Impacts of shale gas revolution on natural gas and coal demand

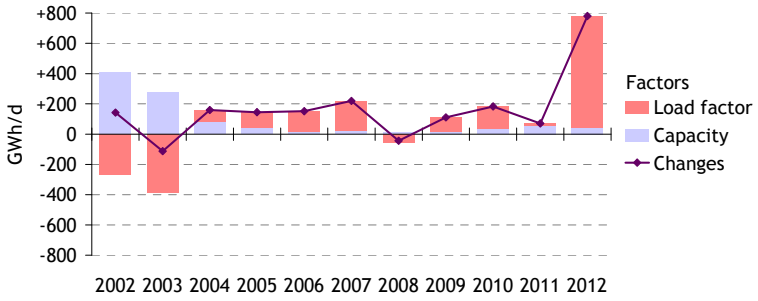
—Power generation mixes in both sides of Atlantic swung with natural gas price in the U.S.—

YANAGISAWA Akira
Energy Demand, Supply and Forecast Group
Energy Data and Modelling Center

Summary

The production of shale gas in the United States is skyrocketing. Supply and demand balance of natural gas is eased significantly and the price sagged to one quarter of the last highest level recorded four years ago. Wider use of natural gas in power generation has been seen due to the drop in natural gas price. The trend was significant in 2012 and electricity generated by natural gas was almost as much as coal in April. However, most of the current increase in natural gas power generation stems from the rise of its load factor—changes in operation—rather than by expansion of capacity. In other words, fuel choice for power generation can be changed significantly depending on fuel prices.

Decomposition analysis of changes in natural gas power generation in U.S.



Substitution between natural gas and coal becomes significant when the relative price of natural gas to coal is lower than a certain level. Under the current situation, the power generation ratio of natural gas to coal will increase by 0.047 and shift to natural gas progresses if the relative price of natural gas to coal decreases by 0.1.

Natural gas prices are less interconnected among markets. The impacts of the shale gas revolution, however, do not stay in the United States domestically. Surplus coal substituted by natural gas in the United States is exported to Europe. Europe has increased coal power generation due to low coal price led by imported coal of U.S. origin and low CO_2 price. The United Kingdom has reduced natural gas power generation sharply while increasing coal. Both electricity generated by natural gas and its share in 2012 were the lowest in the last 15 years.

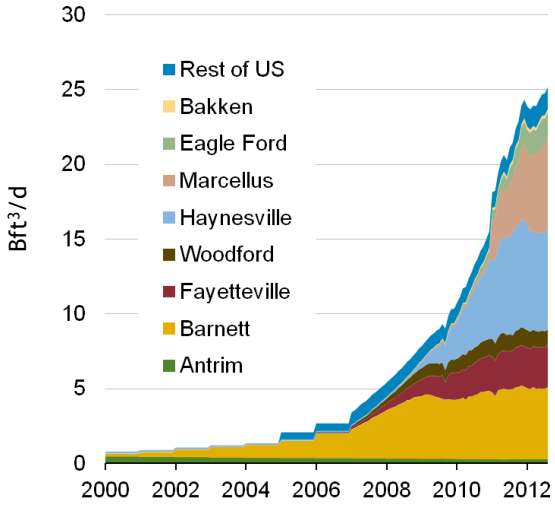
Natural gas price today in the United States is well below production cost of unconventional natural gas. It is not obvious whether the current low natural gas price is sustainable in the future or not. Utilisation of natural gas in the United States will nosedive and the power sector will return to coal once natural gas price rises. This may lead to weakened momentum in the increasing coal power generation in Europe. Consequently, both sides of the Atlantic Ocean may see swing backs in their power generation mixes.

Keywords: Shale gas revolution, natural gas, coal, power generation mix, United States, Europe

Natural gas price sags due to the shale gas revolution

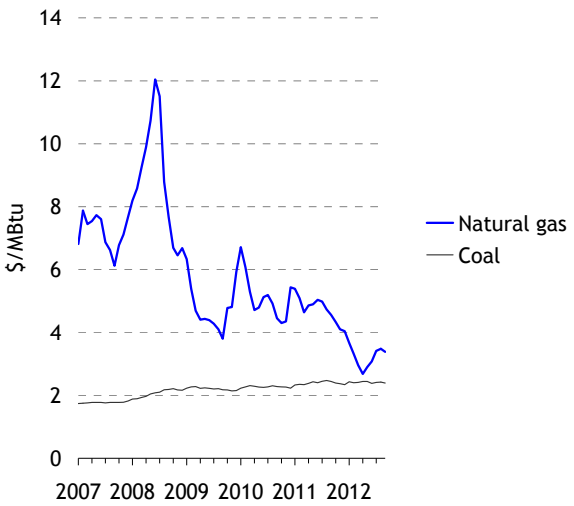
Production of unconventional natural gas, especially shale gas, in the United States is skyrocketing (Figure 1). The increase eased the supply and demand balance of natural gas significantly and lowered the price to one quarter of the last highest level recorded four years ago (Figure 2). The price is as low as one fifth of the import price in Japan, which increased liquefied natural gas or LNG demand as a substitute fuel to nuclear power generation.

Figure 1: Shale gas production



Note: Dry gas
Source: Adam Sieminski, "Outlook for Energy Markets"

Figure 2: Natural gas and coal prices



Note: Price for power generation
Source: U.S. Energy Information Administration, "Electric Power Monthly"

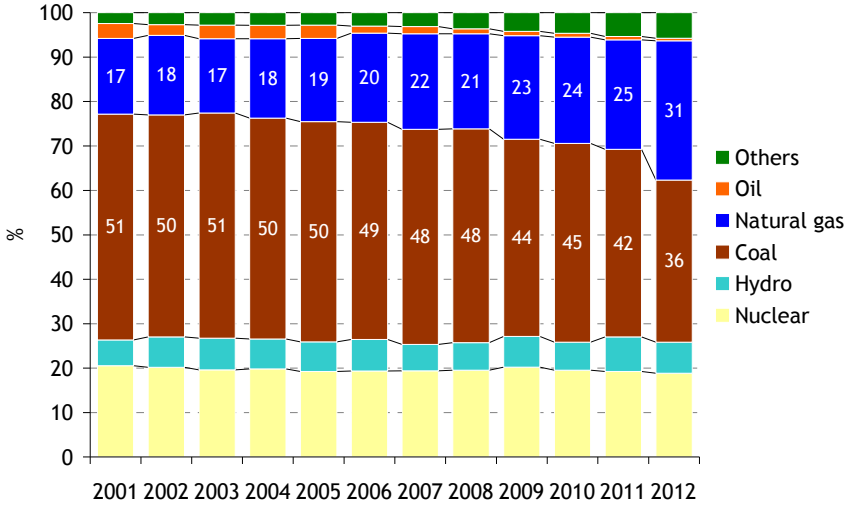
The current natural gas price is lower than the production cost of unconventional natural gas, say, $4–6/MBtu. The low price, however, does not lead to slowdown of shale gas production since some shale gas is associated with shale oil production, which has developed rapidly[1].

Natural gas power generation expands while coal power generation shrinks

The United States has seen wider use of natural gas in its power generation due to the drop in natural gas price. Although natural gas power generation used to account for less than one fifth in total generation[2], its share is growing year by year (Figure 3). An energy source substituted by natural gas is coal. Coal power generation used to account for half of total generation, but we see its shrinking trend in recent years. The trend was significant in 2012 and electricity generated by natural gas was almost as much as coal in April (Figure 4).

[1] Active rigs of oil surpassed those of natural gas in 2011.
[2] Net generation (= gross generation - own use). The same shall apply hereinafter.

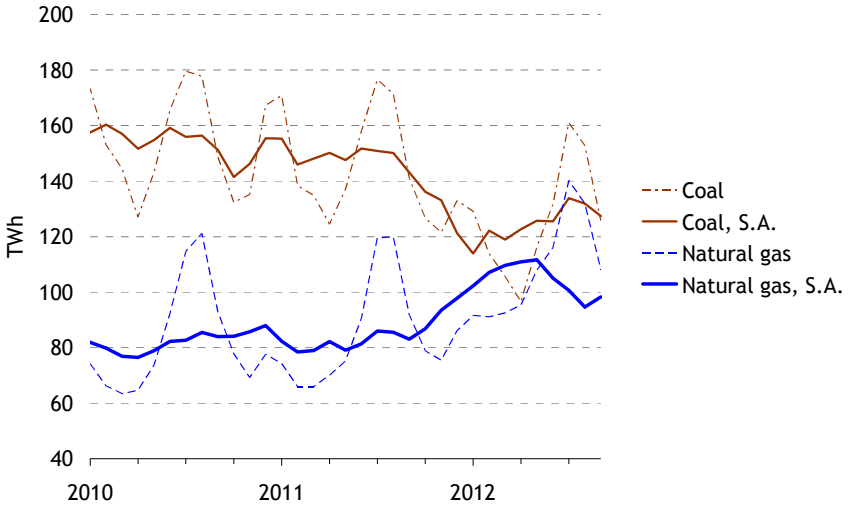
Figure 3: Power generation mix



Note: January to September for 2012

Source: U.S. Energy Information Administration, "Electric Power Monthly"

Figure 4: Electricity generated by natural gas and coal (seasonally adjusted and original)



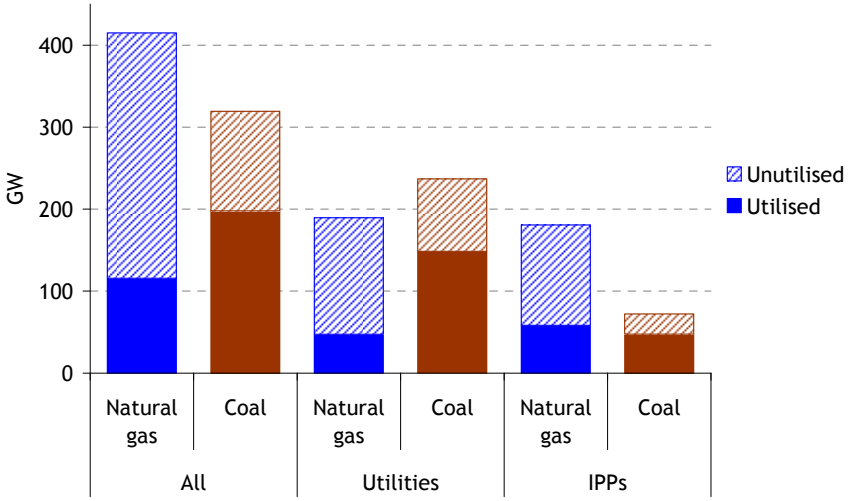
Source: Calculated from U.S. Energy Information Administration, "Electric Power Monthly"

The lead time of natural gas power generation plants is relatively short. However, most of the current increase in natural gas power generation stems from the rise in its load factor—changes in operation—rather than by expansion of capacity (Figure 5). Natural gas power generation plants are often utilised as middle–load power plants and their operation is not round–the–clock. Therefore, there is enough room for increasing their load factor to generate more electricity flexibly if conditions are satisfied (Figure 6).

Figure 5: Decomposition analysis of changes in natural gas and coal power generation

Note: January to September for 2012

Figure 6: Utilised and unutilised capacity of natural gas and coal power generation plants (2011)



Note: Based on annual generation amount. Unutilised capacity does not mean no generation.
Source: Calculated from U.S. Energy Information Administration, "Electric Power Monthly"

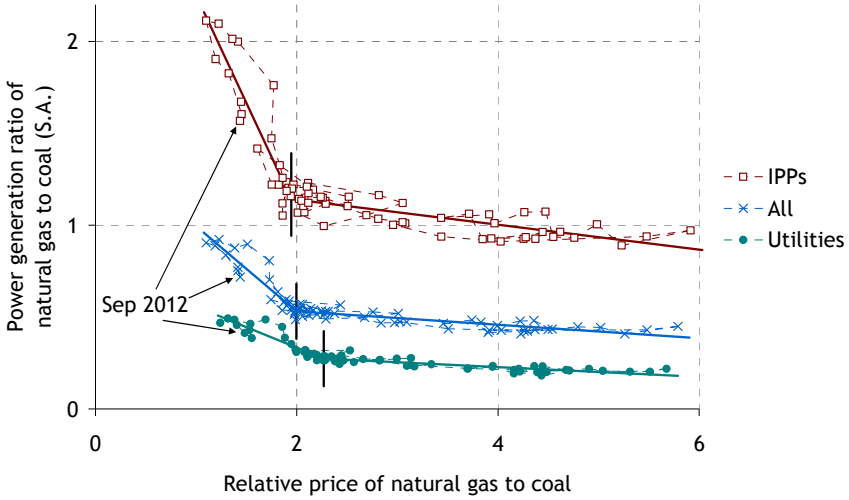
The decrease of coal power generation, which is substituted by natural gas, is also due to change in its load factor. The contribution of low load factor to coal power generation in 2011 (January to September) was as much as in 2009 when the financial crisis caused by the Lehman Shock had an effect.

Substitution between natural gas power generation and coal power generation

It is usual that power generators try to curtail their generation cost by adjusting the power generation mix within all sorts of conditions. Fuel cost plays an important role in the criteria for power generation mix in the short–term.

Substitution between natural gas and coal becomes significant when the relative price of natural gas to coal is lower than a certain level. In this case, a slight change in relative price of natural gas to coal results in a sharp change in the power generation ratio of natural gas to coal (Figure 7).

Figure 7: Relative price of natural gas to coal and power generation ratio of natural gas to coal (seasonally adjusted)



Note: January 2007 to September 2012
Source: Calculated from U.S. Energy Information Administration, "Electric Power Monthly"

To be concrete, the power generation ratio of natural gas to coal will increase by 0.047[3] (natural gas generation increases) if the relative price of natural gas to coal decreases by 0.1 (natural gas price drops) when the relative price is lower than threshold (2.00) as we observe today. On the contrary, the sensitivity is duller when the relative price is higher than the threshold; decrease of the relative price by 0.1 results in increase of the power generation ratio by only 0.004, being one digit smaller. A similar tendency can be observed when utilities and IPPs are analysed separately (Table 1). It is notable that IPPs, which are more economically oriented, have sharper sensitivity and lower threshold.

[3] Corresponding to the slope × 0.1 in Figure 7.

Table 1: Sensitivities of power generation ratio (seasonally adjusted) to change in relative price of natural gas to coal

		All		
			Utilities	IPPs
Threshold in relative price of natural gas to coal		2.00	2.27	1.95
Sensitivity of natural gas/coal generation ratio to change in their relative price by 0.1	<= the threshold	-0.047	-0.022	-0.117
	> the threshold	-0.004	-0.003	-0.007

Note: January 2007 to September 2012

The relative price of natural gas to coal of around 2.0 observed as the threshold is a high level for natural gas power generation if we consider only fuel cost. Parity relative price making natural gas power generation and coal power generation even is 1.33[4]; the threshold is much higher than the parity price. The following may affect the discrepancy: (i) operation costs other than fuel cost, (ii) better response of natural gas power generation to change in load, (iii) no emissions such as coal ashes, and (iv) regional[5] greenhouse gas emission trading systems[6] like Regional Greenhouse Gas Initiative, or RGGI, in the Northeast and Mid–Atlantic states, and Cap–and–Trade Program in California.

Impacts of the shale gas revolution across the Atlantic Ocean

Natural gas prices are less interconnected among the major markets and are hardly arbitraged rapidly. For example, the low natural gas price in the United States does not affect LNG price in Japan directly. The impacts, however, do not stay in the United States domestically. Surplus coal substituted by natural gas is exported to Europe (Figure 8).

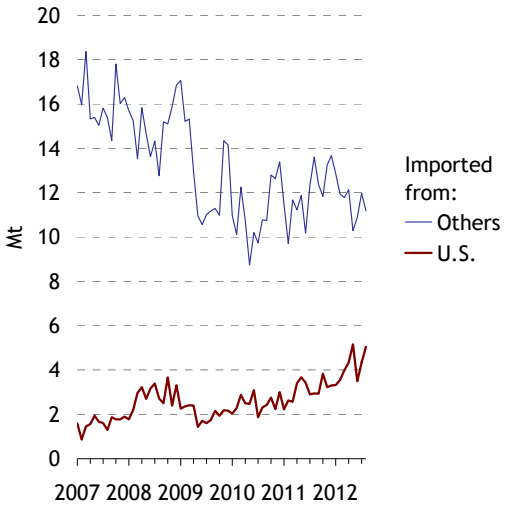
In contrast with the United States, Europe has increased coal power generation and substituted natural gas power generation due to low coal price led by imported coal of U.S. origin, low carbon dioxide price (Figure 9) and high natural gas price.

[4] Calculated assuming natural gas power generation thermal efficiency of 43.2% and coal of 32.5% based on the historical values from January to September 2012.

[5] No introduction in the federal level.

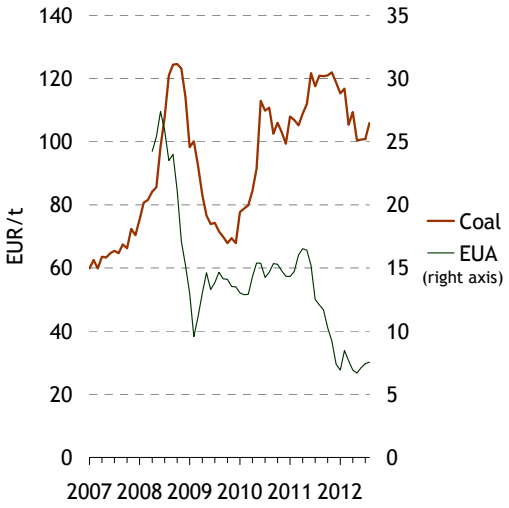
[6] The parity relative price is 1.39 assuming coal price of $2.39/MBtu based on its historical price in September 2012 and CO_2 price of $2/t derived from its historical price in RGGI. It is 1.64 assuming CO_2 price of $10/t derived from California.

Figure 8: Coal imports by the European Union



Source: Eurostat

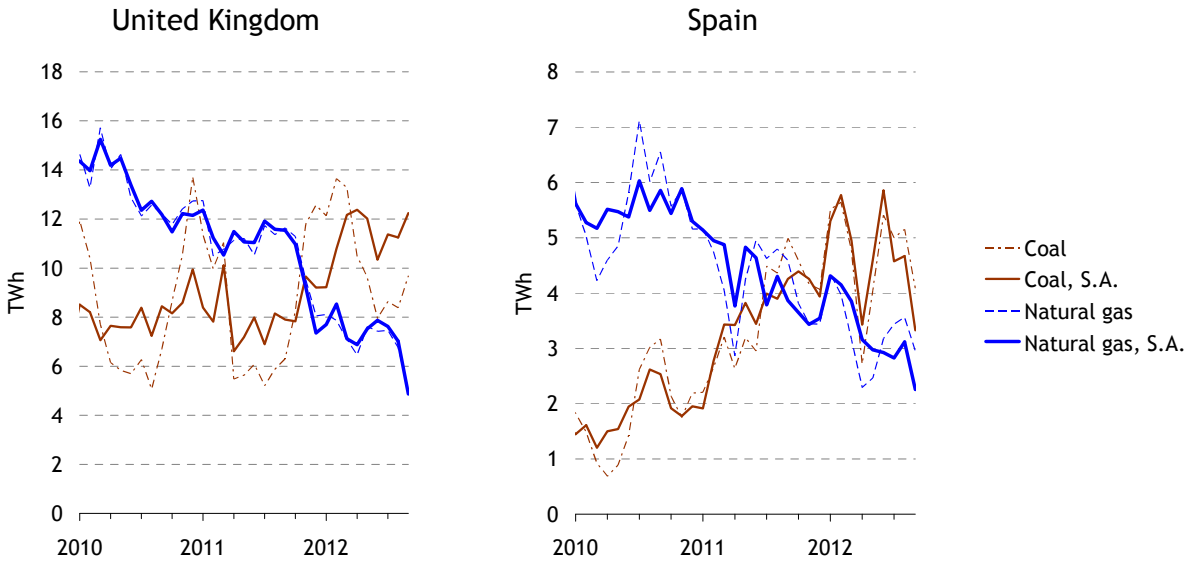
Figure 9: Coal import price of the European Union and EU emission allowance price



Source: Eurostat, IntercontinentalExchange

For instance, the United Kingdom has reduced natural gas power generation sharply since the autumn of 2011 (Figure 10). Both electricity generated by natural gas and its share in 2012 were the lowest in the last 15 years. In Spain, coal power generation, which used to be less than half of natural gas power generation, surpassed natural gas power generation in 2012.

Figure 10: Natural gas and coal power generation in the United Kingdom and Spain (seasonally adjusted and original)



Source: Calculated from U.K. Department of Energy and Climate Change

Source: Calculated from Red Eléctrica De España, "Boletín mensual"

Where are we headed for?

What will be the forthcoming trend after natural gas power generation has increased rapidly in the United States? Natural gas power generation has the characteristics of environment–friendly and good response to load. If natural gas price is low as recorded in mid–2012, it is highly possible that the U.S. power sector will have a preference for natural gas power generation substituting coal power generation. As if to suggest such situation, additions of natural gas power plants are already planned in and after 2013 while little coal power plants are planned to be built. Additions of capacity, however, are little compared with the existing capacity. Change in electricity generation in the next couple of years will be shaped by increased load factor like today.

As described above, natural gas price today in the United States is well below production cost of unconventional natural gas. It is not obvious whether the current structure—low natural gas price—supported by shale oil in terms of business is sustainable in the future or not. Utilisation of natural gas will nosedive once natural gas price rises since the current relative price of natural gas is lower than the threshold.

The "Short–Term Energy Outlook" of the Energy Information Administration has revised downward the projection of natural gas power generation after the upward revision of natural gas price projection, which had been lowered in editions released until mid–2012. Its November 2012 edition says natural gas power generation will reduce by 11% to 1,109 TWh in 2013 from 1,246 TWh in 2012. In contrast, coal power generation is projected to return to 1,635 TWh in 2013 surpassing 2012 by a large degree yet it will not recover to the 1,733 TWh recorded in 2011.

U.S. coal exports to Europe will decrease and the country's power sector will return to coal power generation if natural gas price rises. This may lead to weakened momentum in the increasing coal power generation in Europe. Consequently, both sides of the Atlantic Ocean may see swing backs in their power generation mixes.

Contact: report@tky.ieej.or.jp