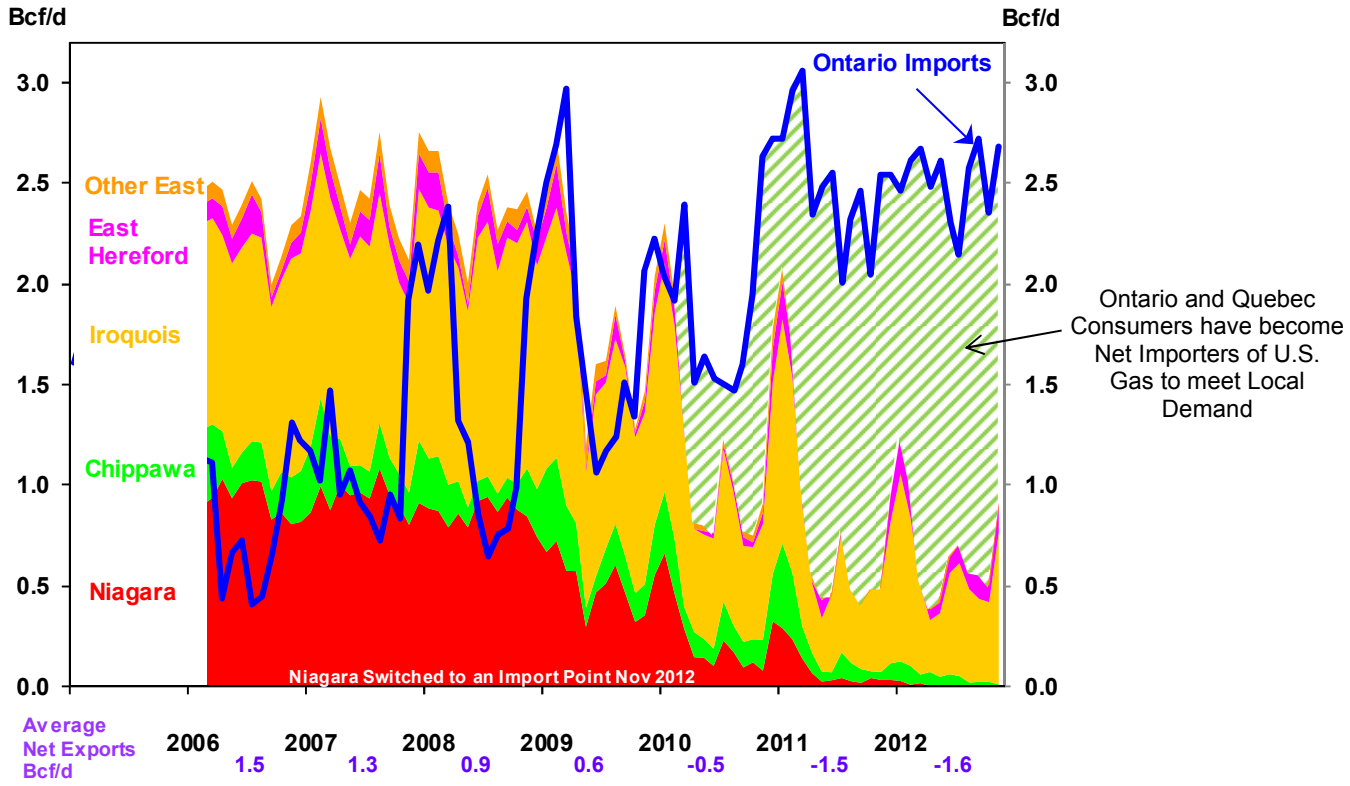
Since 2009, the completion of the Rockies Express, Bison, and Ruby pipelines has increased connectivity and competition from U.S. Rockies gas, and reduced the relative value of the Canadian continental link. Increasing growth from Unconventional Gas sources in the Appalachia and Arkoma Basins continues to push Canadian gas (with a geographic disadvantage) away from traditional U.S. Midwest and Northeast markets. Without new outlets for Western Canada production such as LNG exports or unconventional demand (LNG for heavy trucking, Gas to Liquids), Western Canada production will decrease in importance in the North America market, and production will continue to decline.

Western Canada gas demand is primarily satisfied by supply from Western Canada production. Historically, demand in Ontario and Quebec has been satisfied primarily by Western Canada supply. In recent years, Ontario and Quebec have sourced natural gas from the United States, imported into Ontario via the Dawn Hub, and recently through Niagara and Waddington, as the pipeline grid and infrastructure have adapted to the least cost supply available. Figure 18 shows that, in 2012, 1.6 Bcf/d more gas is imported into this region than is delivered to export pipelines out of this region. Imports of gas from the U.S. are replacing gas delivered via the long-haul TransCanada Mainline system. Consumers in Ontario and Quebec have access to multiple supply sources via multiple pipeline connections, and are sourcing more low-cost imported natural gas via the Dawn Hub and Niagara/Waddington. This is expected to continue with:

- the completion of the Northern Access Pipeline (bi-directional capability) allows Marcellus gas direct access to Ontario at Niagara[48]
- an amended Presidential permit received by Iroquois in September 2010 for gas exports to Canada at Waddington
- recently announced Nexus pipeline has proposed 1 Bcf/d incremental capacity into Dawn and is backed by DTE Energy, Enbridge, and Spectra Energy for a 2016 in-service date.

[48] during the final two months of 2012 imports averaged 350 MMcf/d

## Figure 18
## Canadian Gas Supply-Demand Allocations



## 8.2 North American Natural Gas Market Dynamics

North American gas supply is regionally dispersed among four major regions: Western Canada, U.S. Gulf Coast, Mid-continent, and Rockies. A new supply region in the U.S. Northeast has evolved with growth in Marcellus and Utica Shale Gas. Natural gas is consumed in each supply region, particularly in Western Canada, the U.S. Northeast and the U.S. Gulf Coast, with excess supply transported to regions which lack adequate local supply. Premium natural gas demand centers are located in the U.S. northeast and Eastern Canada, California, and U.S. Midwest. In some regions, natural gas must be imported to satisfy demand. Natural gas consumption varies seasonally because of temperature-sensitive heating loads and, to a lesser extent, because of temperature-sensitive electricity demands for cooling.

To deal with geographical and seasonal variables, the North American gas supply system is characterized by a sophisticated network of gas transportation and storage facilities transferring gas inter-regionally to meet both base load and peak demands.

Subsequent to commodity price deregulation and open access to pipelines, the natural gas delivery infrastructure has developed and adapted in response to changing gas supply and demand. If physical connectivity becomes a challenge, pricing differentials[49] widen and market participants step in to build required infrastructure to enhance linkages. The process of infrastructure enhancement is ongoing and relies on market signals and pricing differentials between trading hubs, storage fields, producing basins, market centers, and LNG facilities. For example, the current market differential between the Western Canada Sedimentary Basin (WCSB) and Ontario is approximately $1.30/Mcf, while the transportation cost is approximately $1.50/Mcf, rendering WCSB supply unattractive for Ontario consumers who can source U.S. supply more cheaply.

If changes develop in supply, for example the development of low cost Shale Gas volumes or changes in regional demand for gas-fired electrical generation, pricing differentials will respond and signal the economic opportunity to create new infrastructure such as new pipelines and laterals or LNG import/export terminals. Similarly, pricing differentials can render existing transportation systems too costly and under-utilized. This process of transportation rationalization is continuous. The physical integration allows gas to be produced, transported, and stored or withdrawn from storage, to respond to changes in gas supply and demand fundamentals. Gas can also be “parked”, “swapped”, or “backhauled”, which are all industry arrangements for efficiently clearing supply and demand.

The natural gas market is characterized by large numbers of competing sellers, buyers, intermediaries, and huge trading volumes. It is highly liquid, price transparent, and facilitated by electronic trading platforms, a vigorous futures market, and availability of financial instruments to enable hedging and related activities. The NYMEX natural gas futures contract clears at Henry Hub, Louisiana where many gas pipelines and storage facilities interconnect. Physical gas volumes transacted at Henry Hub may decline as volumes at other hubs increase due to growing Shale Gas supplies. Prices at major trading hubs relate to Henry Hub and generally respond to local supply and demand conditions, and availability of transportation and storage capacity. Some hubs, such as AECO/Nova Inventory Transfer (NIT) and Westcoast Station 2 in Western Canada, are not

[49] a natural gas pricing differential is the difference in gas prices between two natural gas trading hubs

physically connected to Henry Hub via pipeline infrastructure; however, prices at all major hubs are expressed relative to Henry Hub.

Shippers on major inter-regional and international pipelines may be producers, marketers, or local distribution companies. Pipeline transportation services can be firm or interruptible, and long or short term, pursuant to regulated rates and conditions of service. Shippers are able to re-sell contracted capacity in an open secondary market for pipeline transmission. The existence of this secondary market provides the gas commodity market with another important element of flexibility and contributes to the formation of a fair market commodity price.

The North American natural gas market's commercial structure and activities within that structure reflect market behaviour which results in market clearing prices. Consumers will generally purchase at the lowest possible delivered gas price, taking into account security of supply, financial strength of the supplier, and length of term. Consumers are generally indifferent as to the geographical source of their gas supply. All of the above attributes contribute to the development of a highly liquid, open, and efficient North American natural gas market.

## 8.3 Gas Market Integration

Some areas, such as Western Canada and the U.S. Gulf Coast region, produce more natural gas than they consume, so prices will typically be lower than market areas such as California or Ontario which need to import supply. Hubs, such as Dawn in southern Ontario, which have access to natural gas storage infrastructure, balance temperature-sensitive gas demand on a seasonal, monthly, and day-to-day operational level.

Most markets can access natural gas from multiple sources. The U.S. Midwest can access gas from Canada, U.S. Gulf Coast, U.S Rockies, and U.S. Mid-continent, and other sources. U.S. Rockies supply can access U.S. northeast, Midwest, Canadian, California, Pacific NW, and other markets. North American and Canadian consumers have the choice to purchase the lowest cost delivered gas, and producers can choose to transport gas to the highest paying markets, on a netback basis. Pipeline, storage, and midstream companies ensure facilities are built to connect supply with demand and charge fees for transmission, processing, and storage.

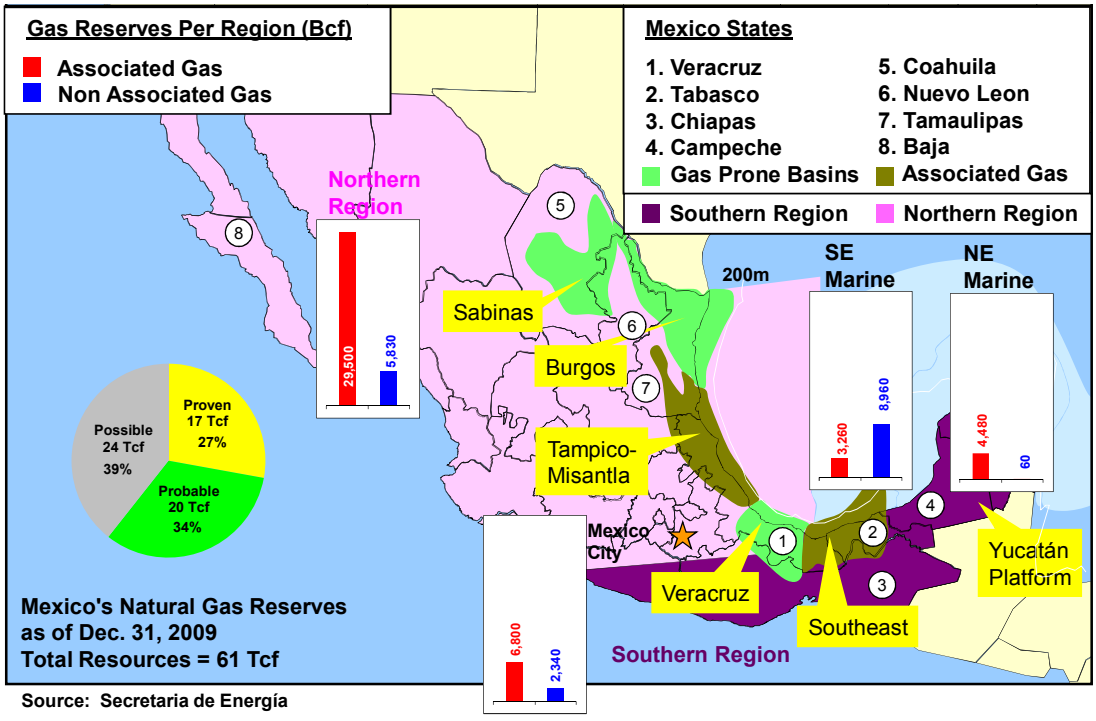
The dynamics of supply and demand have changed since deregulation of natural gas markets in the U.S. and Canada. New sources of gas supply have emerged and new pipelines and other infrastructure constructed. In some cases, new supply has "backed out" supply from traditional sources because transportation differentials are lower, and therefore the netback to the producer is higher. Producers move capital to gas supply areas earning the highest returns. In these areas, production will grow at the expense of higher cost, or lower netback areas. Overall, North American markets will continue to allocate gas supply to markets based on arbitrage opportunities created by market prices and pricing differentials.

## 8.4 Mexican Net Imports

Since 2005, net pipeline imports into Mexico from the U.S. have ranged from 0.7-1.4 Bcf/d. Ziff Energy has assumed imports will increase to 3.0 Bcf/d. Production forecasts include volumes for export to Mexico; however, the gas demand forecast presented in Section 7 excludes Mexico exports. Gas production in Mexico will continue to be challenged by PEMEX resources, and a legal framework that hinders large capital investments. Non-Associated Gas reserves are primarily located in the Burgos and Veracruz basins. In September 2012 it was reported that PEMEX would spend $200 MM on a program to exploit the Eagle Ford shale. The PEMEX March 2013 corporate presentation highlighted 200 exploratory opportunities to develop Shale Gas in Mexico. Figure 19 shows Mexico gas reserves[50] by region. The allocation of gas resources in 2010 is:

- 58% in the northern (35 Tcf) and 15% in the southern region (9 Tcf)
- 20% in southeast marine (12 Tcf) and 7% in the northeast marine region (5 Tcf)
- largest reserves decline (from year end 2008) is in the Northeast Marine region (7%); reserves additions are reported in Southeast Marine region (28%).

**Figure 19**
**Regional Mexico Gas Reserves**




[50] 17 Tcf Proven, 20 Tcf Probable, and 24 Tcf Possible. Mexico reserves definition system is incompatible with SEC reserves disclosure requirements

## 8.5 North American Intercontinental LNG Trade

### U.S. Export Assumptions

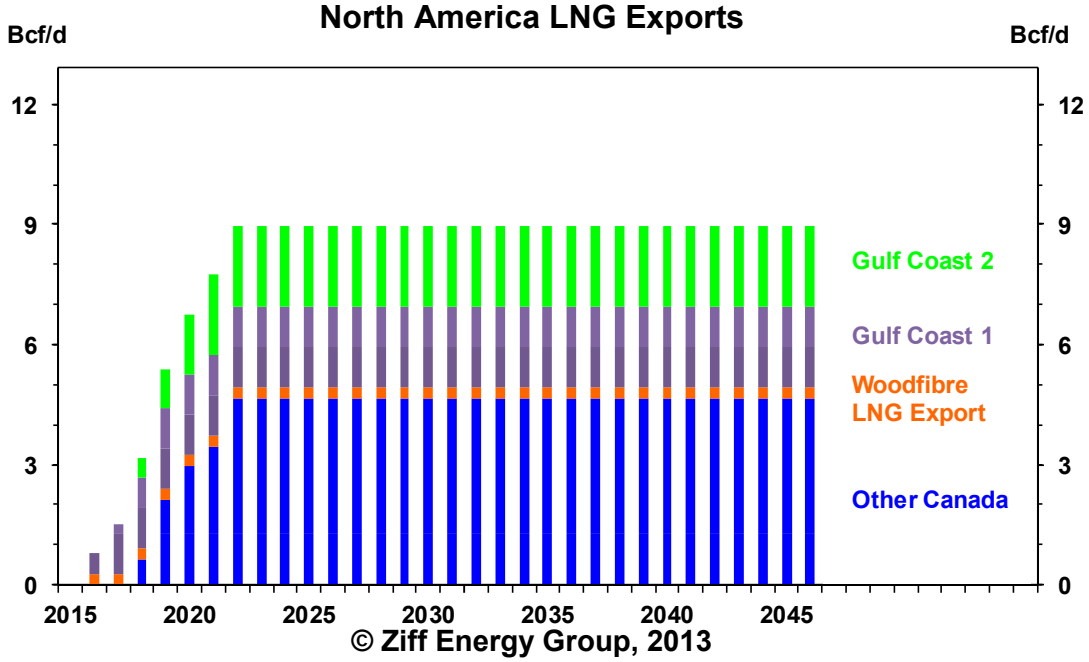
Figure 20 illustrates North American LNG Export assumptions. Ziff Energy forecasts LNG exports reaching 11.7 Bcf/d during the forecast period:

- 1 Bcf/d of U.S. Gulf Coast facilities exports beginning in 2016 and increasing within the U.S. to 4 Bcf/d in 2021
- 0.6 Bcf/d of other Canadian exports beginning in 2018 and growing to 4.6 Bcf/d
- the proposed Woodfibre LNG Export Project beginning in 2016 and ramping up to 0.3 Bcf/d at maximum capacity.

North American gas resource potential is large and could support exports in excess[51] of those modeled in Figure 20. Economics will ultimately determine if increased liquefaction investment by buyers and sellers is warranted. Some major factors which need to be assessed:

- potential overseas sales price
- future cost of facilities[52] and shipping
- competition from supply sources outside North America.

**Figure 20**
**North America LNG Exports**




[51] once built Ziff Energy believes operators will enhance operations through technology improvements, and operations efficiencies; increased output and exports are likely possible over the life of LNG liquefaction facilities

[52] Cheniere Energy's corporate presentation in April 2011 estimated Sabine Pass CAPEX at $400/ton or $3.2 Billion for the 8 Mtpa facility and in their March 2012 corporate presentation Cheniere indicated a lump-sum turnkey EPC contract would be $4.5-5.0 Billion, a one year 40-56% cost increase

## 8.6 North American Supply / Demand Balance

This section summarizes natural gas supply, demand, and resultant flows of gas over the forecast period. Pipeline transmission and infrastructure are expected to continue to adapt, connecting gas from growing supply regions to major demand centers. Ziff Energy forecasts significant changes in North American gas flows will take place in the forecast period through 2046. The elements for some of these changes have already begun to appear. In addition to demand, Ziff Energy models demand for the Woodfibre LNG Project's 0.3 Bcf/d – 0.3 PJ/d - (LNG Terminal outlet) as a North American gas out-flow.

United States Northeast demand has been satisfied from several supply basins, including the U.S. Gulf Coast, U.S. Mid-continent, and Western Canada which has also been the primary supply basin for Ontario and Quebec markets. Canadian gas from Sable Island has flowed into the U.S. Northeast since 1999[53], and the Rockies Express Pipeline has brought U.S. Rockies supply to the Northeast since 2009. The U.S. Northeast is now sourcing increasing quantities of gas from the Marcellus Shale Gas production area. Imports of U.S. gas into Ontario are replacing gas delivered from western Canada via the TransCanada Mainline which is underutilized. This trend is likely to continue as existing pipeline connections are enhanced and as U.S. gas deliveries to Ontario continue through the Dawn hub and Niagara/Waddington delivery points.

Historically, northern California has been an important market for western Canadian gas delivered via the Gas Transmission Northwest (GTN) system from Kingsgate, British Columbia to Malin, Oregon. Expansion of production in the Rockies area has resulted in the Rockies Express Pipeline connecting this supply to points east. The Ruby pipeline, completed in summer 2011, connects the Opal, Wyoming delivery hub to Malin, Oregon. This will push gas back into Canada that was previously accessing the California market. The Bison pipeline has connected U.S. Rockies supply to the Northern Border system for delivery into the Chicago area and possible re-delivery into Ontario via Dawn. Bison deliveries from the Rockies will also back out Western Canada gas volumes which would otherwise flow through Foothills Pipeline into the Northern Border system. The Bakken oil development in North Dakota has grown rapidly, and with it, the amount of Associated Gas production. The connection of the Prairie Rose lateral and recent success of the Tioga Lateral open season will increase gas flows on the Alliance U.S. pipeline utilizing allowable uprate pressure; any further connection of liquids rich Associated Bakken Gas will likely come at the expense of gas flows from Canada.

The North American gas pipeline grid is interconnected and responsive of changes in Henry Hub pricing. Supply-demand fundamentals can change regionally more quickly than enhancements to the North American pipeline grid, which can cause differentials between pricing points to increase, signalling the need for more transmission capacity. With development of growing low-cost supply sources, pipeline infrastructure is enhanced, and gas flows adjust accordingly.

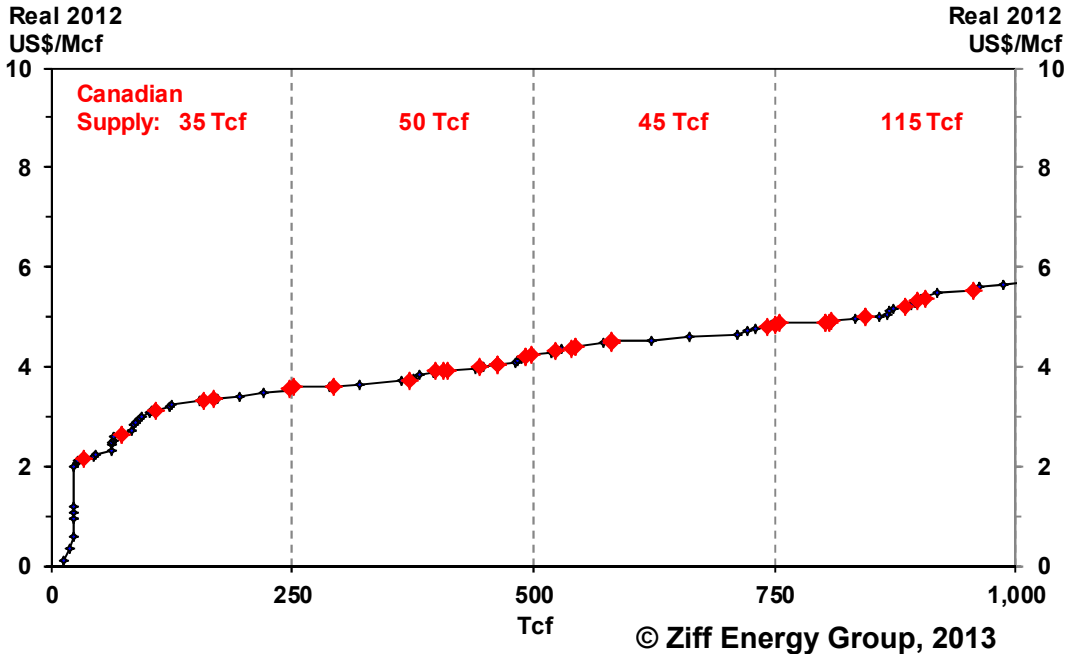
[53] declining Sable Island Production and newly connected Deep Panuke, and other local supply are not expected to be sufficient to cover Maritime demand; for this reason, a reversal of Maritimes and Northeast Pipeline can be expected

Figure 21 illustrates Ziff Energy's view of the lowest cost 1,000 Tcf of North American natural gas (Canadian reserves (red diamonds) and Lower 48 reserves (blue diamonds)). Observations:

- during 2013-2020, 250 Tcf of gas resource is required:
  - to meet growing North American demand
  - for exports of LNG and gas via pipeline to Mexico
  - to offset declines from currently producing supplies
- Canadian natural gas:
  - 14% of Canadian gas resource will be competitive within the first 250 Tcf for North America gas markets
  - over 200 Tcf (28%) of competitive supply is available over the final 750 Tcf of North American resource.

Based on this cost analysis, Ziff Energy believes that Western Canada will continue to compete with lower 48 supplies, albeit with reduced near term exports to Midwest and Northeast markets[54]. U.S. Rockies gas supply is facing similar cost pressures and is expected to decline over the near term. The combination of Western Canada and higher cost new Rockies supply will create a premium priced market on the U.S. Pacific Coast. Connections westward from the growing Permian basin should become highly utilized going forward. Longer-term, competitive Western Canada gas supply is available for Canada Consumption, Lower-48 exports, and LNG exports.

**Figure 21**
**North American Full Cycle Gas Resource Cost at Henry Hub**




[54] Canadian pipelines operating under a cost of service recovery model without long-term contracts will be challenged to compete with Lower-48 pipelines with the ability to discount tolls

Figure 22 shows net inter-regional flows in 2010 and gross Dawn imports, which reflect supply and demand fundamentals and corresponding pipeline and delivery infrastructure. Buoyed by Shale Gas growth, the U.S. Southwest (Texas, Louisiana, Oklahoma, and Arkansas) had 22.1 Bcf/d of gas out-flows in 2010. With the completion of the Golden Pass LNG regasification facility in late 2010, the U.S. Southwest has 11.9 Bcf/d of regasification capacity; however, only 0.4 Bcf/d of LNG imports were realized. On a net basis, the U.S. Northeast sources 83% of gas demand requirements from other regions and LNG.

**Figure 22**
**Inter-regional North American Gas Flows (Bcf/d), 2010**

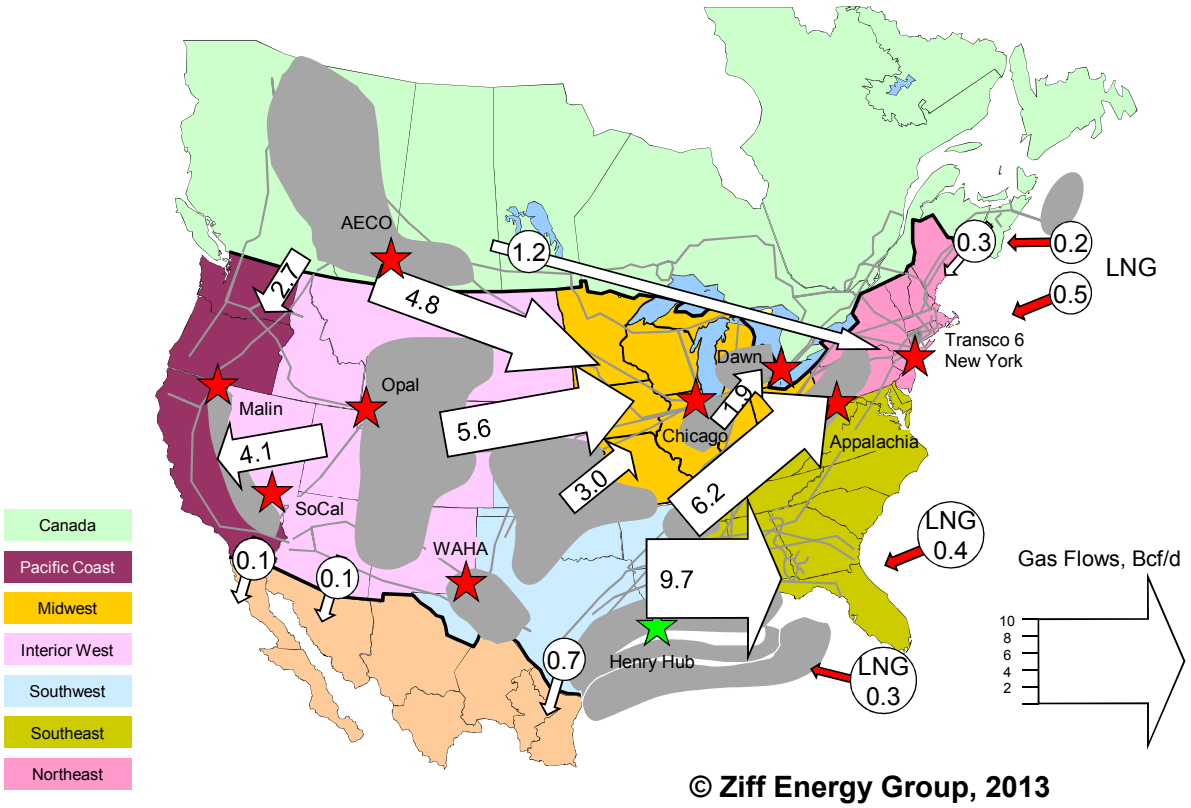
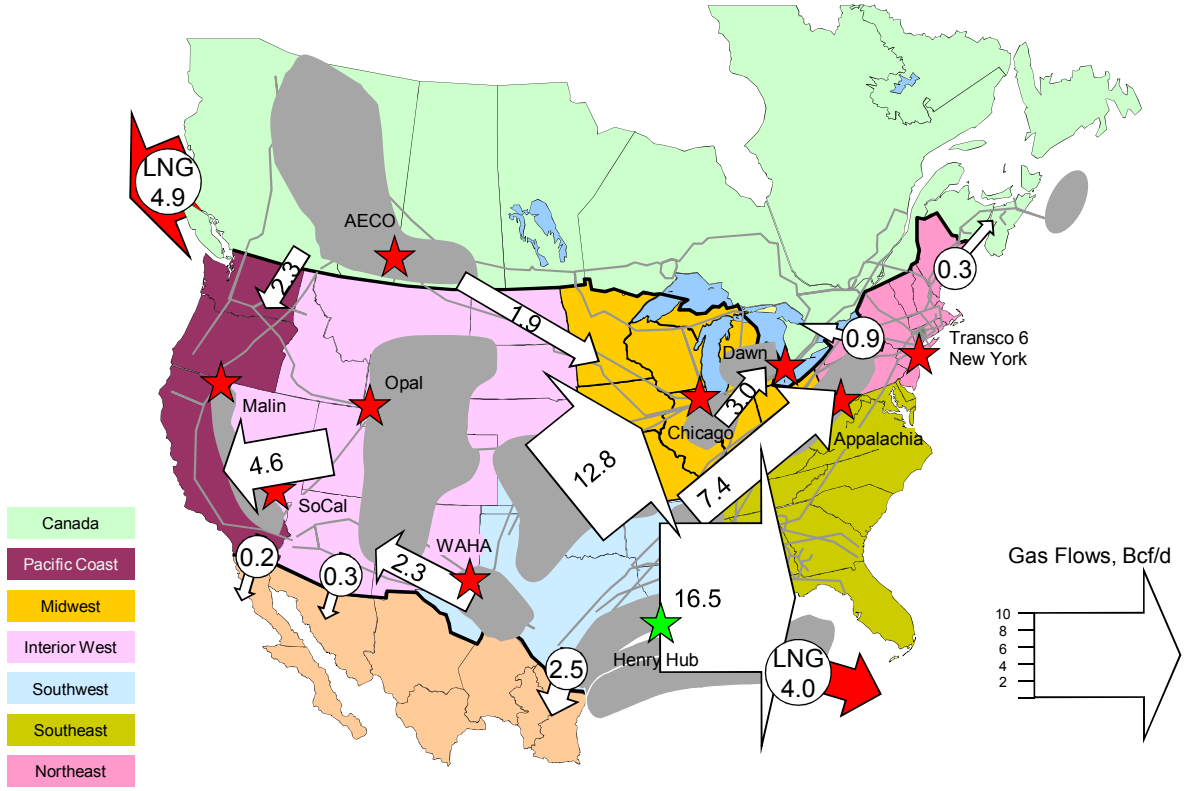


Figure 23 shows expected net inter-regional flows in 2046 which reflect supply and demand fundamentals and corresponding pipeline and delivery infrastructure. Growth in U.S. Interior West and Southwest supply due to new play development allows for demand growth in the U.S. Midwest and Southeast. The U.S. Northeast continues to have more than half of its demand covered by in-region supply.

**Figure 23**
**Inter-regional North American Gas Flows (Bcf/d), 2046**



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## 8.7 Canadian Supply / Demand Balance

Gas supply in lower cost/higher netback areas is growing. The growth in Marcellus Shale Gas supply has prompted pipeline, midstream, and storage operators to propose and develop infrastructure recognizing changing supply dynamics. Western Canadian gas supply will be available for Canadian domestic and export markets, and given a competitive market, will preferentially flow to the markets providing highest netbacks.

Western Canadian gas displaced by downstream pipeline developments (Niagara Reversal into eastern Canada and Nexus Proposal) will access growing Alberta demand, primarily for heating and processing growing Oil Sands production, for power generation, and planned LNG exports. Commercial decisions for disposition of this gas will hinge on prices in downstream markets, transportation costs, and resultant netbacks to producers, versus market prices in Western Canada. Western Canada is expected to have adequate supply for in-region use, and exports to other jurisdictions, including eastern Canada, and planned LNG deliveries.

Figure 24 shows Ziff Energy's analysis of supply, demand, and disposition of Canadian gas in 2010.

**Figure 24**
**Canadian Gas Imports and Exports (Bcf/d), 2010**

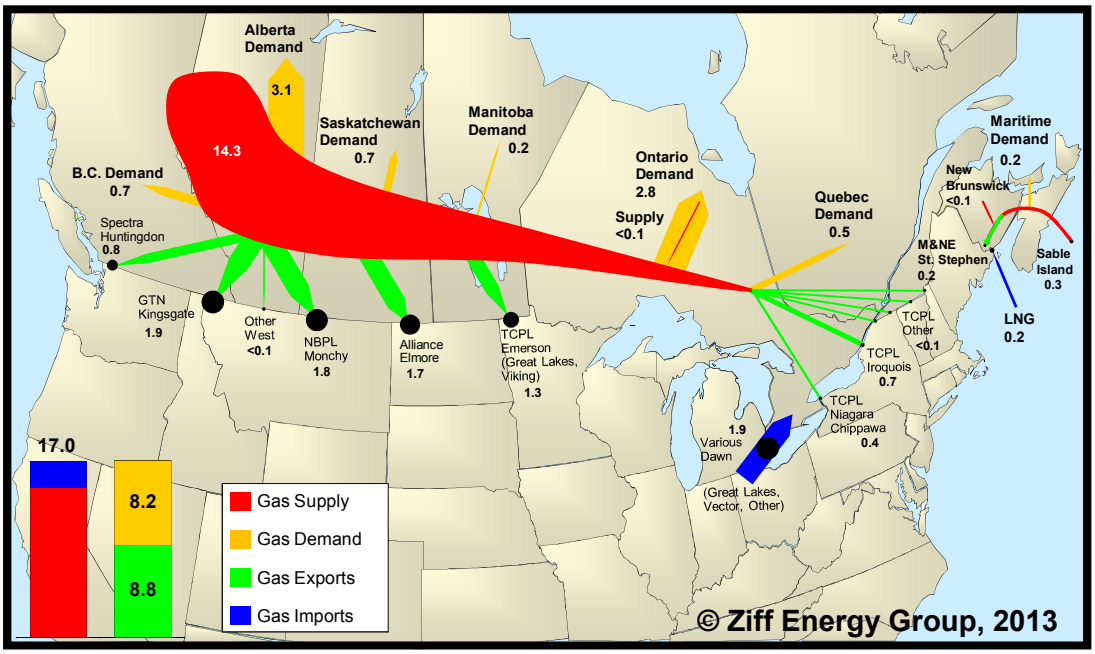
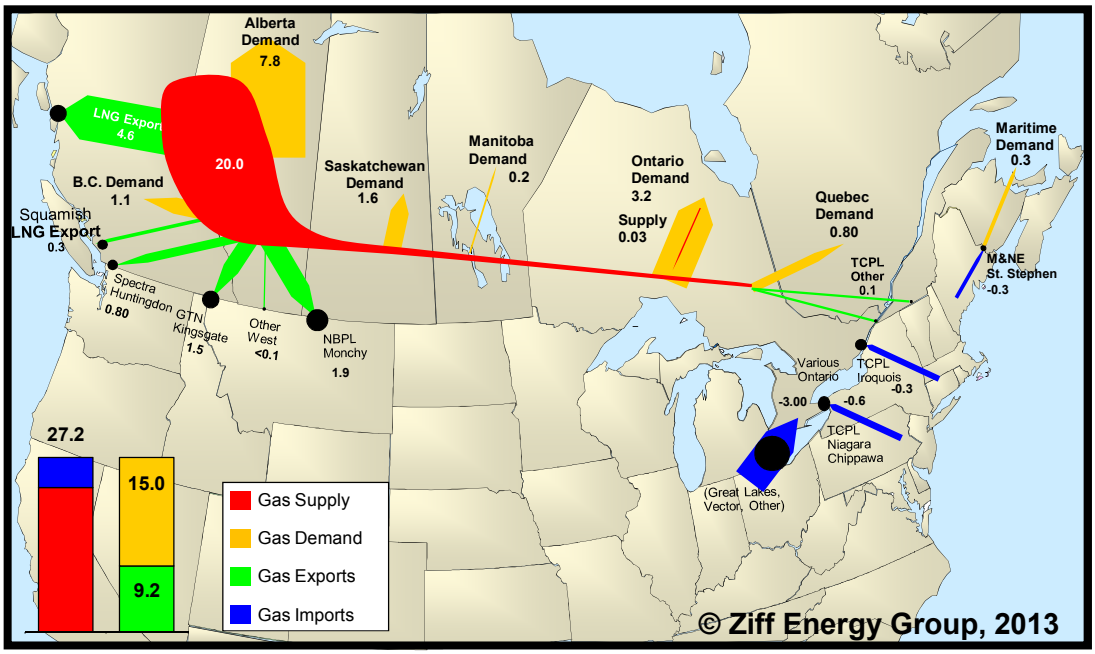


Figure 25 shows Ziff Energy's expectation of supply, demand, and disposition of Canadian gas in 2046. Observations as previously discussed: Western Canada supply increases to 20 Bcf/d (21 PJ/d) in 2046; Alberta demand increases to 7.8 Bcf/d (8.2 PJ/d) in 2046; Ontario demand remains steady at 3.2 Bcf/d (3.4 PJ/d); imports of U.S. gas into Ontario grow to 3.9 Bcf/d (4.1 PJ/d); reversal of Maritimes and Northeast Pipeline; export pipelines at the eastern terminus of the TransCanada system are expected to receive low volumes of gas supply or reverse to deliver gas eastern Canada. Ziff Energy has made the assumption that upstream incremental transportation will be constructed to meet the needs of the Woodfibre LNG Export Project, Spectra T-South domestic, and T-South export consumers.

**Figure 25**
**Canadian Gas Imports and Exports (Bcf/d), 2046**



# 9. GAS PRICE SENSITIVITY

## 9.1 Impact of LNG Exports on Gas Price

Shale Gas revolution has been made possible by the ability to fracture horizontal wells multiple times.

Figure 26 illustrates the inconsequential production of pre-shale technology using average Western Canadian IPs over the 2004-2006 pre-shale era with a representative 1,030 cumulative wells[55] for comparative purposes.

Figure 27 shows 4.7 Bcf/d of actual Haynesville Shale Gas production resulting from 1,030 wells drilled from 2008-2010 (50 times greater than a traditional WCSB well). This production growth benefited from established natural gas plant and pipeline infrastructure which had been developed in Louisiana and Texas to process gas for markets upstream of Henry Hub.

Figure 28 models 1,030 wells over three years using Ziff Energy's forecast for Horn River IP and decline rates. This forecast drilling results in 4.7 Bcf/d of production, over 15 times greater than the 0.3 Bcf/d required for Woodfibre LNG Export's proposed export.

Ziff Energy believes producers can quickly respond to increased LNG export demand by drilling highly productive Shale Gas wells thereby preventing a return to supply-short market conditions and muting upward pressure on natural gas prices. Increases in demand can be quickly matched by increased supply which will mute price increases. During the pre-shale period, increased demand caused price spikes and LNG imports as North American supply was effectively constrained. The availability and exploitation of the low cost North American Unconventional Gas resource endowment is the primary driver for consideration of LNG exports.



**Figure 26**
**Average WCSB**

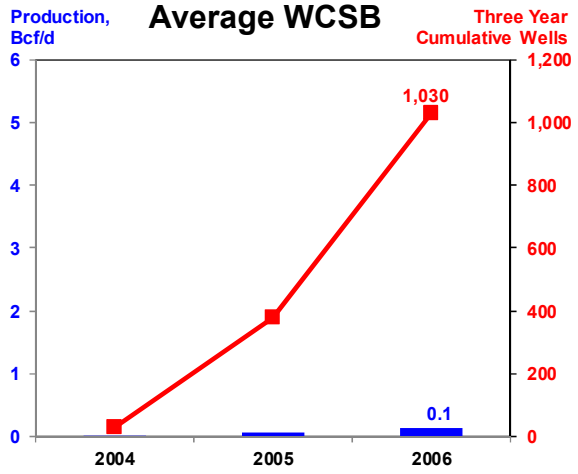



**Figure 27**
**Haynesville**

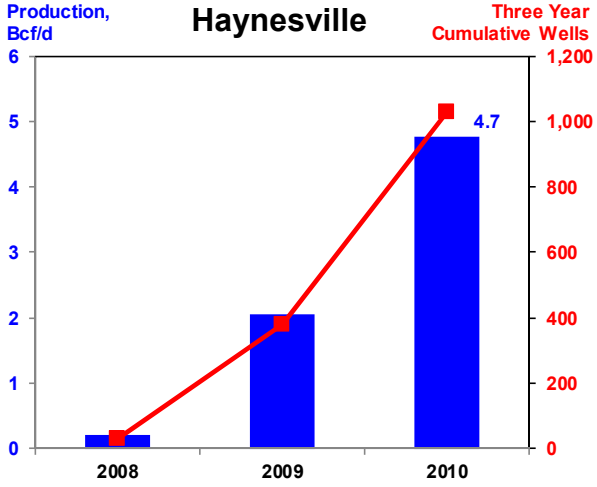
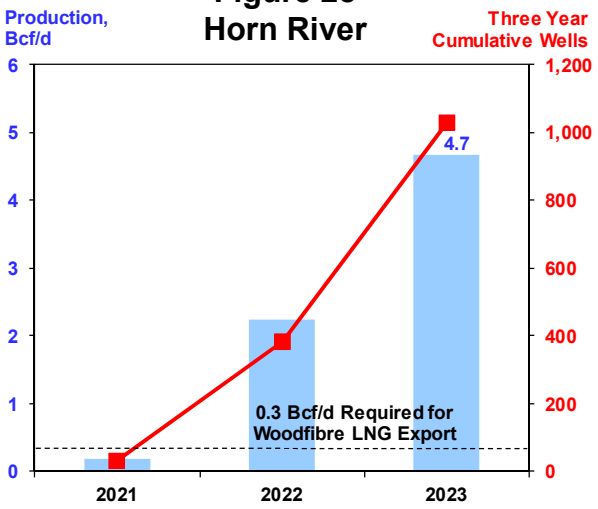



**Figure 28**
**Horn River**




[55] more than 50,000 wells were connected in Western Canada during this period

The North American and Canadian natural gas markets are highly integrated and liquid providing gas purchasers and sellers multiple options to ensure that the most economic natural gas is developed, transported, and sold into the market.

Operating the LNG facility and terminal at high load factors will ensure the lowest unit cost and best economics for the project and provide incentive for proponents to use various options to secure gas supply, including:

- purchase of prospective land or reserves from producers
- using forward markets to secure physical natural gas supplies – North American forward exchanges are robust and well established.

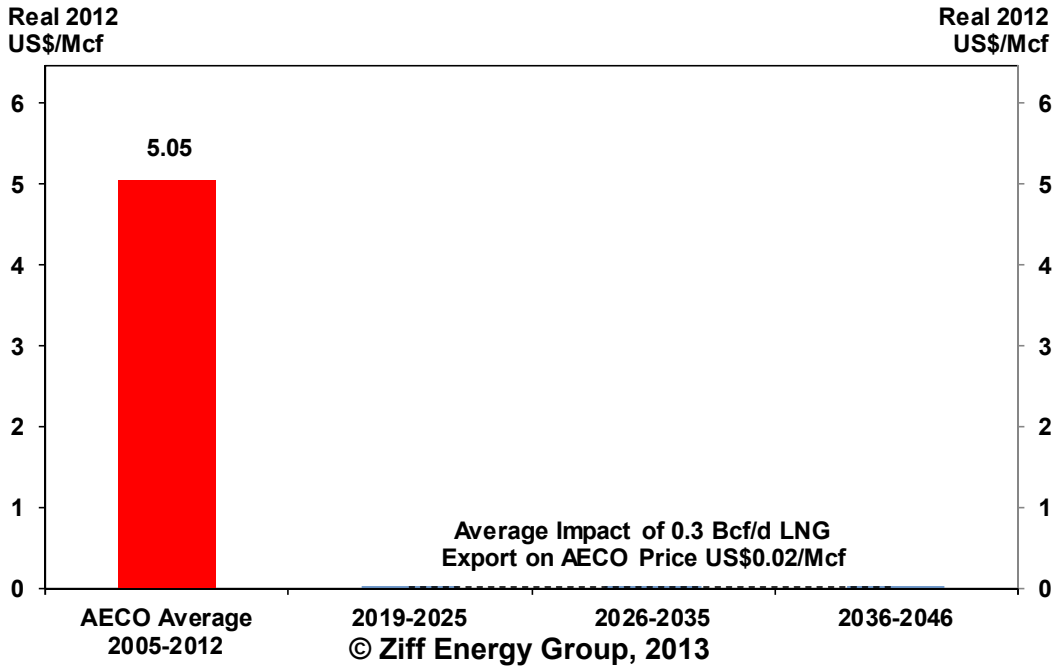
If gas prices on the forward market are less than the cost of developing gas resources, the operator could defer drilling and maximise cost efficiencies through buying gas in the market. Thus new markets for Western Canadian gas provided by the Woodfibre LNG Export Project could provide opportunities for producers in the entire gas market.

It is Ziff Energy's opinion, assuming availability of infrastructure, equipment, people, and capital, the proponents can ramp up supply to meet the Project's staged development forecasted to begin in 2016. Supporting this assertion:

- productivity gains which have been made possible by combining horizontal drilling with multi-stage high pressure hydraulic fracturing techniques:
    - in Western Canada; this technology provides access to large gas resources within the Montney, Horn River, Duvernay, Cordova, and Liard areas
    - large quantities of low cost resource are available for additional gas market growth as illustrated in Figure 21 (Full Cycle Gas Resource Cost Curve)
- well-functioning markets encourage more efficient producers to bring on additional production.

Figure 29 illustrates that the average incremental impact of the Woodfibre LNG Export Project on natural gas prices over the export period is $0.02 /Mcf. To put this in perspective, AECO prices averaged $5.05/MMBtu since 2005[56]. When the Woodfibre LNG Export Project begins operation, the most prolific Western Canadian Shale Gas and Tight Gas plays will still be relatively immature and at the low-cost end of the cost curve[57]. As we move forward in time, lower productivity wells are drilled and movement up the cost curve is accelerated slightly, resulting in marginally higher cost natural gas. Ziff Energy would expect that technology enhancements will lower the cost of producing from (today's) less productive areas. Ziff Energy also expects the marginal resource cost curve (Figure 21) will flatten in later years as technology improves and as emerging[58] and new Unconventional Gas plays are identified and exploited, all of which would likely mute the price impacts of the proposed gas export.

**Figure 29**
**Impact of the Woodfibre LNG Export Project on Natural Gas Price**




[56] Monthly Bid Week Index January 2005 – December 2012 during which prices ranged from US$1.68-11.43/Mcf
[57] illustrated by the red diamonds in Figure 21
[58] Unconventional Gas resources exist in plays others than those currently attracting capital expenditures for development. Gas resources have been identified in a myriad of other plays, including the Quebec Utica, the Collingwood play in the Michigan Basin, the Maverick/Pearsall play in Texas, Colville plays in the Northwest Territories, and the Niobrara play in the U.S. Rockies. Other plays have already been identified, and more are expected. New and emerging plays are not represented in Figure 21

# 10. CONCLUSIONS

This report presents Ziff Energy's North American and Canadian natural gas supply, demand, and inter-regional flow forecasts to 2046. This analysis has taken into account Woodfibre LNG Export's proposed licence to export up to 2.1 million tonnes per annum[59] over the forecast period. Ziff Energy's main conclusions concerning demand, supply, and market dynamics during the forecast period are:

1. North American and Western Canadian gas resources are robust and continue to grow with the development of horizontal drilling and multi-stage fracture technologies

2. North American and Western Canadian gas supply is not constrained to meet projected base demand and incremental demand from the Woodfibre LNG Export Project over the forecast period

3. there is an abundance of low cost natural gas resource available in North American and Canadian Shale and Unconventional Gas plays

4. Western Canada has productive natural gas potential far in excess of projected demand over the forecast period, having regard to trends in the identification of gas resources, particularly Unconventional Gas, and in the development of cost-competitive production from those resources as a result of technological advances referred-to in Number 1 (above)

5. Western Canada has potential natural gas supply in excess of projected demand over the forecast period

6. Canadian gas supply is expected to grow to 20 Bcf/d (21 PJ/d) in 2046 from 13 Bcf/d (14 PJ/d) in 2012, as new gas supplies more than offset declines of higher cost Conventional Gas. In 2012, Western Canada was the source of 98% of Canadian gas supply

7. Western Canadian natural gas is facing competition and significant displacement in traditional markets, including in eastern Canada, from low cost U.S. Lower 48 gas

8. the North American market is highly liquid, open, and efficient

9. despite declining Western Canadian gas production since 2001, Canadian gas markets have been adequately supplied and this is forecast to continue; these markets are a component of the integrated North American market

10. North American gas demand growth will be driven primarily by gas-fired electrical generation, Canadian Oil Sands gas demand, and LNG export liquefaction

[59] natural gas equivalent of approximately 0.3 Bcf/d, 0.3 PJ/d

11. Canadian gas demand growth is expected to be driven principally by a switch away from coal-fired power generation, gas for growing Oil Sands production, and LNG liquefaction

12. Canadian gas demand is expected to increase at an average of 2.5% per year over the forecast period and will comprise a larger component of North American demand, increasing market share to 17 % in 2046 from 11% in 2013

13. the market impact from the proposed Woodfibre LNG Export Project will be muted by the abundance of low cost gas resource available in North America and Western Canada

14. the incremental price impact of the Woodfibre LNG Export Project on AECO natural gas prices over the forecast period will be negligible, averaging US$ 0.02 /Mcf

15. natural gas markets will continue to function over the forecast period with natural gas buyers and sellers establishing fair market prices based on supply and demand fundamentals

16. Ziff Energy considers that the export of gas proposed by Woodfibre LNG Export will not cause Canadians any difficulty in meeting their natural gas requirements at fair market prices over the forecast period.