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Climate change and balance of trade

Authors

Hochman, Gal
Zilberman, David

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University of California, Berkeley
Department of Agricultural &
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Gal Hochman and David Zilberman

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Gal Hochman and David Zilberman

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Abstract

In the absence of a global climate agreement, countries employ local policies to curb pollution and introduce clean energy. These policies limit domestic consumption of a traded energy source but increase exports thus improving a country's energy balance and its balance of trade. While focusing on US energy policy, we show this phenomenon for both petroleum products and for coal.

JEL codes:

Keywords: Energy sources, International trade, Technological change, Climate change, Balance of trade, Green Paradox

During the 20th century petroleum products dominated fuel markets. Discoveries of crude oil were ahead of its use, and petroleum prices tended to decline. All this changed with the beginning of the new millennium. Prices of crude oil spiked, climate change became a reality, and policy ushered changes in energy and agriculture markets – making ethanol and biodiesel viable alternatives to gasoline and diesel.

We argue below that the main benefit to the U.S. from this paradigm shift is significantly improving the U.S. balance of trade. Policy ushered adoption of alternatives to gasoline and diesel, while also reducing the U.S. appetite for fuel.[1] In addition, federal support dating back to the middle of the 20th century led to technologies that, since the beginning of the new millennium, substantially increased the US supply of natural gas and crude oil. While focusing on the U.S. oil and gas industry and its alternatives, we attempt to generalize our findings and argue that energy security and local environmental policy motives usher in an era where the U.S. is much less dependent on foreign imports of crude oil and natural gas.

Our analysis suggests that biofuels accounted for roughly 35% of the decline in gasoline consumption in the US from 2005 to 2011, while policies affecting demand and fuel efficiency (e.g., Corporate Average Fuel Economy), as well as the spike of fuel prices and technological advancements in exploration and discovery of crude oil, contributed the other 75%. The US energy policy led to the decline in gasoline consumption and to the introduction of light vehicle fleets with higher miles per gallon (US Energy Information Administration, 2001 and 2013). Policies and funding also accelerated the modernization and increase efficiency of power generation and transfer.[2] The decline in domestic consumption, however, was not met with a similar decline in production but with an increase in exports: the US became a net exporter of petroleum products. The US oil boom revolutionized the energy sector, contributing to the

[1] Other effects discussed in the literature include The introduction of these and other alternatives has significant yet subtle impacts (indirect land use (Zilberman et al., 2013; Khanna et al., 2012), food commodity prices (Chakravorty et al., 2009; Hochman et al., 2011), indirect fuel use (Rajagopal et al., 2011), the indirect co-product effects (Barrow et al., 2012), among other effects). Although there is much potential for future advancements, current generation biofuel contribution to the reduction of the US GHG emissions is limited (de Gorter and just, 2010).

[2] See US EIA data on power generation and transfer as well as various Electric Power Monthly publications available at http://www.eia.gov/electricity/monthly

decline of the share of US crude oil consumption being met by imports from a peak of 60% in 2008 to a predicted rate of 25% by 2015 (Financial Times, 2014).

Similar outcomes are documented when shifting the focus to coal and the introduction of shale gas. The environmental drivers for energy policy combined with demand for energy independence led to positive and significant effect on the US balance of trade. Newly adopted technologies of hydraulic fracturing and horizontal drilling, as well as new discoveries of shale formation led to abundance of domestic natural gas supplies in the US and to the decline in the price of natural gas (Yergin, 2006). At the same time, proposals to limit pollution from coal power plants led construction of new coal power plants to a complete halt. Coal became an exported commodity, while domestic consumption of coal declined and coal plants were shut down and replaced with ones operating on natural gas (Forbes, 2014).

In reaching these conclusions, we shed new light on some of the more subtle yet important implications of the US energy policy; that is, environmental policy targeting pollution from energy sources, in addition to increase abundance of domestic supplies of crude oil and natural gas, led to a substantial decrease in the US trade deficit.

U.S. climate policies and the balance of trade

Mounting concerns for the environment led to policy that addresses greenhouse gas emissions. In most cases, decision makers identified a polluting sector and constructed a policy instrument whose aim was to curb emissions from a local polluting sector.

Since the US budget deficit peaked in 2008, US trade flows of petroleum-based products changed significantly. These changes contributed to substantial narrowing of the US trade deficit.[3] In retrospect, US energy and environmental policies led to the deterioration of domestic demand for petroleum fuels and coal, but to the increase exports of these commodities. Technological innovation from 1998 to 2003 led the oil and gas industry to adopt

[3] See http://www.bloomberg.com/news/2013-10-30/budget-deficit-in-u-s-narrows-to-5-year-low-on-record-revenue.html (viewed November 6, 2013).

hydraulic fracturing and horizontal drilling (Yergin, 2006). These technologies yielded a substantial increase of domestic supply of oil and gas and transformed the US energy sector. These advancements were not in response to concerns pertaining to the effect of environmental regulation on the oil and gas industry, but an outcome of decades of public investment in technological innovations and federal policies.

The petroleum refining industry

Several factors affected the petroleum fuel market since the beginning of the new millennium, including the introduction of biofuels and fuel efficiency policies.

The introduction of biofuels

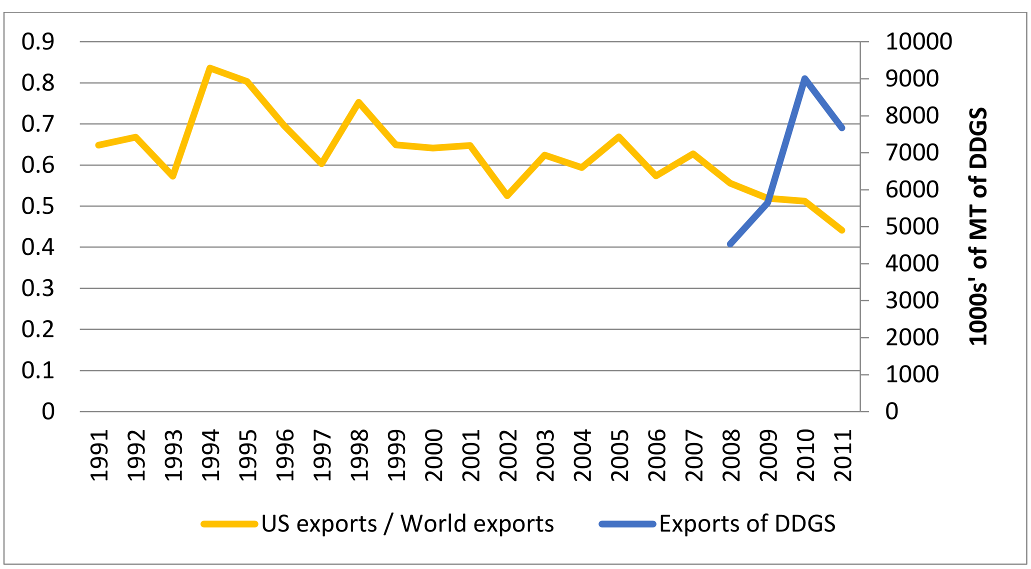
Increasing sales of petroleum fuels first for automobiles and then for airplanes in the early 1900s came as oil discoveries across the United States mounted. As soon as the internal combustion engines created demand, petroleum refiners sought better methods to produce and improve gasoline, and the search for affordable fuels began. Although throughout most of the 20th century petroleum products dominated because of their cost advantages, the beginning of the new millennium came with a paradigm shift whereby ethanol in Brazil (David's book on Brazil) and in the US become a viable alternative to gasoline.

Environmental policy usher in a change when in 1990 Congress passed the 1990 Clean Air Act Amendments that required fuel oxygenates – such as Methyl Tertiary-Butyl Ether (MTBE) and Ethanol – to be added to Reformulated Gasoline (RFG). These oxygenates reduce automotive emissions and improve air quality. Although petroleum refineries preferred the use of MTBE, information toward the end of the 1990s suggested that MTBE is a serious health hazard that contaminates public water systems and private drinking water wells. The gradual phase out of the use of MTBE, led to the introduction of ethanol as a fuel and an oxygenator for gasoline. These changes were followed by a substantial increase in amount of ethanol consumed in the US and in ethanol competing with gasoline.

The introduction of ethanol into the gasoline markets in the US caused fuel prices to decline, although it is likely that OPEC countries alleviated the downward pressure on fuel prices via redistributing benefits from ethanol to their domestic fuel consumers (Hochman et al., 2011b). The introduction of ethanol led to a reduction in domestic demand of gasoline. Although in 2005, the US consumed 3,343,131 thousand barrels of finished motor gasoline annually, in 2011 US consumption of finished motor gasoline declined to 3,194,754 thousand of barrels annually. The amount of ethanol consumed in the US in 2011 equaled 67.25% of the decline of finished motor gasoline consumption from 2005 to 2011. On the other hand, production of US gasoline in 2005 was 3,035,889 thousand of barrels annually but it increased to 3,306,028 in 2011 – an increase of 9%.

The introduction of corn-ethanol, and the policies that ushered its adoption, led to a spike in the use of corn for ethanol (Hochman et al., 2011a), but to a decline in amount of corn-exports. Corn exports declined from 49 MMT in 2000 to 42 MMT in 2011 (Figure 1) – a reduction of 7 MMT. But, because price of corn spiked during the same period, corn-exports ended up contributing to the reduction in U.S. trade deficit. Using FAOSTAT trade data, as well as the IMF corn price index, the value of net-corn exports increased from 2000 to 2011 by 180%.

Figure 1. U.S. corn and DDGS trade flows (source: FAOSTAT and USDA)



Further, corn-ethanol is produced together with a co-product that is a substitute for raw grains in feed, namely, Dried Distillers Grains with Solubles (DDGS). Although in 2005 U.S. corn exports relative to world exports was 0.67, it plummeted to 0.44 in 2011. However, as corn-exports plummeted, production of DDGS increased from 4.5 MMT in 2005 to 7.7 MMT in 2011.

However, the decline of domestic demand for gasoline did not impact much production of petroleum products. Deteriorating conditions domestically, together with the increase supply of domestic crude oil, led refineries to export products abroad and penetrate foreign markets. Petroleum refineries invested to reduce the costs of exporting, but refineries did not invest much to diversify production away from gasoline. The petroleum refining industry invested in blending facilities near ports (e.g., Houston Fuel Oil Terminal Company, located on 310 acres along the Houston Ship Channel (HSC) with marine dock access to the Gulf of Mexico, recently expanded their storage and blending facilities by 1.3 MMBbl) and in converting importing infrastructure to an exporting one.

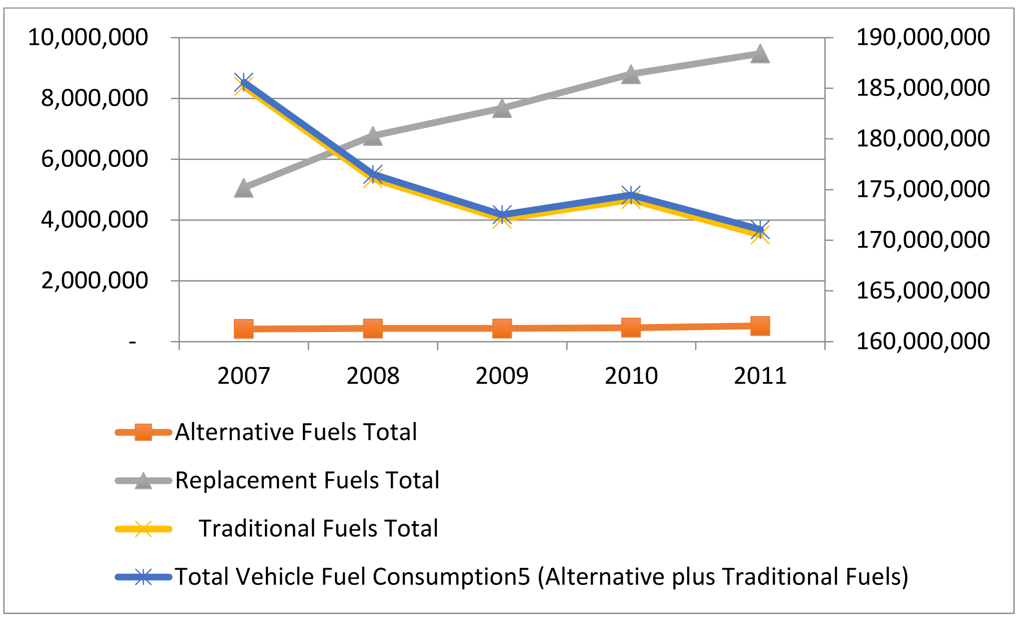
Fuel efficiency

Satisfying increased demand for energy while limiting CO_2 warrants a change in energy use. Affluence needs to be decoupled from energy, and this led regulation in the transportation sector to introduce policy whose goal is to improve fuel efficiency. The U.S. Congress first enacted in 1975 the Corporate Average Fuel Economy (CAFE) standards in response to the Arab Oil Embargo of 1973. The goal of the regulation was to improve the fuel efficiency of light vehicle fleets with gross vehicle weight of 3,856 kg or less. The regulation standards were revised in 2011 and again in 2012 to calculate the CAFE carbon footprint requirements, such that vehicles with larger footprints will have lower fuel economy requirement than vehicles with smaller footprint. Demand for fuel-efficient cars increased further during the beginning of the new millennium, because crude oil prices increased almost ten-folds, from 12 US$ in March 1999 to a 100 US$ and more in August 2013, yielding much higher prices at the pump.

Fuel-efficient policies, especially when coupled with rising fuel prices, led to significant changes in fuel consumption. Since 2007 total vehicle fuel consumption in the US declined from

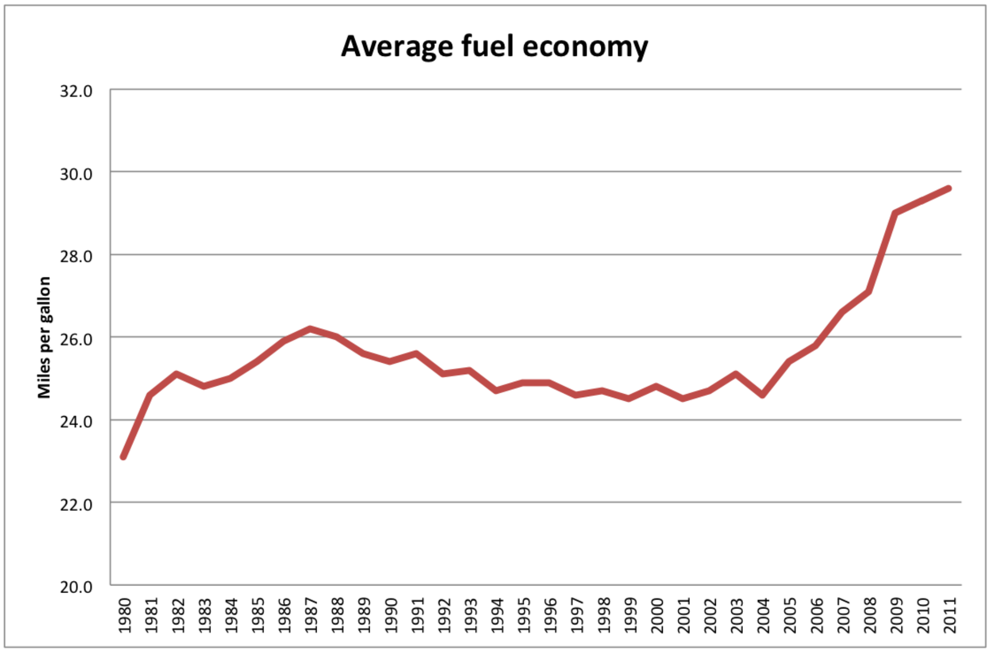
185.5 billion to 171 billion gasoline equivalent gallons – a 7.8% decline (Figure 2, where gasoline and fuel consumption are measured on the secondary y-axis). A similar decline is observed for petroleum fuels (i.e., traditional fuels). However, during the same period, replacement fuels such as ethanol increased by 87.2% while alternative fuels such as compressed and liquefied natural gas increased by 24.4% (Figure 2, measured on the primary y-axis). In sum, since 2007 the decline of traditional fuels (i.e., petroleum fuels) by 14.7 billion gasoline equivalent gallons was met with 4.5 billion of gasoline equivalent gallons of replacement and alternative fuels. The remaining difference is the outcome of fuel efficiency regulation and spiking crude oil prices.

Figure 2. Estimated Consumption of Vehicle Fuels in Thousand Gasoline Equivalent Gallons, by Fuel Type, 2007 – 2011 (EIA)



Since the beginning of the 21st century, fuel efficiency in the US changed drastically: The average miles per gallon of light-vehicle fleet increased from 24.5 miles per gallon in 1999 to 29.6 miles per gallon in 2011 (CITE). While regulation contributed to these changes, the spike in crude oil prices made the changes substantial. The average US retail price of all formation gasoline prices on 1/3/2000 was 1.272 but reached 3.265 on 11/4/2013 (CITE). These changes had a dramatic effect on the vehicle fleets Americans drive. It resulted in a 20.8% increase in average fuel-efficiency, and reduced the amount of gasoline consumed; there was a substantial decline in consumption of gallons per vehicle per year. While in 2000 gallons per light-duty vehicles were 547, fuel consumption dropped to 460 in 2011 – a 16% decline in fuel consumption per vehicle (EIA: Table 8.1).

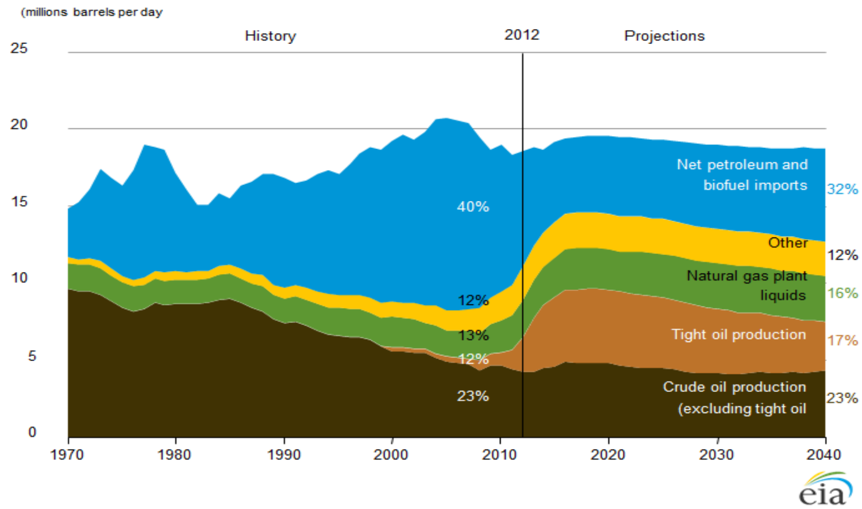
Figure 3. Average fuel economy



Tight oil, hydraulic fracturing and horizontal drilling

A recent report by the International Energy Agency (2013) argued that the North America surge of unconventional oil production (i.e., US tight oil and Canadian oil sands) reshaped oil markets, globally. Currently, the US is second only to Russia in technically recoverable volumes of light tight oil. While crude oil production excluding tight oil is projected to remain stable throughout the first half of the 21st century, tight oil production is skyrocketing. Although the share of tight oil in the U.S. petroleum mix was 1% in 2000 it reached 12% in 2012 and is predicted to reach 17% by 2040 (Figure 4). Tight oil revolutionized the energy sector, resulting in the US ranking 3rd globally in oil production in 2012 (EIA, 2014). However, tight oil became a dominant factor in U.S. energy markets only after 2010.

Figure 1. U.S. petroleum and other liquid fuels supply by source, 1970-2040



The transformation of the U.S. energy markets, however, was preceded with decades of research, development and demonstration, as well as government support (CITE). It was not in response to future expectations regarding the price of oil and gas, or in expectation that in the future regulation may hamper oil consumption.

Directional drilling caught the attention of the oil industry in the late 1920s, and was in response to several law suits alleging that wells drilled in one property had crossed over to an adjunct property and were draining the adjunct reservoir. Directional drilling and portable drilling trucks played a key role in extinguishing the Conroe fire (Wells, 2006). However, not until the 1970s when down-hole drilling motors became common was the technology widely used. Further, although the first hydraulic fracturing experiment was in 1947 at the Hugoton gas field in Grant County of southwestern Kansas (Montgomery and Smith, 2010), only in 1998 did Mitchell Energy achieved commercial shale extraction (Schellenberger et al., 2012).

Although tight oil will substantially impact the U.S. trade deficit from 2011 onward, the drastic improvement in U.S. petroleum trade flows from 2008 to 2011 was largely the outcome of fuel efficiency, high crude oil prices, and the introduction of biofuels. The significant improvement in the petroleum trade flows from 2008 to 2011 was the outcome of local environmental policy that reduced domestic demand for fuel and at the same time ushered in an alternative to petroleum-based fuels.

Electricity and the power industry

The feedstock used to generate electricity in the US is not uniform across the country and fluctuates depending on available sources and market prices. However, in recent years market shares of natural gas increased while coal decreased throughout most of the country. In addition, share of renewables has generally been growing.

Similar to petroleum products, coal is a traded commodity and natural gas can be liquefied and shipped abroad. This is impacting the evolution of the markets for coal and natural gas – markets of commodities that are produced using very capital-intensive processes. Because adapting the distribution system and shipping the commodities abroad is significantly cheaper than adapting production technologies (e.g., adoption of CCS technology), we see a substantial increase in the volume of exports of coal, with a dramatic effect on the US balance-of-trade.

Coal: a victim of hydraulic fracturing and horizontal drilling but also of regulation

In recent years, natural gas in the U.S. became an exception. While prices of other energy sources used by manufacturers were rising, those of natural gas declined. Since 2007, production of natural gas in the United States increased rapidly because of newly discovered shale formations. These discoveries led to a decline of 36% in the average natural gas price paid by manufacturers between 2006 and 2010; price of natural gas dropped from $7.59 to $4.83 per million Btu.[4] The decline in the price of natural gas also resulted in a substantial reduction in total energy cost from all sources. Total energy cost fell by 11% between 2006 and 2010 (2010 Manufacturing Energy Consumption Survey). Since 2010, these trends continued and natural gas prices have fallen further. Natural gas prices hovered around $3.50 per million Btu in mid November 2013 (EIA website).

[4] See http://www.eia.gov/consumption/manufacturing/reports/2010/ng_cost/?src=Consumption-f1 (viewed November 11, 2013).

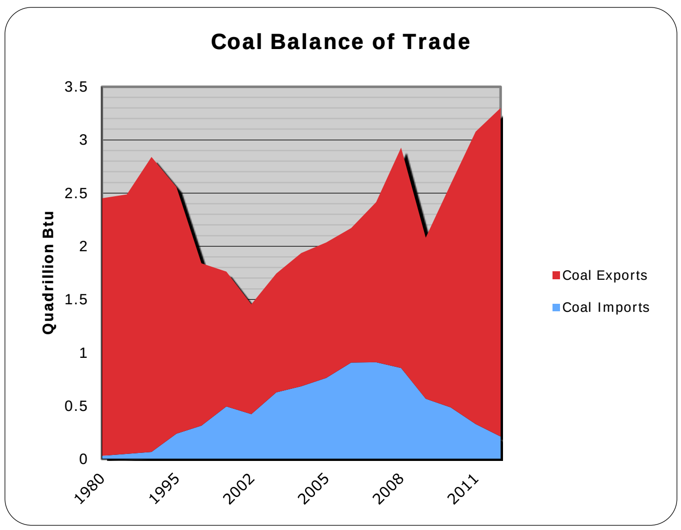
In the face of phenomenal levels of domestic natural gas production, natural gas imports fell by 23% in 2012 and net imports of natural gas as percentage of total natural gas consumed decrease to 6%.[5] The widening of the price gap between the Henry Hub and foreign markets prices led to interests in the US of exporting liquefied natural gas. As of May 17, 2013, 26 applications have been filed with the Department of Energy for authorization to export domestic liquefied natural gas to foreign countries.[6] These changes have the potential to transform natural gas markets and make them global, while also increasing domestic prices: natural gas prices in the U.S. are the lowest in the world, with Europe's prices being more than 5 times those of the U.S. and China's prices about twice as high.

Low natural gas prices are not only impacting nuclear production (e.g., Vermont Yankee nuclear plant decision to close the plant in 2014),[7] but also substantially affecting coal consumption. The coal industry is complaining that there is a war on coal in the US. Coal prices in the US are falling and coal plants are being retired (CITE). However, many of these changes are driven by newly discoveries of shale gas and hydraulic fracturing that lowered natural gas prices (e.g., on November 6, 2013, the Henry Hub spot price was just 3.45 US$ per MMBtu), encouraging utilities to phase out coal in favor of natural gas. This transition has been further augmented with federal environmental regulations that will increasingly limit the type of air pollution associated with old coal plants. The U.S. Environmental Protection Agency released regulations for carbon emissions from new coal-fired and gas-fired plants, which is under the authority of the Clean Air Act and several key Supreme Court decision upholding the agency's authority to regulate GHG emissions: the proposal limits GHG emissions from new coal plants to about 500 kilograms (1100 pounds) per megawatt-hour, where state of the art coal plant emit in mid-November 2013 about 800 kilograms (1800 pounds) per MWh. Although not enacted, the uncertainty regarding newly built coal plants is sufficient to result in utility companies phasing out of old coal plants without rebuilding new ones (CITE).

[5] See http://www.eia.gov/naturalgas/importsexports/annual/ (viewed November 12, 2013)
[6] http://www.eia.gov/naturalgas/importsexports/annual/ (viewed November 12, 2013)
[7] See http://www.eia.gov/todayinenergy/detail.cfm?id=12851 (viewed November 12, 2013).

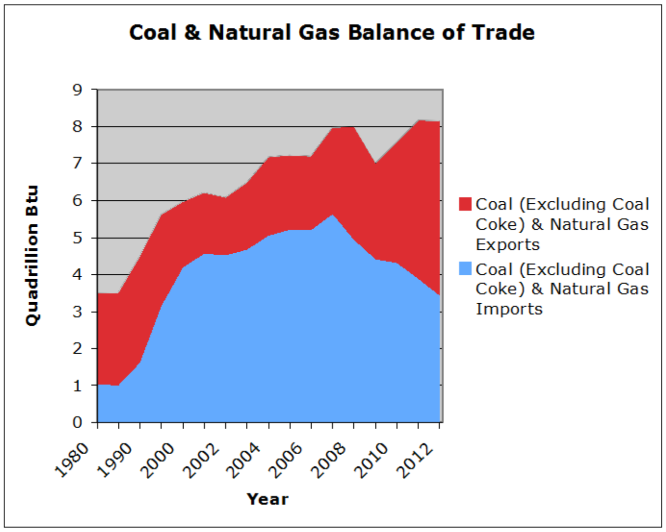
The United States is a net exporter of coal since at least 1955. In 1955, the United States imported just 0.008 Quadrillion Btu, while exporting 1.465 Quadrillion Btu. This trend has continued every year with every year more coal being exported than imported (Figure 4). The most coal the United States imported was in 2007, with 0.909 Quadrillion Btu purchased from other countries, while at the same year 1.507 Quadrillion Btu of coal were exported. The most coal exported by the United States was in 2012, with 3.088 Quadrillion Btu being exported, and only 0.212 Quadrillion Btu imported.

Figure 4. Coal imports and exports



The US produced 22,902 billion cubic feet of natural gas in 2012, which was 19.74% of the world's total production. While being the worlds leading producer, the United States was also the worlds leading consumer of the product, consuming 24,383 billion cubic feet, or 20.54% of the worlds total consumption in 2012. Although the industry has been in a domestic boom the past several years, the United States still has a net trade deficit of 1,962 billion cubic feet of natural gas (see www.EIA.org). However, when combining amount imported and exported of both coal and natural gas, the US became a net exporter in recent years, with the change in trends beginning in 2007 – when extracting natural gas from shale formations began to boom (Figure 5).

Figure 5. Net exports of coal and natural gas in B Btu (2007)



A salient facet of the transition of the US coal industry is the tradable characteristics of coal. Similar to petroleum products, the coal industry responded to the decline in domestic demand, because of new discoveries of shale gas and the proposed federal regulation, by adjusting their distribution infrastructure and significantly increasing export of coal (mostly to Europe).

Policy discussion and concluding remarks:

The new millennium not only came with alternatives to fossil fuels, but also with technology that enables oil and gas companies to exploit shale formations, soft, finely stratified sedimentary rock that formed from consolidated mud or clay and can be split easily into fragile slabs. It led the US to once again become abundant in oil supply (the US was the largest oil producing country in the late 1800s/early 1900s), and to reduce its dependency on foreign oil and gas supply. While technology led to substantial expansion of the US supply of crude oil, the dramatic change of petroleum-based trade flows during the first decade of the current millennium was the outcome of local environmental regulation that usher in the adoption of biofuels and fuel efficiency technologies, as well as rising oil prices.

This paper also alludes to the reasons crude oil and natural gas production boomed in the U.S. toward the second decade of the new millennium. Decades of investments in technologies and their deployment, and not investments in response to concerns pertaining to the effect of environmental regulation on the oil and gas industry, led the U.S. to extract oil and gas from shale formations.

Although US regulation dating back to 1974 prevents exports of crude oil, refineries may refine the petroleum and export its products. Thus, in response to growth in domestic supply of crude oil, importing ports were converted to exporting ports and the US became a net exporter of petroleum products in 2012 with net blending capacity in the US surging and new pipelines coming online (e.g., Seaway pipeline from Cushing to the gulf of Mexico). Powerful forces, however, are raising the question: what should the U.S. do with oil reserves it has in the ground? Should it revisit vestige litigation dating back to the Arab Oil Embargo of 1973 and allow exports of crude oil? Although the idea of free markets justifies such a change, there is also benefit from keep regulation intact. If U.S. policy forces cleaner and more efficient refining processes than in other parts of the world, supplying the rest of the world demand for energy and thus reducing incentives abroad to invest in further exploration, extraction and production of oil and gas may result in a more favorable outcome to the environment. These changes may also postpone future investments in oil and gas in other parts of the world thus prolonging the era of petroleum fuels on Earth.

We predict that the political debates surrounding crude exports, as well as building pipeline infrastructure from Canada to the Gulf, are only the beginning of intense debates regarding future of the fossil industries and their utilization. Although in the past, energy security and environmental motives went hand-in-hand, because of hydraulic fracturing and horizontal drilling these motives have separated, resulting in proponents of one group rejecting actions proposed by the other.

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