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Bureau of Business and Economic Research

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AEO2012 – Annual Energy Outlook 2012

AEP – American Electric Power Company Inc.

AFV – alternative fuel vehicle

ATV – Advanced technology vehicle

BBER – Bureau of Business and Economic Research

Bcf – billion cubic feet

Btu – British thermal unit

CBER – Center for Business and Economic Research

CCS – Carbon Capture and Storage

CFB – circulating fluidized bed

CMAQ – Congestion Migration and Air Quality Improvement program

CMB – coalbed methane

CNG – Compressed natural gas

CO_2 – carbon dioxide

DEP – WV Department of Environmental Protection

DOE – US Department of Energy

EIA – US Energy Information Administration

EOR – Enhanced Oil Recovery

EPA – US Environmental Protection Agency

EVA – Energy Ventures Analysis

EWV – Ergon West Virginia Inc.

GDP – Gross Domestic Product

GHGs – greenhouse gases

GW – gigawatt

IGCC – integrated gasification combined cycle

IHS – IHS Global Insight

kg – kilogram

kW – kilowatt

LDV – light-duty vehicle

LNG – liquefied natural gas

LPG – liquefied petroleum gas

MATS – Mercury and Air Toxics Standards

mmBtu – million British thermal units

MMcf – million cubic feet

MWh – megawatt hours

NAFTC – National Alternative Fuels Training Consortium

NAICS – North American Industry Classification System

NCDC – National clean diesel campaign

NERC – North American Electric Reliability Corporation

NETL – National Energy Technology Laboratory

NGCC – natural gas combined cycle

NGV – Natural gas Vehicle

NGVA – Natural Gas Vehicles for America

NO_x – mono-nitrogen oxide

OPEC – Organization of Petroleum Exporting Countries

SMCRA – Surface Mining Control and Reclamation Act

SO_2 – sulfur dioxide

Tcf – Trillion cubic feet

TWh – terawatt hours

VALE – voluntary airport low emission program

WVGES – West Virginia Geological and Economic Survey

1 Introduction and Overview

The US Energy Information Administration (hereafter EIA) reports that in 2010 the following production and consumption data (trillions of Btus) produced, consumed and the difference (exports) in West Virginia[5,6]:

Table 1: Energy production and consumption, West Virginia 2010

Energy Production	Trillions of Btus
Coal	3,346.1
Natural Gas	283.0
Crude Oil	8.9
Total	3,674.0
Energy Consumption	739.0
Difference	-2,935.0

Source: EIA, State Energy Data, 2010

Nearly 80 percent, or 2,935 trillion Btu, of West Virginia's energy production is exported, second only to Wyoming, which has 9,998 trillion Btu exported. Thus, West Virginia is a major energy state with this sector playing a significant role in the state and national economy. With this in mind, the state needs to ensure that the future growth and development of this sector plays a continuing role in the creation of jobs and wealth within the state, while at the same time protecting the environment for future generations. The opportunities to attract new industry, enhance efficiency of existing industries, maintain the affordability of energy and increase security for energy resources and production are additional goals for state policy makers.

The West Virginia Division of Energy has commissioned the Center for Business and Economic Research (CBER) at Marshall University and the Bureau of Business and Economic Research (BBER) at West Virginia University to assist in the development of its energy policy for submission to the Governor and the Joint Committee on Government and Finance.[7] This policy sets forth a five-year plan for the state's energy policies and provides a direction for the private sector. Responsibility for the fossil energy section was provided to BBER while CBER covers energy efficiency and renewable energy.

This report focuses on the fossil fuels and is divided into the following sections:

US and West Virginia Economic and Energy Outlook

- Coal
- Natural Gas
- Nuclear Energy
- Electric Power
- Hydrogen

5 EIA converts the physical units of the energy source (short tons, mcf, kwh, barrels) into the heat equivalent-BTUs. This data omits biofuels.
6 US Energy Information Administration, "State Energy Data System - State," (2012).
7 See West Virginia code §5B-2F-2.

- Short-term Development Goals

Each section contains statistics and analysis pertaining to that particular energy source and key observations relevant to the development of short-term policies.

2 Economic and Energy Outlook Overview

The US and state economic outlooks, coupled with the US energy outlook, will set the stage for the energy opportunities, options, and strategies identified later in the report. The project team used the IHS Global Insight (IHS) US Economic Outlook 2012-2017,[8] released in March 2012, as a starting point for understanding where the national economy is headed. The associated outlook for the West Virginia economy is based on the West Virginia University Bureau of Business and Economic Research (BBER) annual economic outlook released in November 2011. Finally, the US energy outlook is based upon the US Energy Information Administration's (EIA) *Annual Energy Outlook* (*AEO2012*) Early Release Overview, released in January 2012.

2.1 United States economic outlook 2012 - 2017

A summary of the US economic outlook from IHS in March 2012 is provided in Table 2. While the likelihood that the United States will relapse into recession is decreasing, the nation is far from fully recovered from the Great Recession, and certain risk factors remain that could push back economic recovery. In 2011Q4, the national GDP growth rate was 3.0 percent, but this is expected to slow to 1.9 percent during 2012Q1. The federal budget deficit for FY2011 was $1.3 trillion or 8.7 percent of GDP. Tighter fiscal policies in 2012 suggest that the budget deficit will decrease to $1.0 trillion. Over the course of the calendar year, real state and local government spending is expected to decrease by 1.4 percent. There are many fiscal deadlines set for the end of 2012 and beginning of 2013, including the expiration of the remaining Bush tax cuts, as well as emergency unemployment insurance benefits and a significant cut in defense spending. This forecast calls for a last-minute bargain in Congress wherein entitlement spending cuts and tax increases will be phased in over a number of years.

The Federal Reserve Open Market Committee has signaled its intent to keep interest rates low through 2014. Based on its forecast assumptions, IHS does not expect the rate to increase significantly before 2015. Yields on ten-year Treasury bonds should stay between 2.0 and 2.5 percent through the end of 2012, but are expected to increase over the long term. While the dollar is expected to strengthen against the euro, it will weaken against emerging currencies with the pace dependent upon how quickly China lets the renminbi appreciate. US export growth is expected to slow from 6.8 percent in 2011 to 4.2 percent in 2012, making the current account deficit 3.4 percent of GDP (up from 3.1 percent in 2011).

Though payroll employment is increasing, IHS does not expect the unemployment rate to decline significantly during 2012. During 2011Q4, an average of 245,000 payroll jobs were added each month, and throughout 2012 job growth is projected to average 190,000 positions per month. Because IHS expects increases in job availability to attract people back into the labor force, there will be a slow reduction in the unemployment rate from 8.3 percent in the first two months of 2012 to 8.1 percent by year's end.

Consumer spending, though positively impacted by job growth, is rising more slowly than anticipated. During 2012Q1, consumer spending rose by 1.5 percent on an annualized basis. By the end of 2012, IHS expects consumer spending growth to reach 1.9 percent on an annualized basis, which is lower than it was in 2011 (2.2 percent). Certain areas of consumer spending are expected to improve as employment

[8] Nariman Behravesh and Nigel Gault, *US Economic Outlook 2012-2017: Executive Summary*,[Mar. 2012].

increases; light-vehicle sales are expected to rise as income increases enable consumers to satisfy demands deferred during the recession. The same is expected to be true of housing starts. As young people who stayed at home during the recession want to move out, housing starts, especially in the multifamily segment, are expected to increase in 2012 accompanied by a continued decline in prices. Despite a more positive outlook, consumer spending is not expected to be a major force behind economic recovery in 2012.

Growth of business spending on equipment and software slowed to 4.8 percent in 2011Q4, but is expected by IHS to increase to 7.9 percent on an annualized basis during 2012. Businesses still have to make a lot of capital equipment repairs and replacements that they deferred during the recession, and will now have the cash necessary to undertake improvements. Thus, a three percentage point improvement in capital spending growth is expected by year's end. Spending growth in the business structures area also decreased in 2011Q4, but unlike equipment and software spending, significant building spending growth is not expected until 2013. One factor that will effect business spending in 2012 is the increase in employment. Labor costs are increasing faster than final demand and productivity, resulting in smaller profit margins for employers and a slower pace for corporate earnings growth.

Extra focus on rising oil and gasoline prices and international relations with Iran are also particularly important when looking at US economic outlook for 2012. Average oil price projections for 2012 have increased by about $12 per barrel from 2011 levels. Though recent gasoline prices have actually fallen, the national average price of gasoline was expected by IHS to exceed $4 per gallon in the second quarter of 2012. This projected price increase would have been harmful, according to IHS, decreasing 2012 GDP growth by 0.1 percent. While current oil and gasoline prices are not high enough to drive the US economy back into recession, a significant supply disruption would cause serious economic problems. As tensions over Iran's nuclear program escalate, so do the risks of oil price increases that could derail global economic recovery. IHS estimates a 20 percent probability of hostilities in the Persian Gulf, whether they are accidental or deliberate. The risk premium related to tensions with Iran has increased current oil prices by $20 to $30 per barrel from a more 'normal' level.

Table 2: IHS US economic outlook summary forecast March 2012

	2011	2012	2013	2014	2015	2016	2017
Composition of Real GDP (% change)							
Gross Domestic Product	1.7	2.1	2.3	3.4	3.2	2.7	2.5
Total Consumption	2.2	1.9	2.1	2.4	2.3	2.2	2.0
Nonresidential Fixed Investment	8.7	6.6	5.8	7.7	7.1	5.1	4.6
Equipment & Software	10.2	7.9	7.2	7.5	6.1	4.1	4.0
Structures	4.4	3.2	1.8	8.0	9.9	7.9	6.1
Exports	6.8	4.2	7.2	7.6	7.3	6.9	6.7
Federal Government	-1.9	-2.0	-3.4	-2.8	-2.0	-1.2	-0.8
State & Local Government	-2.3	-1.4	-0.7	0.3	0.7	0.8	0.8
Contribution to Real GDP Growth							
Consumption	1.53	1.35	1.48	1.70	1.59	1.57	1.42
Gross Private Domestic Investment	0.59	1.12	0.83	1.54	1.33	0.70	0.59
Nonresidential Fixed Investment	0.83	0.67	0.61	0.83	0.80	0.59	0.54
Equipment & Software	0.71	0.58	0.56	0.61	0.83	0.59	0.54
Structures	0.11	0.09	0.05	0.22	0.29	0.25	0.20
Net Exports	0.06	-0.05	0.34	0.36	0.33	0.45	0.50
Exports	0.87	0.57	1.00	1.11	1.10	1.08	1.07
Government	-0.44	-0.33	-0.34	-0.17	-0.06	0.01	0.04
Federal	-0.17	-0.17	-0.26	-0.21	-0.11	-0.08	-0.05
State & Local	-0.28	-0.17	-0.08	0.03	0.08	0.09	0.09
Other Key Measures							
Productivity (%ch)	0.8	0.3	0.9	1.7	1.4	1.5	1.7
Total Industrial Production (%ch)	4.2	4.1	2.8	3.6	3.1	2.6	2.4
Unemployment Rate (%)	9.0	8.2	8.0	7.4	6.7	6.3	6.0
Payroll Employment (%ch)	1.2	1.5	1.5	1.7	1.7	1.5	1.1
Current Account Balance (Bil. $)	-471.3	-537.3	-484.1	-469.5	-497.5	-525.1	-507.0
Financial Markets, NSA							
Federal Funds Rate (%)	0.10	0.10	0.10	0.11	1.23	3.27	4.00
10-Year Treasury Note Yield (%)	2.79	2.22	2.69	2.91	3.54	4.57	4.88
Exchange Rate, Maj. Trade Partners	0.846	0.871	0.880	0.877	0.867	0.854	0.847
Exchange Rate (%ch)	-5.9	3.1	1.0	-0.3	-1.2	-1.5	-0.9
Incomes							
Personal Income (%ch)	5.1	3.7	3.9	4.9	4.9	4.8	4.4
Real Disposable Income (%ch)	1.3	1.2	1.6	2.9	2.7	2.7	2.4
Saving Rate (%)	4.7	4.2	3.7	4.1	4.5	4.8	5.0
After-tax Profits (Bil. $)	1476	1494	1601	1689	1620	1556	1508
Billions of Chained 2005 Dollars							
Real GDP	13315.3	13593.4	13908.3	14384.5	14844.5	15249.4	15636.9
Personal Consumption Expenditures	9421.7	9600.3	9800.2	10033.7	10259.8	10490.3	10704.3
Fuel Oil & Other Fuels	14.9	14.6	14.6	14.5	14.5	14.5	14.4
Nonresidential Fixed Investment	1433.4	1527.9	1616.6	1740.6	1864.2	1959.6	2050.1
Equipment & Software	1123.8	1212.4	1300.3	1398.3	1483.9	1544.7	1607.1
Structures	322.8	333	338.9	366.2	402.4	434.1	460.4
Exports	1775.9	1849.7	1982	2133.1	2288.7	2446.7	2610
Imports	2187.9	2264.5	2347	2443.2	2544.8	2629.8	2711.3
Government Purchases	2502.4	2461	2418	2395.4	2388.1	2388.8	2394.3
Federal	1055	1033.6	998.9	970.8	951.7	939.9	932.2
State & Local	1453.5	1433.1	1423.6	1427.8	1438.3	1449.9	1462.2

Source: IHS Global Insight, US Economic Outlook 2012-2017: Executive Summary Table

2.2 West Virginia economic outlook

The economic outlook for West Virginia was released by BBER in November 2011 and covers the period 2011 to 2016 .[9] BBER's forecast was based on IHS's September 2011 forecasts and thus does not reflect any revisions since that time. Table 3 presents a summary of this forecast. Table 4 summarizes key elements of that forecast.

The West Virginia economy has recovered from the recent recession but is still below its peak employment levels. Between 2009Q4 and 2011Q2, the state gained back about one half of the jobs lost during the recession, averaging a slightly faster rate of job growth than the nation. The state unemployment rate peaked at 9.7 percent of the labor force in December 2010, and decreased to 8.5 percent by mid-2011, which was lower than the national rate though still significantly higher than pre-recession unemployment (4.2 percent in 2008).

State coal production during the first half of 2011 was up 1.3 percent from the previous year. The northern coal fields accounted for most of the growth (8.0 percent), while the southern fields decreased production. Coal production growth is attributed to increasing demand for steam and metallurgical coal from the nation and across the globe. Increased global demand has raised prices for Northern and Central Appalachian coals, which are $10 to $20 above what they were in 2010. Natural gas production in West Virginia has also increased (40.9 percent between 2003 and 2009), primarily due to the development of Marcellus shale.

The state population increased by 46,952 residents between 2000 and 2010, an average of 0.3 percent per year, which was significantly lower than the national average (0.9 percent). Per capita personal income reached $31,999 in 2010, before adjusting for inflation, which represented a 3.0 percent growth rate since 2009. This was higher than the national rate and the inflation rate – the West Virginia standard of living improved in 2010.

Real state GDP growth sped up in 2010, surpassing the national growth rate and the growths rates of all except four other states. Over the past three years, West Virginia real GDP has been growing faster than the nation's real GDP due to gains in sectors including mining; real estate, rental, and leasing; manufacturing; and retail trade, as well as other sectors.

Job growth is expected to be positive in the state between 2011 and 2016, though at a slower rate than national job growth. Natural resources and mining job growth is expected to slow over this time due to declining coal production and increasing regulations on air and water quality. This should be somewhat offset by gains in oil and gas mining employment as Marcellus shale development plays a bigger part in the West Virginia economy. Job growth in the construction and manufacturing sectors is expected to be positive, but the major growth will take place in the service-providing sectors: health care; professional and business services; and trade, transportation, and utilities. Employment in the government sector is expected to decline as state, local, and federal budgets tighten.

The overall positive job growth in the state will contribute to a gradual decline in the West Virginia unemployment rate between 2011 and 2016. The state unemployment rate should fall to 6.4 percent in 2016. Job growth will also result in income growth for the state. The real per capita income growth rate is

[9] George W. Hammond, *West Virginia Economic Outlook 2012* (Morgantown WV: Bureau of Business and Economic Research, West Virginia University, 2011).

expected to be 1.8 percent, which is higher than the expected national rate. Because the job growth rate is above the national average, West Virginia can also expect an influx of residents and job seekers.

The positive growth expected between 2011 and 2016 is fragile. West Virginia's growth depends on the growth of its trading partners—a downturn in the national or global economies could easily push West Virginia back into recession. There are also internal risks related to the demand for and regulation of the production of coal and natural gas. Environmental regulations pose limitations to the exploration and development of Marcellus shale plays in the state, and overall production depends on national and international demand. While the health care sector is expected to be a significant source of job growth over the forecast period, actual employment increases depend on the continued funding of the Medicaid and Medicare programs, an issue that is still under consideration. The leisure and hospitality sector has been contributing significantly to job growth in the state, primarily due to increases in the gaming industry, but even this industry faces stiff competition from neighboring states.

2.3 US energy outlook

In January 2012, the EIA released its annual US energy outlook summary (*AEO2012*), which primarily covers 2010 through 2035.[10] The complete outlook report was released in June 2012 .[11] The EIA's reference case assumes that the laws and regulations in place at the time of publication will remain in effect over the projection period, unless they have specific sunset dates. There are a few exceptions to this rule throughout the report and they are openly noted. Also, the economic assumptions made in *AEO2012* do not account for short-term fluctuations.

When projecting energy prices, consumption, production, generation, etc., one must consider the state of the nation's economy. National recovery from the Great Recession is expected to happen more slowly than any other recessional recovery since 1960. The resulting slower rates of employment and income recovery will have an effect on the US energy outlook for the next 25 years. Table 4 presents a summary of the key forecast values in 2025 and 2035.

2.4 Energy production and price forecasts

2.4.1 Crude oil

Prices averaged between $85 and $110 per barrel in 2011, and the *AEO2012* puts the 2016 price at $120 per barrel. By 2035, the price is projected to rise to $145 (2010 dollars) or $230 nominal dollars. This price increase is the result of expected pipeline capacity increases, world economic recovery, and global demand growth outpacing the supply available from non-Organization of the Petroleum Exporting Countries (OPEC)-producers. The *AEO2012* also assumes that these non-OPEC producers have significant potential to produce a lot of liquid fuels in the long-term, due to high oil prices and more infrastructure and investment in exploration and drilling. Upon delivery to the transportation industry, motor gasoline and diesel had real prices of $2.76 and $3.00 per gallon respectively in 2010. The *AEO2012* has marked these figures up to $4.09 and $4.49 (2010 dollars) per gallon for 2035. Diesel prices are expected to stay above gasoline prices on average, due to higher demand for the former fuel.

[10] US Energy Information Administration, "Annual Energy Outlook 2012 Early Release," (2012).
[11] US Energy Information Administration, *Annual Energy Outlook 2012*,[2012b].

2.4.2 Natural gas

Production is expected to increase, but prices will stay below $5 Mcf (2010 dollars) until 2024, as the industry develops wells in shale basins across the nation. Drilling levels should remain high partly due to high oil prices, because drilling into many, but not all, shale formations yields both natural gas and crude oil. Prices for natural gas are expected to increase beginning in 2024, reaching $6.52 Mcf (2010 dollars) in 2035, as domestic demand increases and external US supplies dwindle.

2.4.3 Coal

Prices at the mine mouth are expected to increase by 1.4 percent per year resulting in an increase of $1.76 per million Btu in 2010 to $2.51 per million Btu in 2035 (2010 dollars). This price increase reflects a higher cost of production, as coal companies mine reserves that are more costly to reach.

2.4.4 Biofuel

Consumption is expected to become increasingly important over the projection period, even though challenges remain in the marketplace for certain types of biofuel. Ethanol must be below a certain saturation level to be used in the gasoline pool. Until consumer demand and infrastructure adjust to energy price changes, it will take more time for the volumes of ethanol above the saturation level to reach the market. The EIA suggests that by 2035 biofuels will replace 600,000 barrels/day of other liquid fuels, like gasoline and diesel.

2.4.5 Electricity

Real average delivered electricity prices are expected to decline from 9.8 cents per kilowatt hour in 2010 to 9.2 cents in 2019. The decline results from natural gas prices remaining relatively low, resulting in fuel switching from coal to natural gas at electric generation plants. These plants often have the lowest cost and thus set the wholesale price of electricity. By 2035, the EIA expects electricity prices to rise to 9.5 cents per kilowatt hour based on rising natural gas prices as demand increases in the power sector for natural gas-fired generation.

2.5 End-user consumption

2.5.1 Transportation

This sector is expected to consume an increasing amount of energy over the projection period, from 27.6 quadrillion Btu in 2010 to 28.8 quadrillion Btu in 2035. This consumption can be broken down into light-duty vehicle (LDV) consumption and heavy truck consumption. LDV energy consumption is expected to decline over the first 15 years of the projection, primarily due to improvements in gas mileage for highway vehicles, but also to fewer miles traveled due to lower economic growth and employment rates. LDV energy consumption should increase after 2025, though it is not expected to exceed the 2010 consumption level. Where heavy trucks are concerned, the EIA projects an overall increase in energy demand.

2.5.2 Industrial

In 2010, this sector accounted for about one-third of all the energy consumed in the United States. The *AEO2012* projects an increase of 16 percent from 2010 (23.4 quadrillion Btu) to 2035 (27.0 quadrillion Btu). In 2010, the bulk chemicals industry held the largest percentage of energy consumption in the industrial sector, but the EIA expects the refining industry to hold this title by 2026.

2.5.3 Residential

Delivered energy consumption in the residential sector is expected to increase from 11.7 quadrillion Btu in 2010 to 12.0 quadrillion Btu in 2035. The EIA suggests that some natural gas and petroleum consumption in this sector will be transferred to electricity consumption, with consumption of the latter outpacing natural gas consumption before 2035.

2.5.4 Commercial

The EIA expects the commercial sector's energy consumption to grow at a fairly slow rate, about one percent per year, which is on par with the growth rate of commercial floor area. Commercial energy consumption was 8.7 quadrillion Btu in 2010, while the forecast puts it at 10.3 quadrillion Btu in 2035.

2.6 Fuel consumption

2.6.1 Total energy consumption

The EIA reports that in 2010 total primary energy consumption was 98.2 quadrillion Btu and is expected to reach 108.0 quadrillion Btu by 2035. Fossil fuels will make up a smaller percentage of total energy demand in the US by the end of the same period, shrinking from 83 percent in 2010 to 77 percent in 2035.

2.6.2 Total liquid fuels consumption

This is expected to increase from 19.2 million barrels per day in 2010 to 20.1 million barrels per day in 2035. The transportation sector represents the greatest share of demand for liquid fuels over the projection period, though its share only increases by one percent during the twenty-five year timeframe.

2.6.3 Natural gas consumption

This is expected to increase from 24.1 trillion cubic feet in 2010 to 26.5 trillion in 2035, according to the *AEO2012*. A large part of this growth is due to increased demand for natural gas to be used for electricity production.

2.6.4 Coal consumption (including coal-to-liquids)

The EIA forecasts an increase from 1,051 million short tons in 2010 to 1,155 million short tons in 2035. Most of the coal consumption will be directed toward electricity generation and will slow down through 2015, when some of the coal-capacity begins to be retired. After 2015, however, coal-fired electricity generation increases as production depends more on the smaller number of plants.

2.6.5 Renewable fuels

The EIA forecasts total marketed renewable fuels consumption growing at a rate of 2.8 percent per year between 2010 and 2035. This growth is thought to be the result of federal and state programs that encourage and regulate the use of renewable fuels such as wood, biomass, municipal waste, hydroelectricity, geothermal, ethanol, solar, and wind. Renewable energy sources, apart from hydroelectricity, are expected to make up an increasing share of electric power generation, from 1.4 quadrillion Btu in 2010 to 3.4 quadrillion in 2035. The majority of this growth will come from wind and biomass energy.

2.7 Per capita energy consumption

According to the EIA, per capita energy consumption will decrease over the projection period due to increased electricity efficiency, as well as the slow economic recovery from the Great Recession. Even though the nation's population is expected to increase by one-fourth over the twenty-five year period, energy use only grows by ten percent, resulting in a decline in per capita usage at an annual rate of 0.5 percent on average between 2010 and 2035. Energy usage per dollar of GDP will also decrease, as will CO_2 emissions per dollar of GDP.

2.8 Energy imports

Over the projection period, the nation's net energy imports decline in both percentage of imports and absolute volume. Increased domestic production, rising prices, increased efficiency standards, and decreased demand are responsible for this change. While net import share of total energy consumption in the US was 22 percent in 2010, by 2035 it drops off to 13 percent.

Other key results in the EIA's *AEO2012* include:

- Domestic crude oil production was 5.5 million barrels per day in 2010 and is expected to increase to 6.7 million in 2020. A slight decline takes oil production down to 6.1 million barrels per day by 2035.
- United States dependence on liquid fuels from outside sources continues to decline due to increased domestic oil and biofuel production, as well as falling demand for transportation fuels. Liquid fuel, as a share of national imports, continues to decline from 50 percent in 2010 to 37 percent in 2035.
- Recoverable resources of the nation's shale gas are estimated to be 482 trillion cubic feet. About 84 trillion cubic feet of this is from the Marcellus shale plays and another 16 trillion is from Utica plays in the Northeast. In 2016, the nation emerges as a net exporter of liquefied natural gas (LNG), initially exporting 1.1 billion cubic feet per day that year. By 2021, the United States should become a net exporter of all natural gas products, adding on the distinction of being a pipeline exporter in 2025. Imports from Canada will decrease by 62 percent, and exports to Mexico will increase by 440 percent.
- Coal is still the primary fuel used for electricity generation in the United States. Between 2010 and 2035, domestic coal production grows by an average rate of 0.3 percent per year, starting at 1,084 million short tons and reaching 1,188 million in the last year of the projection. Western mines account for most of this production increase and represent a growing share of coal production in the United States. In 2010, western mines held 47 percent of domestic coal production, but that figure is expected to increase to 56 percent by 2035. Coal production in Appalachia represents a decreasing share of domestic production over the forecasting period, and the middle of the nation holds a steady share, though production in that region increases overall between 2010 and 2035. The EIA estimates that 93 percent of total national coal consumption is by electricity generation; by 2035, the electricity sector should consume about 19.6 quadrillion Btu of coal.
- Total electricity consumption is expected to increase from 3,879 billion kilowatt hours in 2010 to 4,775 billion in 2035, with an average annual increase of 0.8 percent. While coal remains the primary source for electricity generation, its share of total production declines as natural gas and nuclear power become more prominent. Renewable energy represents a large part of overall growth in electricity generation over the projection period.
- The nation's CO_2 emissions related to energy consumption increased by about four percent in 2010. Between 2005 and 2035, the EIA estimates that CO_2 emissions per capita drop by one

percent per year on average. This is because of new regulations and increased fuel prices that will shift production away from coal-fired practices toward lower carbon fuels.

- Between 2010 and 2035, the electricity-related CO_2 emissions will increase by 4.9 percent, and transportation-related emissions are expected to slow compared to their pre-recession levels. Overall CO_2 emissions are 3 percent higher than 2010 levels by the end of the projection period, and the carbon intensity of national energy consumption is expected to have fallen. The EIA anticipates energy-related CO_2 emissions per dollar of GDP to drop by 45 percent over the 25 year span.

2.9 Key observations

- Since the release of the national state and energy outlooks cited above by IHS Global Insights, EIA and BBER, international and national economic forecasts continue to point towards much slower economic growth than was experienced in the 1990s and early part of this century. Continued deterioration in the European economy and slowdowns in Asian economies may jeopardize economic growth in the US. The looming 'fiscal cliff' facing Congress after the elections has resulted in a reduction in current domestic investment and consumption and could result in the US economy tipping back into recession.
- Since increases in energy demand are driven by economic growth, the energy forecasts could be too optimistic if the economy continues to languish. This could affect the levels of production of various fossil fuels nationally as well as the energy demands by the various consumption sectors.

Table 3: WV employment, labor force, and unemployment rate forecasts

Indicator	Actual	Forecast					
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Total Jobs	692.0	698.4	702.3	706.7	714.5	724.4	734.9
Goods Producing	112.8	116.6	116.7	117.1	120.2	124.5	127.3
Natural Resources & Mining	31.1	34.4	35.1	34.9	34.9	35.0	35.3
Mining	29.3	32.8	33.5	33.4	33.4	33.5	33.9
Coal Mining	20.5	22.7	22.4	21.7	21.3	21.1	21.1
Other Mining	8.8	10.1	11.1	11.7	12.1	12.4	12.8
Natural Resources	1.8	1.6	1.6	1.5	1.5	1.5	1.4
Construction	32.7	32.7	31.9	32.1	34.7	37.9	39.9
Manufacturing	49.1	49.4	49.7	50.0	50.7	51.6	52.1
Durable Manufacturing	29.6	30	30.6	31.3	32.3	33.3	34.0
Wood Products	6.5	6.5	6.6	7.1	7.9	8.6	9.0
Nonmetallic Minerals	3.1	2.8	2.7	2.6	2.7	2.7	2.8
Primary Metals	4.7	4.8	5.0	4.9	4.8	4.8	4.7
Fabricated Metals	5.8	6.0	6.0	6.0	6.1	6.2	6.3
Transportation Equipment	4.4	4.5	4.7	5.0	5.3	5.5	5.5
Other Durables	5.2	5.4	5.5	5.6	5.5	5.6	5.6
Non-Durable Manufacturing	19.5	19.4	19.0	18.7	18.4	18.2	18.1
Food Products	3.4	3.4	3.3	3.2	3.2	3.2	3.1
Chemicals	9.4	9.3	9.2	9.2	9.1	9.2	9.3
Plastics & Rubber	3.3	3.4	3.4	3.4	3.3	3.3	3.3
Other Non-Durables	3.4	3.3	3.1	2.9	2.7	2.6	2.4
Service Producing	579.2	581.8	585.6	589.7	594.2	600.0	607.6
Trade, Transportation, & Utilities	131.4	132.7	134.4	135.9	136.2	137.2	138.1
Wholesale Trade	23.0	23	23.4	23.6	23.9	24.2	24.5
Retail Trade	86.6	87.7	89.0	90.3	90.3	90.7	91.0
Utilities	5.6	5.5	5.6	5.6	5.6	5.7	5.9
Transportation & Warehousing	16.2	16.5	16.4	16.4	16.4	16.5	16.7
Information	10.3	10.7	10.8	10.8	10.9	11.1	11.2
Financial Activities	26.4	26	25.6	25.6	25.7	26.0	26.2
Professional & Business Services	60.4	61.8	61.3	61.9	64.4	67.1	69.6
Educational & Health Services	115.2	117.1	120.0	121.6	123.6	125.5	129.3
Educational Services	5.5	5.6	5.5	5.4	5.2	5.1	5.0
Health Care & Social Assistance	109.7	111.4	114.5	116.2	118.4	120.3	124.3
Leisure & Hospitality	72.1	71.4	72.2	72.6	72.5	72.6	72.8
Other Services	20.7	20.6	20.4	20.3	20.3	20.2	20.2
Government	142.6	141.4	141.0	141.1	140.7	140.3	140.3
Federal Civilian	24.4	23.5	23.5	23.6	23.4	23.2	23.2
State & Local	118.3	117.9	117.6	117.5	117.3	117.2	117.1
Labor Force	782.2	781.2	781.5	782.7	783.3	783.8	785.3
Employed	711.1	712.1	713.5	717.3	722.5	728.5	734.8
Unemployment Rate (%)	9.1	8.8	8.7	8.4	7.8	7.1	6.4

Data are measured in Thousands.

*These columns contain the average yearly change during the 2010-2016 period

**Beginning with the West Virginia Economic Outlook 2008, employment is measured by covered employment (ES-202).

Table 4: Annual energy outlook 2012 summary data

Energy and economic factors	2010	2025	2035
Primary energy production (quadrillion Btu)			
Petroleum	14.37	17.48	16.81
Dry natural gas	22.10	26.63	28.51
Coal	22.08	22.51	23.51
Nuclear Power	8.44	9.60	9.35
Hydropower	2.51	2.97	3.06
Biomass	4.05	6.73	9.68
Other renewable energy	1.34	2.13	2.80
Other	0.64	0.76	0.88
Total	**75.52**	**88.79**	**94.59**
Net imports (quadrillion Btu)			
Liquid fuels[a]	20.35	16.33	16.22
Natural gas	2.66	-0.81	-1.39
Coal/other (- indicates export)	-1.58	-1.44	-1.29
Total	**21.43**	**14.08**	**13.54**
Consumption (quadrillion Btu)			
Liquid fuels[a]	37.25	37.04	38.00
Natural gas	24.71	25.80	27.11
Coal	20.76	20.60	21.57
Nuclear power	8.44	9.60	9.35
Hydropower	2.51	2.97	3.06
Biomass	2.88	4.52	5.85
Other renewable energy	1.34	2.13	2.80
Net electricity imports	0.29	0.28	0.24
Total	**98.16**	**107.95**	**107.97**
Liquid fuels (million barrels per day)			
Domestic crude oil production	5.47	6.42	6.12
Other domestic production	6.42	5.71	6.66
Net imports	9.53	7.39	7.36
Consumption	19.17	19.46	20.08
Natural gas (trillion cubic feet)			
Dry gas production + supplemental	21.65	26.07	27.90
Net imports	2.58	-0.84	-1.43
Consumption	24.13	25.20	26.48
Coal (million short tons)			
Production	1,098	1,202	1,204
Net imports	-64	-19	-49
Consumption	1,051	1,182	1,155
Prices (2010 dollars)			
Imported low-sulfur, light crude oil ($/barrel)	79.39	132.50	144.56
Imported crude oil ($/barrel)	75.87	121.23	132.69
Domestic natural gas at wellhead ($/thou. ft^3)	4.16	5.23	6.52
Domestic coal at minemouth ($/short ton)	35.61	43.87	49.24
Average electricity price (cents/kilowatt hour)	9.8	9.3	9.5
Economic indicators			
Real GDP (billion 2005 dollars)	13,088	19,176	24,639
GDP chain-type price index (2005 = 1.000)	1.110	1.459	1.762
Real disposable personal income (bil. 2005 dollars)	10,062	14,474	18,252
Value of manufacturing shipments (bil. 2005 dollars)	4,260	5,735	6,270
Primary energy intensity (thou. Btu/2005 dollar of GDP)	7.50	5.37	4.38
Carbon dioxide emissions (million metric tons)	5,634	5,618	5,806

[a]Includes petroleum-derived and non-petroleum derived fuels and petroleum coke, which is
Source: US EIA *AEO2012* National Energy Modeling System.

3 Coal

3.1 Introduction

Coal has been an integral part of the West Virginia economy since its discovery in Boone County in 1742. Coal extraction and use has created employment, income, gross state product and wealth for countless generations of West Virginians. This has not been without controversy, as mining, distribution, and consumption of coal have resulted in environmental externalities, many of which have been addressed through both private efforts as well as public policy. Coal today is much cleaner than it was in the early part of the twentieth century and will continue to play a vital role in West Virginia's energy future.

This report addresses the current status of the coal industry and the opportunities for future use. The subsequent discussion will address coal markets, electric power generation using coal, coal bed methane, waste coal, and transportation. Opportunities for additional value added uses for coal are identified along with strategies and public policy options for this fossil fuel.

The coal mining industry encompasses all establishments whose primary activity involves one or more of the following: mining bituminous coal, anthracite, and lignite by underground mining, auger mining, strip mining, culm bank mining and other surface mining; developing coal mine sites; and preparing coal.[12]

3.2 Overview

The EIA Annual Coal Report provides an overview of annual data on coal production, prices, recoverable reserves, employment, productivity, productive capacity, consumption and stocks.[13] In 2010:

- US coal production totaled 1,084.4 million short tons, about 0.9 percent increase from the 2009 total of 1,074.9 million short tons. Table 5 provides the coal production by state in 2010, the latest available data. Wyoming led all states, with the bulk coming from the Powder River Basin. West Virginia ranked second with 135, 220 thousand short tons, which was significantly above Kentucky production of 104,960 thousand short tons. It should be noted that the Black Thunder Mine and North Antelope Rochelle Mine is Wyoming produce almost as much coal (in tons) as is produced in the entire state of West Virginia.
- Table 6 provides the employment and wages in mining (except for oil and natural gas) by state in 2010. West Virginia led all states with 22,032 employees making over $1.6 billion in wages.
- Coal consumption totaled 1,048.5 million short tons, up 5.1 percent from the 2009 consumption level of 997.5 million short tons. This increase can be attributed to higher consumption in the electric power, manufacturing, and coke sectors in 2010.
- Coal stocks fell to 231.7 million short tons at the end of 2010, compared to 244.8 million short tons at the end of 2009.
- Coal mine employment was 86,195 in 2010, a 1.8-percent-drop from the 2009 level of 87,755 mine employees.
- Coal mine productivity declined by 1.1 percent to 5.55 tons per miner per hour, slightly below the 2009 level of 5.61 tons per miner per hour.

[12] NAICS Association, "The History of NAICS," (2012).
[13] The Energy Information Administration, US Department of Energy, provides significant statistical information and analysis of all energy sources including coal. Each fall EIA releases *Annual Coal* Report with subsequent updates, and has a series of weekly and monthly updates throughout the year. These highlights are extracted from the July 3, 2012 revised version of the *Annual Coal Report*. http://www.eia.gov/coal/annual/.

Table 5: US coal production 2010

State	Thousand Short Tons
Alabama	19,915
Alaska	2,151
Arizona	7,752
Arkansas	32
Colorado	25,163
Illinois	33,241
Indiana	34,950
Kansas	133
Kentucky	104,960
Louisiana	3,945
Maryland	2,585
Mississippi	4,004
Missouri	458
Montana	44,732
New Mexico	20,991
North Dakota	28,949
Ohio	26,707
Oklahoma	1,010
Pennsylvania	58,593
Tennessee	1,780
Texas	40,982
Utah	19,351
Virginia	22,385
West Virginia	135,220
Wyoming	442,522
US Total	1,084,368

Source: US Energy Information Administration

Table 6: Selected US mining (except oil and gas) employment and wages, 2010

State	Employment	Total Wages
Kentucky	19,085	$1,258,391
Maryland	1,386	$53,290
Ohio	6,458	$332,652
Pennsylvania	17,219	$820,812
Virginia	7,606	$454,475
West Virginia	22,032	$1,669,187

Source: US Bureau of Economic Analysis, Tables SA07N and SA25N

3.3 Coal industry trends

To put this industry's performance in perspective, Figure 1 shows the US and West Virginia coal production from 1995 through 2011. West Virginia coal production was highest in 1997 and has declined since, with the most recent significant decline coinciding with the advent of the 2008 recession. US production climbed during the entire period, largely due to expanded production from the Powder River Basin; however, this production fell off in the 2008 recession and started returning to higher levels in 2011.

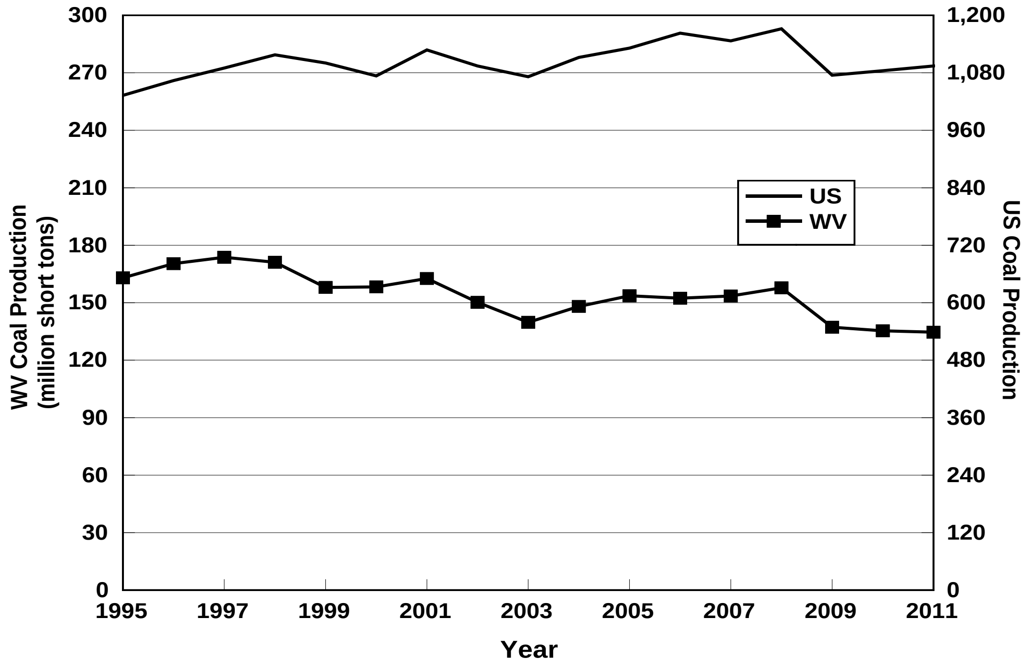
Some other notable trends in the West Virginia coal industry are noted in Figure 2- Figure **8**. Figure 3 shows the annual productivity (short tons per miner per hour) of West Virginia and US mines. From 1990 to around 200 there were advances in productivity, particularly in other states due to the expansion of mining in the Powder River Basin. From 2001 to the first quarter of 2011 there has been a decline in the amount of coal produced per miner that is more pronounced in West Virginia than elsewhere. In part this is a reflection of shifts in the coal resources being mined to seams with more challenging geological conditions. Productivity in West Virginia mines today is less than in 1990 even though there are more advanced mining technologies, such as long wall machines, in operation.

Figure 4 shows the month coal production by region within West Virginia from 1996 to the first quarter of 2012.[14] Production in Northern West Virginia has averaged less than 50 million tons per year over this period. On the other hand, Southern West Virginia has been declining from the late nineties to the present, a reduction of up to nearly 50 million tons per year. A significant part of the Southern West Virginia production decline is due to issues with permits for new and existing mines as well as greater geological problems with resource extraction.

Figure 5 traces the average mine price of West Virginia coal in both nominal and real terms since 1980. While nominal prices were reasonable stable from 1980 to 2003, there has been a significant increase to the present time. Once one adjusts for inflation, the real price decline from 1982 to a trough in 2003 and has rapidly escalated since that time. One of the major contributing factors in the recent real price increase is the significantly higher prices for high quality metallurgical coal relative to steam coal, the latter of which is often produced under long-term contracts with electric utilities. The EIA also predicts real coal prices will continue to rise through 2035 (see Figure 2).

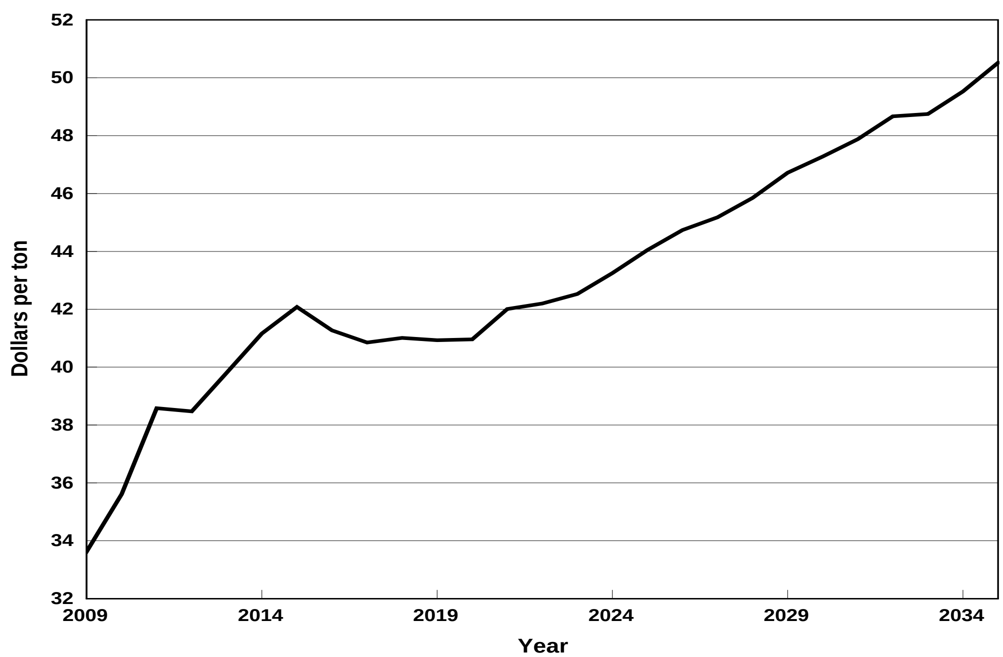
[14] Coal production data for West Virginia is divided into two regions: Northern and Southern. The Northern district is defined as mines in the following counties: Barbour, Brooke, Braxton, Calhoun, Doddridge, Gilmer, Grant, Hancock, Harrison, Jackson, Lewis, Marion, Mineral, Monongalia, Ohio, Pleasants, Preston, Randolph, Ritchie, Roane, Taylor, Tyler, Upshur, Webster, Wetzel, Wirt, and Wood. The Southern district is defined as mines in the following counties: Boone, Cabell, Clay, Fayette, Greenbrier, Kanawha, Lincoln, Logan, Mason, McDowell, Mercer, Mingo, Nicholas, Pocahontas, Putnam, Raleigh, Summers, Wayne, and Wyoming.

Figure 1: Annual coal production WV and US, 1995-2011



Source: US Energy Information Administration

Figure 2: Minemouth coal forecast prices (2010 dollars per ton)



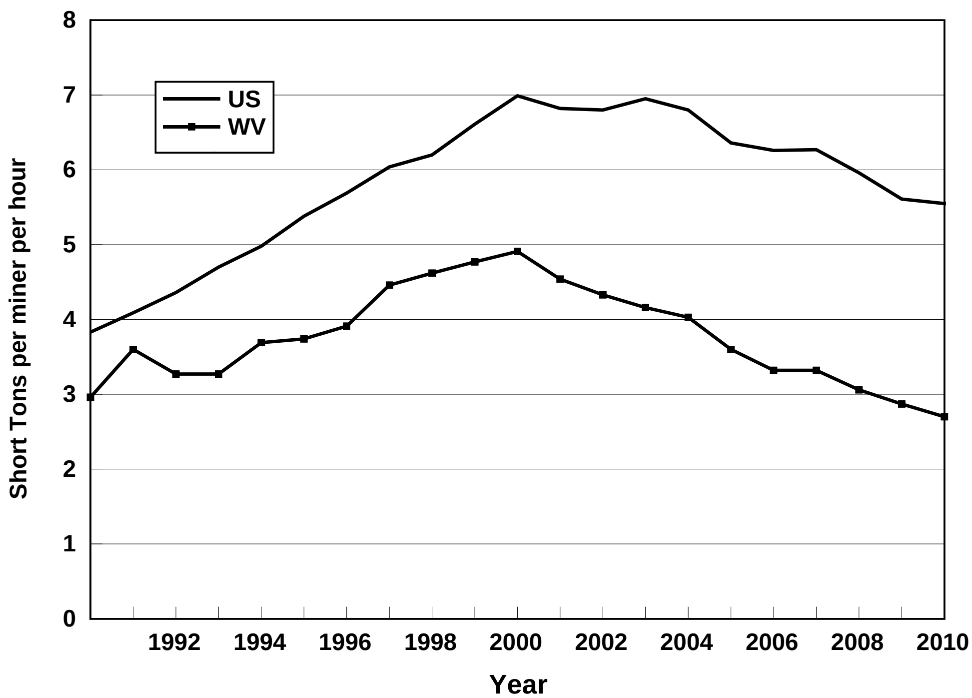
Source: US Energy Information Administration

While West Virginia and US coal mining employment declined from 1990 to about 2004, West Virginia employment has been increasing until recently (Figure 6). Since the beginning of 2012, many coal companies have been curtailing operations either temporarily or permanently. The recent bankruptcy filing by Patriot Coal was just one of many structural changes in the industry in response to reduced demand by utilities for coal relative to natural gas. Adding to the coal market stresses, Patriot also had significant pension and health care costs that strained its financial resources.

Mining continues to be a major contributor to the West Virginia economy as measured by its gross domestic contribution. From 2000 to 2011 mining (except oil and gas) increased its share of GDP from around six to over eight percent. During the same period the relative shares of manufacturing, construction and retail trade fell considerably.

In 2010 *The West Virginia Coal Economy 2008* publication provided an overview of the economic impact of the industry including estimates of the total economic impact of the industry in 2008.[15] This publication provided a detailed overview of the coal industry with a focus on the industry's production, employment, compensation and wages, gross domestic product, taxes and exports. While the data in this report provided reflected calendar year 2008, recent developments and future prospects necessitate reviewing the current status of the industry.

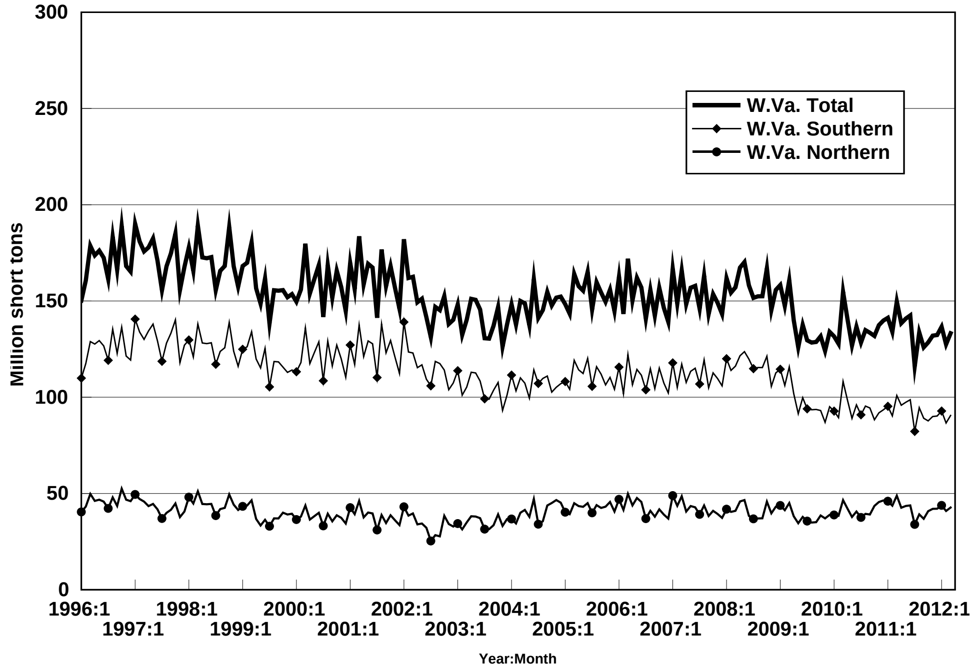
Figure 3: Annual productivity WV and US, 1992-2010



Source: US Energy Information Administration

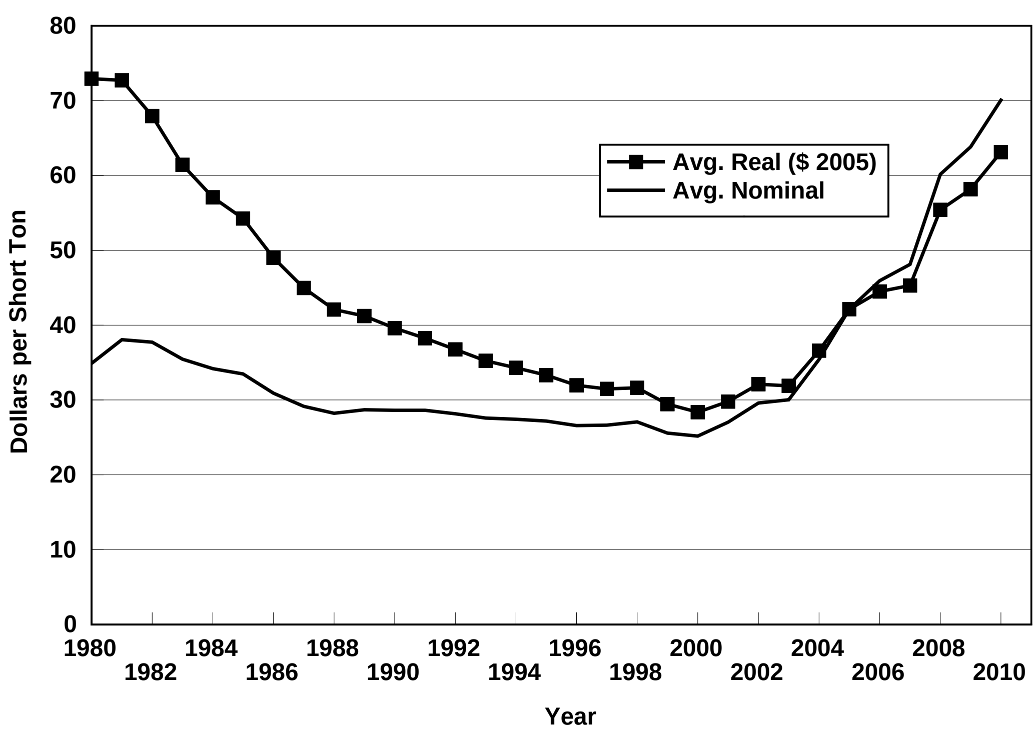
[15] Marshall University Center for Business and Economic Research and West Virginia University Bureau of Business and Economic Research, *The West Virginia Coal Economy 2008*,[2010].

Figure 4: WV monthly coal production by region
(non-seasonally adjusted, annualized in million tons), 1996-2011



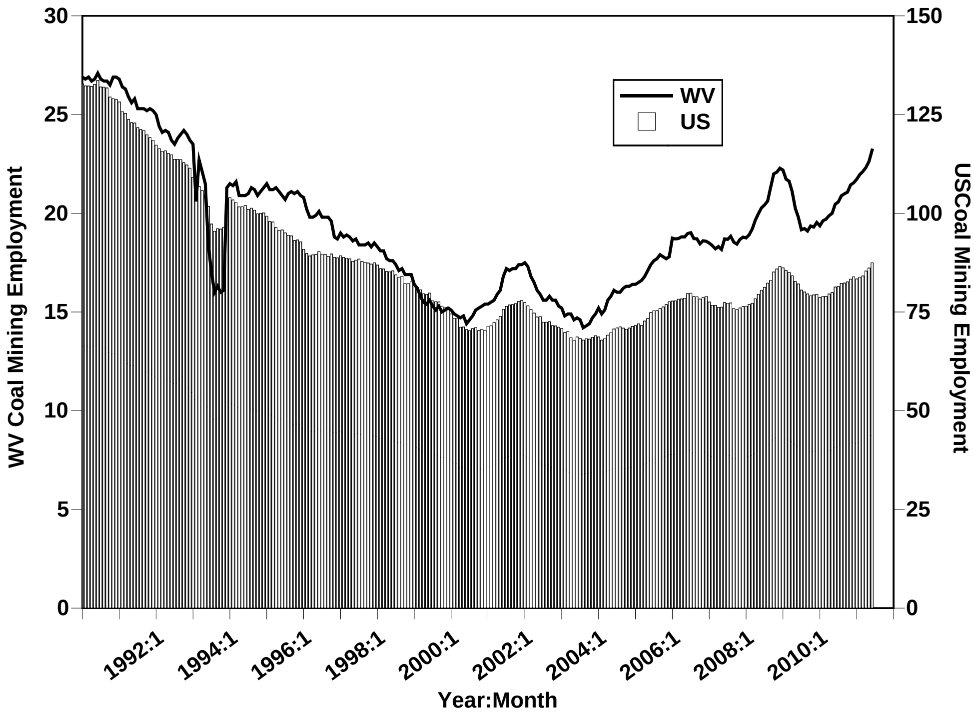
Source: U.S. Energy Information Administration

Figure 5: Average mine price of WV coal, 1980-2010



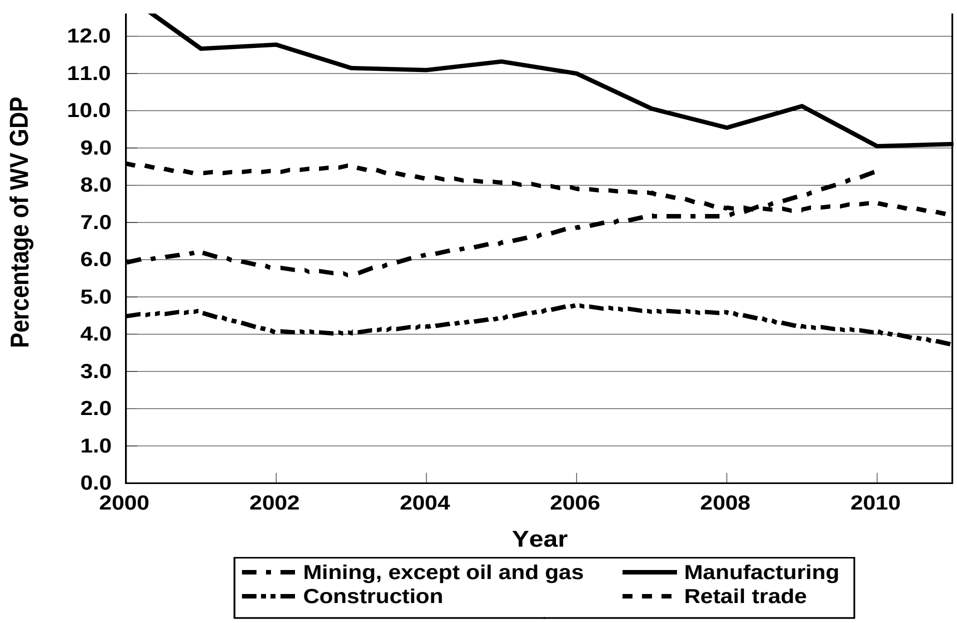
Source: US Energy Information Administration and Bureau of Economic Analysis

Figure 6: Coal mining employment WV and US (non-seasonally adjusted, in thousands), 1992-2010



Source: US Bureau of Labor

Figure 7: WV gross domestic product by major sector, 2000-2011



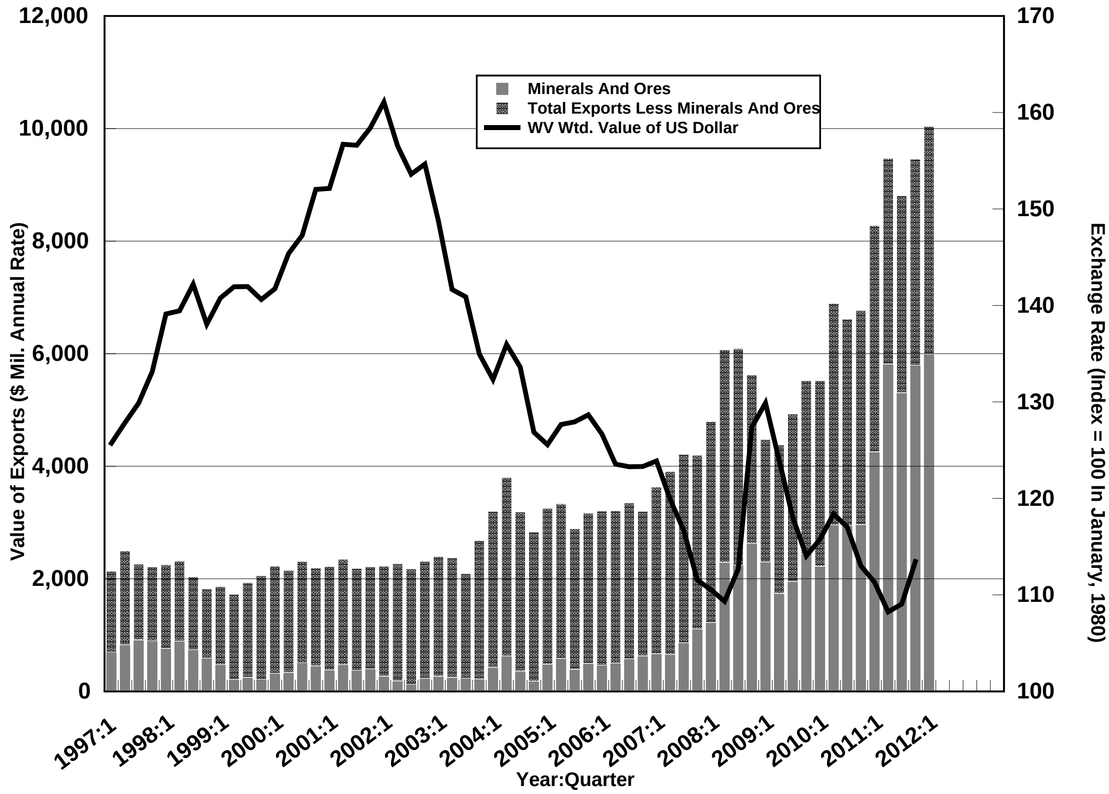
Source: US Bureau of Economic Analysis

Table 7: US coal exports, by type and WV share of total (short tons)

	2009	2010
Metallurgical	37,261,568	56,113,816
Steam	21,835	25,601,859
Total US Coal	59,096,951	81,715,675
Metallurgical Share	63.05%	68.67%
Steam Share	36.95%	31.33%
WV Export Tons	21,373,000	24,537,690
US Export Tons	55,601,000	66,922,480
WV Export Share	38.44%	36.67%

Source: US Energy Information Administration, Quarterly Coal Report and Annual Coal Distribution Report

Figure 8**:** Value of WV commodity exports, 1997-2012



Source: WISERTrade & BBER Calculations

Table 8: Top 10 rankings by value (millions of dollars) and destination of WV coal exports 2008-2011

	2008		2009		2010		2011	
Rank	Total WV Exports	$5,643	Total WV Exports	$4,286	Total WV Exports	$6,449	Total WV Exports	$9,002
1	Canada	$1,286	Canada	$1,201	Canada	$1,474	Canada	$1,532
2	Japan	$497	Brazil	$407	Japan	$408	Brazil	$695
3	Brazil	$357	Netherlands	$364	Brazil	$400	Netherlands	$689
4	Belgium	$323	Belgium	$313	Netherlands	$362	India	$644
5	Netherlands	$302	China	$296	China	$360	Italy	$614
6	India	$293	France	$288	India	$359	Ukraine	$500
7	France	$290	Ukraine	$227	Belgium	$338	Japan	$449
8	China	$252	Japan	$218	U.K.	$277	China	$419
9	Ukraine	$222	India	$208	Italy	$255	South Korea	$377
10	Italy	$174	Italy	$166	Ukraine	$245	U.K.	$357

Source: US Census Bureau, Foreign Trade Statistics

Table 9: Top ten WV mineral and ores export destinations ranked by value of commodity exports in 2011 (millions of dollars)

Rank	Country/Region	2009	2010	2011
1	India	173.9	302.8	593.4
2	Italy	139.9	224.2	581.4
3	Brazil	312.9	280.4	546.9
4	Netherlands	212.4	203.0	524.6
5	Ukraine	50.2	245.1	499.4
6	United Kingdom	189.0	221.3	287.5
7	Turkey	44.5	154.6	274.3
8	Korea, Republic Of	8.3	9.6	267.1
9	France	257.9	151.2	248.8
10	Canada	4.9	103.9	214.2
	European union (27)	1,304.9	1,349.0	2,295.5
	Pacific Rim, including China	60.8	73.5	389.9
	Mexico, Latin America, Caribbean	381.8	350.1	685.3
	Total Mineral and Ores	2,110.0	2,771.7	5,292.6

Source: WISER Trade

Table 10: Top ten WV export industries ranked by value of commodity exports in 2011

Rank	NAICS	Industry	2009	2010	2011
1	212	Minerals and Ores	2,110.0	2,771.7	5,292.6
2	325	Chemicals	1,181.7	1,568.1	1,596.0
3	336	Transportation Equipment	416.1	629.3	977.3
4	331	Primary Metal Manufacturing	170.6	231.4	209.8
5	327	Nonmetallic Mineral Products	90.6	151.4	151.9
6	333	Machinery, Except Electrical	364.0	532.1	142.0
7	339	Miscellaneous Manufactured Commodities	108.0	126.3	138.8
8	334	Computer and Electronic Components	54.1	69.4	104.9
9	326	Plastics and Rubber Products	29.6	44.1	65.8
10	324	Petroleum and Coal Products	44.2	53.8	64.3
		Total All Industries	4,825.6	6,449.2	9,002.2

Source: WISER Trade

3.4 West Virginia coal industry forecasts

BBER recently released updated consensus coal production and coal forecasts for West Virginia for the period 2012-2030.[16] This forecast is derived from forecast of production provided by the EIA (EIA reference case forecast), BBER and Energy Ventures Analysis (EVA). Coal price forecasts are provided by EIA and EVA and details regarding these forecasts are included in the report appendix.

The consensus coal production forecast is summarized in Figure 9 and Table 11. This forecast indicates a decline in West Virginia coal production from 134.6 million tons in 2011 to 130.5 million tons in 2012 and reflects weak demand from the beginning of 2012 accelerating through the end of the year. According to this report:

> The consensus report then calls for state coal production to decline rapidly through 2020. Indeed, production is forecast to fall to 96.0 million tons by 2020, a decline of 28.7 percent during the nine year period. Thereafter, coal production stabilizes and eventually rises to 99.2 million tons by 2030, as natural gas prices begin to gradually rise.[17]

On the other hand, the consensus coal prices rise during the forecast period, primarily the result of inflation and rising mining cost due to depletion of easily mineable reserves, particularly in the southern production regions. Figure 10 and Table 11 summarize the price forecasts.

The projected decline in coal production is due to several factors affecting the demand for and supply of coal. As indicated by BBER:

[16] George W. Hammond, *Consensus Coal Production and Price Forecast for West Virginia*,[June 2012 Update].
[17] (Hammond June 2012 Update p. 11).

On the demand side, coal is likely to be a less attractive fuel for electricity generation, as natural gas production rises and prices remain competitive. Further, restrictions on $SO_{2,}$ NO_x, and mercury (and hazardous air pollutants, more generally) emissions and the related investments in pollution control equipment by electric power producers tend to make coal produced in the southern part of the state less attractive than coal produced in Northern Appalachia and other regions of the country. Compounding these effects will be efforts by electricity producers to start positioning themselves for the eventual regulation of greenhouse gases (including increasing generation from renewables). These forces contribute to the expectation that utilities will phase out less efficient coal-fired plants in favor of those with fewer problematic emissions (such as scrubbed coal-fired plants and plants that burn natural gas and other non-coal fuels, such as biomass). This includes coal-fired plants located in West Virginia (Kanawha River, Phillip Sporn, and Kammer) slated for shut-down by AEP.

Supply-side issues will also contribute to lower coal production in the state. These include the increasingly challenging geological conditions that tend to raise production costs, particularly in the southern part of the state. In addition, the increasing scrutiny of surface mining permits by the Regulations from the US Environmental Protection Agency are also expected to contribute to declining productivity at surface mines, and thus increasing production costs, in southern West Virginia.[18]

Figure 11shows the percent change in central and northern Appalachian coal production given different potential economic scenarios.

[18] (Hammond June 2012 Update) pp.11-12.

Figure 9: WV consensus forecast coal production, 1990-2030

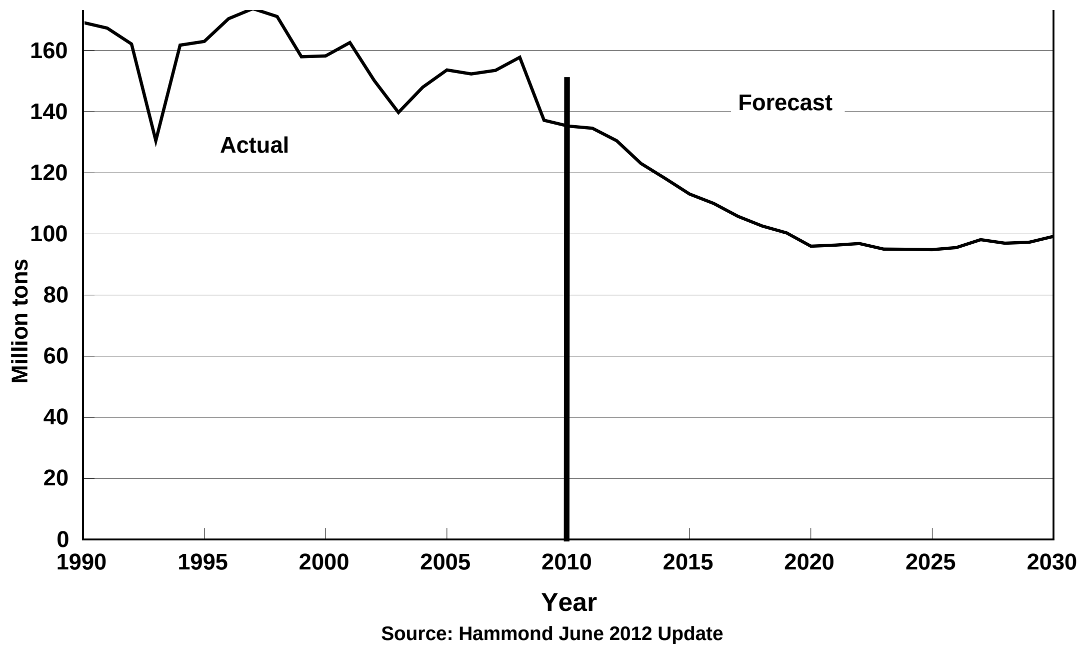


Figure 10: WV consensus forecast nominal coal prices, 2001-2030

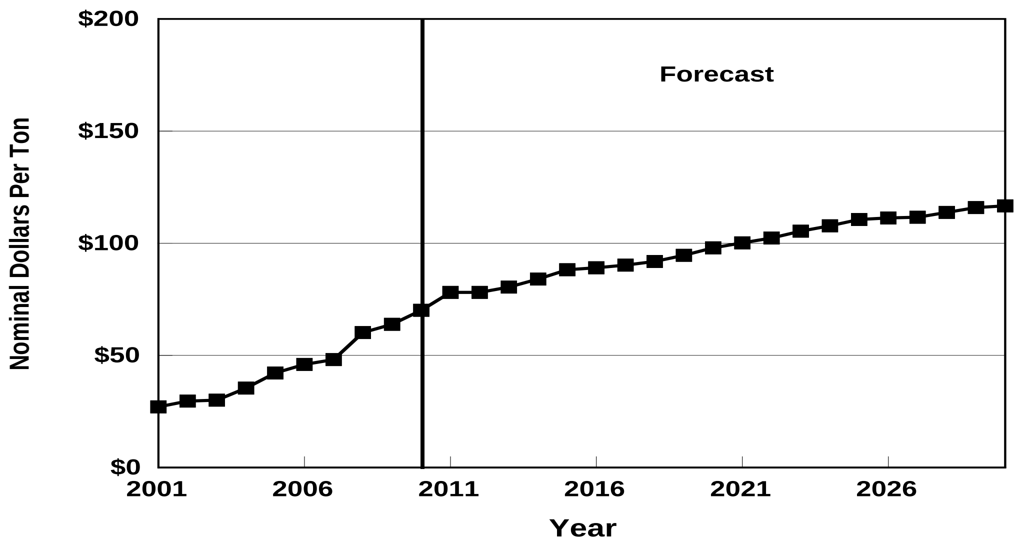
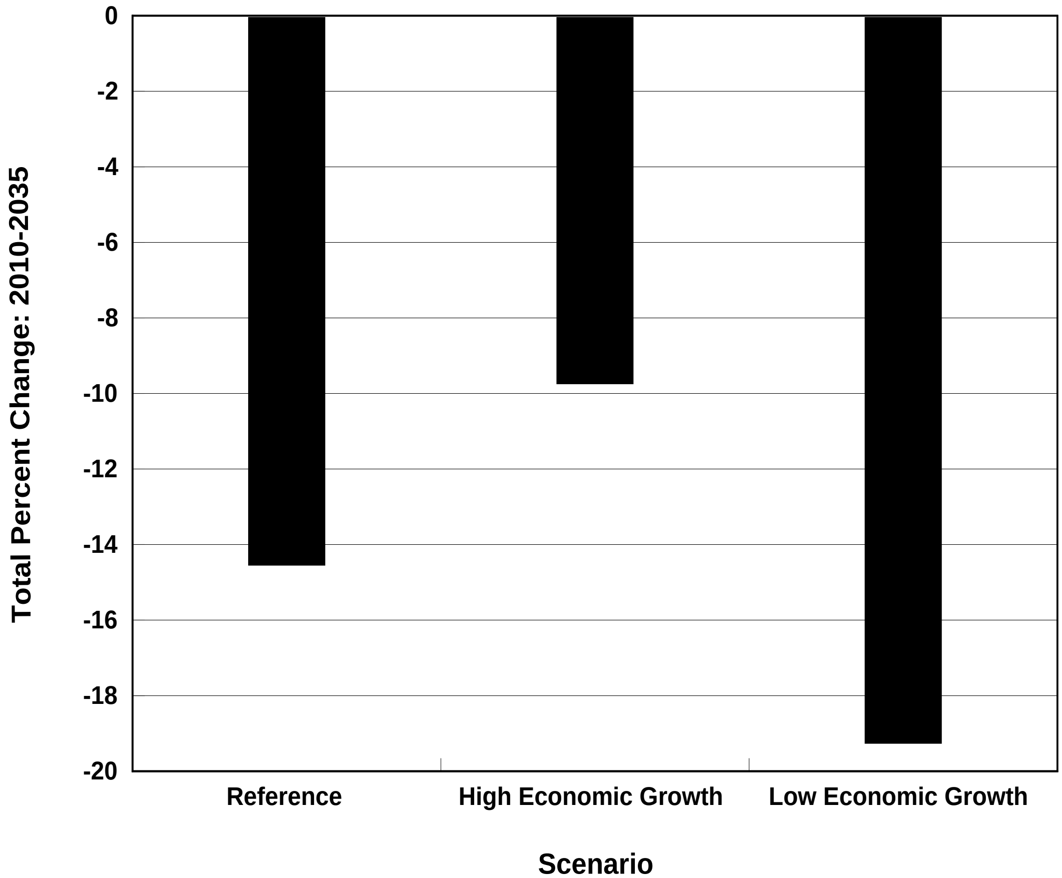


Table 11: WV coal production and consensus forecast
(millions of tons and nominal price per ton*)

	Actual						
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**Ann. Gr. (%)**
WV Coal Production	152.4	153.5	157.8	137.2	135.3	134.6	-2.5
WV Nominal Coal Price	45.94	48.12	60.16	63.83	70.07	78.08	11.2
	Forecast						
	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**Ann. Gr. (%)**
WV Coal Production	130.5	123.1	118.1	113.1	110.0	105.8	-4.1
WV Nominal Coal Price	78.07	80.43	84.00	88.19	89.09	90.23	2.9
	Forecast						
	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**Ann. Gr. (%)**
WV Coal Production	102.6	100.4	96.0	96.3	96.9	95.1	-1.5
WV Nominal Coal Price	91.85	94.61	97.92	100.20	102.34	105.38	2.8
	Forecast						
	2024	**2025**	**2026**	**2027**	**2028**	**2029**	**Ann. Gr. (%)**
WV Coal Production	95.0	94.9	95.6	98.1	97.0	97.3	0.5
WV Nominal Coal Price	107.80	110.59	111.29	111.62	113.77	115.93	1.5
	Forecast						
	2030						
WV Coal Production	99.2						
WV Nominal Coal Price	116.67						

*The coal price for 2011 is forecast. Coal prices are an average of contract and spot prices

Figure 11: Percent change in central and northern Appalachian coal production: three EIA scenarios, 2010-2035



3.5 Potential new coal markets

Though coal has traditionally been used primarily in the electric power sector, technological advances have made it possible to use coal in other applications, as well as extract methane from the coal bed. These advances have allowed coal mines to enter new markets with greater revenue potential.

3.5.1 Waste coal and gob

One of the potential energy sources is the use of waste coal and gob as an energy source for the generation of electricity. These supplies are potentially available through re-mine of numerous waste sites throughout the state. This resource has been extensively reviewed by the 2006 Marshall University study on this subject.[19] This study identified at least 864 disposal sites in West Virginia with reclaimed or unclaimed coal slurry impoundments. Key issues regarding its use for energy production include:

- Size, location, age and energy content of coal waste and gob.
- Cost of reclamation of re-mined site to comply with federal Surface Mining Control and Reclamation Act (SMCRA) guidelines.
- Ability to be cost-effective when used in coal-fired generation systems

[19] Calvin Kent and Christine Risch, *Innovative Energy Opportunities in West Virginia: Final Report*,[2006].

The major use of waste coal and gob is in circulating fluidized bed (CFB) power plants. These plants use a combination of waste coal and unwashed new coal (up to 25 percent) and can meet emission standards. The following is a summary of current or recently announced/cancelled plants in West Virginia.

- Western Greenbrier Co-Production Demonstration Project was a joint project of three West Virginia municipalities and the US DOE. The project was a 98-megawatt CFB plant designed to use wood waste along with waste coal. While permits were approved for the project, the costs rose to nearly $450 million. In 2008 the DOE announced the plant was canceled.
- Grant Town is an 80-megawatt CFB plant that became operational in 1993. The fuel source is waste coal and pond fines from mine sites. Power from this facility is sold to FirstEnergy under a long term power sales contract.
- North Branch is a 74-megawatt CFB that became operation in 1992.This plant is owned and operated by Dominion. Dominion has broken ground for a Warren County Power State (natural gas fired) in Virginia. Under the air permit granted for Warren Dominion will close North Branch.
- Morgantown Energy Associates owns and operates a 50-megawatt CFB that became operational in 1992. Capacity and energy from this facility is sold to Monongahela Power. Steam from this plant is used by West Virginia University.

The future prospects for additional power projects using waste coal and gob is problematic given the capital cost of these plants and their ability to compete in both capacity and power markets.

3.5.2 Coalbed methane

Coalbed methane (CBM) is methane extracted from coal seams.[20] CBM production occurs in conjunction with dewatering of coal seams to allow the methane to be liberated from coal. Coal stores significantly more methane than in is found in the geological formation associated with conventional natural gas reservoirs. The methane liberated through drilling permits the preparation of the coal for further exploitation. The end result in many cases is a safer working environment for underground miners.

CMB production is attractive due to several factors. Coal stores six or seven times as much gas as a conventional natural gas reservoir of equal rock volume due to the large internal surface area of the coal. Since coal is available at shallow depths, well drilling and completion are relatively inexpensive. The costs of finding the methane are also low since methane occurs in coal deposits and the location of coal resources is well known.[21] A comparison of CBM and conventional gas reservoirs is shown in Table 12.

Initially, CBM was produced using vertical wells. Through the adoption of horizontal drilling, fewer wells are needed to liberate the CBM, thus reducing the number of well sites and access roads. Since considerable amounts of waste water are generated, issues arise regarding its disposal. The West Virginia DEP reviews applications for water discharged and issues permits for the efficient and economic disposal of water. Air quality benefits can arise due to the substitution of cleaner burning methane for other dirtier fuels.[2]

[20] West Virginia Surface Owners' Rights Association, "About "Coal Bed Methane","

[21] US Energy Information Administration, "Coalbed Methane Basics," (2012).

Table 12: Comparison of coal bed methane and conventional gas reservoir characteristics

Characteristic	Conventional	CBM
Gas Generation	Gas is generated in the source rock and then migrates into the reservoir.	Gas is generated and trapped within the coal.
Structure	Randomly-spaced fractures	Uniformly spaced cleats
Gas Storage Mechanism	Compression	Adsorption
Production Performance	Gas Rate starts high then declines. Little or no water initially. GWR decreases with time.	Gas rate increases with time then declines. Initial production is mainly water. GWR increases with time

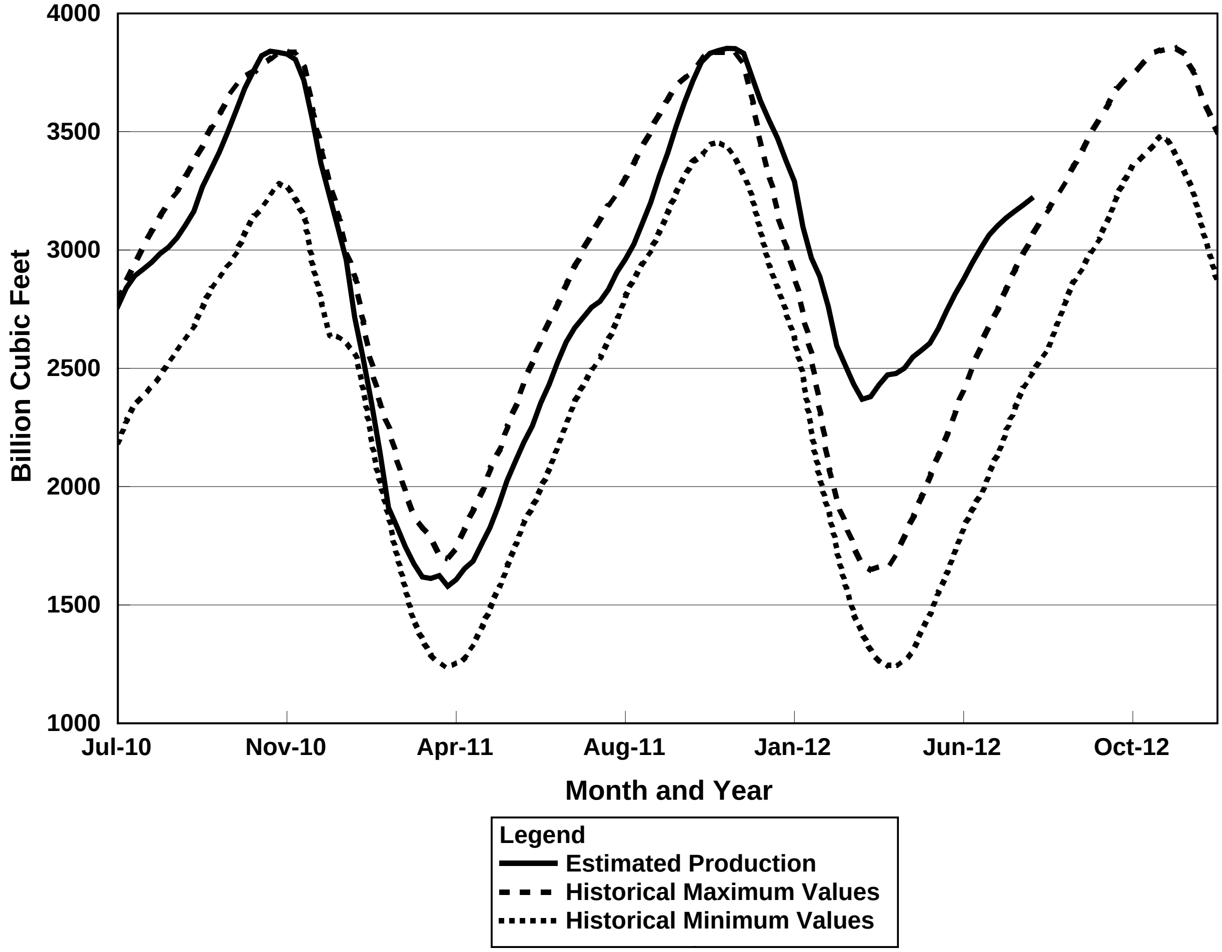
Source: Aminian, K. *Coalbed Methane - Fundamental Concepts*. Morgantown, WV: Petroleum & Natural Gas Engineering Department West Virginia University.

Within West Virginia CBM wells are concentrated in Monongalia, Marion, Wetzel, Marshall, McDowell, Logan, Wyoming, Raleigh, and Boone counties. West Virginia CBM production was 28 billion cubic feet in 2008 and 31 billion cubic feet in 2009, the latest years available from EIA.[22]

Increased production of CBM could pose a problem of insufficient storage. Shown in Figure 12 is a graph of underground natural gas storage capacity for the lower 48 states in the United States. The range between the maximum and minimum lines represents the range between the historical minimum and maximum values for the weekly series from 2007 to 2011. Current production and recent past storage have reached maximum capacity in the months leading up to the winter months. As of January 2012, production began to exceed historical maximums and is this trend is likely to continue. If production continues to increase, construction of new underground storage capacity will be necessary to make use of the excess CBM.

[22] US Energy Information Administration, "West Virginia Coalbed Methane Proved Reserves, Reserves Changes, and Production," (2012).

Figure 12: Working gas in underground storage compared with historical range, 2010-2012



Source: US Energy Information Administration

3.5.3 Coal to liquids

One use of coal entails converting it to a liquid fuel that can be used as an alternative to petroleum. The major methods involve either direct or indirect coal liquefaction. In the direct method coal is dissolved in a solvent under high pressure and temperature for further processing. Indirect liquefaction converts the coal into a gas through proven Fischer-Tropsch or advanced gasification technology processes for further refinement into clean and high quality liquid fuels such as diesel and naphtha. Internationally the leading country with coal liquefaction is South Africa, where Sasol converts coal into a variety of transportation fuels. Current capacity of these operations is over 160,000 barrels per day.

There are many advantages to use of coal as a feedstock according to the National Mining Association.[23]

- Improves national and economic security by lessening dependence on foreign oil.
- Uses domestic resources and produces more jobs for Americans.
- Provides positive influence on U.S. balance of trade and economy.
- Provides environmental benefits, including cleaner fuels that reduce nitrogen oxide and particulate emissions, enabling use of higher efficiency engines.
- Is capable of capturing carbon dioxide (CO2) emissions and serving as a bridge to a hydrogen fuel future through polygeneration (linking multiple types of plants into one, such as co-production of liquid fuels, electricity, hydrogen, etc., embodied in FutureGen initiative).
- Provides geographic diversity of domestic refining capacity.

These plants are very capital intensive and the economics of financing depend upon the spread between the price of coal and the downstream products. Volatility in energy prices, coupled with the projected 30 year financing required for plant construction and operation have restricted the commercial development of CTL plants in the United States. EIA estimates coal-to-liquids production in 2010 as zero but their forecast has coal to liquids increasing to 38 million short tons by 2025.[24]

One exception has been the Adams Fork Energy Plant developed by TransGas Development Systems LLC in Mingo County, West Virginia.[25] This plant is projected to cost $4 billion and would convert 7,500 tons of coal per day to 18,000 barrels of gasoline and 300 barrels of liquidized petroleum gas or propane. The plant has been issued air permits by the West Virginia Department of Environmental Protection and started site preparation work. The developers expect to begin major construction in the first quarter 2013.

A recent study in 2009 identified opportunities for long-term geologic storage of CO_2 associated with the generation of coal to liquids at a plant within West Virginia. [26] This study identified the large amount of CO_2 storage available within West Virginia's oil and gas fields, deep coal seams and saline aquifers. Enhanced oil or natural gas recovery through CO_2 injections are business opportunities that should be studied. The U.S. Department of energy is now focused on enhanced oil recovery through CO_2 as opposed to CO_2 storage.

[23] National Mining Association, "*Liquid Fuels from U.S. Coal*." http://www.nma.org/pdf/liquid_coal_fuels_100505.pdf (accessed 7/30/2012, 2012).

[24] "EIA - Annual Energy Outlook 2012." http://www.eia.gov/forecasts/aeo/ (accessed 7/25/2012, 2012).

[25] Pam Kasey, "TransGas Coal-to-Liquids Plant Construction Expected Q1 2013," The State Journal, http://www.statejournal.com/story/18768936/transgas-coal-to-liquids-plant-construction-expected-q1-2013 (accessed 7/30/2012, 2012).

[26] Timothy R. Carr, Evan Fedorko and Frank LaFone, West Virginia Carbon Capture and Storage Opportunities Associated with Potential Locations for Coal-to-Liquid Facilities (Morgantown, WV: West Virginia Carbon Sequestration,[2009]).

3.6 Key observations

- Coal has been and will continue to be a major contributor to the West Virginia economy, both in terms of jobs, incomes, tax revenues, and gross state product. Coal will remain very important to West Virginia.
- The national and state outlook for coal, however, calls for declines in West Virginia coal production and demand, particularly as it relates to thermal coal. As will be discussed in a later section, low natural gas prices are eroding coal's role in electric power generation.
- Metallurgical coal exports in international markets will continue to be an important, and possibly growing part of the coal industry.
- Opportunities for coal to liquids industrial development should continue but will be dependent upon the spread between coal and the resulting product produced as well as the availability of long-term financing for the significant capital investments required for these products.
- New markets for coal through waste coal development, coal bed methane, and coal to liquids need to be encouraged.
- CO_2 storage should be considered as a new business opportunity, particularly as it relates to enhanced oil and natural gas production.
- National environmental policy will play a critical role in the selection of coal versus other fuel sources for the electric generation industry.

4 Natural Gas and Oil

Oil and natural gas were discovered in West Virginia long before anyone recognized their value or potential. Reports of "burning spring" outflows on the Little Kanawha, Kanawha, and Big Sandy rivers date back to the time of the early settlers. Harvesting of West Virginia's oil and gas reserves was not thought of until the early 1800s when drilling for salt began in the area. Miners first accidentally struck gas in a salt well in Charleston in 1815. As more and more oil and gas was discovered by salt miners, the Greater Kanawha Valley region became a pioneer of oil discovery, on both the drilling and commercial sale fronts.[27]

Burning Springs, WV, was the site of the first well drilled specifically for oil extraction in West Virginia. In 1859, the Rathbone brothers, originally salt miners from Parkersburg, WV, drilled an oil well that produced 200 barrels of oil per day. Shortly thereafter, the brothers developed a second well that produced 1,200 barrels per day. By 1961, a town had sprung up in the area and was lit entirely by natural gas. This technology spread to other areas of the state and beyond. This marked the beginning of natural gas development in West Virginia. The oil produced in the Burning Springs oil field was shipped by river into Parkersburg. From there, the oil was moved by rail or river to other cities, causing Parkersburg to grow into a chief oil shipping hub.[28]

While Burning Springs was only one of two oil fields in the nation before the Civil War, by 1876 there were 292 wells in West Virginia alone, producing roughly 900 barrels per day. Another notable oil field, known as Volcano, was discovered in 1860 and was very active between 1865 and 1870. It was here that the "endless wire" method of pumping oil was invented in 1874. This method allowed one motor to extract oil from up to 40 wells at a time. Volcano was also the site of West Virginia's first oil pipeline in 1879, which ran from the Volcano oil field to Parkersburg, WV.[29]

Oil production decreased in West Virginia between 1879 and 1889. Oil seekers were unable to dig deeper wells because the soft rock they encountered after a certain depth would crumble into the well and prevent further extraction. In 1889, iron pipes were introduced and allowed deeper drilling by preventing well cave-ins. Deeper drilling allowed the discovery of deeper oil reserves, and thus the oil fields of Doll's Run, Eureka, Mannington, and Sistersville came into play.[30] West Virginia's oil industry reached its peak production level in 1900 at 16 million barrels in one year. Thereafter, the decline in oil production was met by an increase in natural gas development.

4.1 Natural gas industry overview[31]

Natural gas is a colorless, odorless, and tasteless gas used to produce electricity, steel, glass, paper, clothing, and a variety of other products.[32] In the United States, more than half of the homes use natural

[27] WV Geological and Economic Survey, "History of West Virginia Oil and Gas Industry," (2012).
[28] Ibid.
[29] Ibid.
[30] Ibid.
[31] This section is abbreviated from a larger BBER report.(Higginbotham and others 2010, 56)
[32] Natural gas consists of hydrocarbon gases including methane, ethane, propane, butane, carbon dioxide, oxygen, nitrogen, hydrogen sulphide and rare gases.

gas as their main heating fuel. The nation's major sectors responsible for natural gas consumption in 2011 included:[33]

- Electric power sector at 7.6 trillion cubic feet[34] (Tcf) or 34% of US consumption
- Industrial sector at 6.7 Tcf or 30% of US consumption
- Residential sector at 4.7 Tcf or 21% of US consumption
- Commercial sector at 3.1 Tcf or 14% of US consumption

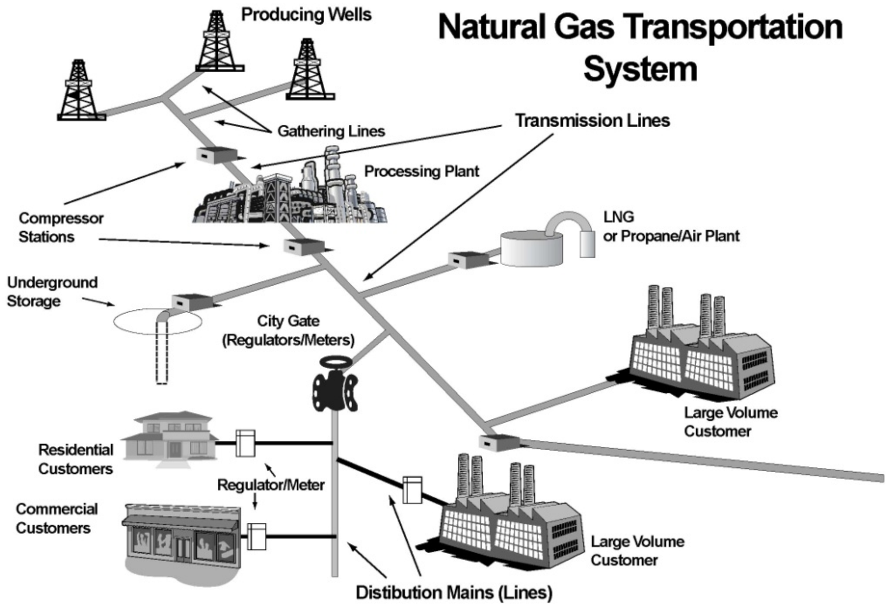
The remaining US consumers of natural gas in 2011 included oil and gas industry operations, vehicle fuel, and pipeline and distribution use.

The process of finding, developing, and preparing natural gas for consumption is quite extensive, expensive and complex. Seismic surveys use echoes to determine the location of natural gas on land and off-shore. Once an area has been deemed promising from a geological perspective, the drilling process begins. As natural gas is found within the deposits of rock formations through the drilling process, it is transported by pipelines to the ultimate consumer.

Transporting natural gas and making it viable for consumers involves many steps (Figure 13). Raw natural gas is gathered in low pressure pipelines and moved from the wellhead to a processing plant or the interconnection with a larger mainline pipeline. Natural gas liquids and impurities, such as liquid hydrocarbons and non-hydrocarbon gases, are separated from the natural gas stream near the site of the well or at processing plants. Natural gas is then transported from the producing area to market areas through wide-diameter, high-pressure interstate and intrastate pipelines. Compressor stations are strategically located throughout the transmission pipeline system to keep the natural gas flowing forward. In low demand times during the year, natural gas is stored in facilities created from depleted oil, natural gas, or aquifer reservoirs or salt caverns. When demand for natural gas increases, such as in the winter months, stored natural gas is delivered back into the mainline pipeline system. Distribution companies take natural gas from the high-pressure mainline system, reduce the pressure to levels suitable for residential and commercial use, and transport it through smaller pipelines called mains. Natural gas is then directly routed to homes and industrial facilities through very small pipelines called services.

[33] US Energy Information Administration, "US Natural Gas Consumption by End Use," (2012).
[34] A trillion cubic feet (Tcf) is one billion Mcf (1,000 cubic feet) and is enough natural gas to heat 15 million homes for one year, generate 100 billion kilowatt hours of electricity or fuel 12 million natural gas-fired vehicles for one year.

Figure 13: The natural gas industry process



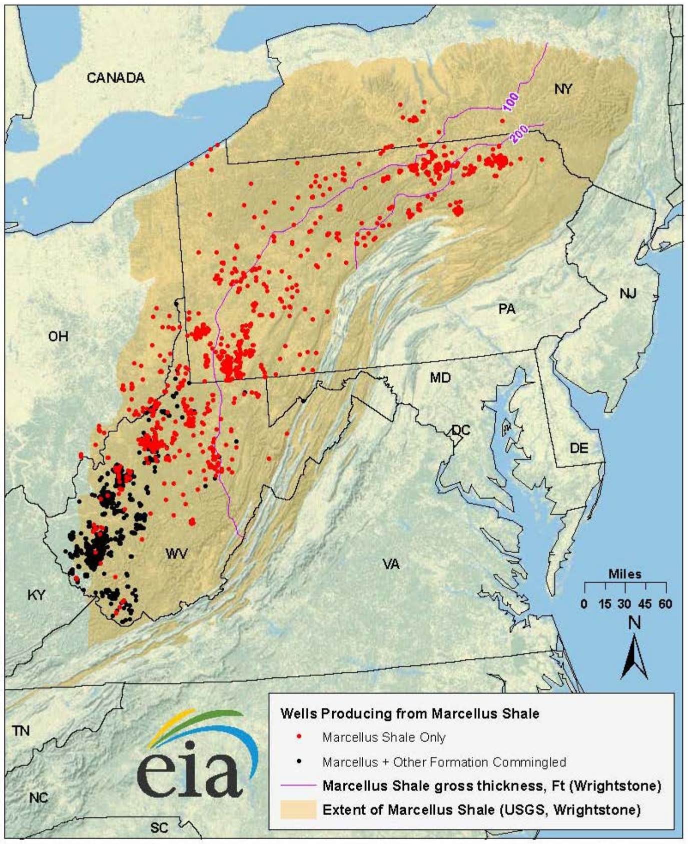
Source: Chesapeake Energy

4.2 The Marcellus Shale changed West Virginia's natural gas industry

Marcellus Shale production of natural gas has become a very important contributor to West Virginia's energy future. As Figure 14 shows, Marcellus Shale can be found beneath the vast majority of the state's territory. Marcellus Shale reserves intermingle with other types of formations such as Utica and Devonian shales.[35]

[35] US Energy Information Administration, *Marcellus Shale Play, Appalachian Basin*US Energy Information Administration, 2011).

Figure 14: Marcellus Shale gas play, Appalachian Basin

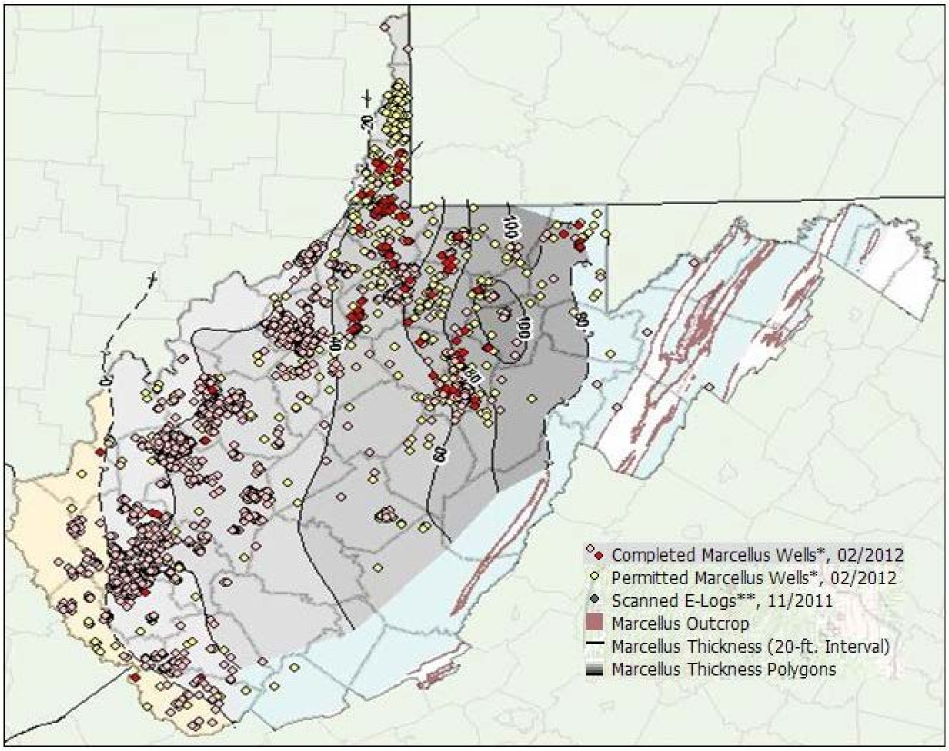


Source: US Energy Information Administration based on data from WVGES, PA DCNR, OH DGS, NY DEC, VA DMME, USGS, Wrightstone (2009). Only wells completed after 1-1-2003 are shown. Updated June 1, 2011

Figure 15 displays completed and permitted Marcellus wells as of February 2012, as well as the thickness of the Marcellus shale across the state. At the time this map was downloaded from the West Virginia Geological and Economic Survey (WVGES) website, the agency was receiving reports of new Marcellus Shale well discoveries. WVGES suspects that the limits of the Marcellus shale thicknesses drawn in this map are conservative depictions. More accurate information will become available as the claims are investigated.[36]

[36] WV Geological and Economic Survey, *Geology of the Marcellus Shale*West Virginia Geological and Economic Survey, 2012).

Figure 15: Marcellus Shale thickness and wells in West Virginia, February 2012



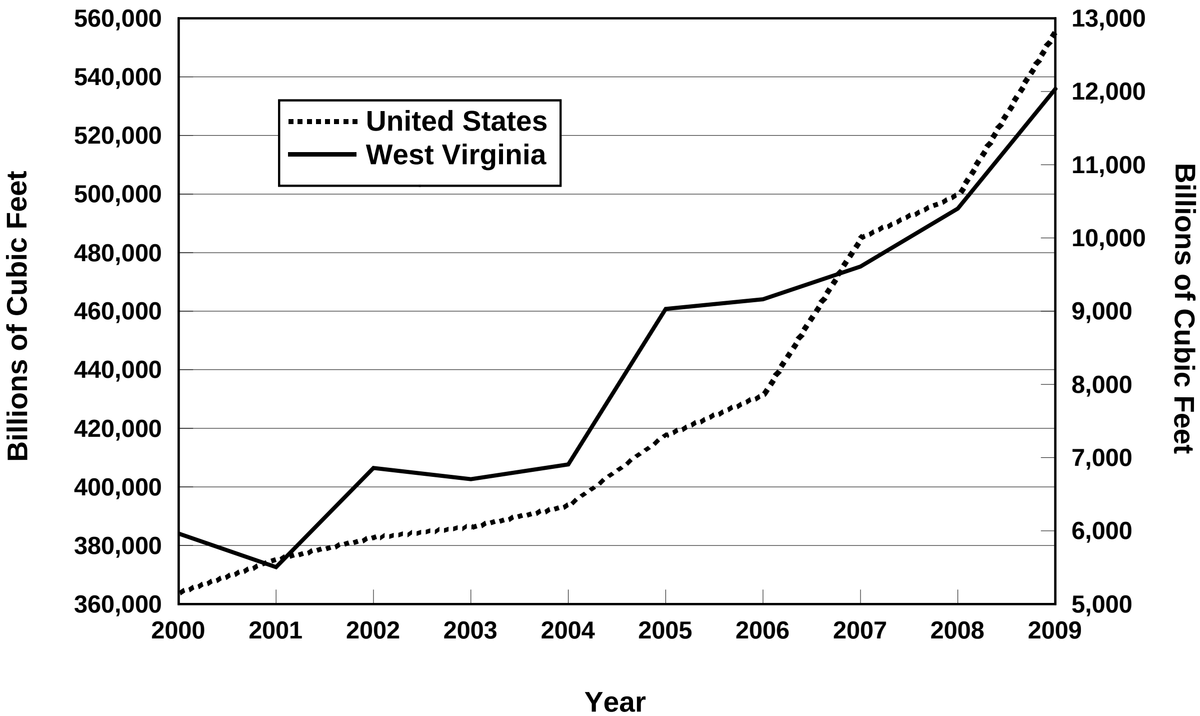
Source: West Virginia Geological and Economic Survey, Marcellus Shale Mapping System

4.3 Natural gas reserves

The proved natural gas reserves trends from 2000 to 2009 for the United States and West Virginia are shown in Figure 16. Proved reserves in West Virginia tended to be more volatile over the time-period than those of the nation. The state experienced several sharp increases and decreases between 2000 and 2005, whereas the nation experienced a steadier increase at an increasing rate. West Virginia's proved natural gas reserves were lowest in 2001, at 5,503 billion cubic feet, but by 2009 had increased to 12,036 billion cubic feet (Bcf). National growth in reserves between 2000 and 2009 amounted to 192,451 Bcf.[37]

[37] US Energy Information Administration, "Natural Gas Reserves Summary as of Dec. 31," (2012).

Figure 16: Proved natural gas reserves, 2000-2009



Source: US Energy Information Administration

Table 13 divides US and West Virginia natural gas reserves by type and also shows West Virginia's share of the national figure. Dry gas is defined as the gas remaining after lease, field, and/or plant separation; it is also known as consumer-grade natural gas. Wet gas is a combination of hydrocarbon compounds and small quantities of non-hydrocarbons in a gas form or in a solution with crude oil. West Virginia's portion of the nation's dry natural gas reserves has increased significantly since 2000, growing from 1.63 percent of US reserves to 2.18 percent in 2009. The state's share of national wet gas reserves has also increased, though incrementally less than dry gas shares, moving from 1.64 percent in 2000 to 2.15 percent in 2009. Overall, between 2000 and 2009, West Virginia's share of national natural gas reserves increased by 0.52 percentage points.[38,39]

[38] Ibid.
[39] Percentage calculations in this paragraph are the work of the author, not the US EIA.

Table 13: Proved natural gas reserves by type, 2000-2009

Proved Reserves, Billion Cubic Feet	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
US Dry Natural Gas	177,427	183,460	186,946	189,044	192,513	204,385	211,085	237,726	244,656	272,509
West Virginia Dry Natural Gas	2,900	2,678	3,360	3,306	3,397	4,459	4,509	4,729	5,136	5,946
WV % Share Dry NG	1.63	1.46	1.80	1.75	1.76	2.18	2.14	1.99	2.10	2.18
US Wet Natural Gas	186,510	191,743	195,561	197,145	201,200	213,308	220,416	247,789	255,035	283,879
West Virginia Wet Natural Gas	3,062	2,825	3,498	3,399	3,509	4,572	4,654	4,881	5,266	6,090
WV % Share Wet NG	1.64	1.47	1.79	1.72	1.74	2.14	2.11	1.97	2.06	2.15
US Total NG Proved Reserves	363,937	375,203	382,507	386,189	393,713	417,693	431,501	485,515	499,691	556,388
WV Total NG Proved Reserves	5,962	5,503	6,858	6,705	6,906	9,031	9,163	9,610	10,402	12,036
WV % Share Total NG	1.64	1.47	1.79	1.74	1.75	2.16	2.12	1.98	2.08	2.16
Proved Reserves, Million Barrels										
US Natural Gas Plant Liquids	8,345	7,993	7,994	7,459	7,928	8,165	8,472	9,143	9,275	(N/A)
West Virginia Natural Gas Plant Liquids	105	106	99	68	85	85	110	115	100	(N/A)
WV % Share NG Plant Liquids	1.26	1.33	1.24	0.91	1.07	1.04	1.30	1.26	1.08	(N/A)

Note: Percentages are the calculations of the author, not the US EIA.

Source: US Energy Information Administration, “Natural Gas Reserves Summary as of Dec.31.”

4.4 West Virginia natural gas production and prices

Between 1906 and 1917, West Virginia was the nation’s leading producer of gas, but the industry saw a decline in production until 1934. After that period of decelerated production, the West Virginia natural gas industry resumed its positive growth until 1970.[40] Production declined until 1983, reaching a low of 130,000 million cubic feet (MMcf), but has been rising slowly since then, with especially high production in 2000, with over 264,000 MMcf .

West Virginia production was only 1,000 MMcf greater in 2010 than it was in 2000 (Table 14). Production declined from 2000 to 2003, but began rebounding in 2004, surpassing its 2000 levels in 2009. State production in 2010, the most recent available data, was 265,174 MMcf.[41]

Table 14 also offers a side-by-side comparison of natural gas proved reserves, production, and consumption in West Virginia from 2001 to 2011. Proved reserves significantly outweighed production in the state. In 2000, production was 4.4 percent of proved reserves, the highest it would be between that

[40] (WV Geological and Economic Survey 2004).
[41] US Energy Information Administration, "Natural GasWellhead and Marketed Production," (2012).

year and 2009. The following year this figure decreased to 3.5 percent and would continue to decline to its lowest point, 2.2 percent, in 2009. Production of natural gas in West Virginia exceeded consumption by between 179,148 MMcf and 258,555 MMcf over the ten-year period for which data was available for both measurements. Consumption reached 4.5 percent of production in 2002 and 2003, but that ratio decreased, reaching a low point of 2.4 percent in 2009, before rising to 2.5 percent the following year.[42,43]

Table 14: West Virginia natural gas production,consumption, and proved reserves, 2000-2011

Year	Proved Reserves (Bcf)	Production (MMcf)	Consumption (MMcf)
2000	5,962	264,139	(N/A)
2001	5,503	191,889	8,491
2002	6,858	190,249	8,575
2003	6,705	187,723	8,525
2004	6,906	197,217	8,185
2005	9,031	221,108	7,536
2006	9,163	225,530	7,125
2007	9,610	231,184	7,359
2008	10,402	244,880	7,040
2009	12,036	264,436	6,290
2010	(N/A)	265,174	6,619
2011	(N/A)	(N/A)	6,988

(N/A) Information not available. Source: US Energy Information Administration.

Table 15 shows natural gas marketed production in West Virginia and surrounding states: Kentucky, Maryland, Ohio, Pennsylvania, and Virginia. Through 2008, West Virginia produced the largest quantity of natural gas of the six states. Pennsylvania surpassed West Virginia in production during 2009 and 2010; however, West Virginia remained the second-largest producer of the six states.[44]

[42] US Energy Information Administration, "Natural Gas Data," (2012).
[43] Percentage calculations in this paragraph are the work of the author, not the US Energy Information Administration.
[44] US Energy Information Administration, *Natural GasWellhead and Marketed Production*

Table 15: Natural gas marketed production (MMcf) in select states, 2000-2010

Year	Kentucky	Maryland	Ohio	Pennsylvania	Virginia	West Virginia
2000	81,545	34	105,125	150,000	71,545	264,139
2001	81,723	32	100,107	130,853	71,543	191,889
2002	88,259	22	103,158	157,800	76,915	190,249
2003	87,608	48	93,641	159,827	143,644	187,723
2004	94,259	34	90,476	197,217	85,508	197,217
2005	92,795	46	83,523	168,501	88,610	221,108
2006	95,320	48	86,315	175,950	103,027	225,530
2007	95,437	35	88,095	182,277	112,057	231,184
2008	114,116	28	84,858	198,295	128,454	244,880
2009	113,300	43	88,824	273,869	140,738	264,436
2010	135,330	43	78,122	572,902	147,255	265,174

Source: US Energy Information Administration, “Natural Gas Wellhead Value and Marketed Production”.

Since 2000, citygate natural gas prices have varied notably in West Virginia and the United States. [45] Figure 17 shows citygate prices on a monthly basis. These prices peaked in the second half of 2008, reaching a level of $13.97 per thousand cubic feet in July of that year for West Virginia, which was slightly higher than the national price. Other peak state prices occurred in December 2001 ($10.14) and August to October 2005 ($13.49). Peak national prices were, on average, lower than West Virginia levels, at $8.91 in January 2001, $12.16 in October 2005, and $12.48 in July 2008. As of April 2012, state prices were as low as $4.60, which was higher than the national average. On average, citygate natural gas prices in West Virginia were higher than those of the nation between 2000 and 2012.[46]

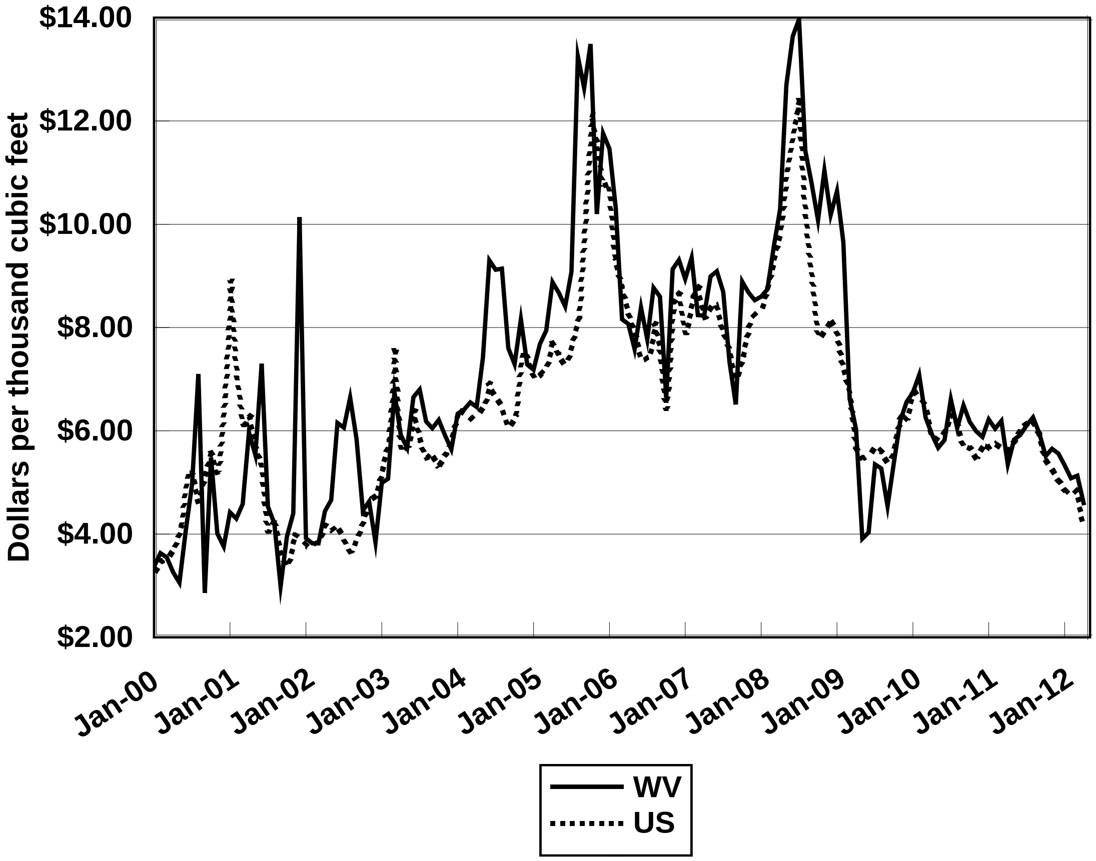
In general natural gas prices, whether citygate or Henry Hub, have historically shown a great deal of volatility. [47] Outside of the spot and futures price, individual midstream and pipeline companies may post prices representing premiums or discount to nationally traded contracts depending on the supply and demand situation within the regional market. The development of Marcellus natural gas production is beginning to affect the spread (difference) between Henry Hub and prices at the Columbia Appalachia (TCO Appalachia) trading point in southwest Pennsylvania.[48] The historic price difference between the TCO Appalachian and Henry Hub natural price was positive until June 2012 and then turned negative due to the significant increase in Marcellus gas production.

As the production increases in the Marcellus and Utica shales, the US natural gas market will change dramatically. Regional price differentials and levels, particularly in the US Northeast, will continue to decline. Natural gas imports will be reduced and as will be seen later, incentives will exist for increasing

[45] Citygate prices at determined at the point when a distributing gas utility receives gas from a natural gas pipeline or transmission system.
[46] US Energy Information Administration, "Natural Gas Prices," (2012).
[47] Henry Hub natural gas prices reflect the spot and futures prices of natural gas as traded on the CME NYMEX futures exchange. In addition, Nymex also has a New York City gate spot price and other natural gas contracts along with crude oil and refined petroleum products. Each contract traded as a reference point for the physical exchange of the commodity detailed in the contract.
[48] US Energy Information Administration, "Spot Natural Gas Prices at Marcellus Trading Point Reflect Pipeline Constraints - Today in Energy -," (2012).

LNG exports to overseas markets, particularly in Japan. This will occur through additional installation of natural gas processing and pipeline capacity.[49]

Figure 17: Monthly citygate natural gas prices, Jan 2000-April 2012



Source: US Energy Information Administration

The EIA Annual Energy Outlook provides forecasts of natural gas prices to 2035. Figure 18 shows its forecast of natural gas prices at the wellhead (nominal dollars per Mcf) through 2035. Figure 19 converts these prices to 2010 dollars. In both cases the long term forecast shows an upward trend in prices from current levels.

[49] Ibid.

Figure 18: Natural gas at the wellhead forecast prices (nominal dollars per Mcf), 2009-2035

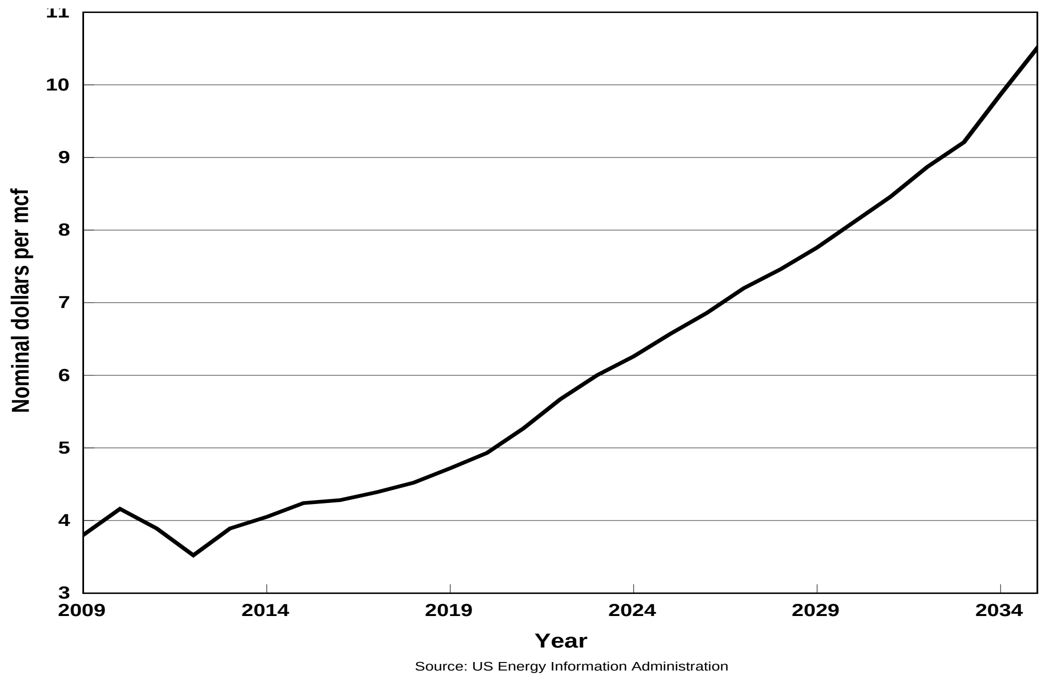
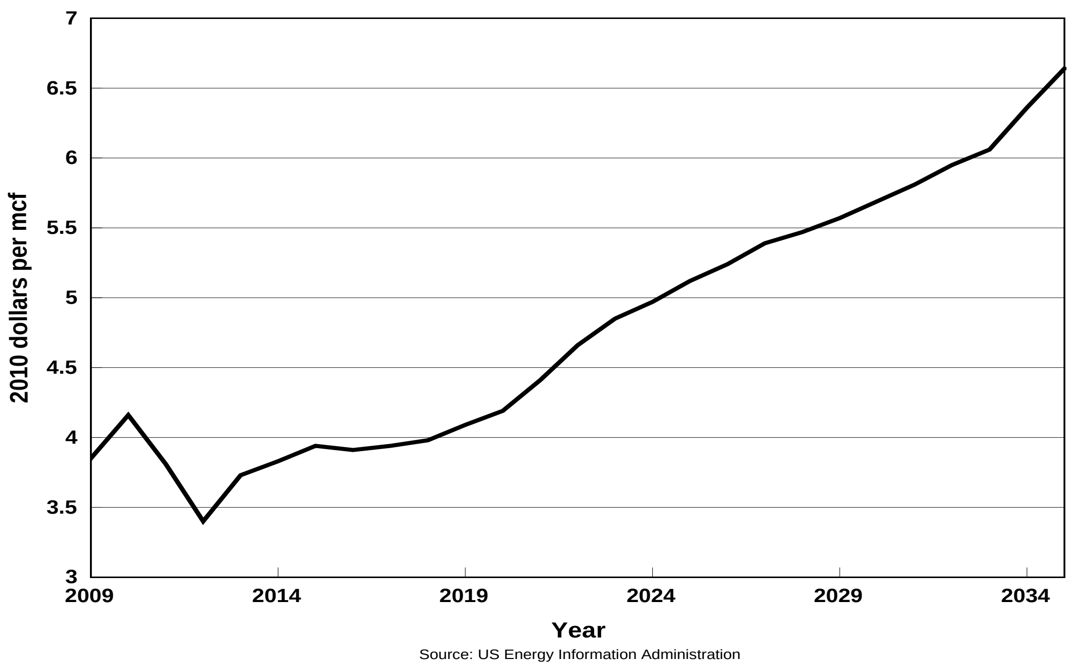


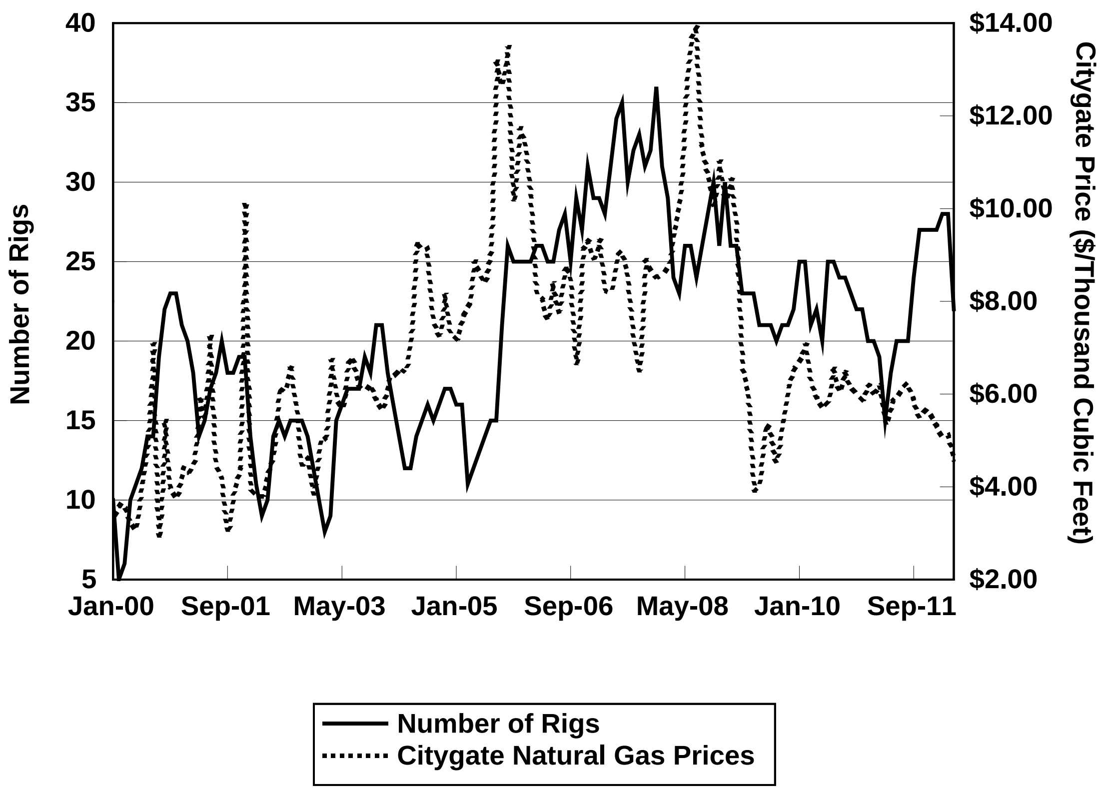
Figure 19: Natural gas at the wellhead forecast prices (2010 dollars per Mcf), 2009-2035



4.5 West Virginia drilling rigs

Figure 20 maps the number of natural gas rigs in West Virginia against the state citygate natural gas prices from 2000 to 2012. The state had the least amount of rigs in February 2000 with only 5 rigs. This coincided with some of the lowest prices for natural gas over the twelve-year period. Rig counts increased after the early months of 2000, but began to fall again after December of that year. The number of rigs and citygate natural gas prices fluctuated dramatically—though not in alignment with one another—over the time frame, with rig counts increasing significantly in mid-2005 and peaking at 36 rigs in December 2007. A downward trend in natural gas rigs and prices began thereafter, reaching a low point in April 2011, before rebounding to 25 rigs in June 2012 despite a falling trend in prices.[50]

Figure 20: Number of rigs and citygate natural gas prices in West Virginia, 2000-2012



Source: Baker Hughes and US Energy Information Administration

4.6 West Virginia natural gas employment trends

Natural gas industries provide many employment opportunities for West Virginian. Table 16 and Figure 21 show state employment in seven different NAICS-defined natural gas-related activities between 2001 and 2011. Though it provided fewer than 1,300 jobs in 2001, support activities for oil and gas operations employed the most individuals of the listed industries after 2007, and had 3,765 employees as of 2011. Oil and gas extraction employed nearly 2,200 people by 2011, followed by oil and gas pipeline and related structures construction with 1,918 employees. Employment in the pipeline transportation of natural gas and natural gas distribution industries experienced overall decreases during the 11-year period.

[50] Baker Hughes, "Rigs by State - Current & Historical," (2012).

Employment in oil and gas field machinery and equipment manufacturing has consistently supplied the least amount of employment of the seven sub-industries, though data is not available after 2009. Workforce West Virginia also had a limited amount of data for drilling oil and gas wells employment.[51]

Excluded from this data are the various ancillary jobs that have been generated from the growth in the natural gas industry associated with the development of the Marcellus shale within West Virginia during the past decade and continuing to the present. For example, the total jobs created (direct, indirect and induced) in 2009 was estimated at 7,600.[52]

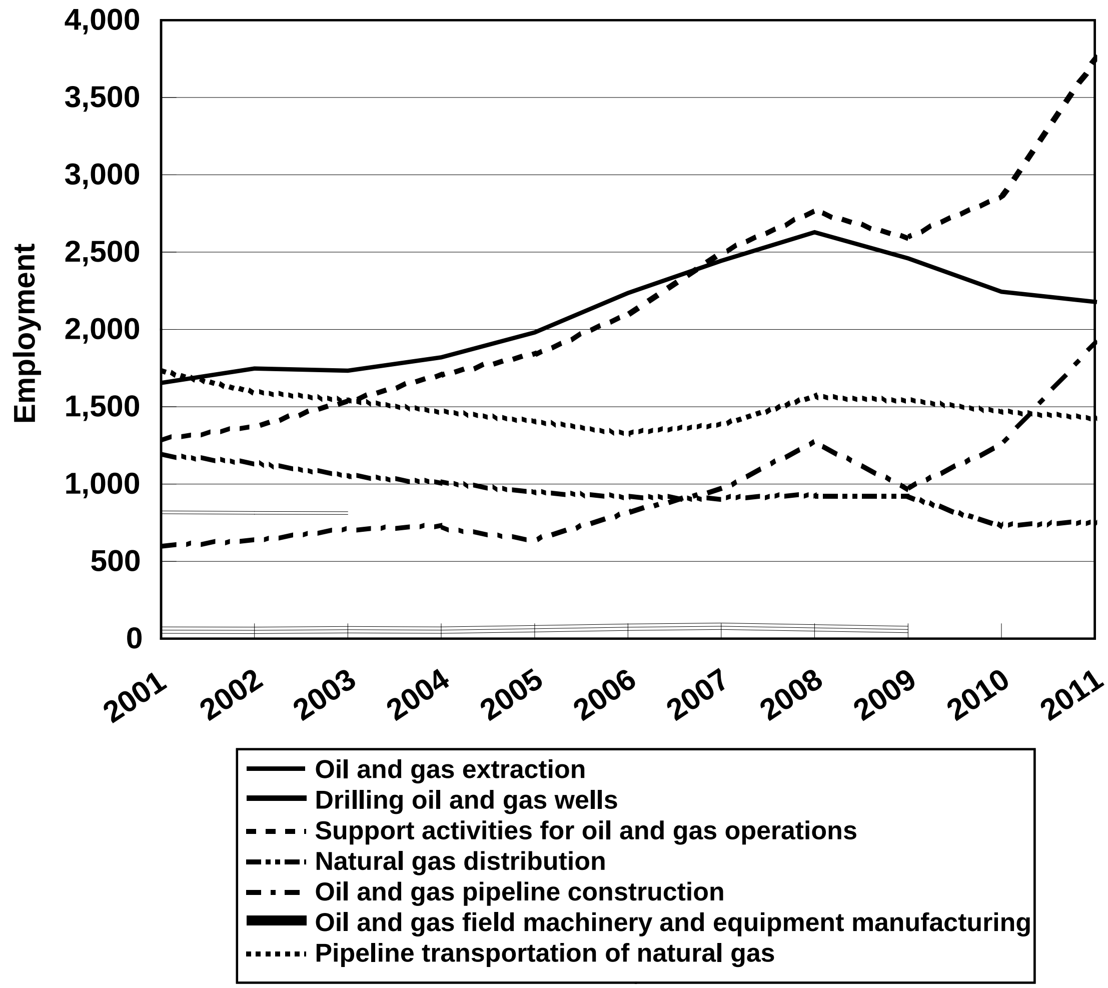
Table 16: West Virginia employment by NAICS industry, 2001-2011

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Oil and gas extraction	1,654	1,747	1,733	1,819	1,980	2,236	2,444	2,629	2,460	2,244	2,179
Drilling oil and gas wells	821	818	816	(N/D)	(N/D)	(N/D)	(N/D)	(N/D)	(N/D)	(N/D)	(N/D)
Support activities for oil and gas operations	1,289	1,370	1,540	1,705	1,841	2,099	2,496	2,773	2,608	2,865	3,765
Natural gas distribution	1,198	1,140	1,059	1,023	961	928	917	923	926	737	751
Oil and gas pipeline construction	601	638	711	727	640	826	965	1,276	983	1,257	1,918
Oil and gas field machinery and equipment manufacturing	60	59	63	60	69	79	85	(N/D)	64	(N/D)	(N/D)
Pipeline transportation of natural gas	1,738	1,600	1,549	1,483	1,419	1,334	1,387	1,571	1,551	1,473	1,437

(N/D) Non-disclosure. Source: Workforce West Virginia.

[51] Workforce West Virginia, "Wage Data," (2012).
[52] Amy Higginbotham et al., *The Economic Impact of the Natural Gas Industry and the Marcellus Shale Development in West Virginia in 2009*Bureau of Business and Economic Research, West Virginia University, 2010), 56.

Figure 21: West Virginia employment by industry, 2001-2011



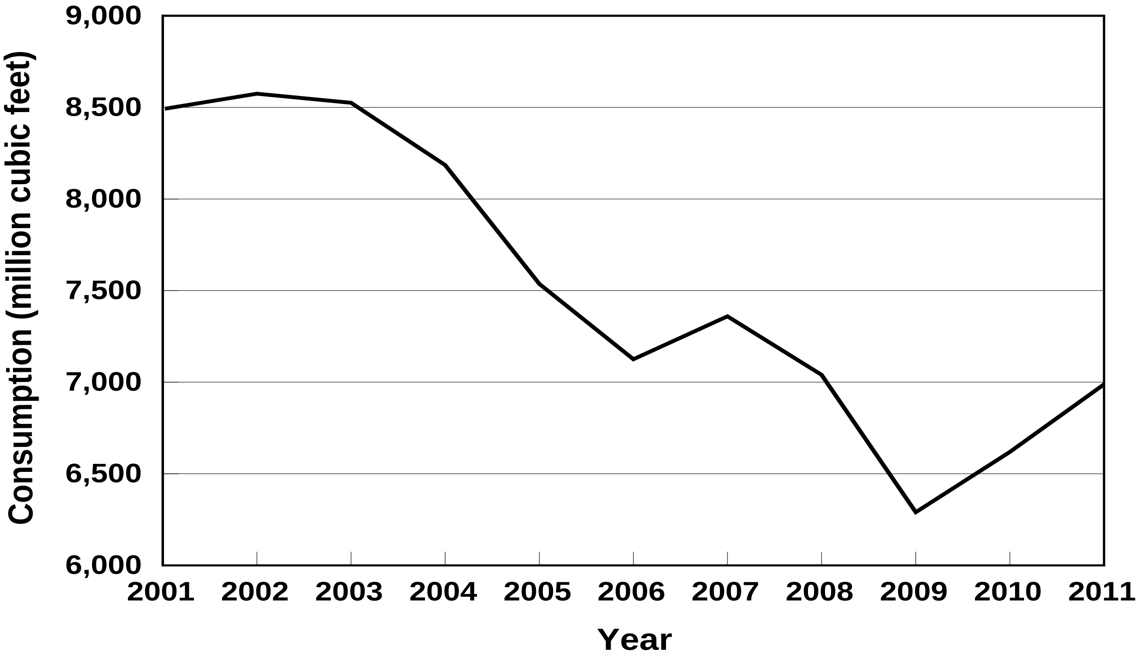
Source: Workforce West Virginia

4.7 Consumption and value added opportunities associated with natural gas

Consumption of natural gas in West Virginia experienced an overall decline between 2001 and 2011, as shown in Figure 22. In 2001, state natural gas consumption was recorded at just less than 8,500 MMcf and peaked the following year at 8,575 MMcf. Over the next four years, consumption decreased to 7,125 MMcf in 2006. Despite an increase in 2007, consumption continued to fall at an increasing rate, reaching a low point of 6,290 MMcf annually in 2009. Since then, consumption has been increasing, and was 6,988 MMcf in 2011, the most recent year data was available.[53]

[53] US Energy Information Administration, "Natural Gas Delivered to Consumption in West Virginia (Including Vehicle Fuel)," (2012).

Figure 22: West Virginia annual natural gas consumption, 2001-2011



Source: US Energy Information Administration

4.7.1 Natural gas as a transportation fuel

As oil prices rise along with environmental concerns, the need for an alternate fuel vehicle becomes more pressing. One of the best options available to meet the country's growing demand for a substitute for gasoline and diesel is natural gas vehicles (NGVs). NGVs can be light-duty (sedans, vans, and small trucks), medium-duty (large passenger vehicles such as buses, shuttle vans, and large trucks), or heavy-duty (large freight-hauling vehicles), though the technology is currently most commonly used for large fleet vehicles that travel long distances.

These vehicles run on either compressed natural gas (CNG) or liquefied natural gas (LNG). Light-duty NGVs use CNG, which requires more storage space than gasoline, so these vehicles tend to have smaller trunk spaces and need to refuel more often than their gasoline or diesel-fueled counterparts. Medium- and heavy-duty vehicles can run off either type of natural gas fuel, but LNG requires less space than CNG and therefore supports longer travel distances. CNG is less expensive to produce and store than LNG because the liquefied form must be cooled and stored in cryogenic tanks.[54] It is anticipated that most fueling stations that come to the area will supply CNG.

In addition to vehicles that run solely on natural gas, known as "dedicated" vehicles, some systems are able to run on natural gas or gasoline. These vehicles are called "dual-fuel" or "bi-fuel" systems. Rather than buying a new dedicated NGV, there is also the option of converting an existing vehicle to run on natural gas by retrofitting equipment that will allow the vehicle to process the different fuel. CNG can be used in certain vehicles that have been converted to run on both natural gas and gasoline. The national organization Natural Gas Vehicles for America (NGVA) asserts that the conversion of a light-duty

[54] Christopher R. Knittel, *Leveling the Playing Field for Natural Gas in Transportation*,[2012].

vehicle would cost between $12,000 and $18,000, depending on the amount of fuel capacity requested by the customer. Approved conversion kits for heavy-duty vehicles (over 14,000 lbs.) are scarce, though as there is growing interest in that market more systems may be expected in the future.[55]

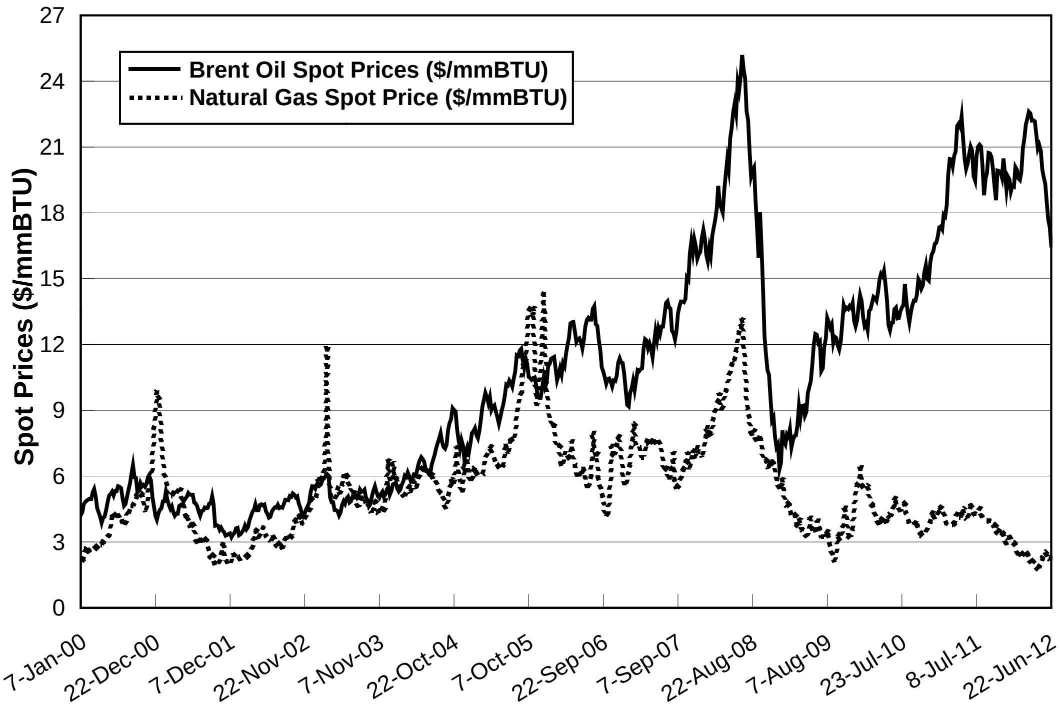
The Honda Civic GX is currently the only passenger NGV in the US market, according to NGVA, and is significantly more expensive in purchase price and maintenance than its hybrid or original counterparts. The demand for light-duty NGVs is not growing very quickly, and due to economies of scale, vehicle production costs will not decrease until more units are sold. On the other hand, General Motors, Ford, and Chrysler have said they will build several thousand medium-duty pickup trucks and vans this year that will run on bi-fuel systems to meet the growing demand for NGVs in the natural gas exploration and production industries. [56]

While there are roughly 12 million natural gas vehicles in operation around the world, only 110,000 to 120,000 of them are found in the United States. Between 25,000 and 30,000 of these are light-duty vehicles used as government or private fleets, while medium-duty vehicles, primarily shuttle vans and work trucks, make up around 20,000 of this number.[57] As of 2010, fewer than 40,000 heavy-duty NGVs were on US roads—that accounted for only 0.4 percent of all heavy-duty vehicles in the nation. Less than 1,000 heavy-duty NGVs were sold in 2010, and natural gas represented only 0.3 percent of fuel consumed by heavy-duty vehicles.[58]

The reasons for increasing NGV usage are many. With the recent discoveries of large domestic natural gas reserves (see Table 13), the United States could decrease its dependence on foreign oil and thereby reduce the trade deficit and US economic vulnerability to oil shocks. In addition, as oil prices rise, natural gas is remaining relatively inexpensive—in fact at the end of 2011, oil was trading at a premium five times higher than natural gas (see Figure 23). From an environmental perspective, using natural gas instead of other fossil fuels reduces emissions of greenhouse gases (GHGs) and health problems associated with them. While natural gas also bears fewer negative externalities than gasoline usage, petroleum fueling is the status quo and the market will require policy interference if it is to reach an efficient balance between the two fuels.[59]

[55] Natural Gas Vehicles for America, *Fact Sheet: Converting Light-Duty Vehicles to Natural Gas* (Washington, D.C.: Natural Gas Vehicles for America, 2011).
[56] Tom Fowler, "America, Start Your Natural Gas-Engines," (2012)
[57] Stephen Yborra, "The Compelling Case for Natural Gas Vehicles (NGV)" Feb. 16, 2012, 2012).
[58] US Energy Information Administration, *Annual Energy Outlook 2012*
[59] Knittel, *Leveling the Playing Field for Natural Gas in Transportation*

Figure 23: Weekly oil and natural gas spot prices, 2000-2012 ($/MMBtu) [60]



Source: US Energy Information Administration

The private benefits of switching from a gasoline-powered vehicle to an NGV must also be taken into consideration. When comparing the Honda Civic CNG and gasoline models, the vehicles' combined city and highway fuel economies are equal at 31 mpg, and though the CNG model stores significantly less fuel, it produces 18 percent fewer CO_2 emissions. Also, due to the low price of natural gas compared to gasoline, savings on fuel outweigh the extra cost of an NGV. The lifetime savings from purchasing a NGV rather than a traditional gasoline vehicle are estimated to be about $2,000 in the case of a 30 mpg sedan and over $116,800 for a 5 mpg heavy-duty truck.[61]

One of the obstacles to widespread light-duty NGV use is the high cost of production, and therefore the high sales price. A CNG-fueled vehicle costs so much more than its gasoline-fueled predecessor that it can take over nine years for the car to pay for itself through fuel savings. However, many companies are currently working on design changes that will lower production costs and entice more buyers. Some of these design changes include making lighter, higher-capacity fuel tanks made from alternative materials.[62]

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[60] One may note that midway through October 2005, oil prices exceed natural gas prices per unit of energy. This trend continues without exception through June 2012. The natural gas spot price data for this figure were collected directly from the US EIA in dollars per million British thermal units ($/mmBTU) form. The Brent oil spot price data was gathered from the EIA in $/barrel form and converted to $/mmBTU by the authors. For a ratio of oil and natural gas prices per unit of energy, please see Figure 1 in (Knittel 2012).

[61] For a more in depth cost-benefit analysis of buying an NGV rather than a conventional gasoline vehicle, see Table 2 in (Knittel 2012).

[62] (Fowler 2012).

Natural gas vehicles require a fueling infrastructure to service the vehicles. When it comes to fueling NGVs, there are several different options for fill-up stations. Some stations can be used by members of the public with personal vehicles, while others are restricted to private fleet-use only. Some private stations allow public users to fill-up at their pumps, but of the 1,100 natural gas stations in the nation, over half are used only by fleet vehicles and are not open to the public. Furthermore, many of these stations are located in one state: California. Compared to the 157,000 public gasoline stations in the United States (2010), NGV fueling stations are very scarce.[63]

Natural gas fueling stations may also carry either CNG or LNG. CNG stations have either fast-fill technology or time-fill technology. The fast-fill option is typical of retail stations that attract light-duty vehicles that need to fill-up often. Because the fuel is provided as a gas and not a liquid, a significant amount of new infrastructure would need to be added to retrieve the natural gas from a local utility line, compress it and store it so that it will transfer to the vehicle quickly, and finally dispense it into the vehicle. The equipment needed for each fueling "pump" would be about the size of a regular parking space. Time-fill CNG stations are primarily used by fleets that have a central refueling station and time available to fill their large tanks overnight, or by private drivers with a home fueling station. The CNG at these stations is delivered at a lower pressure, so though it takes more time to fill-up the fuel is pumped directly from the compressor, eliminating the extra storage space required at fast-fill stations.[64]

LNG stations can be mobile, containerized, or customized. The mobile stations are carried by a tanker truck with metering and dispensing capabilities. Containerized stations, also known as starter stations, include a storage tank and dispensing, metering, and containment equipment. Custom LNG fueling stations have larger storage capacities that are suited to a fleet's needs. Because the natural gas at an LNG station is a liquid, the fueling infrastructure is much like that of gasoline or diesel. However, protective clothing is required while fueling due to the dangerously cold nature of the liquid form.[65]

Installing CNG capacity to an existing gas station can cost around $500,000, if the original station has access to natural gas pipelines. Despite high costs new CNG fueling stations are beginning to emerge. Love's Travel Stops & Country Stores, a company from Oklahoma City, has partnered with Chesapeake Energy and will open 10 new retail outlets with CNG pumps during the summer months of 2012. This spring, another company, Kwik Trip Inc., also opened its first of several CNG fueling stations aimed at personal NGV divers in La Crosse, WI.[66]

In-home fueling stations are available for private NGV owners that require only close proximity to an electrical outlet and access to a natural gas line. These systems take about six hours to fill a tank and cost around $4,000 before installation charges. In an effort to make in-home fill-stations more attractive, Atlanta Gas Light Company is offering to install the system for free when a customer agrees to a five-year lease of the equipment at $60 per month.[67]

[63] (US Energy Information Administration 2012b; US Energy Information Administration 2012d).
[64] US Alternative Fuels Data Center, "Compressed Natural Gas Fueling Stations," (2012).
[65] US Alternative Fuels Data Center, "Natural Gas Fueling Infrastructure Development," (2012).
[66] Fowler, *America, Start Your Natural Gas-Engines*
[67] Ibid.

While the upfront costs for fueling infrastructure can act as significant deterrents to potential investors, the federal government has created a number of grants, programs and other incentives that make pursuing natural gas transport options worthwhile:[68]

- Advanced Energy Research Project Grants
- Advanced Technology Vehicle (ATV) Manufacturing Incentives
- Alternative Fuel Tax Exemption
- Improved Energy Technology Loans

Federal legislation is also in place that affects alternative fuel vehicles and infrastructure development:

- Aftermarket Alternative Fuel Vehicle (AFV) Conversions
- Vehicle Acquisition and Fuel Use Requirements for Federal Fleets, Private and Local Government Fleets, and State and Alternative Fuel Provider Fleets
- Vehicle Fuel Economy and Greenhouse Gas Emissions Standards

An increasing number of federal programs are being set in place to encourage and inform about the possibilities for natural gas transportation in the United States:

- Air Pollution Control Program
- Alternative Transportation in Parks and Public Lands Program
- Clean Cities
- Clean Fuels Grant Program
- Congestion Mitigation and Air Quality (CMAQ) Improvement Program
- National Clean Diesel Campaign (NCDC)
- Transit Investments for Greenhouse Gas and Energy Reduction (TIGGER) Program
- Voluntary Airport Low Emission (VALE) Program

Existing incentives for natural gas vehicle (and NGV infrastructure) owners in West Virginia include the AFV Tax Credit and the Alternative Fuel Infrastructure Tax Credit. The AFV Tax Credit is available for up to $7,500 or $25,000—depending on the weight of the vehicle in question—and applies to a converted vehicle or a new original that runs on either a dedicated or bi-fuel system. This credit is due to sunset on December 31, 2021. The infrastructure tax credit, scheduled to sunset on the same day as the AFV credit, benefits “taxpayers who construct or purchase and install qualified alternative fueling infrastructure.” The credit is for up to $10,000 for a home fueling station and $250,000 for a private fueling station; but is available up to $312,500 if the station serves the public, granted that the tax credit does not exceed construction costs.[69]

In addition, any county in West Virginia that uses one or more school buses that run on CNG is entitled to reimbursement from the state Department of Education. This payment is ten percent of the costs of maintenance, operation, etc. of the CNG school bus.[70] Also, there is a Provision for Establishment of Alternative Fuel Vehicle (AFV) Acquisition Requirements, which states that the state “Department of Administration may require that up to 75 percent of a state agency’s fleet consist of AFVs.” This

[68] US Alternative Fuels Data Center, "Federal Incentives and Laws for Natural Gas," (2012).
[69] *Alternative-Fuel Motor Vehicles Tax Credit,* Public Law 11-6D, (2011): 1.
[70] *Public School Support, Foundation Allowance for Transportation Cost,* Public Law 18-9A-7, (2011b): .

provision can be waived if undertaking the process and maintaining such a fleet would be unreasonably expensive when compared to conventional vehicle or fuel use. It also excludes law enforcement, emergency, school buses, and several other distinctions of agency or vehicle class.[71]

Despite the above incentives for vehicle owners and infrastructure constructors, legislative measures exist in West Virginia that are harmful to further progress with the NGV industry. Currently, the Alternative Fuel Production Subsidy Prohibition prevents political subdivisions from offering incentives or subsidies to producers of alternate fuels, excepting some coal-based liquid fuels.[72]

Other states, however, are moving forward with plans to make CNG and LNG fueling stations more readily available by following a “hub and spoke” model that will ensure fueling infrastructure is in place on major transportation corridors. Texas has a plan to connect its major cities, while California, Nevada, Arizona, and Utah are working on an interstate web to connect six significant transportation hubs. Closer to home, Pennsylvania is developing a plan for a Clean Transportation Corridor that is intended to supply CNG and LNG on routes between Pittsburgh, Harrisburg, Scranton, and Philadelphia.[73]

On June 19, 2012, West Virginia Governor Earl Ray Tomblin signed an executive order that created a Natural Gas Vehicle Task Force. This task force—consisting of current members of the state government and civilian members with relevant industry experience, all appointed by the governor—will “assess the feasibility of transitioning the state’s vehicle fleet to natural gas as a fuel source and developing an infrastructure to support compressed natural gas vehicles,” according to a press release from the Office of the Governor. The task force’s research will include a cost analysis of converting gasoline- or diesel-fueled vehicles to run on natural gas, the potential for a state-operated system of public natural gas fueling station, and possible partnerships with industry producers, developers, and manufacturers that would lead to expansion of the fueling infrastructure and investment in natural gas fuel opportunities.[74] In July, the governor also announced that the 2013 Appalachian Basin NGV Expo & Conference will be held in Charleston, WV, in May.[75]

A discussion paper published by the Brookings Institute suggests a number of infrastructure-, vehicle-, and fuel-based policy changes or implementations that would promote the expansion of natural gas usage in transportation. The author proposes pricing CNG at marginal cost for the retailer; forming an industry consortium to ensure LNG fuel at reasonable prices along major interstate routes; set a date by which a certain percentage of all new vehicles must be dual-fuel systems; create subsidies for NGVs due to their low negative externalities; and also to make the retrofitting certification process less expensive and more widespread. The paper offers several other suggestions and a cost/benefit analysis of each of its proposals.[76]

Another alternative to gasoline and diesel is currently being explored: propane. Propane, or liquefied petroleum gas (LPG), has been used to power propane vehicles for decades, and is a clean-burning, high-

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[71] *Use of Alternative Fuels in State-Owned Vehicles*, Public Law 5A-2A, (2011c): .
[72] *Intergovernmental Relations, Prohibition of Subsidies Or Incentive Payments; and Eligible Investment for Industrialization Revitalization*, Public Law 8-27A-3 and 11-13S-3D, (2011a): .
[73] US Energy Information Administration, *Annual Energy Outlook 2012*
[74] Office of the Governor Earl Ray Tomblin, "Governor Tomblin Signs Executive Order Establishing the Natural Gas Vehicle Task Force," (2012).
[75] Office of the Governor Earl Ray Tomblin, "Governor Tomblin Announces Appalachian Basin Natural Gas Vehicle Expo & Conference," (2012).
[76] Knittel, *Leveling the Playing Field for Natural Gas in Transportation*

energy fuel that accounts for only a fraction of a percent of transportation fuel used today. While relatively inexpensive, propane has a lower energy by unit rating than gasoline or CNG—it takes more fuel to drive the same distance. There are currently about 270,000 propane vehicles in use in the nation. Many of these are fleet vehicles. Because propane burns cleanly, engine life in a propane vehicle is often double that of a similar gasoline-powered machine.[77]

The fueling infrastructure for propane is similar to that of gasoline and diesel, and because production, storage, and bulk distribution capabilities for the fuel are already widespread across the United States, only the individual dispensing equipment needs to be purchased or constructed in many places. The cost for the storage tank, pump, and dispenser combined can range between $37,000 and $175,000. Retailers with existing refill capabilities for small tanks (used for gas grills, mowers, etc.) can upgrade relatively easily to accommodate vehicle fueling. Propane fueling infrastructure and vehicle development often fall under the same federal and state legislation, programs, and incentives for alternate fuel vehicles as NGVs and natural gas fueling infrastructure.[78]

As oil supplies decline and prices rise, it is imperative to start looking at alternative fueling methods for transportation. Natural gas should be high on the list of options, due to the large domestic reserves recently discovered. There are many benefits to developing NGVs, whether they are private or public, economic or environmental. However, without fueling infrastructure, drivers are unlikely to purchase NGVs; without a consumer-base, retailers are unlikely to carry CNG or LNG. In order to encourage widespread use of NGVs and the accompanying infrastructure, policy changes must be enacted that will allow both sides of the industry (consumers and producers) to thrive with diminished risk of losing their investment.

4.7.2 Liquefied natural gas for export

While natural gas is being transported or stored throughout the US for consumers, it is also being liquefied to be stored and transported to other countries. Liquefied natural gas is natural gas that has been cooled to -260ºF. It is approximately 600 times smaller by volume than the gaseous form and can be loaded onto takers to be transported outside of the country. Liquefied natural gas, once transported, is returned to a gaseous form for use by residential, commercial, and industrial consumers at its ultimate destination.

Dominion received approval in July 2012 from the DOE for a license to use its Cove Point facility in Maryland to export LNG overseas and has begun the FERC Pre-filling Process. The projected in-service date for the Dominion Cove Point LNG terminal for export would be March 2017. Once operational, the use of Dominion’s pipelines will extend West Virginia natural gas supplies to an additional market.

4.7.3 Other value-added opportunities from natural gas

Natural gas at the well is categorized as either ‘dry’ or ‘wet’ depending upon the amount of other hydrocarbons present besides methane. The other hydrocarbons present include ethane, propane, and butane, among others. Most gas will need to be processed at a natural gas processing and fractionating plant prior to delivery to pipelines for transport to the ultimate consumers. With the Marcellus Shale development additional supplies of gas are being supplied to existing plants, necessitating the development of new natural gas processing and fractionation facilities.

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[77] US Alternative Fuels Data Center, "Propane," (2012).
[78] Ibid.

Dominion has announced a $500 million construction project along the Ohio River at Natrium, West Virginia, that can process upwards of 200 MMcf per day and fractionate 36,000 barrels of natural gas liquids per day.[79] This plant is projected to be in service by December 2012 and may be expanded in a second phase if sufficient additional producer commitments are secured. This plant addition complements other natural gas liquids processing plants in the state and will primarily produce ethane, propane and butane.

The future development of the Marcellus Shale plays within West Virginia will result in significant amounts of ethane, propane and other hydrocarbons being delivered to markets, primarily out of state at this point. To capitalize on these opportunities Governor Tomblin created the West Virginia Marcellus to Manufacturing Task Force in 2011 with the following goals:

- Analyze the feasibility of converting ethane to ethylene in West Virginia including available sites for ethane crackers.
- Locate and analyze existing infrastructure including pipelines and storage facilities.
- Identify potential companies specializing in the construction and operation of ethane crackers.
- Identify companies with capital and other resources to invest in the natural gas, ethane conversion and revitalization of the state's chemical and manufacturing industries.
- Formulate a comprehensive Marcellus to Manufacturing Action Plan.

One outcome was the passage of HB 4086 during the 2012 Session that was signed into law by Governor Tomblin. This bill provided a reduction in personal property taxes for a company that invests at lead $2 billion in building an ethane cracker in West Virginia.

Aither Chemicals has announced its plan to build an ethane cracker in the Kanawha Valley while other firms are also considering locations within West Virginia. If one or more ethane crackers are located in the state, the economic impacts could be considerable. According to a 2011 study by the American Chemistry Council, the ongoing development of new petrochemical production resulting from a world-class ethylene cracker and affiliated polyethylene and other downstream derivative plants could be upwards of over 12,000 jobs annually.[80]

4.8 Natural gas pipelines

The US natural gas pipeline network is a sprawling interconnected transmission and distribution grid that can transport natural gas to and from locations across the nation. The pipeline and grid system is comprised of more than 210 natural gas pipeline systems composed of more than 305,000 miles of interstate and intrastate transmission pipelines. Roughly 1,400 compressor stations maintain pressure on the pipeline network and assure continuous forward movement of the gas to more than 11,000 delivery points, 5,000 receipt points, and 1,400 interconnection points that provide for the transfer of natural gas throughout the United States. Running underneath the pipeline network are 400 underground natural gas storage facilities. There are also 49 locations where natural gas can be imported and exported via pipelines including eight LNG (liquefied natural gas) import facilities and 100 LNG peaking facilities.[81]

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[79] Dominion, "Dominion News," (2012).
[80] American Chemistry Council, *Shale Gas and New Petrochemicals Investment in West Virginia*,[September 2011].
[81] Electricity Administration Association, "About US Natural Gas Pipelines," (2012).

Currently twenty natural gas pipelines are operational within the Northeast region.[82]These interstate pipelines transport natural gas to intrastate natural gas pipelines, local distribution companies throughout the region, industrial firms, and increasingly natural gas fired electric power generation facilities.

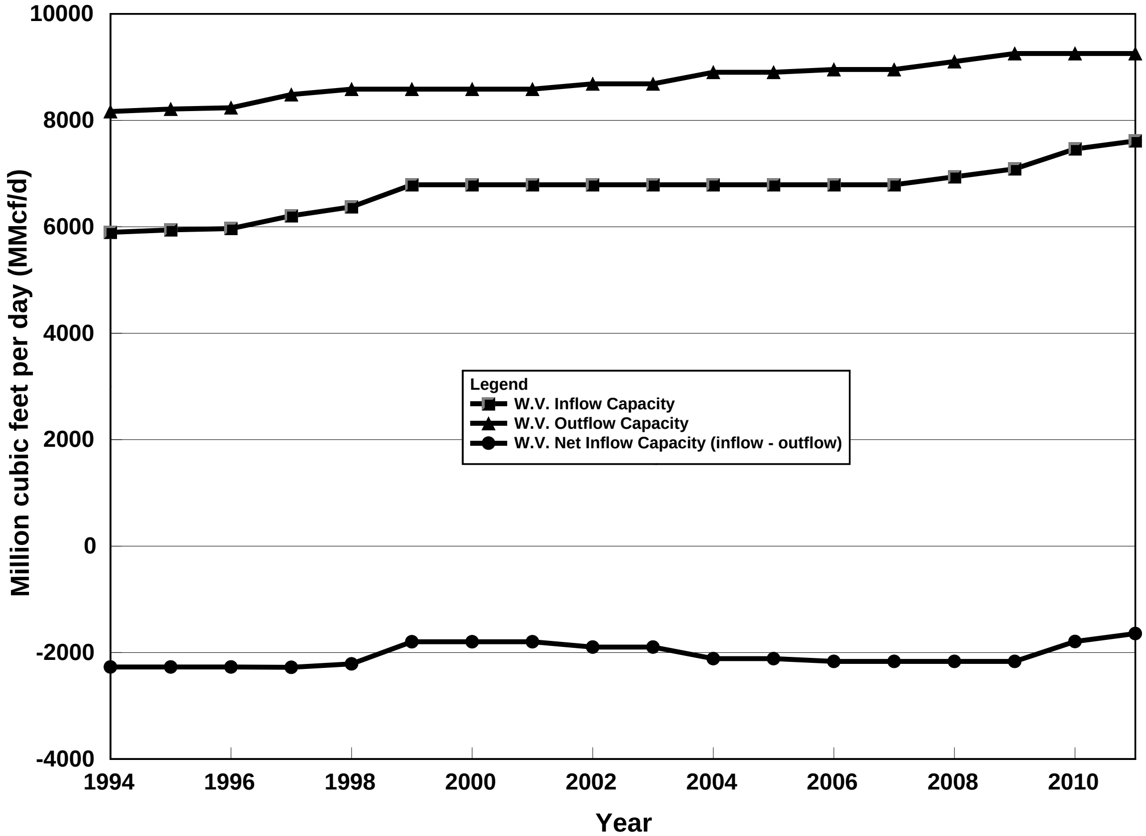
The Northeast region pipeline system and local distribution centers have access to supplies from several major domestic natural gas producing areas and from Canada. Domestically produced natural gas flows into the Northeast region from the southeast into Virginia and West Virginia. From the Midwest it flows into West Virginia and Pennsylvania. Imports from Canada enter the region primarily through New York, Maine, and New Hampshire.

The largest interstate natural gas pipeline system in the Northeast region is operated by the Columbia Gas Transmission Company with a daily capacity of 9.4 bcf (billion cubic feet) per day. Columbia's pipeline network provides regional service to the states of Maryland, New Jersey, New York, Pennsylvania, Virginia, and West Virginia, but also extends into the Ohio in the Midwest region and Kentucky and North Carolina in the Southeast region.

In addition to those that transport natural gas into the region, several smaller interstate natural gas companies operate totally within the Northeast region. These pipelines were developed to transport local production to regional markets. One of these systems is operated by Equitrans Inc. (0.1 bcf/day), serving West Virginia and Pennsylvania. The areas of West Virginia and Pennsylvania were once the Northeast region and the nation's largest natural gas producing area and, consequently, have many local gathering, distribution, and storage interconnections.[83]

[82] The Northeast region is comprised of Connecticut, Delaware, Massachusetts, Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Virginia and West Virginia.
[83] Electricity Administration Association, "Natural Gas Pipelines in the Northeast Region," (2012).

Figure 24: West Virginia natural gas state-to-state transmission capacity, 1994-2011



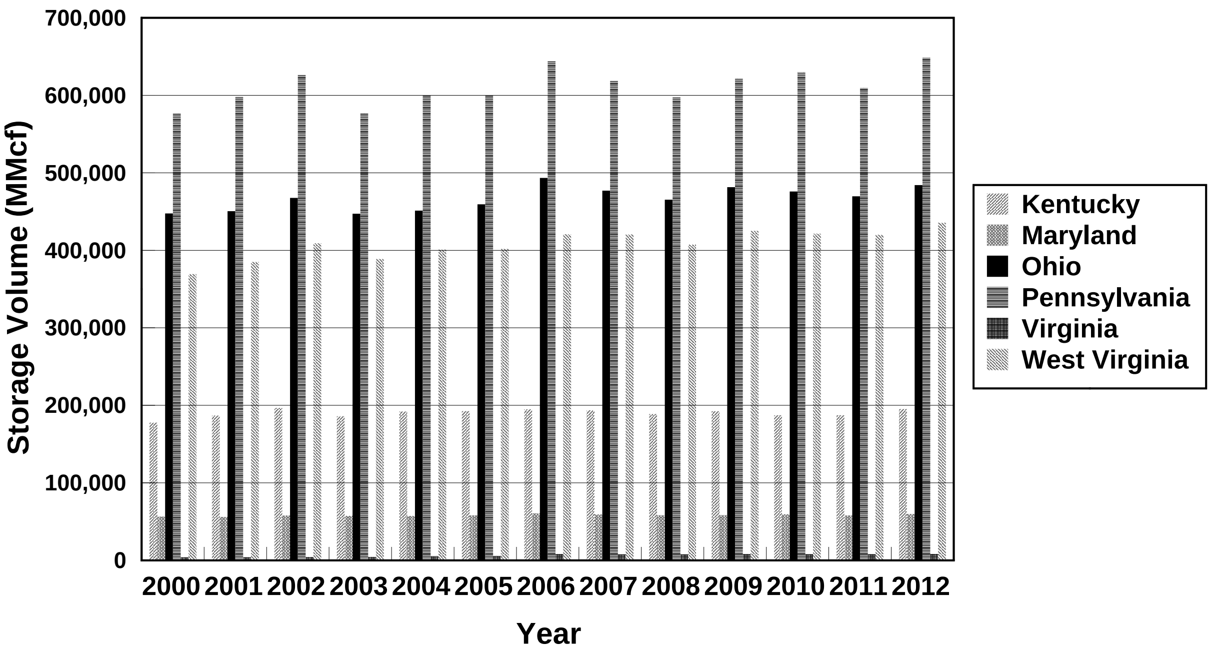
Source: U.S. Energy Information Administration

4.9 Storage of natural gas

Figure 25 displays underground natural gas storage volume in Kentucky, Maryland, Ohio, Pennsylvania, Virginia, and West Virginia. At 435,670 MMcf feet in 2012, West Virginia's storage volume was the third largest of the states listed above. Pennsylvania has the largest capacity (648,699 MMcf), followed by Ohio (484,228 MMcf). Kentucky and Maryland have significantly smaller storage capacities, and Virginia can store only a fraction of what West Virginia is able to hold, with only 8,186 MMcf capacity. Between 2000 and 2012, West Virginia's storage volume increased by over 66,000 MMcf, while Pennsylvania's capacity increased by just over 72,000 MMcf, and Ohio's storage volume grew by 36,616 MMcf. The other states experienced much less storage capacity growth over the same time period.[84]

[84] US Energy Information Administration, "Underground Natural Gas Storage by all Operators," (2012).

Figure 25: Annual average natural gas underground storage volume (Mcf) of select states, 2000-2012



Source: US Energy Information Administration

National underground storage volume is listed along with the same select states in Table 17 includes those states and the nation. In 2000, West Virginia represented 5.9 percent of US storage capacity, while Pennsylvania had 9.3 percent and Ohio had 7.2 percent. Kentucky, Maryland, and Virginia all had portions of national underground storage volume that were less than 1.9 percent.[85] By 2012, West Virginia, Kentucky, and Virginia's shares of national storage capacity had increased minimally, while Pennsylvania, Ohio and Maryland saw declining shares of national natural gas storage volume.[86]

[85] Percentage calculations in this paragraph are the work of the author, not the US Energy Information Administration.
[86] Ibid.

Table 17: Annual Average Natural Gas Underground Storage Volume (MMcf) of Select States, 2000-April 2012

Year	Kentucky	Maryland	Ohio	Pennsylvania	Virginia	West Virginia	US
2000	177,661	56,288	447,612	576,602	3,910	369,341	6,210,104
2001	186,717	55,774	450,624	598,361	4,126	385,062	6,335,558
2002	196,629	57,835	467,731	626,455	4,345	409,127	6,715,545
2003	185,823	57,248	447,234	576,665	4,421	388,867	6,256,805
2004	191,931	57,174	451,346	599,821	5,263	400,933	6,460,054
2005	192,380	58,004	459,423	600,002	5,542	401,819	6,492,884
2006	194,809	60,476	493,449	644,299	8,047	420,817	6,860,307
2007	193,482	59,160	477,015	619,177	7,767	420,602	6,837,505
2008	188,646	58,204	465,402	597,431	7,660	407,325	6,592,182
2009	192,368	58,315	481,516	621,825	8,039	425,138	7,052,343
2010	187,069	59,337	475,993	629,697	7,969	421,438	7,052,461
2011	187,140	57,919	469,772	609,680	7,931	420,059	7,008,084
2012	195,142	59,678	484,228	648,699	8,186	435,670	7,309,614

Source: US Energy Information Administration, Data Table "Underground Natural Gas Storage by All Operators"

4.10 Oil

It is generally believed that over thousands of years, the remains of animals and plants were covered by layers of mud, sand, and silt that formed into sedentary rock. Geologic heat and the pressure of the overlying rock turned the biomass into a hydrocarbon-rich liquid that we call crude oil. Pressure underground eventually forced it into porous rock strata called reservoirs. There are also deposits of hydrocarbon-saturated sands and shale where geologic conditions have not been sufficient to turn the hydrocarbons into liquid.

Wells are drilled into oil reservoirs to extract the crude oil. When the reservoirs are first drilled, the pressure underground provides a “natural lift” to force the oil to the surface. The “natural lift” method is sufficient for a while until the natural pressure dissipates. Once the pressure has dissipated the oil must be pumped out using “artificial lift” created by mechanical pumps powered by gas or electricity. The previous methods are generally referred to as “primary” extraction methods and over time become less effective and “secondary” methods must be used. A common secondary method is “waterflood” injection of water into the reservoir to increase pressure and force the oil to the drilled shaft or “wellbore.” Eventually the secondary extraction methods become less effective and “tertiary” methods must be used to increase the oil’s flow characteristics. These methods include injecting steam, carbon dioxide, and other gases or chemicals into the reservoir. In the United States primary extraction methods account for less than 40% of daily oil production, secondary methods account for half, and tertiary methods cover the remaining 10%. Following extraction, the crude oil is sent to refineries where it is processed.[87]

Another more recent technological advance in oil production has been the use of horizontal drilling into oil shale deposits. Horizontal drilling is combined with multi-staged hydraulic fracturing to create

[87] Consumer Energy Report via EIA. "Crude Formation and Production." Consumer Energy Report, accessed 8/3, 2012, http://www.consumerenergyreport.com/research/crude-oil/crude-formation-and-production/.

permeable flow paths from wellbores into shale units.[88].Horizontal drilling allows for multiple wells to be tapped from one drilling pad, whereas traditional vertical drilling allows for only one well to be drilled from pad site.

Originally built in 1972 by Quaker State, the refinery at Newell, WV was acquired by a new firm Ergon – West Virginia Inc. (EWV) in 1997. The Newell refinery utilizes high-pressure hydro treating technology to produce highly refined paraffinic specialty products and fuels from local Appalachian grade crude oil. EWV currently has the capacity to produce 20,000 barrels of crude oil per day which represents 0.1% of total US production. EWV processes 100% Appalachian grade paraffinic crude oils, particularly Pennsylvania grade gathered from approximately 40,000 facilities throughout Ohio, Pennsylvania, West Virginia, Kentucky, and New York.

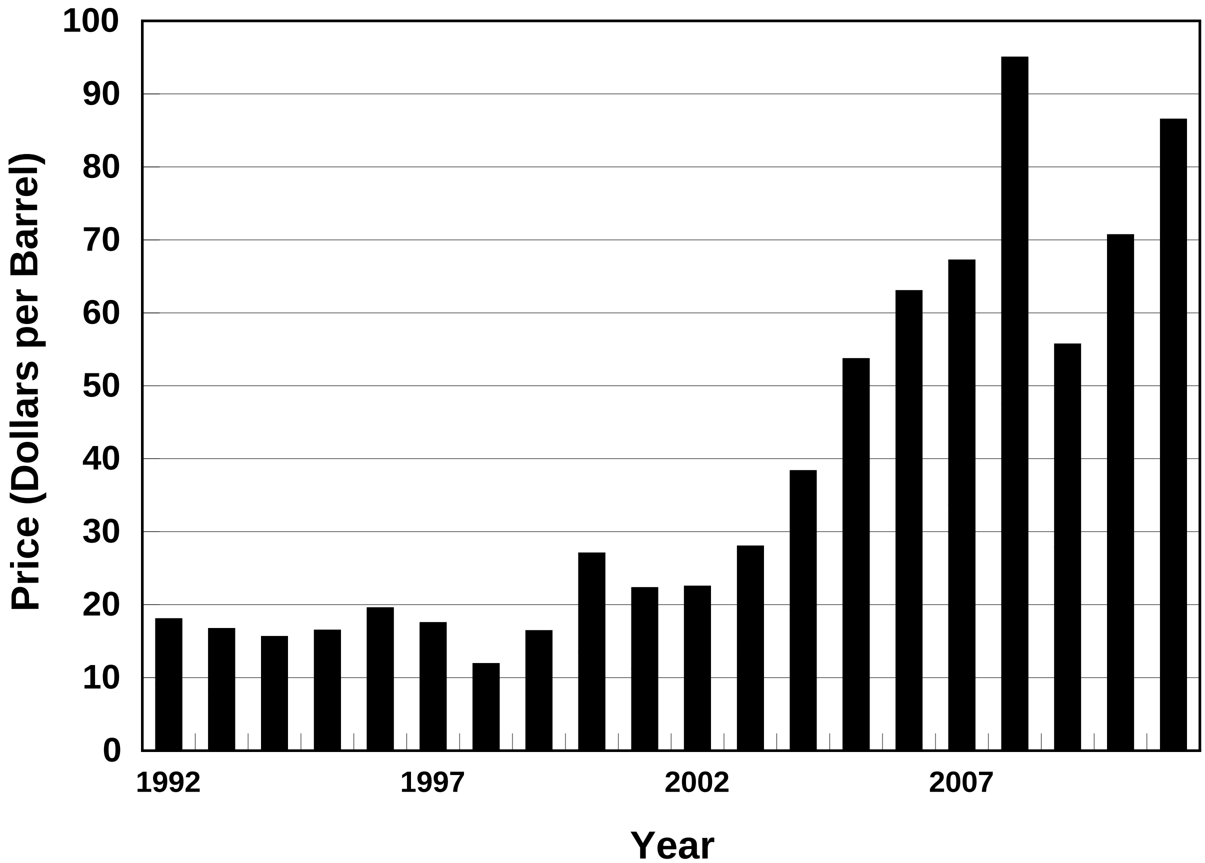
Crude refined at EWV produces a very high yield of paraffinic specialty products when compared with other types of crude oil processed by paraffinic competitors. Initially the crude is handled by Ergon Oil Purchasing and is then transferred by truck or pipeline to gathering centers in Ohio and Pennsylvania before moving on to the refinery via barge, truck, and pipeline.

After the refining process, the ultra-low sulfur fuel products are sold at the refinery rack or by barge within EWV's regional market. The process and base oils refined by EWV are used in a wide variety of applications, including compounding motor oils, gear oils, greases, pharmaceutical and agricultural spray oils, food grade applications, and in high-temperature rubber applications.

As of 2009 West Virginia had 19 million barrels of crude oil reserves or about 0.1% of total US reserves and 3,965 crude oil producing wells or about 0.8% of the US total. Petroleum fired electricity generation facilities generated 10 thousand MWh of power during the month of April 2012. Figure 26-Figure 28 provide information on historical West Virginia crude oil prices, reserves, and production.

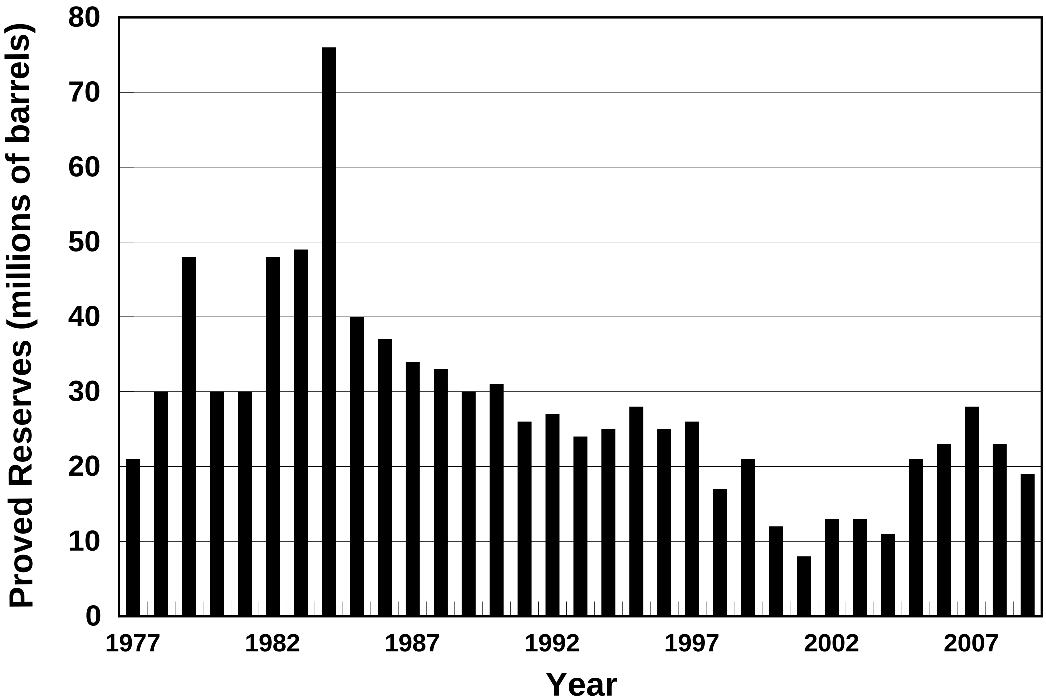
[88] Ohio Department of Natural Resources. "Marcellus and Utica Shales Data." Ohio Department of Natural Resources, accessed 8/7, 2012, http://www.dnr.state.oh.us/tabid/23014/default.aspx.

Figure 26: West Virginia annual crude oil first purchase price, 1992-2011



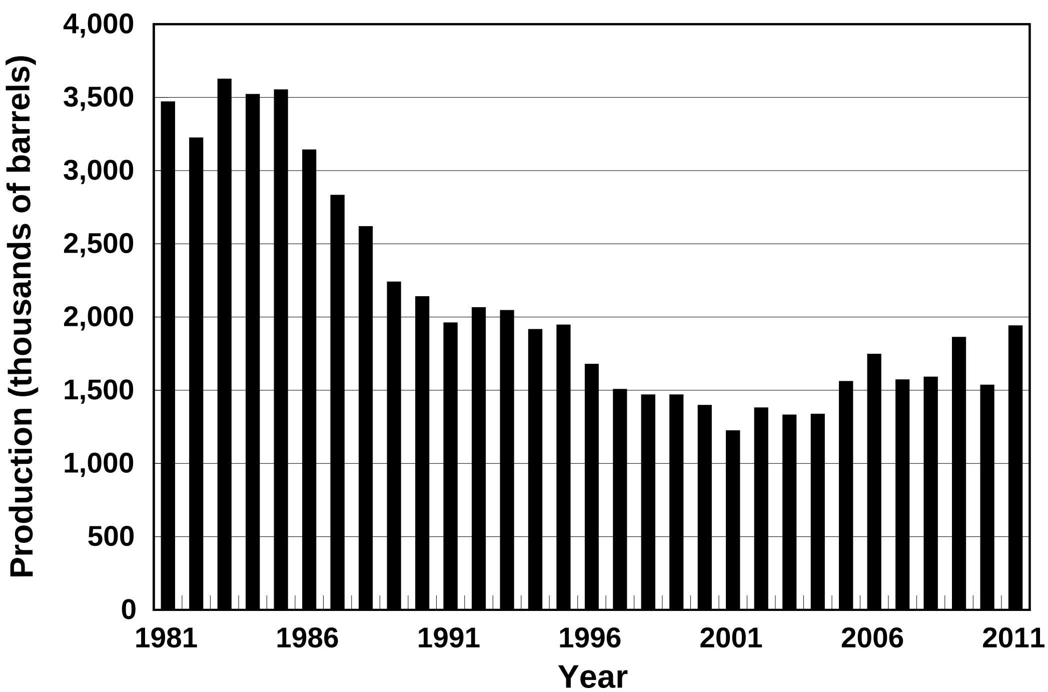
Source: US Energy Information Administration

Figure 27: West Virginia crude oil proved reserves, 1977-2009



Source: US Energy Information Administration

Figure 28: Annual West Virginia field production of crude oil, 1981-2011



Source: US Energy Information Administration

4.10.1 The future of oil shale

There is considerable uncertainty regarding the ultimate size of recoverable shale gas and shale oil resources. Since most shale gas and shale oil wells are still in their infancy, their long-term productivity is untested. Consequently, the amount of long-term production and the estimates of their ultimate recovery potential of oil and gas are uncertain. In emerging shale plays, production has been largely confined to those areas known as “sweet spots” that have the highest known production rates for the play. “Sweet spots” are the portions of the formation referred to as the “active area,” while the remaining portion of the formation that has seen little or no drilling activity is referred to as the “undeveloped area.” If the production rates for the sweet spots are used to infer the productive potential of entire shale plays, then their production potential will probably be understated. Many shale spots are so large (e.g., the Marcellus shale) that only portions have been extensively production tested.[89] While little shale oil has been produced from the Marcellus shale, many rigs have migrated to Ohio to develop the Utica shale, which has significant potential for oil along with ‘wet’ gas. The greatest oil shale development today is in the Bakken shale formation, particularly in North Dakota. Oil production in this state now ranks the state as the third leading oil producing state in the United States.

The United States has been a net importer of oil for more than 50 years, and today still imports a significant portion of its liquid hydrocarbon needs. The US Department of Energy (DOE) projects that US imports may double to 19.8 million barrels of oil per day by 2025. By then imports will exceed 70 percent or demand with the vast majority coming from the Organization of Petroleum Exporting Countries (OPEC). As imports rise, America’s vulnerability to price shocks, disruptions and shortages will also increase.

The OPEC embargoes in the 1970s provide an historic lesson and offer insight to the potential impacts of petroleum shortages. Although temporary, the shortages of the 1970’s drove oil prices higher, and led to high inflation, high unemployment and high interest rates almost simultaneously. These adverse effects can be expected in the future if the US once again experiences a supply shock.

US options for producing more liquid fuels are effectively limited to unconventional fossil energy sources, namely liquids from oil shale, coal and tar sand. The world’s conventional oil resources total 2.7 trillion barrels while North America’s unconventional resources total 3.7 trillion barrels. North America’s resources base of unconventional oil exceeds the world’s remaining conventional oil by nearly 40 percent.[90] Future production of US oil shale reserves could help maintain price stability in gasoline prices due to the increased supply from oil shale and oil sands.

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[89] EIA. Review of Emerging Resources: US Shale Gas and Shale Oil Plays. Washington, DC: EIA, 2011.
[90] Office of Deputy Assistant Secretary for Petroleum Reserves. Strategic Significance of America’s Oil Shale Resource. Washington, D.C.: Office of Naval Petroleum and Oil Shale Reserves, 2004.

4.11 Key observations

- The continued development of the Marcellus shale formation will lead to significant additions to natural gas reserves and subsequent production.
- Wellhead prices of natural gas should rebound from recent low levels but Marcellus gas may trade at a discount to Henry Hub until additional processing, pipeline and end-user demand has been generated Future natural gas prices should be less volatile and, on average, tend to be relatively lower than prices experience in the early part of this century.
- Natural gas midstream processing is essential for realization of production potential.
- Natural gas storage capacity is reaching its limit much earlier in the year so development of more storage may be essential to allow for increased production.
- Natural gas liquids production provides significant opportunities for value added industry such as ethane crackers
- Introduction of LNG and CNG transportation vehicles and conversion of existing fleet, coupled with dedicated fueling stations, will increase the demand for natural gas.

5 Nuclear

Nuclear power is the source for 20 percent of the total electricity supply in the US[91] At the present time there are 31 states with at least one commercial nuclear reactor, with most located east of the Mississippi River to take advantage of water resources. All states surrounding West Virginia, except for Ohio, have nuclear power generation facilities.

Recent announcement by USEC Inc. of the American Centrifuge Demonstration, LLC, project in Piketon, Ohio, may result in job opportunities for West Virginians residing either in close proximity to the plant or working at West Virginia firms manufacturing parts for the plant.[92] This plant is designed to construct and operate centrifuge machines that can be used in the enrichment of uranium used in nuclear reactors.

West Virginia code (§16-27A-2) has a limited ban on the construction of nuclear power plants within West Virginia. No nuclear power plant, nuclear factor or nuclear electric power generating plant may be constructed or initiated until the West Virginia Public Service Commission has approved the application for this facility under the provisions outlined in West Virginia code. As a result nuclear power is not an option for consideration in the time period 2013-2017.

5.1 Key observations

- Nuclear Power will not be an option without a change in West Virginia code

[91] US Energy Information Administration, "What is the Status of the U.S. Nuclear Industry?" (2012q)
[92] http://www.usec.com/american-centrifuge

6 Electric Power

6.1 Overview of US electric power industry

In recent years the United States has experiences dramatic changes in the market for electric power. The 2008 recession reduced demand for electricity significantly from a peak of 3,766 TWh in 2007 to a low of 3,597 TWh two years later. The national market has mostly rebounded, but demand in West Virginia, which was 32 TWh in 2010, is still off its peak of 34 TWh in 2008. (See

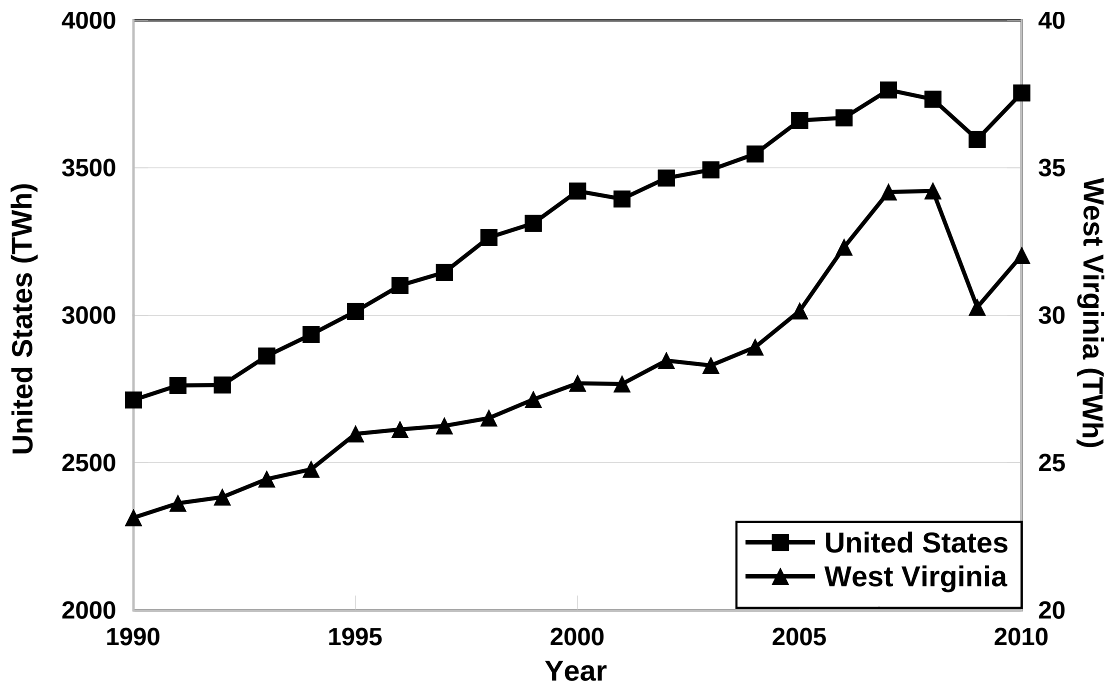
Figure 29).

The sources of fuel for power generation have also shifted substantially in the last five years (See Figure 30). So far in 2012, coal's share of national power generation has averaged 35 percent. In April 2012, the share of electricity generation from natural gas rose to 32 percent, almost identical to the share from coal, a first in the nation's history. Generation from natural gas has risen primarily because of historically low natural gas prices due to increases in supply from shale gas production (see

Figure 31).[93] The EIA projects that the high natural gas generation levels will be short lived, however. Demand for natural gas at electric power generators is expected to fall over the next six months to a year as natural gas prices rise. This rise in natural gas versus coal will start to tilt economic dispatch back to coal at the margin. But natural gas will continue to provide a growing share of generation over the next 25 years as the overall demand for electricity increases, as will renewable sources, which are estimated to rise to 15 percent of generation by 2035.[94]

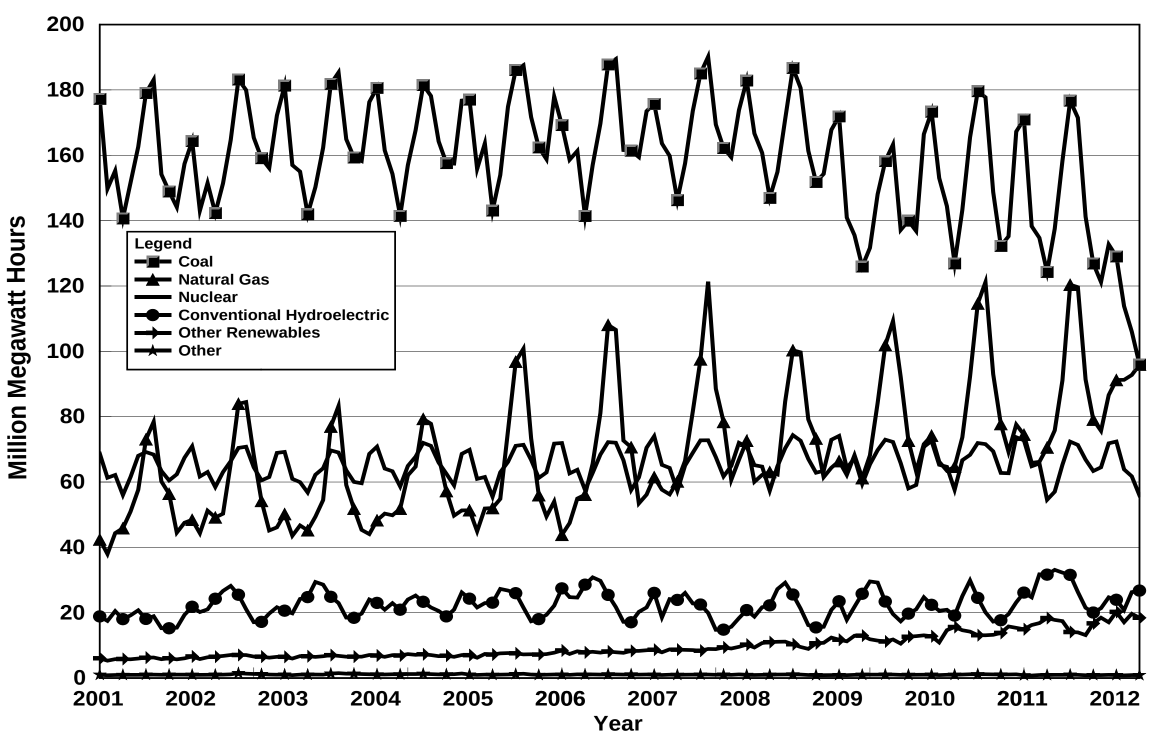
[93] US Energy Information Administration, "Electricity Monthly Update," (2012).
[94] US Energy Information Administration, "Fuel used in Electricity Generation is Projected to Shift Over the Next 25 Years," (2012).

Figure 29: US and West Virginia electricity sales 1990-2010



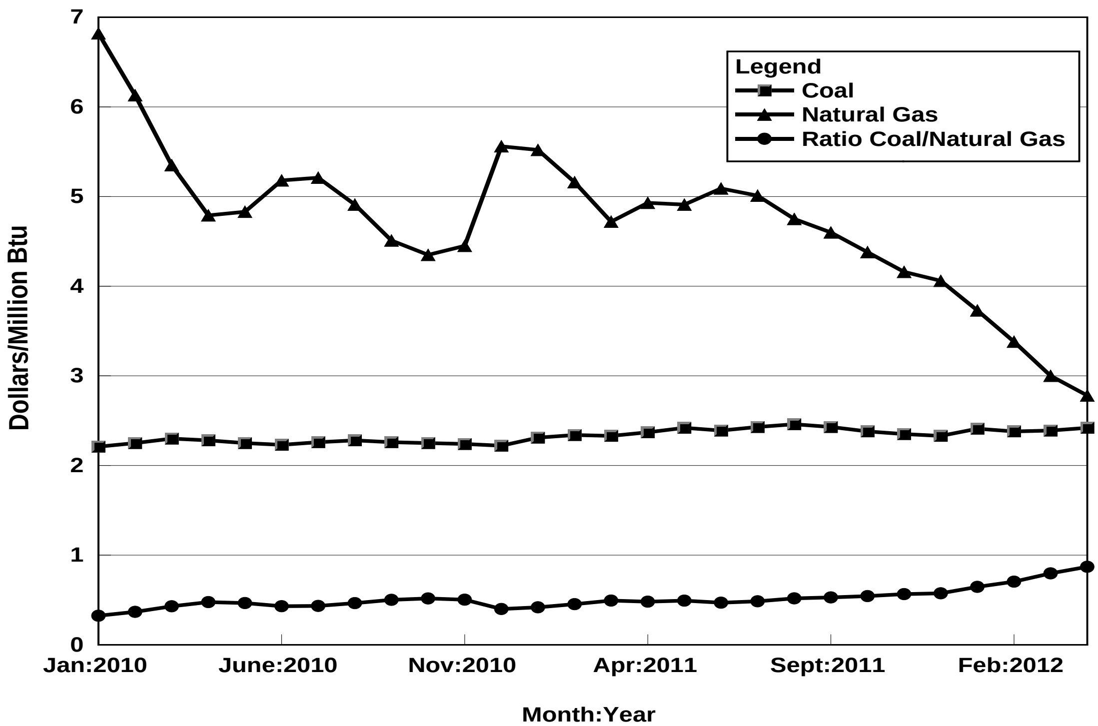
Source: US Energy Information Administration, Electric Power Annual

Figure 30: US Monthly net power generation January 2001 - April 2012



Source: US Energy Information Administration

Figure 31: Average cost of coal and natural gas for electricity generation



Source: US Energy Information Administration

6.2 Overview of fossil fuel electric power generation in West Virginia

West Virginia is largely a regulated utility market with 54 percent of electric power generation plants under regulation as utilities, representing 71 percent of capacity. The rest of the capacity comes from the state's seven independent power producers and four industrial producers. The state's utilities fall into the North American Electric Reliability Corporation's (NERC) Reliability First Corporation region, and are centrally dispatched through the PJM Interconnection. All power is dispatched on a lowest-marginal-cost basis.

West Virginia consumers receive the majority of their power generation from coal, though coal's share has slightly fallen in recent years. In 2012, coal's market share fell to 94 percent on average, down from an average of 97-98 percent over the last two decades. The majority of the drop is attributable to renewable sources. Hydroelectric increased to 2.9 percent from 1.9 percent a year earlier; wind rose to 2.5 percent of West Virginia's generation so far this year, up from 1.4 percent in 2011.[95] Table 18 lists the fossil fuel power plants, which range from 2900 MW capacity at the Appalachian Power John E. Amos plant to 5.6 MW at the Union Carbide South plant.

[95] US Energy Information Administration, "Electric Power Monthly," (2012).

Table 18: West Virginia Power Plants Listed by Fuel and Capacity[96]

Utility	Plant Name	County	Energy Source	Net Summer Capacity
Appalachian Power	John E Amos	Putnam	Coal	2900
Allegheny Energy	FirstEnergy Harrison Power Station	Harrison	Coal	1954
Virginia Electric & Power	Mt Storm	Grant	Coal, Jet Fuel	1602
Ohio Power	Mitchell	Marshall	Coal	1560
Appalachian Power	Mountaineer	Mason	Coal	1300
Allegheny Energy	FirstEnergy Pleasants Power Station	Pleasants	Coal	1288
Monongahela Power	FirstEnergy Fort Martin Power Station	Monongalia	Coal	1107
Appalachian Power	Philip Sporn	Mason	Coal	1020
GenPower	Longview Power LLC	Monongalia	Coal	700
Ohio Power	Kammer	Marshall	Coal	600
Appalachian Power	Ceredo Generating Station	Wayne	Natural Gas	450
Appalachian Power	Kanawha River	Kanawha	Coal	400
Big Sandy Peaker Plant	Big Sandy Peaker Plant	Wayne	Natural Gas	300
Pleasants Energy	Pleasants Energy LLC	Pleasants	Natural Gas	288
Monongahela Power	FirstEnergy Albright	Preston	Coal	283
Monongahela Power	FirstEnergy Willow Island	Pleasants	Coal	235
Monongahela Power	FirstEnergy Rivesville	Marion	Coal	125
PPG Industries	PPG Natrium Plant	Marshall	Coal	123
American Bituminous Power	Grant Town Power Plant	Marion	Waste Coal	80
Virginia Electric & Power	North Branch	Grant	Waste Coal	74
Morgantown Energy Associates	Morgantown Energy Facility	Monongalia	Waste Coal	50
WVA Manufacturing	Alloy Steam Station	Fayette	Coal	38
Bayer CropScience	Bayer CropScience Institute Plant	Kanawha	Coal	12.6
Union Carbide	Union Carbide South Charleston	Kanawha	Natural Gas	5.6

Source: US Energy Information Administration; author calculations[97]

[96] Only plants that generated from fossil fuel sources are listed in this table.
[97] US Energy Information Administration, "Form EIA-860 Detailed Data," (2012).

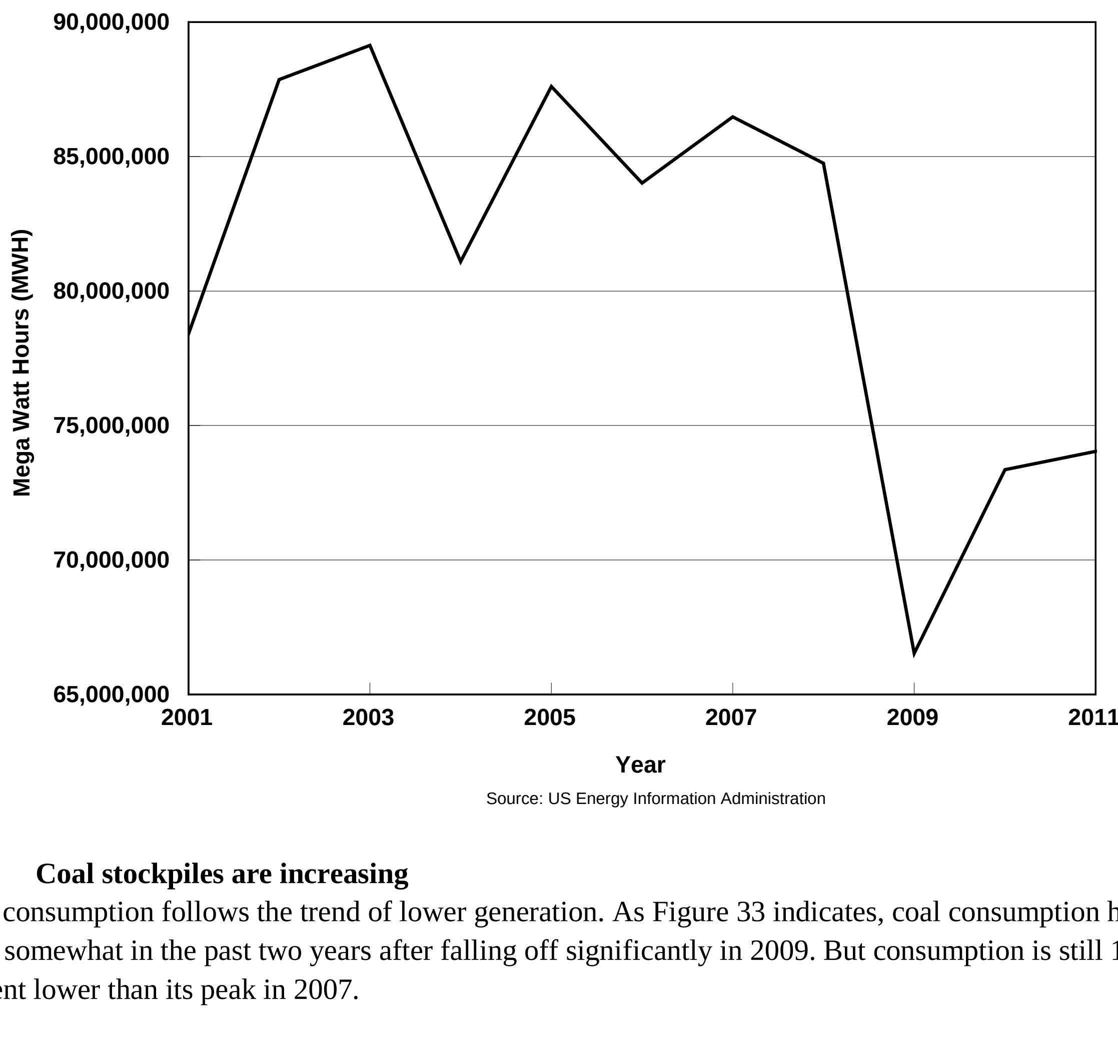
6.3 Trends in coal generation

Coal-fired power generation faces serious adverse market conditions in the short term. Coal plants are running at low capacity factors compared with recent history, mostly due to changes in relative prices between coal and natural gas. Coal stockpiles are also high, indicating the potential for lower sales over the near term. Over the longer term, a significant amount of coal capacity is set to retire with little prospect for replacement, and coal is set to lose market share to natural gas and renewables.

6.3.1 Capacity factors are declining

In April, AEP announced that its coal plants ran at less than half capacity in the first quarter of 2012, compared to a 61 percent capacity factor in the first quarter last year.[98] This mirrors overall trends for coal plants across the state as natural gas takes a larger share of electricity generation. Capacity factors are not yet available for 2011, but as Figure 32 indicates power plants in West Virginia have reduced their generation significantly since 2008.

Figure 32: West Virginia power plant net generation (MWH), 2001-2011



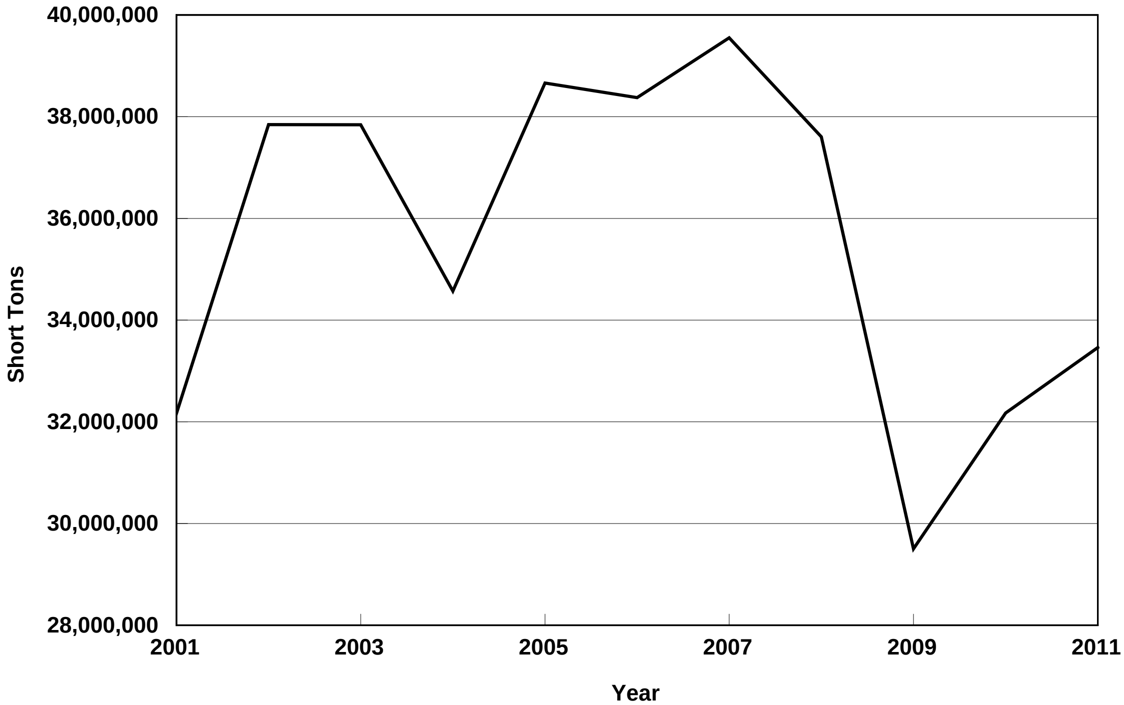
Source: US Energy Information Administration

6.3.2 Coal stockpiles are increasing

Coal consumption follows the trend of lower generation. As Figure 33 indicates, coal consumption has risen somewhat in the past two years after falling off significantly in 2009. But consumption is still 15 percent lower than its peak in 2007.

[98] Pam Kasey, "AEP Eastern Coal Plants Now Running Less than Half the Time," (2012)

Figure 33: West Virginia power plant fuel consumption quantity 2001-2011



Source: US Energy Information Administration

The drop in coal consumption sent coal stockpiles higher in the first quarter of 2012.[99] Coal stores in March 2012 were almost 18 percent above the level in 2011, and represent 91 days of burn time, more than 25 percent above the previous year.

The rise in coal stores has caused some power plants to refuse additional coal orders, or shift orders to later dates. Duke Energy has bought out existing contracts in order to keep from having to buy a new coal, and GenOn used force majeure to stop shipments, claiming they had no space left to store the coal.

6.3.3 Plant closures have been announced

The EIA announced in July that approximately 27 GW of coal capacity would be retired in the next five years.[100] Of that approximately 2.5 GW will be in West Virginia. These retirements are among the largest in the nation's history. The EIA cited several reasons for the retirements, including slow electricity demand, the relative prices of natural gas vs. coal, aging coal-fired generation, and environmental and other compliance costs. Over the longer term, the EIA projects that 49 GW of coal capacity will be retired nationwide by 2035, to be replaced with only 1.7 GW of new unplanned capacity. [101]

Citing new EPA rules,[102] FirstEnergy and American Electric Power (AEP) have announced plans to retire a combined 2,290 MW of older coal-fired power capacity based in West Virginia.[103] The companies said

[99] US Energy Information Administration, "Coal Stockpiles Above Five-Year Range in First Quarter of 2012," (2012).
[100] US Energy Information Administration, *Electricity Monthly Update*
[101] US Energy Information Administration, *Annual Energy Outlook 2012*,[2012c].
[102] See Environmental policies and implications for the electric power sector, page 7.
[103] FirstEnergy, "FirstEnergy, Citing Impact of Environmental Regulations, Will Retire Three Coal-Fired Power Plants in West Virginia," (2012).; American Electric Power, "AEP Notifies Reliability Organizations of Planned Plant Retirements," (2012).

in news releases that the EPA's Mercury and Air Toxics Standards (MATS) necessitate retiring the plants. These actions will have a significant impact on power production and employment in West Virginia. FirstEnergy estimates that 105 employees at the plants will be affected; AEP didn't release employment figures for the plants to be closed. FirstEnergy also announced that transmission system upgrades will be required to enhance system reliability as the power plants are shut down.[104]

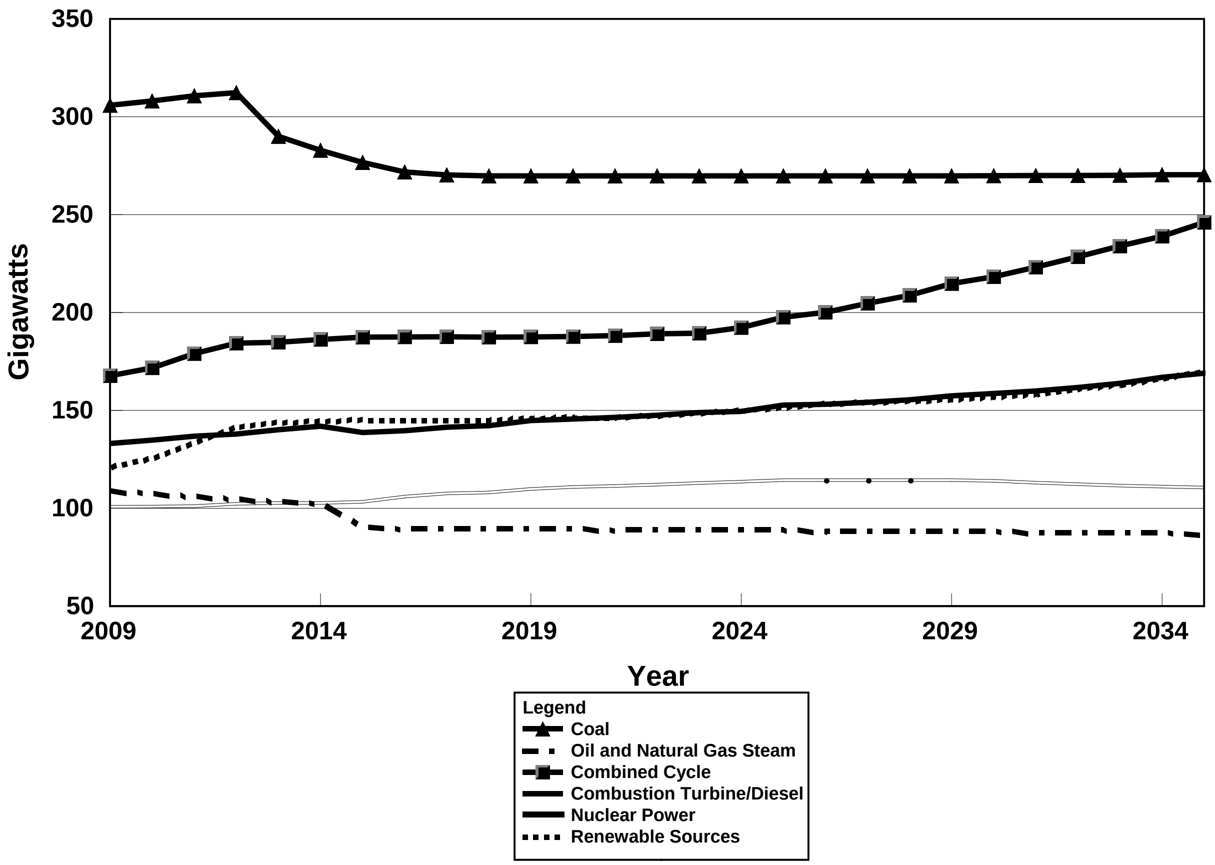
6.3.4 New generating capacity moving to natural gas

The decision to build new generating capacity is based primarily on capital and operating costs, including transmission costs. Coal, nuclear and renewables are very capital-intensive, while natural gas combined cycle plants have low capital costs, but higher operating costs. The total cost over the lifespan of the plant is typically described using levelized electricity costs. The EIA estimates that through 2035 levelized costs for new power plants, excluding subsidies, will be significantly lower for natural gas plants than for other types of generation. This leads the EIA to predict that natural gas plants will constitute the substantial majority of new capacity additions over that time frame.

In the EIA's reference case no new unplanned coal capacity is added until 2017; a total of 1.7GW is added by 2035. This is in addition to 9.3 GW of planned capacity increases. Coal continues to provide the largest share of electricity generation in 2035, but its share drops to 39 percent in 2020 from 45 percent in 2010.[105] Natural gas combined cycle capacity is expected to gain a total of about 65 GW by 2035, providing 28 percent of total generation by 2035. Figure 34 shows projected net summer capacity by type of fuel from 2009-2035.

[104] FirstEnergy, "FirstEnergy Announces "Energizing the Future" Initiative to Ensure Transmission System Reliability," (2012).
[105] US Energy Information Administration, *Annual Energy Outlook 2012* p. 87

Figure 34: Projected net summer capacity by fuel type, 2009-2035



6.4 Environmental policies and implications for the electric power sector

West Virginia's utilities operate in an ever-changing regulatory environment. This section outlines new policies and plant closures that could affect the market for power in the state.

6.4.1 Carbon emissions rule

In March 2012, The EPA issued new proposed rules to limit carbon emissions from electric utilities. [106] The rules stem from a June 2012 decision by the US Appeals Court upholding the EPA's power to regulate greenhouse gas emissions.[107] The rules would prevent new power plants constructed after the rule goes into effect from emitting more than 1,000 pounds of CO_2 per MWh of generation, a level determined to match the emissions from natural gas combined cycle (NGCC) plants. Coal technologies currently in use would not be able to meet the EPA standard, though the agency states that Carbon Capture Storage (CCS) plants would meet the standard with little difficulty. Certain types of super-efficient plants that currently do not meet the standard initially could potentially use a 30-year average emission standard that

[106] US Environmental Protection Agency, "Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units," (2012).
[107] US Environmental Protection Agency, "US Court of Appeals - D.C. Circuit Upholds EPA's Actions to Reduce Greenhouse Gases Under the Clean Air Act," (2012).

would allow coal plants to emit more in the first few years of use and then cut back later on as carbon capture technology advances and becomes less expensive.

The EPA estimates that the new rule will not have a significant economic impact through 2020. [108] This finding is due primarily to the agency's determination of the current economic environment for coal. Low natural gas prices have made NGCC plants less expensive than coal on a levelized cost per MWh basis. Thus the EPA estimates that no new coal capacity without federally supported CCS is likely to be built through 2020 whether the rule goes into effect or not. The EPA estimates that natural gas prices would have to rise to $10/MMBtu before coal will again become competitive for electricity generation. The EPA's report also indicates that because it expects most new capacity to come from natural gas, the new standard will do little to change greenhouse gas emissions for the near future. Nevertheless, the EPA states that a cost-benefit analysis shows that the rules do provide benefits by encouraging cleaner generation trends.

The new carbon rules proposed by EPA mean no non-CCS coal-fired power plants will be able to be built going forward, according to a 2012 report from Bloomberg Government.[109] The average emission rate for coal plants is 1,937 pounds of CO_2 per MWh, putting coal plants well above the EPA's new standard. By comparison, the average NGCC plant emits 790 pounds of CO_2 per MWh. And CCS coal plants are unlikely to be cost-competitive with natural gas without significant subsidies by the federal government. This will lead to replacement of older coal plants with other types of generation, most likely natural gas combined cycle. The study also posits that the new rules might trickle down to existing plants if they undergo significant modification, which normally requires plants to meet new-source performance standards as they upgrade. The new rules specifically exempt existing sources, however. Table 19 shows CO_2 Emissions and cost-related capture and storage for different technologies.

[108] US Environmental Protection Agency, Regulatory Impact Analysis for the Proposed Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units,[2012b].
[109] Rob Barnett, The Twilight of Coal-Fired Power,[2012].

Table 19: CO_2 emissions and cost-related capture/storage for different technologies

Coal-Fired Electricity Generating Unit (EGU) Technology	40-yr. BusBar Cost without carbon price ($/MWh)	40-yr. BusBar Cost Including carbon price ($/MWh)	CO_2 Emission Rate (lb/MWh)
Subcritical PC-fired (standard)	101	136	1940
Supercritical Pulverized Coal (PC) fired 830 MW	97	133	1880
Subcritical Circulating Fluidized Bed (CFB) Boiler	108	145	2020
Supercritical CFB Boiler	108	144	1960
Integrated Gasification Combined Cycle (IGCC) Plant	128	162	1860
Ultra-supercritical PC-fired	98	133	1860
Supercritical PC-fired with Carbon Capture and Storage (CCS)	135	139	220

Source: EPA Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from Coal-Fired Electric Generating Units.(US Environmental Protection Agency 2010)

6.4.2 Mercury and air toxics standards (MATS)

The EPA finalized new mercury and air toxics standards in February 2012. The new MATS rules require emissions reductions of heavy metals, including mercury, arsenic, chromium, and nickel; and acid gases, including hydrochloric acid and hydrofluoric acid.[110] The EPA estimates that approximately 1,400 generating units will be affected by the action, though the EPA is currently reconsidering the standards for technical reasons and expects to be completed by March 2013.

6.5 Carbon reduction technologies

Faced with increasing pressure to reduce carbon emissions, power plants have been looking for ways to cut carbon from both coal-fired and natural gas power plants. The primary line of research has been CCS, which directly reduces carbon by capturing it before it enters the atmosphere. Power plants have also pursued more efficient combustion techniques, such as supercritical boilers and oxy-combustion.

6.5.1 Carbon capture and storage

Carbon Capture and Storage is the common name for the process of capturing a portion of a utility's CO_2 emissions and storing it, generally in underground geologic formations, to prevent its release into the atmosphere.[111] CO_2 captured in this way is generally liquefied and stored in deep wells where the gas remains under high enough pressure to maintain its liquid state indefinitely. CCS offers one of the primary ways of significantly reducing greenhouse gas emissions from coal-based power generation. CCS

[110] US Environmental Protection Agency, "Mercury and Air Toxics Standards (MATS)," (2012).
[111] US Congressional Budget Office, *Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide*,[2012].

has also been proposed for natural gas combined cycle (NGCC) plants, but the majority of research has emphasized applications in coal power generation.

Carbon can be captured both before and after combustion of coal.[112] Pre-combustion approaches to CCS are usually performed through coal gasification, where the carbon is separated from the gas stream prior to combustion. Since most coal plants currently in operation are more traditional pulverized coal combustion plants, much research has focused on post-combustion strategies for capturing CO_2. Absorbent materials are applied to the output stream of power plants, while allowing the remainder of emissions to pass through. The carbon is then removed from the absorbent materials and stored.

6.5.1.1 Storage

One of the major considerations with CCS is finding locations to store captured CO_2. The most efficient geologic storage is at depths greater than 2400-2600 feet, where pressures are high enough to maintain CO_2 in a supercritical fluid state.[113] A 2009 study on carbon capture and storage found that West Virginia has enough geologic storage potential to last several decades at the state's current levels of CO_2 output. Potential sites include deep coal seams, saline aquifers and oil and gas fields, which have the added benefit of increasing oil recovery. The report concludes that more study is needed, but all indications point to the fact that West Virginia provides excellent potential for CO_2 storage sites, but it may require coordination with neighboring states.

Storage of captured carbon represents a significant portion of the long-term costs for CCS, according to a report from the West Virginia Carbon Dioxide Sequestration Working Group.[114] Cost estimates for sequestration range from $5 to $10 per ton of CO_2, with additional costs of approximately $25 million for site characterization.

6.5.1.2 Economic viability of CCS

Despite progress on CCS technology, a Congressional Budget Office report concludes that coal plants using CCS are unlikely to be built in the near future without government subsidies.[115] Power produced using CCS technology is significantly more expensive than traditional methods, potentially increasing the cost of coal-based power by 76 percent. New proposed environmental regulations all but require CCS for new coal plants, but competition from natural gas will likely lead to few coal plants being built in the near future.

Currently there are six large-scale CCS power plants planned to open in the next five years.[116] Located in Illinois, California, Mississippi, and Texas, the plants total 2.2 GW of generation. In West Virginia, AEP has a demonstration plant in New Haven that uses chilled ammonia process to capture carbon.[117] This pilot project ended in 2011 after capturing 37,000 metric tons of CO_2.

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[112] Ibid.
[113] Timothy R. Carr, Evan Fedorko and Frank LaFone, *West Virginia Carbon Capture and Storage Opportunities Associated with Potential Locations for Coal-to-Liquid Facilities*,[2009].
[114] WV Carbon Dioxide Sequestration Working Group, *Report to the Legislature: Findings and Recommendations with Respect to the Development and Widespread Deployment of Carbon Dioxide Sequestration Throughout West Virginia*,[2011].
[115] US Congressional Budget Office, *Federal Efforts to Reduce the Cost of Capturing and Storing Carbon Dioxide*
[116] Ibid.
[117] American Electric Power, "Carbon Capture and Storage," (2012).

6.5.1.3 Markets for captured CO_2

Though power production from CCS can increase costs significantly, those costs can be mitigated with new revenue sources from selling CO_2 for Enhanced Oil Recovery (EOR). A 2012 study by the National Coal Council found that EOR has the potential to increase the recoverable oil reserves in the United States by 67 billion barrels, but it will require large amounts of CO_2 to inject into existing wells.[118] In the study's ideal case, CCS would offset 100GW of capacity over 20 years, producing enough liquid CO_2 to recover an additional 4 million barrels per day of petroleum. The study also states that CO_2 captured from coal plants could be used to produce substitute natural gas, as well other chemicals.

CO_2 is in high demand for EOR operations across the country, as low supplies of CO_2 are constraining EOR production efforts.[119] But it remains to be seen whether CCS can produce liquid CO_2 at a cost-effective price for EOR. A recent NETL report concluded that EOR can be viable at an oil price of $85 per barrel and a price of $40 per metric ton of CO_2.[120] The study states that the $40 CO_2 price would represent a cost of $12 per barrel of oil. Under these assumptions, NETL estimates an additional 67 billion barrels of oil could be recovered nationwide, including 1.3 billion barrels of oil in Appalachia. Oil reservoirs could store 45 billion metric tons of CO_2. The report did not estimate if a $40 per metric ton price would offset the additional cost of CCS installation at existing or future power plants. Transportation to oil recovery sites would add additional cost, as it requires new pipelines to transport the liquefied CO_2. Oil reservoirs do offer a low-cost storage option for captured CO_2 that could be permitted and used relatively quickly.

6.5.2 Increased combustion efficiency

While CCS provides a way to extract carbon from a power plant's emission stream, new technologies have also been adopted to increase combustion efficiency in order to reduce carbon emissions directly. Two of the most promising are Advanced Super Critical Boilers and Oxy-combustion.

6.5.2.1 Advanced Super Critical Boilers

Advanced super-critical boilers operate at extremely high pressure and heat to improve the boiler's efficiency,[121] thus reducing emissions. Supercritical boilers operate at pressures above 705 degrees Fahrenheit and 3,212 psi, which is the point at which water enters a supercritical state where steam and liquid water achieve the same density. Supercritical boilers can increase efficiency of a plant to between 40-42 percent up from 36-38 percent for a subcritical plant. Ultra-supercritical plants that operate at pressures over 4,400 psi can reach thermodynamic efficiency of 48 percent. New materials developed primarily in Europe and Japan show promise in reaching the pressures and temperatures needed for ultra-supercritical efficiency.

Approximately 400 supercritical boilers are in operation around the world.[122] In early 2011, the Longview Power Plant in Maidsville began operation with a new type of advanced supercritical boiler that was the

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[118] Richard A. Bajura et al., *Harnessing Coal's Carbon Content to Advance the Economy, Environment, and Energy Security*,[2012].
[119] Ibid.
[120] Vello A. Kuuskraa, Tyler Van Leeuwen and Matt Wallace, *Improving Domestic Energy Security and Lowering CO2 Emissions with "Next Generation" CO2-Enhanced Oil Recovery (CO2-EOR)*,[2011].
[121] US National Energy Technology Laboratory, "Coal-Fired Power Plants (CFPPs): Supercritical and Ultra Supercritical Boilers," (2012).
[122] Ibid.

first of its kind in the world. The new boiler increases efficiency to approximately 41 percent,[123] making it among the least emitting power plants in the country.

6.5.2.2 Oxy-combustion CO_2 control

Oxy-combustion is a method of generation that injects purified oxygen into the combustion process in order to increase efficiency.[124] The process also produces a highly concentrated CO_2 stream, which is more suitable for carbon capture and storage than traditional pulverized coal methods. Oxy-combustion is still largely experimental, and requires low-cost supplies of oxygen in order to become economically viable.

The National Energy Technology Laboratory is funding several experimental and pilot projects related to oxy-combustion.[125] Alstom Power in Connecticut has a contract to develop concept designs for retrofitting existing generators for oxy-combustion. The project conducted several pilot-level tests of the technology with a variety of coal types. Reaction Engineering International, based in Utah, is conducting tests to gather data on how oxy-combustion will affect the performance of power plants. None of the projects under way are in West Virginia.

[123] Stephen J. Goidich, Richard J. Docherty and Kenneth P. Melzer, "World 1st in West Virginia: Longview Supercritical Benson Vertical PC Boiler," (2012)
[124] US National Energy Technology Laboratory, "Coal-Fired Power Plants (CFPPs): Oxy-Fuel Combustion," (2012).
[125] US National Energy Technology Laboratory, "Innovations for Existing Plants: Oxy-Combustion CO₂Control," (2012).

6.6 Key observations

- Demand for coal-powered generation has fallen significantly as a result of both the recession and competition with natural gas. In April 2012, the share of electricity generation from natural gas rose to 32 percent, almost identical to the share from coal, a first in the nation's history. Coal continues to provide the largest share of electricity generation in the longer term, but its share drops to 39 percent in 2020 from 45 percent in 2010.
- The EIA announced in July that approximately 27 GW of coal capacity would be retired in the next five years, with approximately 2.5 GW of that in West Virginia. Levelized costs for new power plants will be significantly lower for natural gas plants than for other types of generation. This leads the EIA to predict that natural gas plants will constitute the substantial majority of new capacity additions over that time frame.
- A proposed EPA rule would prevent new power plants from emitting more than 1,000 pounds of CO_2 per MWh of generation. Coal technologies currently in use would not be able to meet the EPA standard, though the agency states that CCS plants would meet the standard with little difficulty. A Bloomberg Government report states that if the regulations are enacted no non-CCS coal-fired power plants will be able to be built going forward.
- Despite progress on CCS technology, a CBO report concludes that coal plants using CCS are unlikely to be built in the near future without government subsidies. Power produced using CCS technology is significantly more expensive than traditional methods, potentially increasing the cost of coal-based power by 76 percent.

7 Hydrogen Fuels

7.1 Introduction

Hydrogen comprises a small but growing part of the nation's energy infrastructure, with uses in transportation, electric power and material handling, among others. Hydrogen is not a major part of West Virginia's infrastructure, but it has the potential to utilize the state's coal and natural gas resources in a number of different ways.

Hydrogen is a colorless, odorless gas that has been viewed as having great potential as an emission-free fuel source. [126] Unbonded hydrogen is rarely found in Earth's atmosphere, so in order to use it to produce energy it needs to be extracted from another source, typically water or methane. The hydrogen can then be recombined with oxygen, usually in a fuel cell, to release its energy, producing only water as a byproduct. Because it has to be split from water or other sources, however, hydrogen is generally considered to be an energy carrier rather than a generation mechanism. [127]

7.2 Hydrogen production

Hydrogen can be produced in a number of different ways, with electrolysis of water and steam methane reforming among the most prominent. Approximately 9 million metric tons of hydrogen were produced in the United States in 2011, enough to power between 36 and 41 million fuel-cell electric vehicles.[128] Most hydrogen is produced for in-house use at factories or refineries, with approximately 36 percent sold on the market. Market-sold hydrogen supply increased by 77 percent between 2009 and 2011, and is projected to rise another 41 percent by 2016.

Hydrogen production costs remain high compared with fossil fuel prices, but have come down more than 30 percent since 2005.[129] As of 2008, production costs ranged from $1.21 per kilogram (kg) for hydrogen from coal gasification to $7.26 derived from distributed wind power.[130] One kg of hydrogen is considered roughly equal to the power of one gallon of gasoline in transportation fuel.[131] Fuel cell costs have come down by approximately 80 percent since 2002, falling to $49 per kW, which is on track to meet the per kW price of gasoline engines within the next few years.[132]

7.2.1 West Virginia

As on the national level, the market for hydrogen remains small in West Virginia, though there is less data available for the state than the nation. The most recent direct study of the hydrogen market by the BBER was in 2003.[133] The BBER surveyed firms and individuals involved in production, consumption and delivery of hydrogen to determine the status of hydrogen usage in the state. The low response rate of 2.6 percent, and the survey responses indicate that West Virginia has a limited hydrogen infrastructure. The state's hydrogen consumers include the aerospace and chemical industries.

[126] US Alternative Fuels Data Center, "Hydrogen Basics," (2012).
[127] US Energy Information Administration, "Energy Technologies on the Horizon," (2012).
[128] Fred Joseck, "DOE Hydrogen and Fuel Cells Program Record," (2012).
[129] Breakthrough Technologies Institute, *2010 Fuel Cell Technologies Market Report*,[2011].
[130] US Energy Information Administration, "The Impact of Increased use of Hydrogen on Petroleum Consumption and Carbon Dioxide Emissions," (2012).
[131] US Alternative Fuels Data Center, *Hydrogen Basics*
[132] Breakthrough Technologies Institute, *2010 Fuel Cell Technologies Market Report*
[133] Armando Alzate and Tom S. Witt, *Hydrogen Infrastructure in West Virginia 2002*,[2003].

West Virginia is well positioned to take advantage of a hydrogen economy on the production side. Four of the seven respondents in the BBER survey produced hydrogen, which indicates West Virginia may become an important supplier of hydrogen to the world market. The largest amount of hydrogen production comes from steam methane reforming, which would allow use of West Virginia's natural gas resources. And production of hydrogen from coal gasification is currently the least expensive way to produce hydrogen, with costs from gasification in a carbon-capture and sequestration plants also cost-competitive at $1.82 per kg.[134]

7.2.2 FutureGen

One potential benefit of a hydrogen economy for West Virginia is that production of the fuel often requires significant amounts of electricity. In an effort to produce emission-free hydrogen, the DOE announced in 2003 that it was creating the FutureGen project, which was designed to build the first commercial-scale carbon capture and sequestration coal plant in the country. The plant would have produced both electricity and hydrogen fuel, but because of hydrogen market uncertainty, FutureGen was canceled in 2008.[135] The DOE announced in 2010 that it would bring back the project under the designation FutureGen 2.0,[136] though in a much reduced form. The new project plans to renovate an existing coal plant to produce energy using oxy-combustion technology and capturing 90 percent of CO_2 emissions. The new facility will not produce hydrogen, however.

7.3 Primary markets

7.3.1 Transportation

Transportation remains the primary expected use of hydrogen fuel cell technology, though the technology is still largely experimental. The Energy Information Agency estimates that there were 421 hydrogen-powered vehicles on the road in 2010, up from 357 in 2009.[137] The data do not specify in which state the vehicles are located. The number of hydrogen vehicles is significantly lower than those powered by other alternative fuels, including ethanol, propane, electricity, and compressed natural gas. Hydrogen fuel consumption in the transportation sector remains small. The EIA estimates that 152,000 gallons of gasoline equivalent were used in 2010, compared with 134 billion gallons of gasoline consumed by cars in that same year.[138]

One of the most significant barriers to widespread use of hydrogen-powered vehicles is the lack of refueling infrastructure. According to the DOE's Alternative Fuels Data Center (AFDC), only 56 hydrogen refueling stations exist in the country. The majority of these stations are private refueling stations for fleet vehicles. Only five are open to the public, all of which are located in the vicinity of Los Angeles and Palm Springs.[139]

West Virginia had one hydrogen refueling station at Yeager Airport in Charleston.[140] This station is being moved to a site near West Virginia University's Morgantown campus. According to William A. Davis,

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[134] US Energy Information Administration, *The Impact of Increased use of Hydrogen on Petroleum Consumption and Carbon Dioxide Emissions*
[135] US Department of Energy, "DOE Announces Restructured FutureGen Approach to Demonstrate Carbon Capture and Storage Technology at Multiple Clean Coal Plants," (2012).
[136] US Department of Energy, "Secretary Chu Announces FutureGen 2.0," (2012).
[137] US Energy Information Administration, "Independent Statistics and Analysis," (2012).
[138] US Energy Information Administration, "How Much Gasoline does the United States Consume?" (2012).
[139] US Alternative Fuels Data Center, "Hydrogen Fueling Station Locations," (2012).
[140] National Alternative Fuels Training Consortium, "WVU's National Alternative Fuels Training Consortium Receives $1.15 Million to Develop West Virginia's Second Hydrogen Production/Fueling Station," (2012).

assistant director – operations for the National Alternative Fuels Training Consortium (NAFTC),[141] in 2010, the NAFTC received a $1.15 million grant from the US DOE's National Energy Technology Laboratory (NETL) to build the station. Davis said that the university is currently taking bids and expects to begin construction in August 2012. The NAFTC also plans to acquire five hydrogen-fueled vehicles that will use the fueling station.

7.3.2 Electricity generation

Hydrogen does not play a large role in electricity generation currently. Nationally, 0.06% of electricity 2011 was generated by fuels in the other category, of which hydrogen is a part.[142] In West Virginia, no electricity generation came from the other fuels category. At the end of 2011, 625 hydrogen-powered electricity generation systems had been deployed nationwide, more than triple the year before, but still small relative to generation from fossil sources.

Hydrogen fuel cells have been used as backup power in case of power outages.[143] This usage is particularly prevalent in the telecommunications industry where hydrogen fuel cells have been used to provide emergency power for cell-phone towers in remote locations that are difficult to refuel. In this guise, hydrogen fuel cells are competitors with batteries.

7.3.3 Material handling

Hydrogen fuel cells are also in use powering forklifts in locations where combustible fuels are not feasible, such as indoor factories.[144] Fuel cell forklifts often have greater power than battery-operated lifts, and can operate for longer periods over multiple shifts without recharging. Fuel costs are higher for fuel cells than for batteries, however, falling in the range of $7 to $8 per working shift as compared with between $1.50 and $2 per shift for batteries. Sales volumes of hydrogen-powered forklifts reached between 150 and 200 units per year in 2010.

7.4 Public policies to support hydrogen

The federal government has more than 25 programs and incentives to support adoption of and research into hydrogen fuel cells.[145] Among the most prominent are: the Hydrogen Fuel Infrastructure Tax Credit, which provides a tax credit up to 30 percent of the cost of fueling stations; and the Fuel Cell Motor Vehicle Tax Credit, which provides a tax credit of up to $4,000 toward the purchase of a fuel-cell vehicle. The federal government also has requirements for government purchase of alternative fuel vehicles, as well as electric and hybrid vehicles. A number of other programs not specifically directed at fuel cells also have supports for hydrogen adoption.

West Virginia has its own Alternative Fuel Vehicle Tax Credit and a tax credit for alternative fuel infrastructure, both of which include hydrogen among the allowed fuels. West Virginia also has subsidies for alternative fuel buses, and procurement of alternative fuel vehicles by government agencies. Hydrogen fuel cells are also one of the eligible fuels in West Virginia's Alternative and Renewable Energy Portfolio Standard.[146]

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[141] William A. Davis, Update on WVU's hydrogen fueling station, July 19, 2012, 2012.
[142] US Energy Information Administration, "Annual Electric Utility Data – EIA-906/920/923 Data File," (2012).
[143] David L. Greene, K. G. Duleep and Girish Upreti, "Status and Outlook for the US Non-Automotive Fuel Cell Industry: Impacts of Government Policies and Assessment of Future Opportunities," (2012).
[144] Ibid.
[145] US Alternative Fuels Data Center, "Federal Incentives and Laws for Hydrogen Fuel Cells," (2012).
[146] Database of State Incentives for Renewable Energy, "West Virginia Alternative and Renewable Energy Portfolio Standard," (2012).

7.5 Future research

Hydrogen energy is still very much an evolving technology, with an active research agenda on the federal and state levels.[147] The federal government continues to fund research to improve hydrogen fuel technology, both to reduce costs and increase efficiency of hydrogen fuels. The US DOE's Fuel Cell Technologies Program aims to reduce the cost of hydrogen for transportation purposes to between $2 and $4 per gallon of gasoline equivalent (approximately one kg of hydrogen). The program also plans to fund research into better ways to store and transport hydrogen to improve delivery of the fuel.

Aside from research into better technologies, the DOE is also examining ways to provide education and institutional change to improve the environment for hydrogen adoption.[148] The program's goals include setting national standards for safety of hydrogen storage and use, creating and distributing educational materials, and furthering adoption in early hydrogen markets as a way of pushing wider adoption of hydrogen technologies.

7.6 Key observations

- The primary markets for hydrogen include transportation and material handling. Electricity generation is a small market, mostly limited to providing backup power.
- Hydrogen production costs remain high compared with fossil fuel prices, ranging from $1.21 per kg (roughly equivalent to one gallon of gasoline) for hydrogen from coal gasification to $7.26 for distributed wind power.
- The federal and state governments provide numerous subsidies for hydrogen production and deployment, both on the supply and demand side of the market. The federal government also supports a variety of research into hydrogen fuels and fuel cell technologies.
- West Virginia has the potential to become a significant producer of hydrogen, especially if IGCC power plants facilities become more prevalent. However, hydrogen has little potential for widespread adoption in the next five years, and thus the state is unlikely to generate a significant amount during the frame of this report.
- A hydrogen fueling station at West Virginia University is set to begin construction this summer, adding another hydrogen node on the national refueling system.; however, this potential will most likely be limited to fleet cars in the near future.

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[147] US Department of Energy, "Fuel Cell Technologies Program: Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan," (2012).

[148] US Department of Energy, *Secretary Chu Announces FutureGen 2.0*

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