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Weighted Average Cost of Retail Gas (WACORG) highlights pricing effects in the US gas value chain: Do we need wellhead price-floor regulation to bail out the unconventional gas industry?

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ABSTRACT

The total annual revenue stream in the US natural gas value chain over the past decade is analyzed. Growth of total revenues has been driven by higher wellhead prices, which peaked in 2008. The emergence of the unconventional gas business was made possible in part by the pre-recessional rise in global energy prices. The general rise in natural gas prices between 1998 and 2008 did not lower overall US gas consumption, but shifts have occurred during the past decade in the consumption levels of individual consumer groups. Industry's gas consumption has decreased, while power stations increased their gas consumption. Commercial and residential consumers maintained flat gas consumption patterns. This study introduces the Weighted Average Cost of Retail Gas (WACORG) as a tool to calculate and monitor an average retail price based on the different natural gas prices charged to the traditional consumer groups. The WACORG also provides insight in wellhead revenues and may be used as an instrument for calibrating retail prices in support of wellhead price-floor regulation. Such price-floor regulation is advocated here as a possible mitigation measure against excessive volatility in US wellhead gas prices to improve the security of gas supply.

1. Introduction

The depressed natural gas prices of 2009, 2010 and 2011 in North America threaten to decelerate the development of its unconventional gas resources. The US and Canadian unconventional gas potential is huge, but the technical, economic and environmental challenges remain steep. The resources are there: assessment of the technically recoverable unconventional resources in North America suggests that shale gas resources lead the way and translate to 274 Tcf technically recoverable shale gas for North America (US and Canada; Navigant, 2008). The US Department of Energy puts the total volume of US proved gas reserves at 211 Tcf (about 40 Boe), of which technically recoverable unconventional gas accounts for 60% of the onshore recoverable resources (DOE, 2009). The stated aim of unconventional gas developments in North America is to accelerate filling the imminent supply gap that would occur due to decline in conventional gas production (PTAC, 2006). Meanwhile, successful unconventional gas production already accounts for over half the US domestic production. The US natural gas value chain served 24% of the US primary energy need in 2009 (DOE, 2009).

The total volume throughput in the natural gas system from wellhead to burner tip is tediously monitored by the Energy Information Administration of the US Department of Energy. The present study uses the EIA/DOE database (EIA/DOE, 2010) to reveal the major trends in the natural gas prices (wellhead, wholesale, city gate, and various retail prices) across the US value chain over a 12 year period (1998–2009). The 1998 starting date of our analysis coincides with the onset of the 2nd price hike in US wellhead prices (Fig. 1). Wellhead prices provide a reliable indicator for the revenue stream that must pay for natural gas production. In 2009, natural gas prices declined but annually averaged wellhead gas prices have seen two previous epochs of upward price hiking in the past 40 years (Fig. 1). A 1st price hike occurred after the 1973 oil crisis (till about 1983, when North Sea oil started to relief global energy prices) and a 2nd price hike started in 1998 and peaked in 2008.

The depressed natural gas prices now threaten to slow down the development of the US unconventional gas resources.

Abbreviations: APM, Administered Price Mechanism (India); BOA, Bank of America; Bbl, billion barrels; Boe, barrels oil equivalent; CAPEX, Capital Expenditure; DOE, Department of Energy (US); EIA, Energy Information Administration (US); FERC, Federal Energy Regulation Commission (US); LDC, local distribution company; LNG, liquefied natural gas; Mcf, thousand cubic feet; NARUC, National Association of Regulatory Utility Commissioners (US); NCEP, National Commission on Energy Policy (US); NELP, New Exploration Licensing Policy (India); NYMEX, New York Mercantile Exchange; PTAC, Petroleum Technology Alliance Canada; WACORG, Weighted Average Cost of Retail Gas

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The average wellhead break-even price for unconventional natural gas lies at 8.03 $/Mcf in 2009 (BOA, 2009). The average US wellhead price paid was 3.71 $/Mcf in 2009 (EIA/DOE, 2010), which differed only fractionally from the Henry Hub gas wholesale price of 3.99 $/Mcf due to effective liquidity in the US natural gas market. Consequently, natural gas production from unconventional sources has become largely sub-economic over the past three years for a large portion of the US natural gas operators. A majority of gas operators continues to outspend their net earnings on CAPEX programs. They must do so, because of the short-life cycle of unconventional gas wells. If they were to stop CAPEX for new wells, free cash flow would dry up quickly. Low well productivity data, together with high cost of recovery (well completion cost and frac-jobs), low gas prices and drying up of access to new capital are the underlying causes for lagging cash flow from unconventional wells.

The insight in the retail price fluctuations from this study establishes an analytical basis to define the Weighted Average Cost of Retail Gas (WACORG). The WACORG may serve as a tool to model future retail prices that would need to be charged to establish a floor for unconventional gas wellhead prices. The introduction of such a price-floor would render technically recoverable unconventional gas resources economically viable, by removing downward volatility in wellhead prices. The concept of wellhead price-floor regulation is new for the upstream US natural gas industry and requires further debate, but some of the underlying fundamentals are elaborated in this study. A list of acronyms used is given in a footer at the start of this article. The value chain analysis in this study provides useful insight for corporate planners (upstream, midstream, and downstream), regulators, investors, analysts, and academic researchers interested in understanding and enhancing the performance of the natural gas business.

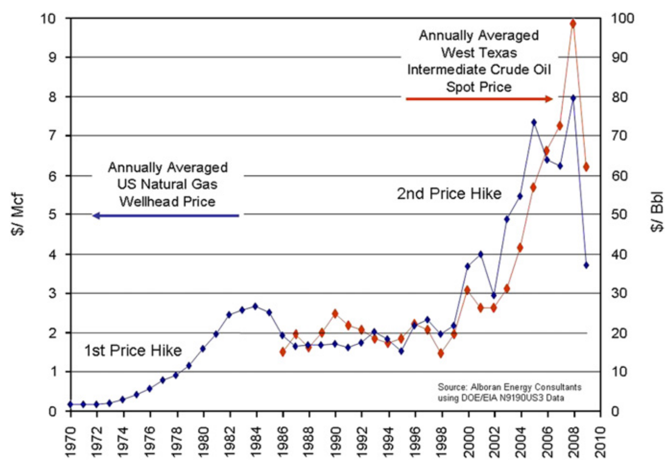

Fig. 1. Annually averaged US natural gas wellhead price development over the past 40 years. The second price hike concurred with a global rise in energy prices; WTI crude is given here as a reference curve.
Sources: Natural gas annual wellhead price EIA source key N9190US3; West Texas Intermediate Crude Oil, McDaniel and Associates.

2. Revenue streams in the US natural gas value chain

A concise schedule for the US natural gas value system is given in Fig. 2. The financial transactions across the gas value chain make use of the following reference prices:

- *Wellhead price:* natural gas price at the mouth of the well, considered to be the sales price obtainable from a third party in an arm's length transaction.
- *Wholesale price:* natural gas spot market price, with Henry Hub providing the reference for NYMEX futures for natural gas prices.
- *City gate price:* natural gas price at a point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system.
- *Transmission tariffs*: paid by shippers to the transmission company, accounting for the difference between wellhead and city gate prices.
- *Retail price:* natural gas price by end-consumers, traditionally comprised of four groups: power stations, industrial, commercial, and residential consumers.

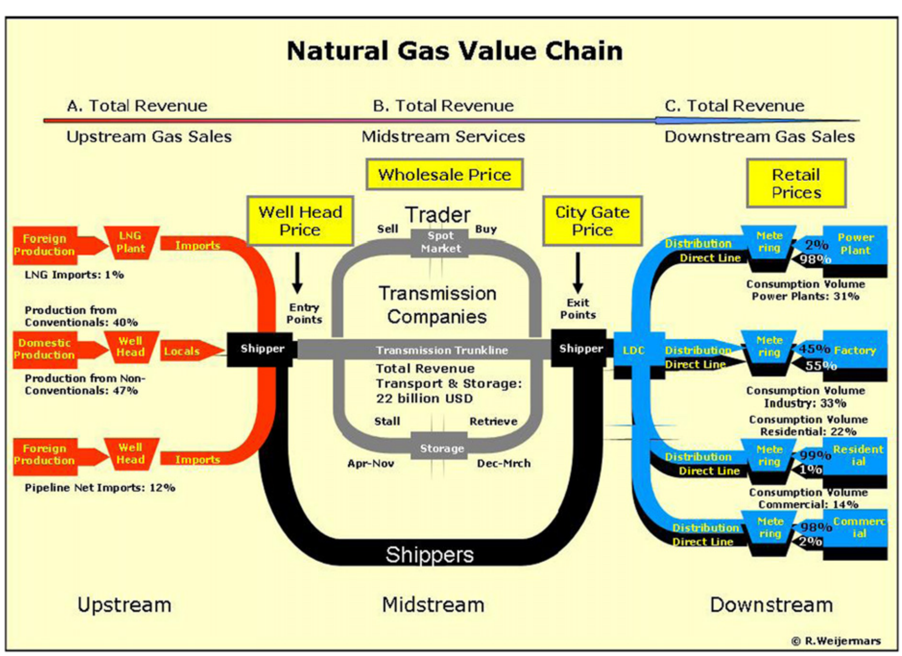

Fig. 2. Physical architecture of gas flows in the natural gas value chain (after Weijermars, 2010a). Financial transactions and billing occurs at wellhead, wholesale trading hub, city gate, and utility retail provision to end-consumers.

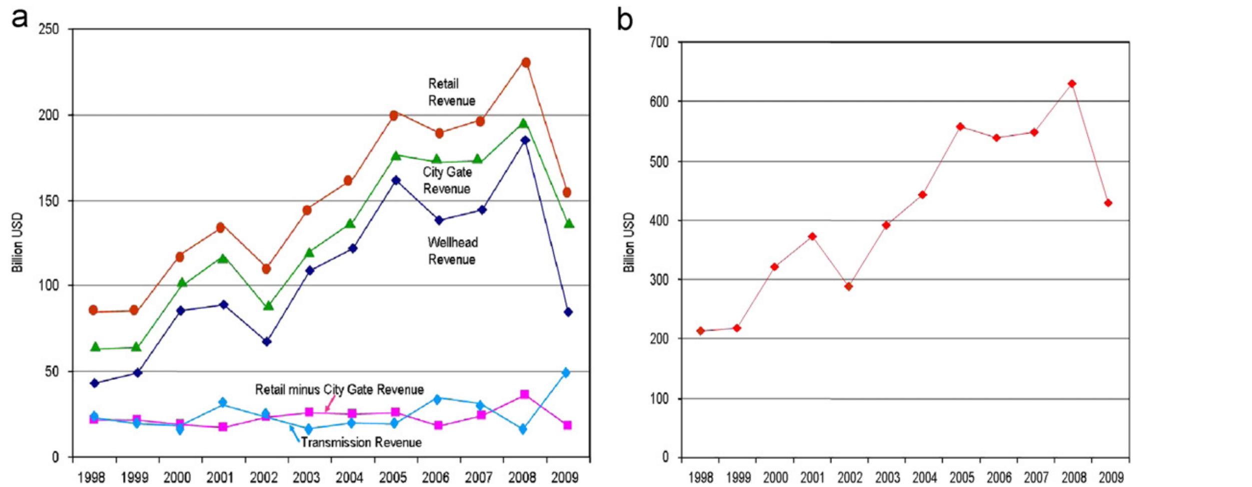

Fig. 3. (a) Total annual revenue per value chain segment: by upstream (production), midstream (shipping and transmission), and downstream (LDCs) natural gas companies. (b) Total annual revenue development in the US natural gas value chain (based on wellhead revenue, transmission revenue, city gate revenue, and retail revenue). Note that the ups and downs in the total value chain revenue closely match those of the wellhead prices in Fig. 1. (Total revenues based on spreadsheet compilation by author using segment volumes and prices of EIA/DOE, 2010).

The associated revenues can be calculated from annually averaged throughput volumes for each consumer group, times annually averaged prices (Fig. 3a). The total downstream or LDC revenue is approximated by retail revenue minus city gate price. The midstream segment revenue is given by city gate revenue minus wellhead revenue. The total upstream revenue is given by wellhead prices times total production. A summary of the combined revenue streams in the US natural gas value chain is compiled in Fig. 3b.

What is important is the insight that the past growth of total annual revenues in the US natural gas value chain is entirely driven by rising wellhead prices (Fig. 3a). This is remarkable itself and demonstrates that regulation of the mid and downstream gas segments swiftly discount the short-term retail prices when wellhead prices drop. In other words, midstream and downstream operators do not appear to effectuate any significant price-making influence on the natural gas market dynamics. Wellhead prices drop when global energy markets are depressed and generally rise when economic growth accelerates.

Trader revenues from options and futures on wholesale prices – while volatile – are accounted for in the volume times wholesale price based revenues as specified in this study. Some companies may incur trading losses, while others may win on trading. Such effects may significantly affect the cash flow position of individual companies, and may help to improve earnings on their physical gas flow operations. A simple hedge involves buying "futures" contracts to lock in prices. For gas exploration and development companies, hedges in effect guarantee the amount of revenue that companies will receive on a future production, thus giving them some financial stability. Two current proposed US bills ('*Derivatives Markets Transparency and Accountability Act of 2009*' and '*Prevent Excessive Speculation Act*') would limit speculation on future commodity prices.

3. US gas consumption pattern and price development

The total US natural gas consumption volume has remained relatively flat over the past decade (Fig. 4). Noteworthy, the rise in the gas price from 1998 onward (coined here the 2nd price hike, Fig. 1) has not resulted in a major consumption decline. In contrast, the 1st gas price hike in the period 1973–1983 was accompanied by a 25% drop in gas consumption (Fig. 4). The trend of rising wellhead prices in the 2nd gas price hike epoch was not caused by any significant rise in overall natural gas consumption in the US market. Instead, the natural gas price increased in step with the climbing energy prices after the turn of the millennium (Fig. 1).

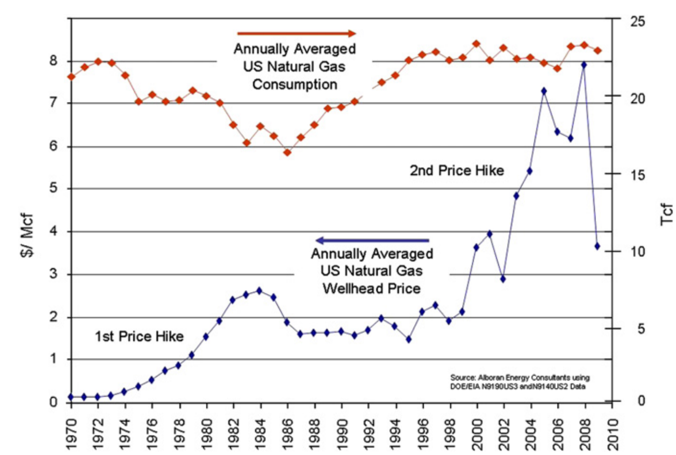

Fig. 4. Annually averaged wellhead price (left scale) and annually averaged total consumption (right scale) of natural gas in the US. The 25% drop in natural gas consumption between 1973 and 1983 was further compounded by low oil prices in the period 1981–1988.
Sources: Total US natural gas consumption, EIA source key N9140US2; natural gas annual wellhead price, EIA source key N9190US3; DOE/EIA, 2010.

Although the 2nd gas price hike did not result in a consumption decline, significant shifts have occurred over the past decade in the gas consumption volumes between US end-consumer groups. The retail prices for natural gas end-users traditionally differ for the following main groups:

- *Power stations:* natural gas used by electricity generators (regulated utilities and non-regulated power producers) whose line of business is the generation of power.
- *Industrial users:* natural gas used for heat, power, or chemical feedstock by manufacturing establishments or those engaged in mining or other mineral extraction as well as consumers in agriculture, forestry, fisheries, and construction.

- *Commercial users:* natural gas used by non-manufacturing establishments or agencies primarily engaged in the sale of goods or services such as hotels, restaurants, wholesale and retail stores, and other service enterprises; and gas used by local, State, and Federal agencies engaged in non-manufacturing activities.
- *Residential users*: natural gas used in private dwellings, including apartments, for heating, cooking, water heating, and other household uses

Between 1998 and 2009, industrial consumption of natural gas declined from 41% to 29% of the total US gas consumption (Fig. 5). The decline of industrial consumption was compensated for by an increase in power station consumption from 22% to 33% of total US gas consumption. Over the same period, commercial consumption remained flat, at 15%, and residential consumption rose marginally, from 22% to 23%, with a 2% dip in 2006 due to a warm winter. Gas for vehicle fuel consumption has grown from 0.05% in 1998 to 0.2% in 2009 but still remains a negligibly small consumer group as compared to the four traditional consumers of Fig. 5. Gas used for – and lost in – gas transport facilities between wellhead and end consumer accounts for about 10% loss in the US natural gas system (EIA/DOE, 2010; source keys N9160US2 and N9170US2).

The individual retail price development for the four major US consumer groups over the study period (1998–2009) is graphed in Fig. 6a. Power stations and industrial consumers consistently pay the lowest tariffs, and commercial and residential customers pay higher tariffs. The latter two are 100% served by local distribution companies (LDCs or energy utilities). The LDC services result in a surcharge that roughly equals the difference between the city gate price and the retail price for natural gas. For example, the US average city gate price in 2009 was 6.47 $/Mcf, and the commercial and residential retail price was 9.75 and 11.97 $/Mcf, respectively. The commercial retail price for gas is lower than the residential retail price (Fig. 6a), because commercial users (shops, offices, etc.) enjoy a volume discount, which increases with increasing consumption volumes.

Fig. 6b shows how the retail gas prices for industry and power stations are consistently lower than city gate gas prices. Industry and power generation stations have mostly direct pipelines to the transmission company or even to the wellhead of the production company. These end-consumers thus bypass the LDC tariffs and the commodity price accounts for the major portion of their natural gas retail price, as follows from a comparison of industrial

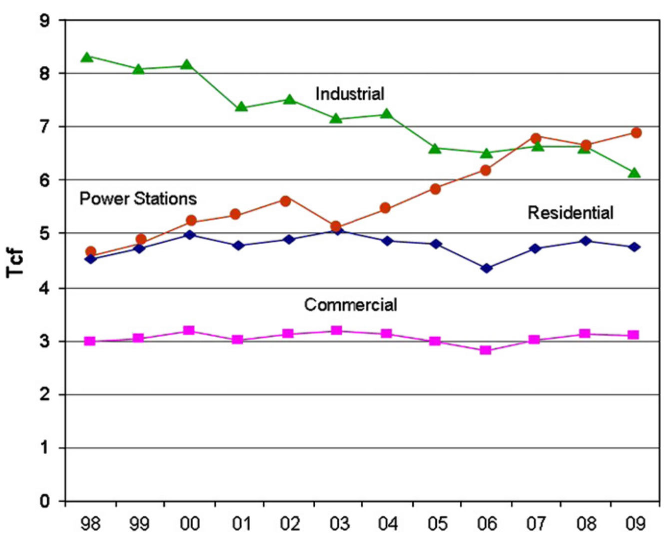

Fig. 5. Annual retail consumption volume of natural gas in the US per major consumer group. [EIA source keys for consumption volumes: Industrial – N3035US2; Power Generation Stations – N3045US2, Residential – N3010US2, Commercial – N3020US2; EIA/DOE, 2010].

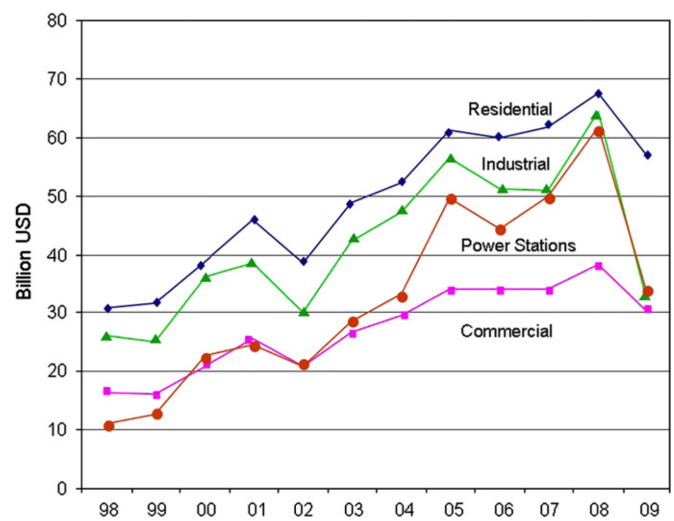

Fig. 7. Total annual revenue per consumer group of natural gas in the US. *Sources*: product of retail consumption volumes in Fig. 5 and retail prices in Fig. 6a.

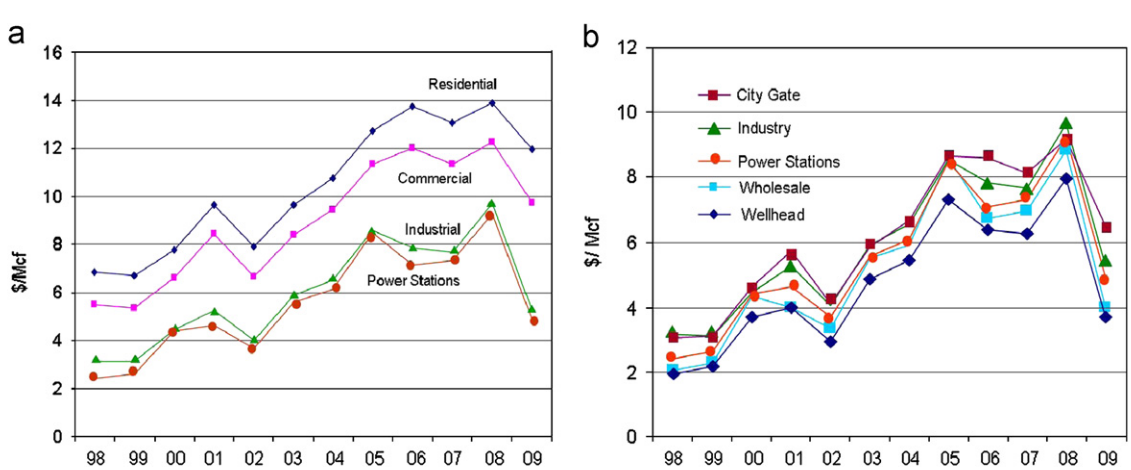

Fig. 6. (a) Annually averaged retail price per major consumer group of natural gas in the US. (b) Comparison of annually averaged retail price for power stations, industry, and wellhead price in the US. [EIA source keys for gas prices: Residential – N3010US3, Commercial – N3020US3, Industrial – N3035US3, Power Stations – N3045US3, City Gate – N3050US3, Wellhead – N9190US3, Wholesale – McDaniel and Associates; EIA/DOE, 2010].

and power sector gas prices with wellhead prices (Fig. 6b). In 2009, the price reduction for industry and power station gas consumers were steeper than that for commercial and residential users. The dedicated pipeline for 98% of power stations and 55% of industrial users means commodity price accounts for nearly all cost as follows from a comparison of industry and power station gas prices with wholesale prices (Fig. 6b). The total revenue generated from US retail gas sales to each consumer segment is graphed in Fig. 7.

4. Weighted Average Cost of Retail Gas

This study introduces the Weighted Average Cost of Retail Gas (WACORG) as a means to concisely monitor the overall price development in the US retail segment. The definition of WACORG is as follows:

$$\text{WACORG} = (P/V)RGP_P + (I/V)RGP_I + (R/V)RGP_R + (C/V)RGP_C \qquad (1)$$

with P/V, fraction of total consumption volume (V) used by power stations (P), RGP_P, retail gas price (RGP) for power stations; I/V, fraction of total consumption volume (V) used by industry (I), RGP_I, retail gas price for industrial users; R/V, fraction of total consumption volume (V) used by residential users (R), RGP_R, retail gas price for residential users; and C/V, fraction of total consumption volume (V) used by commercial users (C), RGP_C, retail gas price for commercial users. The definitions of the four main consumer groups have been specified in Section 3.

Vehicle fuel consumption can easily be included in the WACORG, but is negligibly small (see Section 3) and therefore has been excluded in the present study. Nonetheless, use of natural gas as a vehicle fuel may be expanded if gasoline prices peak again to record highs as in 2008. Congressional concern for energy independence that grew out of the summer 2008 oil price spikes has engendered at least one highly publicized proposal to substitute natural gas for transportation fuel (PickensPlan, 2010). Additionally, America's Low-Carbon Fuel Standard Act of 2009 would amend the Clean Air Act to convert renewable fuel standards into low-carbon fuel standards. Low-carbon fuel would be defined as a transportation fuel that has lifecycle greenhouse gas emissions, equal on an annual average basis to a defined percentage less than baseline lifecycle greenhouse gas emissions. Starting at 20% in 2015, the percentage would increase to 42.5% after 2031. Such regulation could ensure that increasing volumes of low-carbon fuel would be sold in the United States as transportation fuel; beginning with 10% in 2015, and 32.5% by 2030.

The efficiency of the overall value chain system for natural gas in passing price adjustments on to each adjacent segment follows from a plot of WACORG and wellhead prices (Fig. 8). This reveals that the cost of the mid and downstream segments is covered by 2.55 $/Mcf over the past 12 year. The 3-year average mid and downstream segment cost for 1999–2000 amounted to just 1.99 $/Mcf. The 3-year average for the mid and downstream segment has risen to 3.03 $/Mcf for the period 2007–2009.

A major new insight from the value chain analysis portrayed in Fig. 8 is that whether world energy markets rise or fall, none of the price volatility is absorbed by the mid and downstream energy segments. In fact, any price reduction is entirely leveraged back to the wellhead, as a consequence of effective price regulation in the mid and downstream segments. Retail prices may rise or drop in response to the global energy demand and supply balance, but regulation ensures the US mid and downstream transport and distribution assets and services are always paid for (Fig. 8).

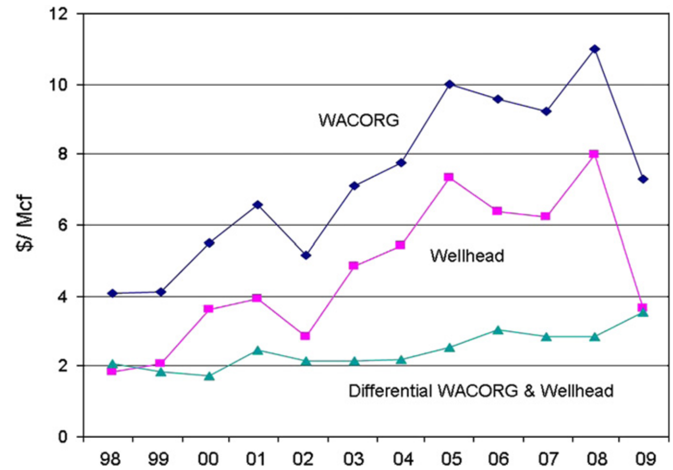

Fig. 8. WACORG and wellhead prices over the study period 1998–2009. Their price differential pays for assets and services in the mid and downstream segments of the US natural gas value chain system.

While FERC regulation of gas transmission tariffs and public utility commission regulation for LDC tariffs meant to avoid excessive price inflation in the mid and downstream segments servicing a captive consumer market, such regulations also provide a stable floor for returns on investment in gas transmission and LDCs. Price regulation ensures that utility companies have a rate-making mechanism that facilitates recovery of most of their costs plus a fair return on investments. US energy utilities may bill the cost of their distribution and metering services, but the commodity price itself is billed at actual wholesale price and any rebates must be passed on in natural gas retail prices (Weijermars, 2010a). In other words, every penny saved on the commodity price must, by US federal law, be discounted to the end consumer. While this rate-making in the downstream energy business is the result of a complex negotiation between state regulators and consumer advocacy groups – this study reveals from the macroscopic price development how effective commodity price drops are passed back to the wellhead by down and midstream utilities. Utility company returns remained extremely slim over the past decade as a result of stern regulation (Olson, 2009).

The introduction of Weighted Average Cost of Retail Gas (WACORG) visualizes the price effect of the downstream segment on the upstream wellhead prices. In the liquid US natural gas market, wellhead price, and WACORG differed only 2.55 $/Mcf over the past decade, and 3.03 $/Mcf over the past 3 years. This means domestically produced gas can be brought to the US customer from the production location for a concurrent wellhead price, plus 3.03 $/Mcf determined by WACORG minus wellhead prices. For comparison, LNG wellhead prices now require less than about 3 $/Mcf add-on to liquefy, ship and re-gasify at US coast terminals (Hartley and Medlock, 2006). This means that in effect both gas systems, i.e. landed LNG and domestically produced gas, compete mostly on wellhead price efficiency in their respective production regions, as the cost of getting the gas to the retail customer are similar at about 3 $/Mcf.

Unlike the price regulation for mid and downstream energy utility companies, the US upstream energy segment has been deregulated in 1989 (Dahl, 2003). The Decontrol Act of 1989 enabled both up and downward price competition for wellhead production, which until then had been effectively price-capped by the US Phillips Court ruling of 1954. Ironically, any change in global energy prices is now hitting directly back at the US wellhead price, as a consequence of mid and downstream price regulation in conjunction with upstream wellhead price deregulation. The Wellhead Decontrol Act of 1989 removed all price regulation from the upstream sector. However, downstream retail price regulation could easily be adjusted such as to set WACORG that ensures say 8 $/Mcf wellhead prices (see Section 5 for details). This concept is entirely different from the past US wellhead price regulation system.

The analysis in this study reveals which end-consumers have benefited most from depressed wellhead prices in the short-term. Table 1 plots an example of the WACORG 2009 computation for US natural retail gas, which gives a nationwide WACORG of 7.32 $/Mcf. The differential between WACORG 2009 and the actual retail prices for each consumer group are included in Table 1 (5th column), and shows which consumer group pays most for natural gas retail services. It follows that residential users paid 61% above WACORG 2009, commercial users paid 33% above WACORG 2009, and industry and power stations paid 28% and 33% less than WACORG 2009, respectively (Table 1, 6th column). The annual deviation or spread from WACORG varies from year to year. Table 2 specifies WACORG and retail price spreads for 2008.

The historic spread of retail prices for the four end consumer groups relative to the 12 year annually averaged WACORG is graphed in Fig. 9. The 12 year average for the spreads is given in Table 3. The annual variation in spreads is subject to intricate rate-making adjustments at the level of individual utilities and agreements between power stations and transmission companies. Nonetheless, the calculated spreads show consistent trends and accurately reflect the individual price differential over WACORG for each retail gas consumer group. The maximum spread in retail prices is between residential and power station retail prices, and is graphed in Fig. 10a. WACORG for the period 1998–2009 is graphed in Fig. 10b. This shows that the natural gas retail price spread tends to reduce as WACORG rises, which fits with the trend reversal of 2009 when WACORG dropped steeply.

Table 1
Weighted Average Cost of Retail Gas (WACORG).
Source: 2009 vol% calculated from EIA source keys in Fig. 5; 2009 retail prices from IEA source keys given in Fig. 6a.

2009	Volume %	Retail price (USD)	Weighted retail price	Differential retail price and WACORG (USD)	Percent offset retail price from WACORG
Residential	23	11.97	2.71	+4.47	+61
Commercial	15	9.75	1.46	+2.43	+33
Industrial	29	5.27	1.53	−2.05	−28
Power station	33	4.89	1.61	−2.43	−33
Total	100%	–	**WACORG= 7.32 USD**	–	–

Table 2
Weighted Average Cost of Retail Gas (WACORG).

2008	Volume %	Retail price (USD)	Weighted retail price	Differential retail price and WACORG (USD)	Percent offset retail price from WACORG
Residential	23	13.89	3.19	+2.99	+27
Commercial	15	12.23	1.84	+1.33	+12
Industrial	31	9.67	3.00	−1.23	−11
Power station	31	9.26	2.87	−1.64	−15
Total	100%	–	**WACORG= 10.9 USD**	–	–

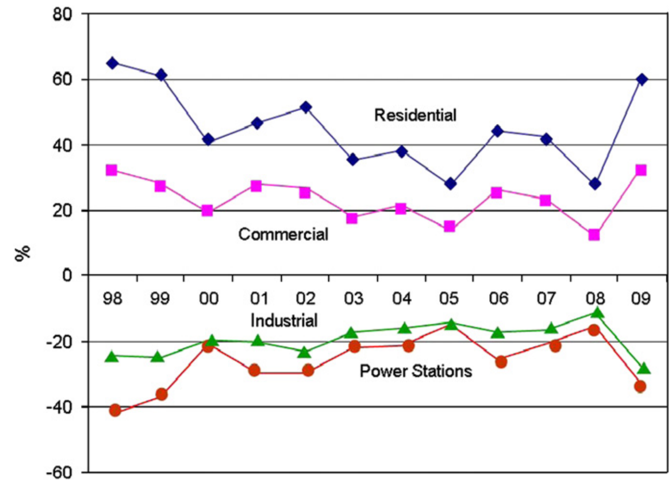

Fig. 9. Annual variation of spread of retail prices over WACORG (1998–2009). Table 3 gives the 12 year mean of spreads for each consumer group.
Source: Calculated using differential of retail prices in Fig. 6a and WACORG as per Eq. (1).

Table 3
Mean spread of retail prices over WACORG.

1998–2009	Spread over WACORG (12 Y mean) (%)
Residential users	+45
Commercial users	+24
Industrial users	−19
Power stations	−26

5. Price-floor concept

India was first in setting a price-floor for natural gas. The Administered Price Mechanism (APM) indexes the gas price to international price of oil products and ensures a handsome 12% post tax profit for gas operators (Weijermars and McCredie, 2011). Development of India's domestic gas resources is stimulated by a New Exploration Licensing Policy (NELP) set up in 1999. NELP ensures a wellhead price-floor based on cost plus a reasonable margin, as well as a ceiling based on domestic prices for alternative fuels. The gas price formula was reset in 2007 to a price-floor of 2.50 $/Mcf and a price-ceiling of 4.20 $/Mcf, both linked to Brent oil prices. India's gas consumption is set to rise at a rate of 10 bcm/y over the coming decade—its share rising to 5% of global gas consumption by 2020. Effectively, India has set the precedent for mitigating the wellhead gas price slump in the US.

Price-floor regulation was barred in the US until a 2007 landmark ruling by the US Supreme Court removed the 96 year old ban on price floors. Consequently, it is no longer automatically unlawful for producers and manufacturers to agree on setting a minimum retail price for their goods. Consumers' demand for an item may vary seasonally or conjecturally, but for reasons of economies of scale and focus manufactures may find it necessary to continuously produce. Distributors then add value by holding inventory until demand increases. There is a marked difference between vertical and horizontal price floors (Nagle and Holden, 2002). Vertical price floors are minimum prices set by manufactures and managed through the vertical distribution chain. An example could be gas production companies agreeing to set a price-floor for unconventional gas with retailers to help them avoid becoming later captive of foreign supply at rates inflated in future geopolitical tensions.

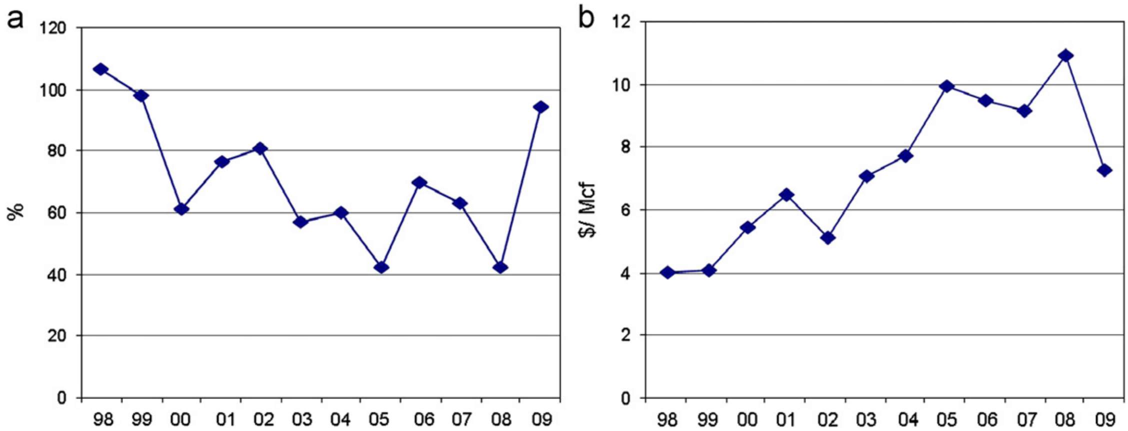

Fig. 10. (a) Annual variation in spread between retail prices of residential and power generation consumers (1998–2009).
Source: Annual differential between maximum and minimum spreads in Fig. 9. (b) WACORG provides a single retail price reference graphed here as annual averages for the period 1998–2009. *Source*: Calculated from Eq. (1) and EIA data keys as specified in Figs. 5 and 6a.

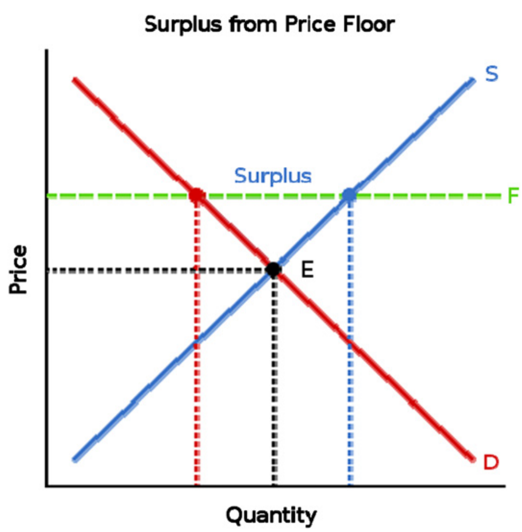

Fig. 11. Relationship between US natural gas wellhead floor price (*F*), supply (*S*) and demand (*D*), with equilibrium point (*E*).

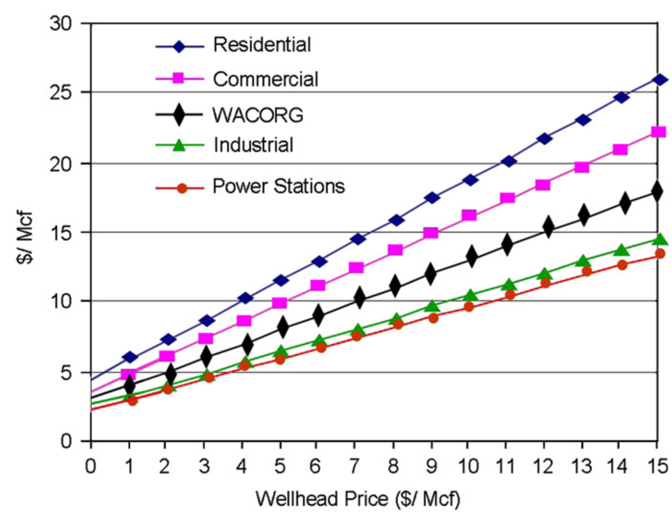

Fig. 12. Relationship between US natural gas wellhead prices (horizontal scale) and retail prices (vertical scale), assuming a concurrent cost of 3 $/Mcf for transmission, distribution and retail delivery services. Retail prices follow from historic mean spread on WACORG as derived in Table 3 for period 1998–20009.

Horizontal price floors, where distributors collaborate and set a minimum price remain illegal according to US law. A gas wellhead price-floor should leave sufficient room for competition. In fact, setting floor prices for US energy supply has been considered before, and in some cases been adopted. For example, a price-floor was in place for 6 years between 2002 and 2007 in Texas (2008) to keep incumbent electricity providers from pricing new companies out of the market by dumping prices. Deregulation combined with the price-floor lead to lower retail prices for the end-consumers: 15 cent/kWh was common in 2002 and cost was between 9.9 and 13.5 cent/kWh in 2010. The Lugar bill of 2006 by Senate member Dick Lugar (representative for Indiana, Republican) proposed legislation for an oil price-floor of $45/bbl to promote investments in alternative fuels. In 2010, a price-floor of 300 $/MWatt for renewable energy credits was proposed in Massachusetts. A price-floor for carbon emission credits is also debated in the UK (Hepburn, 2006) and elsewhere. Such a carbon tax of 30 $/ton sets a price-floor for carbon certificate credits and '*would further accelerate the conversion of coal-fired power generation to cleaner gas fired power stations*'.

The idea of the adoption of a wellhead price-floor for unconventional natural gas has been briefly outlined in a concise policy paper (Weijermars, 2010b). Some fundamental issues on price-floor economics are outlined here in support of the wellhead price-floor concept. A price-floor is an agreed limit on how low a price can be charged for a given product. Setting a price-floor above the free-market equilibrium price (Fig. 11) makes sense when, for example, the continuity of natural gas supply is threatened by price volatility that pushes the commodity price below the break-even price for sustainable production. Economic theory on price floors warns for consumption reduction when commodity prices rise (Posner, 1975; Peltzman, 1976). However, such an effect has not been seen during the 2nd gas price hike, when natural gas consumption remained steady (Fig. 4). The explanation may be that incentives have provided support for increased gas consumption by power stations (switch to clean energy), while residential consumers are relatively indifferent to price fluctuations as long as security of supply is guaranteed; commercial use is stimulated by US Energy Act, while industry use has indeed declined due to price pressure.

A price-floor for natural gas production could be incorporated in the downstream retail rate-making mechanism. The impact on consumer prices resulting from a wellhead price-floor of $8/Mcf can be easily calculated using WACORG spreads and the 3 $/Mcf add-on to wellhead prices for transmission and distribution services in the mid and downstream segments. Fig. 12 graphs the wellhead price against WACORG and the spreads of Table 3 are incorporated to give consumer prices per segment. Fig. 12 provides the consumer prices that would sustain a widely reported wellhead break-even price-floor of $8/Mcf.

The powerful implications of WACORG as an indicator for decision makers for strategic planning of gas consumption and prices can be further considered as follows. Taking Fig. 6 and Eq. (1) into account, one can conclude that WACORG will increase with a higher share of the use of gas in the residential sector and a lower share in the power plant sector. In an ideal world were energy portfolios could be set at will, the desired basic level of WACORG can be reached by increasing the use of renewables or nuclear—because it would lower the power sectors' use of gas consumption and therefore effectuate a relative rise in the share of total gas consumption by the sectors with higher retail prices. Even if one takes into consideration that retail prices will decline because of a reduction in demand, an increase in WACORG is theoretically still possible.

6. Discussion

6.1. Break-even cost debate

Growing concerns about the sustainability of the US natural gas business model (Cohen, 2009; Schaefer, 2009; Spears, 2009; Berman, 2009a,b, 2010a,b,c,d; Nasta, 2010) must be addressed and the underlying causes have indeed become clearer in the course of the debate. Technological innovation has not yet lead to a significant improvement in cost efficiency for unconventional gas production to absorb the negative business impact of volatility in the gas price (Weijermars and Watson, 2011). Wellhead prices have remained consistently below the break-even cost benchmark for many producers of unconventional gas (Fig. 13).

Proprietary analyst reports consistently confirm the weak cash flow results that prevailed over most of the past decade for a significant number of US unconventional natural gas companies. For example, 24 of the 45 leading US gas operators had CAPEX/cash flow ratios larger than 1 in Q1 of 2010 (Dell and Lockshin, 2010), meaning free cash flow from operations needs additional financing to cover CAPEX programs. Unconventional gas operations are financed by tax credits, equity finance, and credit finance raised from investors and banks, and as of lately, asset sales and right-out mergers; all these external cash sources are persistently drawn upon by most companies in order to supplement lack of margin on revenues from wellhead gas sales (Weijermars, 2010c, 2011a).

The free cash flow of US gas companies is under further pressure from the imposition of severance taxes on unconventional gas plays. For example, the Marcellus shale development is estimated to result in 30% lower gas drilling between 2009 and 2020 as a result of the introduction of new taxes in Pennsylvania that address the State's concerns about future wealth loss due to environmental impact (Considine et al., 2009).

A recent cash flow analysis based on 5-year averages (2004–2008) showed that even prior to the Great Recession, unconventional operators commonly could not fund capital expenditures (CAPEX) for end-of-life-cycle replacement from the free cash flow of their short life-cycle wells (Weijermars, 2010c, 2011a). The underlying reason is that the average break-even price of about 8 $/Mcf (Fig. 13) has not been met in anyone year of the unconventional gas life-cycle (Fig. 1).

6.2. Natural gas price volatility

The break-even price is not met by many unconventional gas producers, because volatile gas prices continue to move at the lower end of the energy elasticity price spectrum (Fig. 14a and b).

A third price hike epoch is now needed quickly to provide a sustainable price-floor for wellhead prices that must pay for unconventional gas production. Such a wellhead price-floor is needed because wellhead prices have not risen enough, not even in the 2nd price hike (Fig. 1), to cover break-even for a substantial number of unconventional natural gas plays (Fig. 13). But a quick turnaround seems unlikely, because the depressed gas price is due to oversupply and lagging consumption growth. The current short-term oversupply of US indigenous natural gas is only in part due to the technical success of unconventional gas that now fuels over half of the *US upstream natural gas industry*. The other part is due to

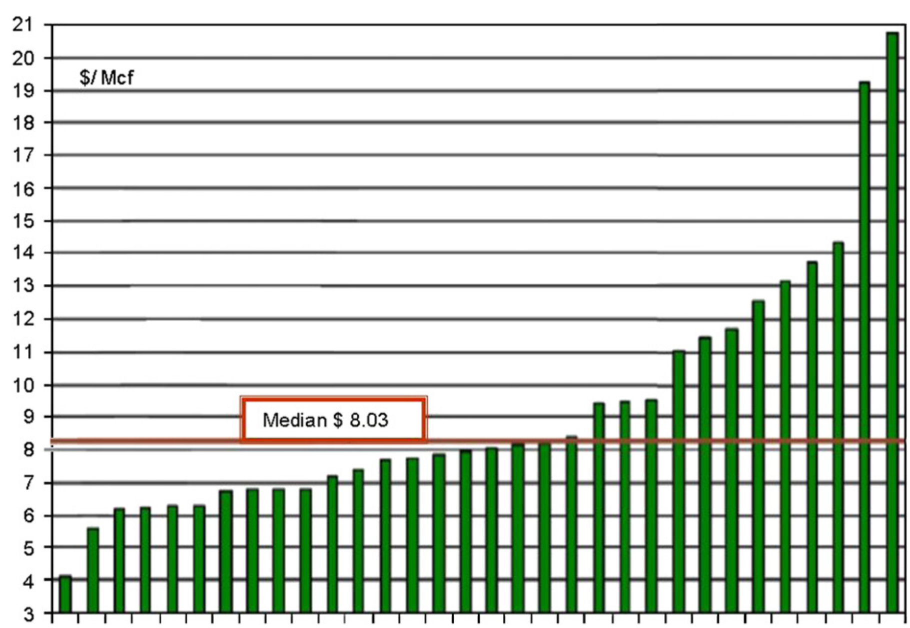

Fig. 13. Break-even analysis by Bank of America of 32 major US unconventional gas operators sets a median break-even price for the industry at 8 $/Mcf using 2008 data. The benchmark rate is not met by 13 companies. But at 2009 wellhead price and spot prices, none of the 32 operators met break-even cost.
Source: BOA, 2009.

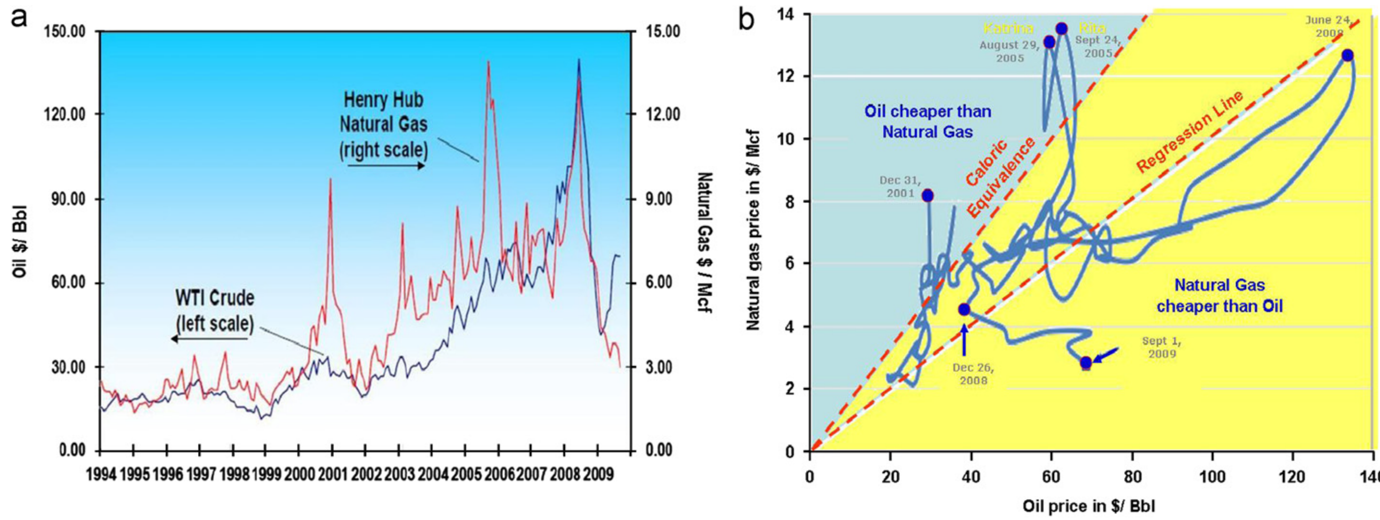

Fig. 14. (a) Volatility in natural gas spot prices. Average spot prices for natural gas and oil correlate at about 1–10 if simply matching prices for 1 Mcf of gas with 1 Bbl of oil. (b) Regression line plot shows the relationship 1:10 holds over time, but calorific equivalence line indicates oil trades at a premium price most of the time. Historically, spot market prices for oil trade at 1.5 times that of gas on a heat equivalence basis (6 Mcf is about 1 Bbl of oil heat equivalence).
Sources: EIA/DOE, 2010.

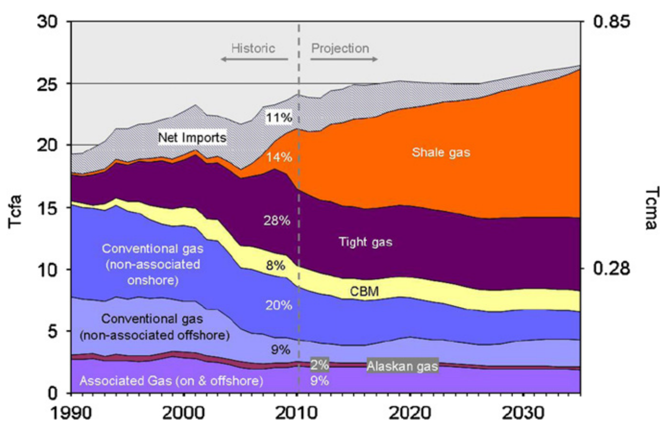

Fig. 15. US natural gas production separated into reservoir type. Tight gas accounts for 28% of US 2010 total gas consumption. Shale gas accounts for 14%, but is DOE/EIA expects this to have tripled by 2035. According to DOE, US gas net imports will be displaced further by growth in the domestic shale gas production. (data from DOE/EIA, 2009).

the simultaneous success (and price pressure) of ambitious LNG landing programs led by the *US mid and downstream transmission providers and energy utilities* (Foss, 2007). Incentives and drive for more LNG landing capacity on the US East and West coasts – like unconventional gas production itself – also are a consequence of the US natural gas security of supply policies (NCEP, 2003; NARUC, 2005). LNG imports are produced from low cost acreage in hydrocarbon regions remote from the world's major consumption markets. LNG imports were expected to account for 25% of the US gas supply by 2025 (PTAC, 2006), but now are phased out in the most recent forecast for US gas production (Fig. 15).

Removing investor's doubts about break-even cost and liquidity of unconventional gas companies is crucial for sustaining the US success in converting technically recoverable unconventional resources to economically recoverable resources. Investors play a crucial role in financing unconventional natural gas projects, but weaker energy prices and tighter credit contributes to reluctance among investors to invest in hydrocarbons at large. Prudent investors typically look for capital gains, profit growth from high return on assets, and increased net free cash flow yield payable as dividends or share buy backs. The unconventional gas business has seen higher than average returns in the past, but recent multiples have not outperformed the market (Dell and Lockshin, 2010).

One effect to be considered in connection with fixing a US gas floor price is that it may lead to excess production. Could such a price-floor fuel gas oversupply? Should the excess gas be sold on the world market? Would the excess US gas production put gas extraction in other countries at risk? This dynamic aspect of price-floor regulation should be examined in the broader strategic context. Fig. 15 shows that US gas production from conventional sources has been declining over the past few decades. Without the emergence of unconventional gas supplies, half of the US natural gas consumption would now have come from gas pipeline imports and LNG imports. Consequently, unconventional natural gas production plays a key role in the US energy security. This also means that the business fundamentals may need to be stabilized by adequate policies in order to maintain security of unconventional gas supply, when the industry begins to show signs of imminent failure.

7. Conclusions

Wellhead price-floor regulation is recommended here as a means to underpin security of US natural gas supply. Introducing wellhead price-floor would mean a new gas policy and requires new legislation. But wellhead price-floor regulation can easily be included in retail price-making mechanisms using WACORG to determine what rate pays for the utility provider, plus the transmission segment, while ensuring a wellhead price-floor at the same time. Instead of capping wellhead prices as was the case in the Phillips decision of 1954, the introduction of a minimum commodity price in the retail rate-making mechanism would ensure upstream break-even prices for natural gas operators. The Wellhead Decontrol Act was useful when introduced in 1989, but market conditions have changed and security of supply may mandate the introduction of wellhead price-floor regulation. A quantitative basis is provided in this study to substantiate what cost coverage is needed to ensure break-even wellhead prices for unconventional natural gas operations.

The adoption of such a system is fair as gas consumers will then foot the bill for the full value chain and not taxpayers, as was the case when tax breaks were given to unconventional gas producers. Investors in the upstream gas companies will still be subject to risks and rewards associated with outperforming the market in the energy peer group. And if markets function efficient, the wellhead price-floor should come down over time, as companies learn to bring down break-even cost. They will have an incentive to do so, because natural; gas producers want to increase their profit margins to satisfy shareholders—even when price-floor regulation guarantees break-even in principle. Some companies will be in basins that have lower gathering costs and may consistently benefit from a differential between their break-even cost and that of others. But remember, a wellhead price-floor gives no monetary presents to any party, but only sets a minimum price for the commodity while still leaving room for efficient companies to increase profit margins over competitors.

A 2005 testimony for the US Senate Committee on Energy prepared by Lawrence Berkeley Natural Laboratory (Wiser, 2005) recommended to diversify power generation to renewables in order to reduce natural gas consumption and avoid outpacing supply by uncontrolled demand (mostly from power stations). The Berkeley study (Wiser, 2005; Wiser et al., 2005) recommended that putting downward pressure on natural gas prices would benefit consumers by saving energy bills. The introduction of Renewable Portfolio Standards (RPSs; NARUC, 2001; EPA, 2009) has indeed stimulated renewable energy supply. While the lowering of natural gas prices has now occurred, the present gas price reduction is not sustainable for unconventional gas operators and has already lead the industry to shift from gas to oil drilling (Weijermars, 2011b).

In times where government needs to be prudent about balancing fiscal budgets to avoid sovereign default, it is not sustainable to subsidize renewables in favor of premature life-cycle decline of natural gas resources. US taxpayers have funded subsidies to renewables, which has put downward pressure on gas prices and arguably exacerbated the losses of the unconventional gas industry. The short-term gas rebate for consumers (Weijermars, 2010b) will lead to a rapid decline in the natural gas business as production becomes sub-economic. This in fact means a loss of capital investments in the natural gas business. Valued at approximately 6 trillion USD, premature loss of this industry is economically in-efficient, particularly if the decline is accelerated by subsidies that lower the threshold cost for renewables.

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