US Energy and Climate Legislation – The Big Deal

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1. Introduction and Summary

a. Summary of the argument

US climate change legislation will play a central role in determining the substance and effectiveness of any global agreement to replace the Kyoto Protocol when it expires in 2012. This paper analyzes draft US climate change legislation, in particular the Waxman Markey (WM) Bill that was passed by the House of Representatives earlier this year. I argue that WM and the Kerry-Boxer (KB) legislation that is being debated in the Senate will fail to promote an early transition to a low carbon economy. I propose amendments that would bring the legislation more into line with the aim of making that transition as soon as possible. Below, I summarize the main points of the paper.

First, draft US legislation is timid in a number of respects. It postpones significant emissions cuts until well into the future. Furthermore, it relies on price signals from CO2 markets to drive CO2 emission reduction in the short and long term, but introduces various 'cost mitigation' measures to keep CO2 prices down – thereby weakening the incentive to cut emissions. Generally, this leaves investors and the rest of the world wondering whether and when the US is going to take action that will be effective in cutting emissions, especially from existing coal stations.

Second, the legislation is timid because it aims to win support from those sectors that are most negatively affected by it. One goal of the legislation is to provide transitional support for the coal industry and its customers, notably in the power sector. A central point is that the WM legislation does not regulate emissions from *existing coal-fired power stations*, which are a very substantial source of CO2 emissions. Under the Clean Air Act, the EPA is now authorized to regulate those emissions. In this respect, the draft legislation weakens the direct regulation of emissions from existing coal-fired stations.

Third, the likely result of timidity has been described as equivalent to merging slowly onto a highway with very fast moving traffic – in other words, it is very dangerous. Going too slowly on climate creates several potential problems.

- The US may not shut down important sources of CO2 emissions, notably coal-fired power stations, for a long time, leading to a large build up of CO2 that has to be offset rapidly and expensively later.
- Legislation creates inadequate price incentives to finance the development of zero and low carbon generation technologies, including CCS on new and existing coal and gas power stations, as well as renewable and nuclear power.
- Prices will also be too low to provide the necessary demand-side incentives to cut energy consumption and related emissions.
- The legislation could therefore slow the move towards a zero carbon electricity sector, postponing the adoption of PHEV that would lower dependence on imported oil.

- Coal dies slowly rather than being transformed into a new technological base, and meanwhile the US builds a lot of natural gas plants[2] that will be obsolete before the end of their engineering lives.
- The failure of weak market mechanisms to achieve climate objectives will eventually lead to their abandonment and to regulated procurement – but with a very significant delay.

Fourth, the draft legislation does not send the right signal to the rest of the world, in particular to China. The US is signalling that there is no need to take urgent measures to cut CO2 emissions from existing coal-fired plants. Indeed, existing US plant is much older and less efficient than Chinese power stations and there is a stronger case to shut plant in the US than in China. If China follows the US down the path of not cutting emissions from existing plant, the prospects of stabilizing the concentration of GHG in the atmosphere would virtually disappear. And if China moves ahead of the US to develop and adopt carbon capture and storage (CCS) for their existing and new coal plants, then the US will lose an important commercial opportunity.

Fifth, faced with these prospects, I propose a plan to revise US legislation. There are two alternatives – both of which involve making an earlier transition to a low carbon economy. My preferred approach is to rely on CO2 markets, but this would only make sense if legislation promises significantly higher and stable CO2 prices to encourage investment in a range of carbon reducing technologies and to drive down emissions from existing plant. Even in this case, targets are seldom credible, especially if they lie well into the future. If this approach is not politically realistic, then we cannot rely on CO2 markets to promote the necessary investment and transformation. The alternative approach is to rely more on non-price signals (e.g. CO2 emission standards) to promote retrofitting of existing coal plants to lower CO2 emissions, or a timetable for their closure. Following the latter approach, the EPA would be responsible for administering the emission standards identified in the legislation. Finally, I conclude that for either alternative, the legislation should leave as much room as possible for technological innovation, to promote a range of technologies in addition to CCS.

b. Outline of the paper

The paper has six sections in addition to this introduction and summary. Section 2 introduces my understanding of the conclusions of the science of climate change and the role of policy in addressing it. I accept the view that public policy aimed at cutting greenhouse gas (GHG) emissions, significantly and urgently, is a form of insurance against truly cataclysmic climate change. A wide range of technologies – from renewable energy to nuclear and CCS, as well as energy efficiency and the end of deforestation – will be required. The question is what sort of public policy will promote the enormous investment required in order to achieve significant, early and sustainable cuts in emissions.

Section 3 examines the importance of *coal-based emissions from existing power stations*. These account for a very large and growing share of global emissions, especially in the US and China. There is no way to stabilize the global concentration of GHG at acceptable levels without cutting emissions from these stations.

[2] Some natural gas-fired plants will certainly be needed, not least to back up renewable energy. However, these plants also emit CO2. These emissions must also be eliminated in order to decarbonize the electricity sector.

Section 4 examines briefly the basic technologies (including CCS) available to cut emissions from these stations. It concludes that CCS could potentially play a very significant role in meeting the challenge of climate change, but there is still a significant uncertainty about the costs of CCS and the likelihood that it will be adopted on a large scale in the next twenty years.

Section 5 analyzes US draft climate legislation, and in particular the way it deals with coal-related power. The focus on coal is for three reasons. First, coal-based power is a major source of energy and of CO2 emissions in the US. Second, the US has the world's largest reserves of coal and it is evident and understandable that the main parties want this vast resource to be somehow accommodated in US climate and energy policy. However, the protective political instincts being applied are not in the long-run interests of the coal producers, the environment, or the US economy. As I explain later, a policy of cautious gradualism with respect to conventional coal will lead to its extinction, not a soft landing. Third, the influence of the coal lobby, and the need to obtain their support, is the main reason why that legislation is so timid.

Section 6 identifies a number of concerns with draft US legislation and its reliance on politically-influenced markets, especially to reduce emissions from existing coal plants. I argue that the legislation is too tentative and will not enable the US to make an early transition to a low carbon economy.

Section 7 proposes a plan to make the legislation more effective. As mentioned above, there are two possible ways forward, which place a greater or lesser reliance on market forces. My overall conclusion is that, in the current political and economic situation, it is difficult to have confidence in the CO2 price and targets as a basis for making the transition to a low carbon economy. Non-price measures may well be more effective, in particular as a basis for cutting CO2 emissions from existing coal-fired power stations. However, it will be important to design and implement those measures in a way that is technology-neutral, leaving as much room as possible for technological innovation.

2. The challenge of climate change – science and politics

Most climate scientists who are studying the link between climate and greenhouse gas emissions have little doubt that man-made emissions are the cause of an increasingly serious crisis of climate change[3]. Of course, some disagree strongly. I find it difficult to understand how the world's governments could take the risk of catastrophic climate change lightly, given the fact that we have only one planet. The Financial Times put this quite well in a recent editorial[4].

> "Ultimately, when all the uncertainties are combined with the scientists' view that we are doing something significant to the global climate, a good reason why the world should invest hundreds of billions of dollars in cutting carbon emissions is to insure against truly cataclysmic climate change that might destroy industrial civilization".

[3] IPCC Climate Change 2007: Synthesis Report, adopted by IPCC Plenary XXVII (Valencia, Spain, 12-17 November, 2007).

[4] Financial Times, Monday November 2, 2009, Editorial, Page 10.

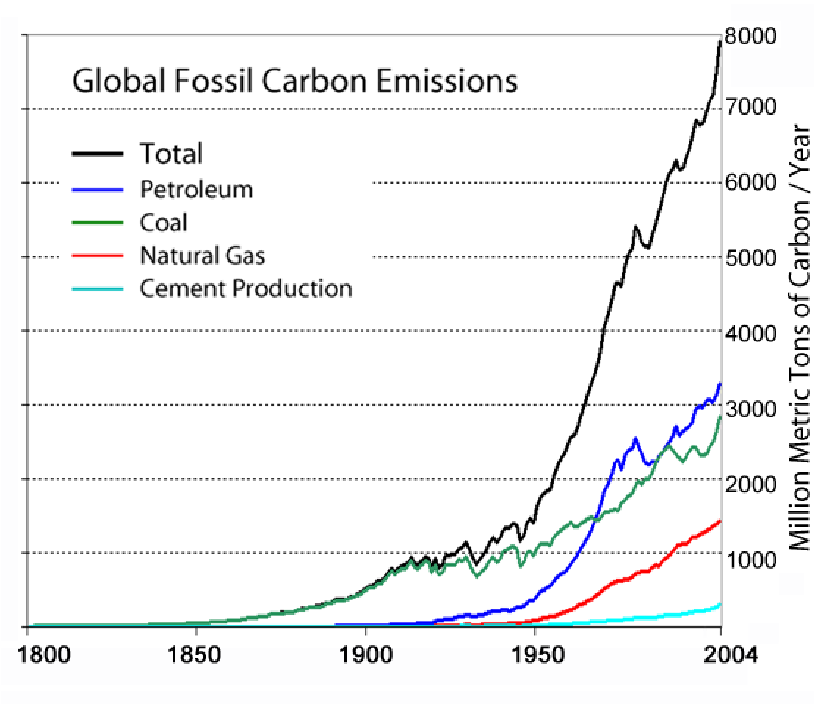
Although I claim no scientific expertise, I am sufficiently persuaded by the weight of the evidence in the IPCC's reports to accept that there is a good economic case to curb greenhouse gas emissions, if only as a form of insurance. In this part of the paper, I summarize briefly some of the recent scientific evidence of climate change, the evidence of growing global CO2 emissions from fossil fuels, and the politics of curbing those emissions.

a. The Science

Recent evidence from MIT,[5] published in the American Meteorological Society's *Journal of Climate*, indicates a median probability of surface warming of 5.2 degrees Celsius by 2100, with a 90% probability range of 3.5 to 7.4 degrees. This can be compared to a median projected increase in the 2003 study by MIT of just 2.4 degrees Celsius. The conclusions of the recent MIT study are presented on a large roulette wheel, which reminds us of the significant uncertainty and, perhaps, also that we are gambling with the world's future!

As the graph below illustrates,[6] global fossil carbon emissions have been growing steadily for more than 200 years, but accelerated quite substantially after 1950. This acceleration has strained the earth's capacity to reabsorb the emissions naturally, leading some climatologists to argue that we are closer to the probability of abrupt (or runaway) climate change.

Figure 1: History of Global Carbon Emissions (1800 – 2004)



Source: Carbon Dioxide Information Analysis Centre, http://cdiac.ornl.gov/trends/emis/glo.html.

There are a number of positive feedbacks that appear to contribute to global warming. One is through the release of methane gases (for instance, through the melting of Artic permafrost) which are far more powerful greenhouse gases than carbon dioxide. The melting of sea ice

[5] http://web.mit.edu/mitei/research/spotlights/change-odds.html
[6] CDIAC, http://cdiac.ornl.gov/trends/emis/glo.html.

also creates an albedo affect. The sea absorbs heat from the sun, while the ice largely reflects the sun's rays back to space. When sea ice melts, it exposes the sea to the sunlight; this heating will contribute to further warming. Along with changes in atmospheric and ocean currents, this is a further reason why the IPCC predicts that polar temperatures in the northern hemisphere will rise up to twice as much as those of the rest of the world. Scientists are increasingly concerned that positive feedbacks like these will cause a runaway greenhouse effect.

The consequences of the failure to stabilize CO2 concentration at acceptable levels would affect hundreds of millions of people. The hardest hit will be in developing countries, with growing problems of health, access to food and water, loss of homes to floods, drought and radical weather events, and more frequent wars over access to resources. The governments of the wealthiest countries, including the US, also recognize that this could undermine global political, economic and military stability, and that climate change will create serious problems for their own citizens.

b. The politics

Governments have been discussing domestic and international policy action to address climate change since the late 1980s. So far, they have delivered very little. Consider the following figures.

- CO_2 emissions have risen almost 30% since these negotiations began in 1988.
- CO_2 emissions rose at 1.1% per annum from 1990 to 2000, but rose to 2.9% after 2000, after the signing of the Kyoto Protocol in 1998.
- Coal-based emissions grew at 1% from 1990-2000, but at 4.4% since 2000.

To avoid dangerous interference in the world's climate, the world's governments have committed to limiting temperature increases to 2 degrees Celsius in this century, which apparently requires the stabilization of GHG concentration at 450 ppm of CO2 equivalent, and probably less.[7] The longer the world waits to take action, the faster and more expensively we will have to finish the job.

To achieve the 450 ppm level of GHG concentration, global emissions must peak and then start dropping between 2015 and 2020. Since developing country emissions will continue to grow for some time after that, industrialized countries must start by cutting emissions by 25-40% by 2020, using 1990 as the base year.

Two things are very clear. First, stabilization of GHG concentration levels will require massive investments in many different low-carbon technologies to decarbonize the power sector (through nuclear power, renewable energy and CCS), to electrify the land transport sector (e.g. plug-in hybrid vehicles), to substantially reduce energy consumption and to end deforestation. Second, on current performance, the world is unlikely to meet any of these climate targets. The clock is ticking and the bomb could go off at any moment.[8]

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[7] IEA World Energy Outlook 2008, page 47.
[8] There is a global campaign of NGOs pressing for an ambitious climate deal in Copenhagen. It is called Tcktcktck. See *www.**tcktcktck**.org/*

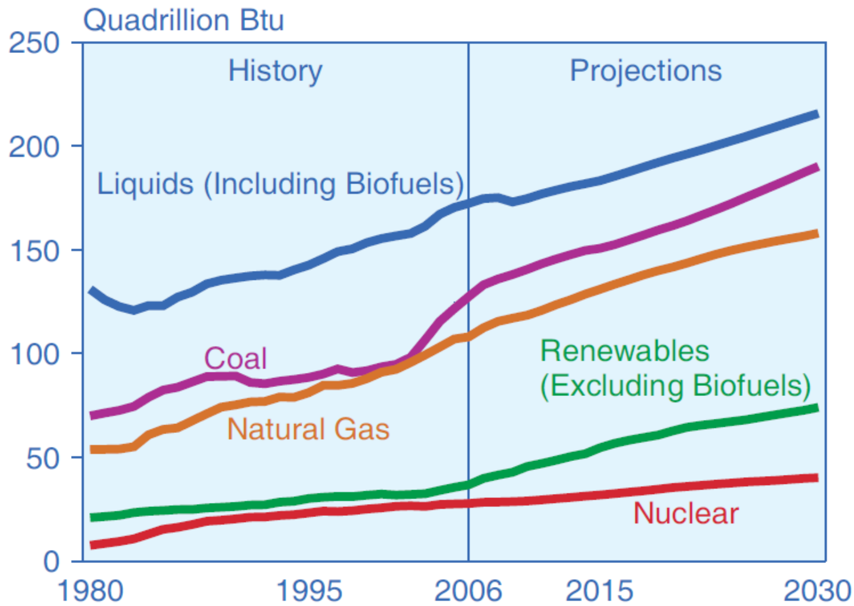
There is no silver bullet, but one critical part of the solution involves reducing CO_2 emissions from coal-based electricity – which is now the largest source of CO_2 emissions. Below, I explain why it is so urgent to cut emissions from *existing coal-based power stations*, especially in the US and China.

3. The threat from existing coal-fired power stations

a. Coal as an increasingly source of energy and CO2 emissions

Coal demand has grown more in absolute terms than any other energy source over the past ten years. Notice in particular the growth since about 2000, when Chinese demand for coal began to grow substantially.[9]

Figure 2: Global Energy Demand by Source (1980 – 2030)



Source: IEA (2008), *World Energy Outlook*, page 80.

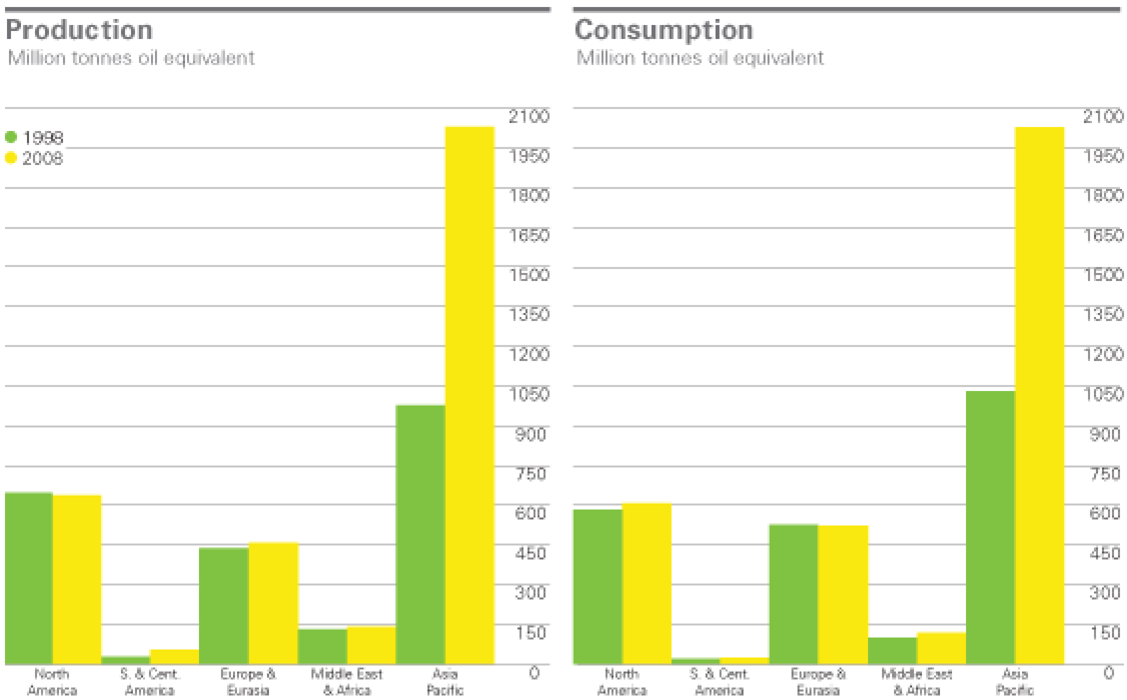
Coal is also the largest and fastest growing source of anthropogenic CO_2 emissions in absolute terms. According to the IEA, in 2006, coal accounted for 42% of world (energy related) CO_2 emissions of 27.9 billion tons. By contrast, petroleum accounted for less than 39%.[10]

On current trends, coal will become an even more important source of emissions than it already is. The IEA Reference Scenario in their 2008 World Energy Outlook, for instance, forecasts that by 2030, petroleum's share will be down to 36% and coal's share will be up to 46% of a much higher level of global energy-related CO_2 emissions, of 40.6 billion tons CO_2.

[9] IEA (2008), *World Energy Outlook*, page 80.
[10] IEA (2008), *World Energy Outlook*, page 507.

The US and China currently account for more than half of the world's production and consumption of coal, and of coal-related CO2 emissions. In 2006, together they accounted for about 57% of coal-based CO2 emissions. In 2030, their combined share of emissions will rise to 62% according to the IEA Reference Scenario. This increase comes primarily from China, whose annual consumption of coal will account for more than 60% of the global increase! The BP graph below reflects the importance of Asia (China) and North America (US) in the production and consumption of coal.[11]

Figure 3: Global Production and Consumption of Coal (1998 & 2008)



World coal consumption grew by 3.1% in 2008, the first below-average increase since 2002. Coal nonetheless remained the fastest-growing primary energy source for the sixth consecutive year. China accounted for more han 85% of global growth even though Chinese consumption growth was below average.

Source: BP Statistical Review of World Energy, 2009

b. Electricity as the key source of coal-based emissions

By far the most important source of CO2 emissions from coal is associated with electricity generation. Outside China, nearly all coal is used for electricity generation. Globally, in 2006, coal-source electricity accounted for 8.3 billion tonnes of C02 – more than 30% of world energy related CO2 emissions. The IEA Reference scenario predicts that coal-based electricity emissions will rise to 13.5 billion tonnes CO2 by 2030, and account for 33% of the much larger global total of 40.6 billion tonnes.[12]

The US and China together account for over 50 % of the world's coal-based power capacity, which is about 1,333 GW. Over the past five years, China has brought on stream coal-based capacity approximately equal to the entire US coal fleet; China also plans significant further additions.

[11] BP, Statistical Review of World Energy 2009.
[12] IEA (2008) *WEO 2008*, page 507.

Together, these two countries are responsible for almost 60% of current emissions from coal-based electricity. In the US in 2006, coal accounted for 80% of emissions from the power sector, and coal-based generation alone accounted for 34% of US energy-related CO2 emissions. US emissions from coal-based power are currently more than the oil-based emissions of the entire US transport fleet of all kinds.[13] And US coal-fired power plants over 35 years old alone account for 7% of global CO2 emissions.[14]

By far the most significant anticipated increase in coal-based emissions comes from China. There, the IEA Reference Scenario is that Chinese coal-based power emissions will rise from 2.8 to 6.0 GtCO2 between 2006 and 2030, with the power sector accounting for over 50% of total Chinese emissions at the end of the period. Chinese emissions from coal-fired power plants could account for 15% of world CO2 emissions by 2030.[15]

c. The magnitude of the problem posed by existing power stations

Between 1750 and 2005, about 1,200 billion tons of CO2 were released into the atmosphere from the consumption of fossil fuels and cement production. Half of that has occurred since the mid 1970s.[16] Looking forward, coal-fired power stations will be the most important source of incremental emissions.

How important will emissions from coal-fired stations be in comparison with accumulated emissions? According to the 2008 IEA Reference Scenario, coal-source emissions from power stations in 2020 will be about 12.1 billion tonnes CO2. If these plants were to run for 65 years and their output was never CO2-mitigated, their total emissions would be equivalent to 786 billion tons of CO2, almost 2/3 of the total volume of fossil-based emissions over the past 250 years. Using the IEA forecast capacity figure for 2030, emissions over the life of the plant would yield 877 billion tons, over 70% of total accumulated fossil-based emissions up to 2005. Even if we were to use the 2006 capacity figure, allowing these plants to operate without emission controls over 65 years would generate a volume of emissions equal to about 50% of the historic total. Even if these figures are only approximately right and subject to many qualifications[17], the order of magnitude of the potential emissions from existing coal plant should be a cause for concern

d. The US power fleet and coal[18]

The US coal-based power fleet has a capacity of about 315 GW, which is only 30% of total US generation capacity, but accounts for 50% of output. In comparison with the best available technology, US coal stations are relatively old and inefficient, and are an important

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[13] IEA, WEO, page 513.
[14] Dale Simbeck and Waranya Roekpooritat, 2009, *Near-term technologies for retrofit CO2 capture and storage of existing coal-fired power plants in the United States*, MIT Energy Initiative Symposium on Retrofitting Existing Coal Plants for CO2 Emissions Mitigation, March 23, 2009, Cambridge MA.
[15] IEA, WEO. Pages 531 and 507.
[16] Boden, T.A., G. Marland, and R.J. Andres, 2009. Global, Regional, and National Fossil-Fuel CO2 Emissions. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, TN, U.S.A. doi 10.3334/CDIAC/00001.
[17] Whether coal plant will actually run as they have in recent years will depend on many factors, one of which is the price of gas and of CO2. If gas prices were to fall significantly, for instance, this would make coal plants less competitive. We discuss this issue later in the paper.
[18] See Simbeck and Roekpooritat, 2009, Op.Cit.

contributor to global CO2 emissions. For instance, the average age of a US coal plant is about 35 years (65 years being a normal plant life), with over 70% more than 30 years old. Average efficiency is below 33% compared to modern coal plants of closer to 40%. The average CO2 emissions are about 0.97 metric tons CO2 per MW-hour, which is about 20% higher than modern coal plants. US coal plants 35 years and older account for 7% of the world's anthropogenic fossil fuel CO2 emissions.

The high percentage of emissions reflects the type of technology that is currently in use. Most of the US fleet employs pulverized coal combustion technology, either subcritical or supercritical. Subcritical systems operate at about 1025º F and typically have efficiencies of 32%. Supercritical power plants operate at higher temperatures, allowing for efficiencies of up to 42%. The US has about 75 GW of supercritical capacity (23% of the total). This is higher than the world average (13%) but lower than some other countries, in particular Japan (70%), which has the most efficient fleet in the world.

e. Conclusion

First, coal is the world's most important and growing source of CO2 emissions. Second, China and the US are the world's two most important emitters of GHG, mainly because they rely heavily on coal for power generation. US coal-fired power stations are relatively old and inefficient and account for a substantial share of global CO2 emissions. Third, US coal-fired stations are very old in comparison to the Chinese fleet.
A major challenge is to significantly and urgently cut emissions from existing coal-fired power plant, especially in the US and China. As an MIT study recently concluded, ***'there is no credible pathway towards stringent GHG stabilization targets without CO2 emissions reduction from existing coal power plant.'.***[19]

4. Clean coal – oxymoron or possible solution?

It would be very attractive if we could cut emissions from coal-based power stations, basically because they account for such a large share of world emissions and because there are relatively few of them – less than 5000. If we were able to cut the CO2 emissions at a significant proportion of these stations, it would make an enormous difference to global emission levels. By contrast, trying to cut an equivalent volume of CO2 emissions in other activities would be more difficult, requiring changes in behaviour and in emissions from a vast number of smaller sources.

One option is to shut down the existing coal-fired stations. This is very unlikely to happen in the foreseeable future, for reasons explored later in this paper. The alternative is to find ways to cut CO2 emissions from coal-based generation plants. This section explores briefly the technological options and looks in a bit more detail at the economics of the most promising technology on the horizon – carbon capture and storage (CCS).

[19] MIT Energy Initiative Symposium on Retrofitting Existing Coal Plants for CO2 Emissions Mitigation, March 23, 2009, Cambridge MA, page 5.

a. Range of clean coal options for existing stations

'Clean coal' sounds like an oxymoron. As long as coal is being burned, it will emit CO2, as well as nitrous oxides, sulphur dioxide and particulates. Clean coal technologies are those that aim to reduce the environmental impact of coal-based generation. Most commonly, clean coal refers to technologies that deal with the atmospheric problems associated with burning coal. Originally, the focus was on sulphur dioxide and particulates which were the cause of acid rain. However, in this paper, I am interested in technologies that aim to reduce carbon dioxide emissions from existing coal-fired power stations.[20] These include:

- Retrofitting existing plants to allow CO2 capture, or rebuilding them to allow for carbon capture and storage (CCS);

- Increasing the efficiency of existing coal-fired power stations through retrofits and operational changes;

- Repowering of existing power stations, which would involve replacing coal as the main fuel, for instance by natural gas; and

- Co-firing of coal plants with biomass to lower CO2 emissions.

CCS offers the most significant reduction of CO2 emissions, potentially as much as 90% of emissions on those plants where it can be fitted. Although this technology has not been fully demonstrated at scale and is facing a number of regulatory, economic and technical barriers, it is the central 'bet' behind the US draft legislation and requires some further explanation.

b. CCS – technology

Carbon capture and storage involves three phases: the capture of CO2 from the fossil fuel, its transport to a storage site (or to the site where it will be used) and then its storage (or sequestration). All three of these phases are important. Below, I focus on the most expensive phase – capture.

There are three ways to capture CO2 from coal-fired power plants, all of which involve substantial 'residual' power requirements:[21]

- *Post combustion capture* – 'the process of transforming … low-pressure, low concentration CO2 into a relatively pure CO2 stream' which can then be compressed, transported and stored. This is the most appropriate technology for retrofitting existing plants.

- *Pre-combustion capture* – involving coal gasification to produce synthesis gas that is then used to produce CO2 and H2 streams. The higher efficiency of the capture process compensates for the higher fixed cost of the gasification. This approach is

[20] *Retrofitting of Coal-Fired Power Plants for CO2 Emissions Reductions*, MIT Energy Initiative Symposium, 23 March 2009. This symposium addressed the subject in great detail.
[21] *Retrofitting of Coal-Fired Power Plants for CO2 Emissions Reductions*, MIT Energy Initiative Symposium, March 23, 2009, page 19.

most suitable for new power stations using integrated gasification combined cycle (IGCC) technology.

- *Oxy-combustion* is the combustion of coal with pure oxygen instead of air. It has large power requirements, but enables the separation of highly concentrated CO2 and has lower efficiency losses. This approach is most suitable for new power stations.

Figure 4: CO_2 Capture Systems

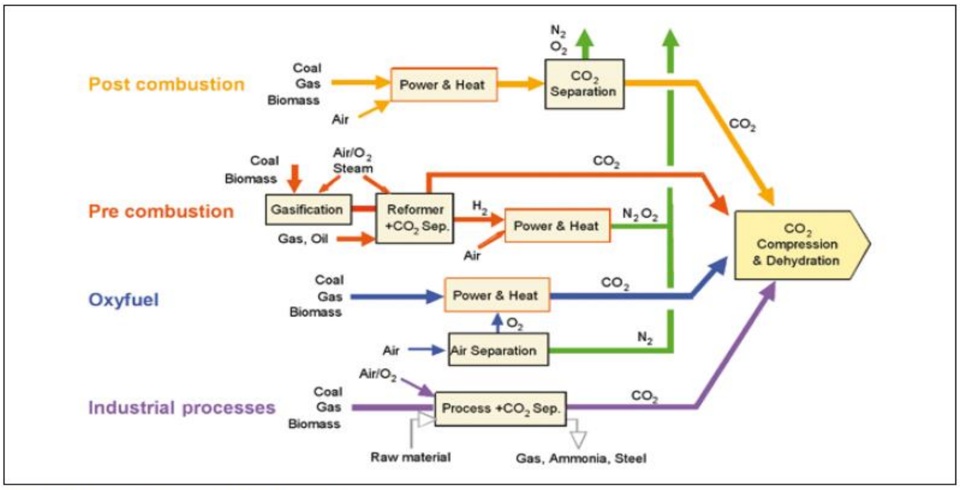

Figure 3.1 CO_2 capture systems (adapted from BP).

Source: IPCC Special Report: Carbon Capture and Storage, 2005, page 108.
http://www1.ipcc.ch/pdf/special-reports/srccs/srccs_chapter3.pdf

It is important to note that not all of these technologies are equally suitable for existing power stations. Only the first, post-combustion technology is suited to existing power stations without major modifications. On the other hand, for a variety of reasons, many existing power stations are not well suited to CCS: e.g., lack of space for the required capture equipment or they are simply too small and inefficient.

According to the IPCC, the potential for CCS is substantial.[22] Their analysis concludes that CCS could provide between 15 -55% of the global, cumulative emission mitigation effort by 2100. Although the role of CCS is expected to grow over time, most scenarios assume that CCS may begin to play an important role after 2020.[23]

c. CCS - economics

A significant determinant of the speed of technology take-up is the relationship between the expected price of CO2 and the cost of avoiding CO2 emissions through CCS. If the expected CO2 price is below the expected cost of avoided CO2 emissions through CCS, then investors

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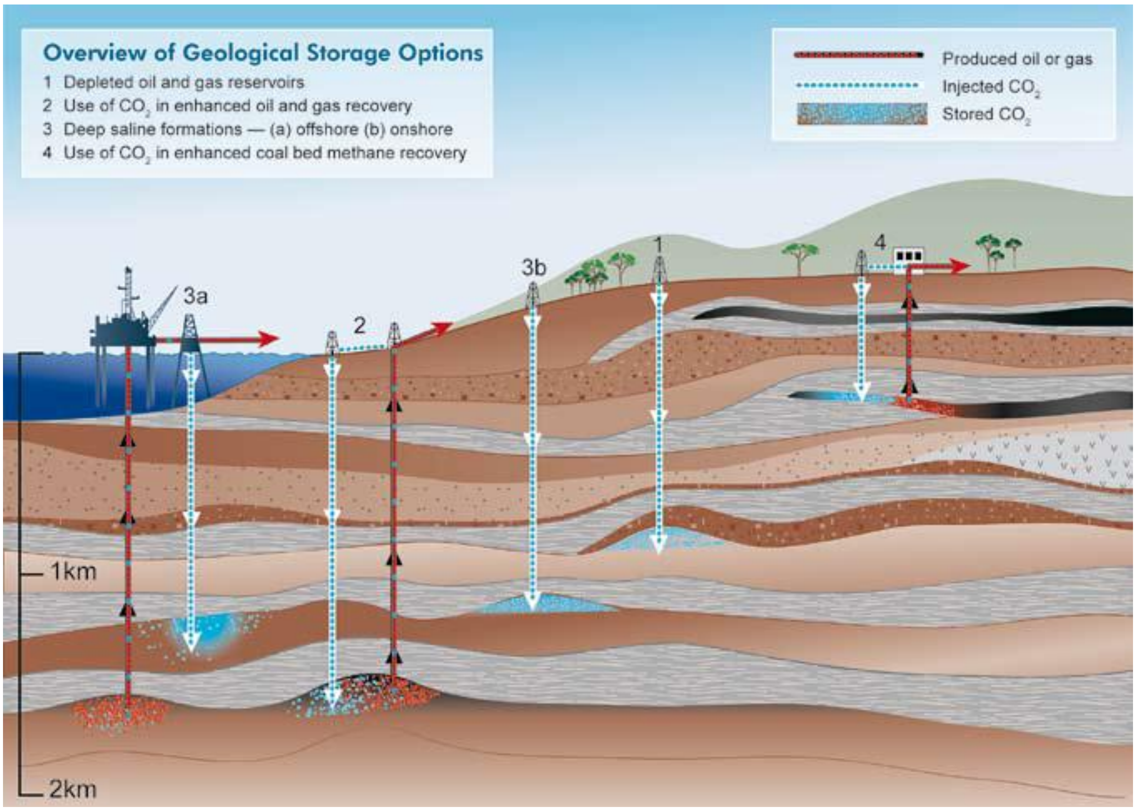
[22] IPCC Special Report on CCS. See http://www1.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf. Also, see IPCC slides at http://www.ccs-africa.org/fileadmin/ccs-africa/user/docs/Dakar_6_9/Dakar_Davidson_06sept07_IPCC-SRCCS.pdf

[23] Most of what I see suggests that large scale demonstration plants will be the focus for the next 5-10 years before commercial viability can be proven. Alstom, however, says that it will have a commercially available capture technology by 2015.

will not fit the CCS. The cost of avoiding COS emissions with CCS is significantly higher for older and less efficient plants.

The IPCC estimates a significant take-up of CCS for efficient plants if CO2 prices are in excess of $25-30/tCO2. This estimate does not reflect the early stages of the development of the technology and sounds optimistic in comparison with more recent studies. McKinsey estimates that the CCS costs for demonstration plants will initially be in the range of €60-90/tCO2, before eventually falling to between €30-45/tCO2.[24] The Brattle Group has concluded that prices of $65-70/tCO2 would be required to justify investment in CCS due to the effect of volatility on the cost of capital.[25]

Figure 5: CCS Storage Options



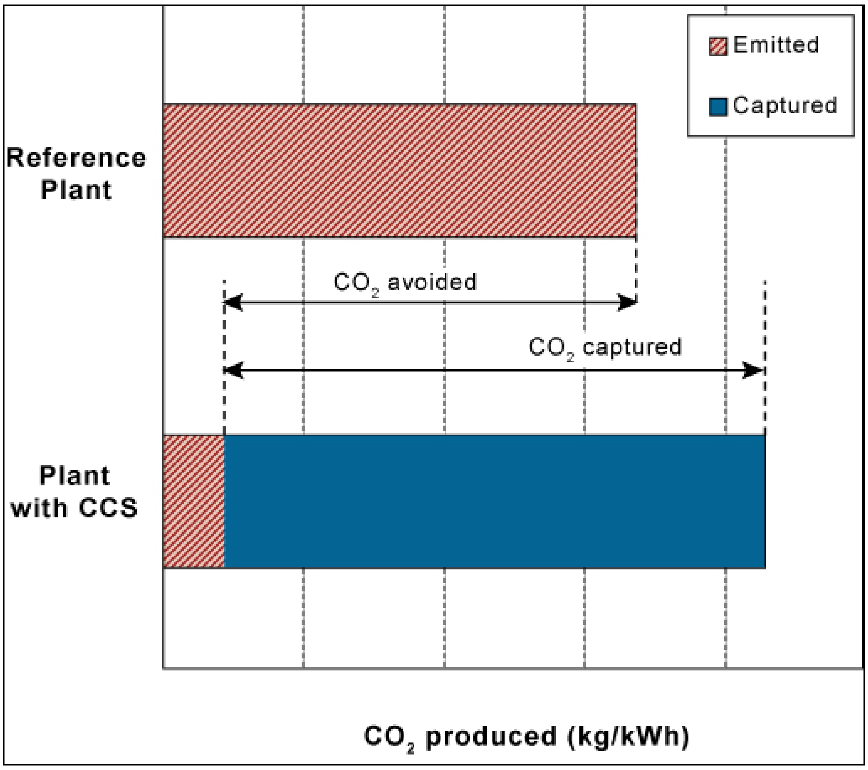
Source: IPCC Special Report Carbon Dioxide Capture and Storage, Executive Summary, page 6. http://www1.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf

The capture phase is the most expensive part of CCS, normally accounting for at least 60% of the costs. On the other hand, transport costs will depend on the location of the storage facility, and the cost of storage will also be subject to significant variation. Each of these technologies has been available and in use for some time, but they are only now being demonstrated at scale in 20 projects that are under way or about to start. There continues to be considerable uncertainty about costs.

[24] McKinsey & Company, 'Carbon Capture and Storage: Assessing the Economics', September 2008, page 6.
[25] Celebi, Metin and Frank Graves, The Brattle Group, 'CO2 Price Volatility: Consequences and Cures', January 2009 Discussion Paper, page 8.

The main reasons for the high capture cost are the increased capital cost for the capture technology itself, plus the 'parasitic energy' requirement involved in capturing the CO2 from existing coal plants.

Figure 6: CO_2 Capture and Storage from Power Plants



Source: IPCC Special Report Carbon Dioxide Capture and Storage, Executive Summary, page 4. http://www1.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf

The graph above[26] illustrates that a plant with CCS is capturing a large percentage (90%) of the CO2 emitted, but has produced more CO2 due to the energy requirements of the capture process itself. The additional 'parasitic' energy requirement can be between 10% and 40% more to produce the same electricity output. To put the overall cost of CCS in perspective, the IPCC estimates that it could add $.01 - .05/kWh to the current price of coal-fired electricity – which in China is currently about $0.03/kWh and in the US about $0.04/kWh. In other words, with current technology, CCS would very substantially increase the cost of coal-fired power. In contrast, $50/tCO2 would add about the same $.05/kWh to the cost of a conventional coal plant.

[26] IPCC Special Report on CCS. See http://www1.ipcc.ch/pdf/special-reports/srccs/srccs_summaryforpolicymakers.pdf, page 4.

d. Conclusion

In 2005, the head of the US Department of Energy's research department told me that developing CCS had long been a strategic priority for the US. The problem is that they had planned to develop the technology by 2065! With the latest scientific findings on climate change, and the fact that the Bush Administration had recognized that these findings warranted early action, the DOE had brought forward the deadline for successful development by 40 years, to 2025! I do not know if his story is true, but it gives one pause for thought. Given the significant uncertainty that remains about the costs of CCS and its deployment, it is reasonable to be concerned that we are some way away from knowing how to cut coal-based CO2 emissions. Yet, this technology is an important part of US legislation.

5. The big deal – smoothing the transition for coal

a. Introduction

This section provides an overview of draft US climate legislation, its treatment of the US coal industry, and its key clients in the power sector. The first part summarizes briefly the draft legislation. The second explains how it affects coal, and the third explains why the coal lobby has been so effective so far. It remains to be seen how the legislation will evolve in the Senate, but I am betting that the coal industry will be at least as successful as it was in the House of Representatives.

Draft US climate legislation is the first systematic attempt to secure a future for coal in a low-carbon environment. It aims to do so by promoting the development of CCS, and to smooth the transition in a number of ways. If CCS achieves its promise, it would be one absolutely vital 'wedge' in the global effort to cut global greenhouse gas emissions. Whether and when it will achieve that promise is central to any analysis of draft US legislation.

Perhaps the most important question is whether the arrangements to smooth the transition for coal will undermine the efforts to convert the US economy into a low-carbon economy and will condemn US coal production to a path of gradual elimination rather than early transformation to an environmentally sustainable source of energy. I will argue that the proposed legislation will indeed have the former, negative effects.

b. US Climate Legislation

The American Clean Energy and Security Act (ACESA), or Waxman-Markey (WM) Bill, was passed by the House of Representatives earlier this year. A similar piece of draft legislation, called the Clean Energy Jobs and American Power Act (CEJAPA) or Kerry-Boxer (KB) Bill, is now being debated in the Senate. I refer below simply to WM and KB.

The central features of both pieces of legislation that are relevant to this paper can be summarized as follows. Since WM has already been passed and KB is still being debate, I will use WM as the starting point for the summary.

- A *reduction in carbon dioxide emissions from major US sources.* MW calls for reductions by stationary sources (e.g. power stations) of 17% by 2020 and over 80%

by 2050 through a cap-and-trade mechanism. KB calls for 20% by 2020 and over 80% by 2050. All reductions are relative to 2005, making both bills fairly non-ambitious in early years – they effectively amount to a 0-4% reduction in emissions compared to 1990.

- *Cost mitigation measures to limit the CO2 price and the overall cost of the legislation.* The measures include unlimited banking of CO2 emissions; a two-year compliance period (which allows borrowing one year in advance); the use of a reserve of CO2 permits that can be released onto the market if CO2 prices are considered too high; and above all, offsets.

- *Offsets.* Entities that are required to cut emissions may submit 'offset' credits in lieu of emission allowances to meet their compliance obligations. The EPA will issue offset credits to qualifying projects. For the federal program as a whole, the total quantity of offsets cannot exceed 2 billion tCO2, of which half can be international projects. This is a substantial offset program, which is expected to depress the price of CO2 in the US. The coal industry strongl3y supports this provision.

- *Free allocation of emission permits to coal interests.* WM allocates a large proportion of the emission permits free of charge to different groups as a means of gaining support for the legislation and providing transitional support to affected groups. In particular, merchant coal-based generators obtain 3.7% of the permits free of charge, equivalent to an average of $2-4 billion per year until 2020, depending on the CO2 price. Electricity local distribution companies (LDCs) will receive 31.8% of the free allowances in 2012, equivalent to about $11-36 billion per year on average over the period 2012-2020, depending on the CO2 price. These allowances will be allocated in a way that favours coal-based consumers, since half will be based on annual average CO2 emissions attributable to generation of electricity that is sold at retail by such companies.

- *International trade restrictions.* Under WM, US industries (such as iron, steel, cement and paper) that are energy intensive and compete with foreign suppliers, receive two kinds of support. First, they will receive an allocation of 12.2% of emission permits free of charge. Second, imports from countries that do not have similarly stringent CO2 legislation will be required to purchase CO2 permits. Third, they may also get rebates from local distribution companies.

- *Promotion of renewable energy and energy efficiency.* WM requires electric utilities to meet 20% of their electricity demand through renewable energy sources, and energy efficiency by 2020. The original version of KB did not include this requirement.

- *Financial support along with mandates and incentives to instal CCS on new coal power plant.* This is an important feature of the legislation as far as the coal sector is concerned.

c. *What does WM do for coal?*[27]

There are at least six ways in which WM positively favours the coal industry, its customers and employees. The first three are positive in terms of their environmental impact, whereas the last ones are not.

First, introducing a price for CO2 sends an important signal to investors. It raises the cost of producing electricity with coal and other hydrocarbons, moves coal down the merit order, and encourages investment in lower carbon technologies.

Second, the legislation would resolve a significant degree of regulatory uncertainty, particularly with respect to the path for reducing greenhouse gases, the regulations that affect the geological storage of CO2, and the permitted CO2 emissions and performance standards for new coal plant. Indeed, the performance standards for new coal plant amount to a mandate to instal CCS on new coal plant.

Third, to make CCS investment more likely, the legislation introduces important financial subsidies, incentives to fit CCS early, and creates a fund to establish CCS demonstration projects. First, WM authorizes fossil fuel generators, with the approval of state regulators, to create a Carbon Storage Research Corporation (CSRC), to be funded by a surcharge on fossil-fuel generated electricity sales. The CSRC would collect up to $1 billion per year for ten years to help fund at least 5 commercial-scale CCS demonstration projects. Beyond these demonstration projects, WM awards bonus CO2 allowances (from the cap and trade system) to subsidize the cost of CCS. The cumulative potential amount of these bonus allowances is estimated by the Pew Center (see their graph below)[28] at $100 billion by 2030 and $240 billion by 2050. The first phase will include 6 GW on a first-come-first-serve basis, and the second phase will fund up to 66 GW of additional coal plant. The payments will reflect the level of capture of CO2 (from the smokestack) and will reward early initiatives. In the second phase, the EPA will select plants on the basis of a reverse auction to fund the most cost-effective CCS projects in different categories; these funds are supposed to cover a range of capture technology options, including retrofitting of existing plant.

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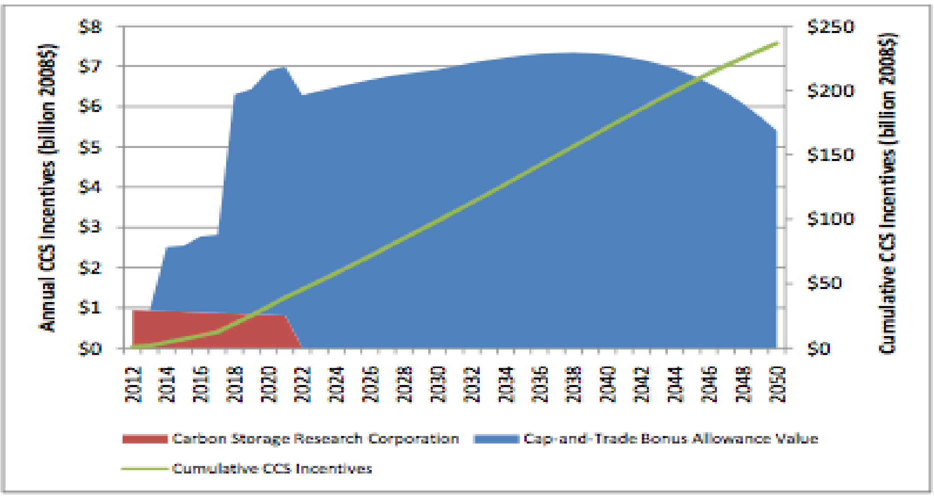
[27] For the first three of my arguments, see The Pew Center, 2009. http://www.pewclimate.org/federal/what-waxman-markey-does-for-coal.

[28] Ibid.

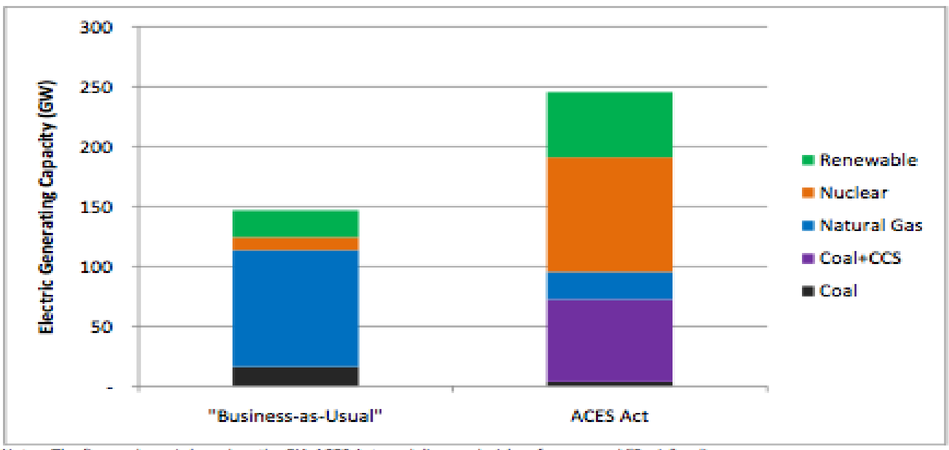
Figure 7: Waxman Markey Bill - Support for CCS



Source: The Pew Center, 2009. http://www.pewclimate.org/federal/what-waxman-markey-does-for-coal

According to the US EIA (as reported by the Pew Center), the combination of CO2 prices, CCS mandates and financial support will help to secure the future of the coal-based electricity sector. Their forecasts (see the graph below)[29] suggest that the power sector will be responsible for 80% of the savings required under the cap and that CCS will account for 25% of the power sector savings. Under their BAU scenario, almost no coal plant would be built, whereas with the WM legislation, they argue that coal with CCS will account for about 70 GW of plant and 11% of US electricity generation in 2030. Note that coal with CCS plant produces about 25% of the CO2/kWh as a new gas plant. So the building of coal with CCS is a lot cleaner than saying no to coal and leaning on natural gas.

Figure 8: Waxman Markey Bill – Forecast New Generation Capacity



Notes: The figure above is based on the EIA ACES Act modeling analysis's reference and "Basic" policy cases.

Source: The Pew Center, 2009. http://www.pewclimate.org/federal/what-waxman-markey-does-for-coal

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[29] Ibid.

Fourth, the legislation provides protection for coal lobby customers – small and large – from price increases. In particular, electricity customers will receive rebates from their local distribution companies to compensate them for the increase in electricity prices that results from an increase in coal prices. Although WM designs the rebate in a way that aims to preserve the incentive to consume less (by putting the rebate in the fixed component of the tariff), the customer's bill does not increase. This will probably weaken the disincentive to consume.

Fifth, the legislation has a number of cost mitigation measures that are likely to keep CO2 prices from rising. Offsets are potentially the most important source of lower-cost permits to the extent that these offsets will be available at a low price. However, it is also worth noting that the minimum (floor) CO2 price levels in WM are below the estimated costs of CCS.

Sixth, the legislation postpones significant emission reductions. For large domestic sources of emissions (e.g. power stations) the legislation calls for a 17% reduction in CO_2 emissions by 2020, and an 83% reduction by 2050, in both cases using 2005 as the base year. This is not ambitious by international standards. If the proposed US emissions target of 17% were measured by reference to 1990 as the base year, it would amount to approximately a 0-4% reduction by 2020. Even though these US targets are not ambitious, there will be a strong effort to weaken them further. By postponing the most significant cuts in emissions, WM gives the coal-based electricity sector time to adjust, but another way of putting this is that the legislation has taken some of the pressure off the existing coal-powered stations to cut their emissions.

These last three measures are a concession to the coal industry and its customers and, in particular, to the owners of existing coal-fired power stations and their customers. This reflects a deal explained below.

d. The Big Deal

What is proposed is effectively a deal to obtain the support of the coal lobby for climate change legislation. On the one hand, the coal industry and the US power industry that relies on coal are given time and substantial funding to develop CCS. The WM legislation effectively mandates CCS on 'new' coal-fired power stations, but does not impose performance standards on existing power stations, nor on stations which have already initiated their permitting requests – so plants that enter into operation over the coming years will not face these standards if they *initiated* their permitting before 2009.[30] The WM legislation would waive explicit regulation of CO2 emissions by the Environmental Protection Agency (EPA) that would otherwise be the consequence of the 2007 Supreme Court decision that authorized the EPA to regulate CO2 emissions.[31] Furthermore,

[30] The Bill establishes that units initially permitted starting in 2020 must reduce CO2 emissions by 65%. Units initially permitted after January 1, 2009 shall reduce CO2 emissions by 50% by the earlier of (a) four years after the commercial operation of 4 GW of generating capacity equipped with CCS, or (b) 2025. Note, however, that plants that were initially permitted before 2009 will not be obliged to fit CCS. This means that a number of new power stations will be built without a performance standard.

[31] The Supreme Court , (in Massachusetts v. EPA 2007) ruled that CO2 could be considered a pollutant under the Clean Air Act, allowing the EPA to regulate CO2 emissions. Obeying the ruling, the EPA declared CO2 a danger to the health and welfare of Americans, setting in train its apparatus to regulate those emissions. This is likely to lead to litigation that would delay the implementation of CO2 emission controls. Nevertheless, the

merchant power companies that rely on coal would receive a share of CO2 emission permits for free, and regulated utilities relying on coal would receive free permits and be in a position to protect their customers (through rebates) from the price implications of climate legislation. This is clearly a favourable outcome for the coal and coal-fired power sectors. On the other hand, and in return, the proponents of federal climate legislation would gain the necessary political support to pass climate legislation that introduces a price on carbon, encouraging a shift towards low carbon energy production. The proponents argue that, given current political and economic realities, this is a deal worth doing because getting US climate legislation on the books is necessary to achieve a global agreement in the near future.

It is natural to compensate those who lose out from legislation. However, in this case, the compensation has been very substantial and it is worth asking – why?

e. Why favour coal?

This deal is a reflection of the influence of the coal lobby in political terms and of the perception that a healthy coal sector is beneficial to the US. Although coal is often considered to be 'bad' because of its effect on the environment, coal has support for four reasons: (a) national security, (b) the cost of electricity, (c) the regional and social distribution of wealth, and (d) the global competitiveness of US industry. Simply put, there are trade-offs between the environmental benefits of reducing coal emissions and the economic and political benefits of relying on coal. Below, we examine each of the key trade-offs and then explain how this is likely to influence voting behaviour in the Senate.

National and energy security. The US has the world's largest coal reserves. Estimates of the remaining life of those reserves vary, but in all cases are sufficient to be considered of strategic importance. Currently, one of the few energy objectives that enjoy cross-party support is the reduction of US dependence on imported oil, especially from the Middle East and Venezuela. Looking forward, coal will become of even greater strategic importance in the transport sector as electricity replaces oil as a transport 'fuel'.

Cost of electricity. Coal's high share (50 %) of US electricity generation reflects the economics of the industry prior to the introduction of a price for CO_2 emissions. Domestic coal is relatively inexpensive to mine, whereas (until recently) gas prices were relatively high and volatile. The resulting low variable costs of coal compensate for the relatively high fixed costs of large-scale coal plants. When CO_2 emission costs are ignored, the levelized cost of new conventional coal-based generation has generally been lower than the cost of alternatives. The economics change when CO_2 emission costs are internalized, but conventional coal plants continue to be competitive until CO_2 emission costs rise substantially and gas prices fall significantly. CO_2 prices have to reach quite high levels before it is uneconomic to run these plants, once they have been built. One of the central objectives of the coal industry is to keep CO_2 emission prices as low as possible until the technology to capture and store CO_2 is commercially available.

White House appears to be determined to use the threat of EPA regulation as a stick to encourage the coal lobby to accept cap-and-trade legislation. Note that KB does not waive EPA regulation, but I suspect that this will be amended in the Senate or later.
I can't do comments in footnotes, but want to confirm 'Senate or later' as I don't see the sense of it, but I am sure you do!

Regional and social distribution of wealth.[32] The benefits of the coal industry are shared unevenly. Typically, the beneficiaries of coal live or operate in the coal mining areas of the east and the Rockies and the coal-based electricity areas of the Midwest. Introducing a CO_2 price will negatively affect the economies, companies and generally the people of these regions. Naturally, political representatives will resist climate legislation that adversely affects their constituents. There is a disproportionately high representation (per capita) in the Senate of regions that will be adversely affected by CO2 pricing.

Competitiveness of US industry. Some industries, for instance cement and iron and steel, point to the risk of leakage (*i.e.*, that business will move to other parts of the world where emissions are not controlled adequately).[33] Although these industries now accept the inevitability of federal climate legislation, they have lobbied for mechanisms that will effectively protect them from cost increases and from foreign competitors.

The trade-offs described above add up to strong and organized political support for weakening climate change legislation, compensating the losers, and helping the coal and related power industry to make a transition to a low carbon future. The fight is, to a large extent, between those regions and interests that benefit from low cost coal now, and those that do not. This fight will now be waged in the Senate, which is considering KB. There are three features of the Senate negotiations that could lead to an even weaker bill from the environmental perspective.

First, the Senate is more sensitive than the House of Representatives to regional political interests. Support for aggressive climate legislation comes mainly from Senators in the states that rely least on coal, in particular the Pacific West and the North East. The states that rely heavily on coal are more concerned about the introduction of climate legislation. This was already evident in the House of Representatives, whose representation is based on popular vote (*i.e.*, population), but will be even more clear-cut in the Senate, where each state has the same voting weight.

Second, a significant proportion of the Senators from the states with coal interests are 'blue dog' Democrats. Thus, while the Democrats now have 60 Senators and could pass legislation without the support of Republican Senators, there are many Democratic Senators who will press for further concessions, for instance, an easier emissions cap.

Third, the states that rely most on coal are demographically the poorer states, both in terms of income per capita and unemployment. It is difficult for the current administration to pass legislation without ensuring that these groups are protected. In the current economic climate, the prospect of creating additional unemployment in these regions is especially unpalatable.

[32] For a detailed analysis of the impact of 'carbon geography', see 'Carbon Geography: the Political Economy of Congressional Support for Legislation Intended to Mitigate Greenhouse Gas Production', Michael Cragg and Matthew Kahn, 2009.

[33] To the extent that foreign producers of these products have more efficient production facilities and emit lower CO2 per unit of output, the leakage argument becomes mainly a protectionist one.

6. Concerns with draft US Legislation

a. So, what is wrong?

So what is wrong with WM? In many respects, it sounds like a good deal. It is an impressive commitment to cutting emissions from new coal plant through a major investment in CCS technology that could be adopted in other countries. It also allocates funding to the development of other clean coal and low carbon technologies. I think it is the first systematic attempt to tackle the coal problem head on.

On the other hand, I have one minor concern and two major concerns. The relatively minor concern has to do with compensating coal industry customers – in particular the small customers who face increased electricity bills. The deal leaves customers facing approximately the same bill as before, possibly for decades or more. Although the legislation requires the rebate to be paid on the fixed component of the customer's invoice, most customers may take no notice. I do not expect this to elicit any demand-response from consumers unless the local utilities have strong regulatory incentives to encourage customers to make savings. However, to be fair, the Obama Administration has decided to make a concerted effort to promote energy efficiency, in part through the development of smart metering and the smart grid, and in part with regulatory incentives that promote energy efficiency. So, on balance, this is less of a worry than it might appear.

The first major concern is that the deal does not put enough pressure on existing coal plants to cut emissions. Whereas new plants face performance standards, 'existing' plants do not, where the term 'existing' has been extended to include plants that were initially permitted before 2009. The assumption is that existing coal plants will be disciplined by the market. Below, I argue that the market may well not impose much discipline on these plants. In that case, they will continue to be a very significant source of emissions, sending a signal to China that there is no need to act on their own existing plants. Furthermore, by not putting sufficient pressure on the emissions of existing plant, the legislation is not providing strong enough incentives to develop the technologies that will be suitable for retrofitting them (CCS, repowering, improved efficiency) or for replacing them by low or zero-carbon generation capacity.

The second major concern is that CO2 prices will be depressed by a combination of factors, including cost mitigation measures (e.g. offsets, use of the reserve) and the decision to postpone more aggressive CO2 cuts. This cocktail of measures means less pressure to cut emissions from all sources, especially coal but also natural gas. Indeed, if anything, it puts natural gas in the dominant position for new plant expansion for decades, far longer than it should be, since it is also an emitter of CO2.

In this section, we ask whether 'market forces' alone will lead to a significant decline in coal-based emissions in the next twenty years through the replacement of coal-fired generation by lower carbon generation – natural gas, nuclear or renewables. In particular, can we expect CO2 prices and competition from other fuels to reduce coal-based generation from existing plant, and if so, by how much? Although the consensus view is that market forces will substantially reduce coal-based generation in the US, there are a number of reasons to expect coal-based generation to continue at relatively high levels. In particular, I will make reference to a recent presentation by a representative of the US EIA that sheds light on the difficulties of backing existing coal out of the generation mix.[34]

b. Why it will be difficult to back out existing coal-fired stations

In the next 20 years or so of US climate policy, the major coal displacement will be from the substitution of coal by natural gas in the power despatch supply curves[35]. We can illustrate the difficulty of backing out coal by referring to three kinds of competition: existing coal plant v. existing gas plant; existing coal plant v. new coal or gas plant; and new coal plant v. new gas plant. Since gas is the main competitor for coal in the US, the question is: how easy is it for gas to replace coal?

Existing coal v existing gas. For the first of these, the question is: at what CO2 price will gas plant replace coal plant? This will depend on not only the CO2 price, but also on the relative prices of coal and gas. The graph below[36] illustrates that if coal costs $2/MMBTU, and natural gas is at $5/MMBTU, gas replaces coal in the merit order when CO2 prices are above $35/tCO2. However, while coal prices have historically been very stable, gas prices have not. If gas prices are $7/MMBTU, CO2 prices have to rise above $60 before gas replaces coal. At $13 gas prices (close to parity with current oil prices), CO2 prices would have to reach levels in excess of $120/tCO2. Although it is very unlikely that gas prices will reach the upper end of this range, it remains quite possible that it will be in the $5-7/MMBTU range[37]

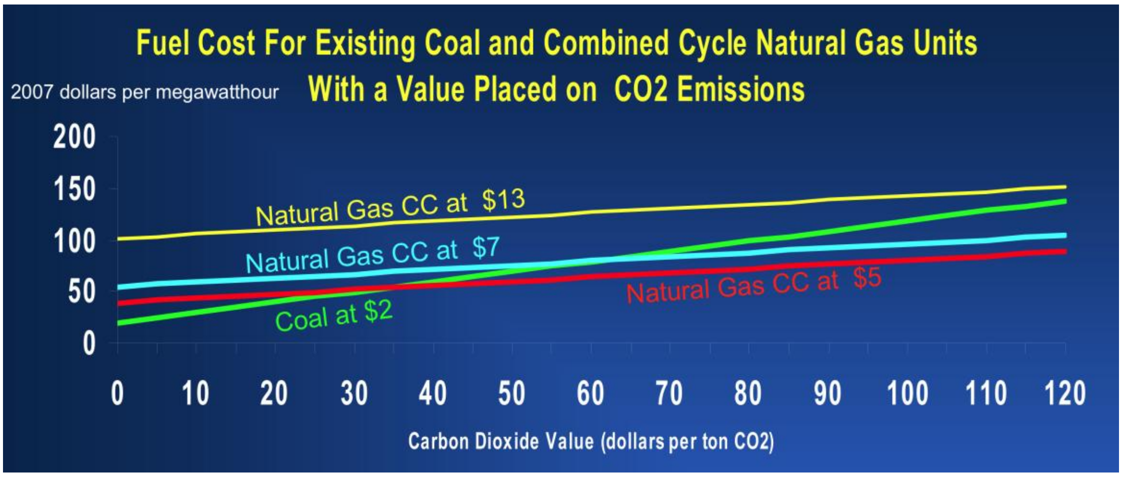
[34] Howard Gruenspecht, EIA, ‘The Outlook for Natural Gas in Electricity Generation: Climate Policy and Other Drivers’, LDC Gas Forum, Chicago IL, September 15, 2009. The graph used below is from this presentation.

[35] Although nuclear power is an alternative to existing coal-fired plant, market forces alone are unlikely to raise substantially its market share over the next twenty years. On the one hand, existing nuclear plants have very high levels of utilization, so there is not much room to replace coal through increased operations. Existing gas plant, on the other hand, is relatively underutilized and could replace coal-based generation if the relative prices were right. Gas also has the advantage of allowing for quick ramping up and ramping down, which is especially important as a form of back-up to intermittent renewable energies. As for new capacity, it is evident that investment in nuclear power involves substantially longer lead times, capital costs and public resistance than is the case for gas-fired plant.

[36] Ibid.

[37] We should not rule out the possibility of even lower gas prices, in view of the recent development of unconventional gas.

Figure 9: Comparison of Fuel Cost for Existing Coal and CCGT Units with Diferent CO2 Prices



Source: Howard Gruenspecht, EIA, 'The Outlook for Natural Gas in Electricity Generation: Climate Policy and Other Drivers', LDC Gas Forum, Chicago IL, 15 September 2009.

New coal v. new gas. When comparing new plants, the economics are generally much more favourable to gas than to coal plants (conventional or IGCC). In other words, the CO2 price that justifies a switch to gas from coal is much lower when the comparison is between new plants than when it refers to existing plants. However, that begs the question of when investors will choose to build new plants. (And it also reminds us that CCS will be needed for gas plant, too.)

Existing coal v. new coal or gas. There will be a strong incentive to operate using existing coal-fired stations, rather than build new power stations. This is simply because the going-forward cost of an existing coal station does not include fixed capital costs, whereas the costs of new stations do. To the extent that demand can be met by existing power stations, investors will be reluctant to invest in new ones, especially if CO2 prices are very uncertain and volatile. The fact that 'overnight' build capital costs have risen significantly in recent years simply strengthens the case for delaying investment in new plant.

In short, there are strong incentives to continue operating older inefficient plants, which are often nearly fully amortized. (In much the same way, people have weak economic incentives to buy more efficient cars.) In states where utilities face rate of return regulation, existing coal plants offer low cost electricity.
In the liberalized markets where prices are set by the cost of the most expensive plant operating, low capital charges (on fully amortized coal plant) offer high returns to coal plant owners.

It is also worth noting that investors in Europe saw substantial benefits in improving the efficiency of their coal plants because prices reflected the internalization of CO2 costs of the marginal plant. Much higher electricity prices induced this sort of investment. If prices in the US are, instead, based upon the average cost of service, the incentives to lower emissions and improve efficiency will be less strong.

Even if we anticipate reduced output from coal plant, shutting down these plants will face strong opposition. For a start, the cost of replacing the coal-based generation will be substantial. The fact that coal-based generation tends to run at base-load means that replacement power must either be an alternative base-load capacity (CCGT or nuclear) or, if it is renewable power, must be backed up with sufficient reserve to deal with intermittency of wind and solar generation. If the coal plant is shut down and replaced by renewable power, there will also be significant additional transmission capacity and costs to recover. Finally, the US coal fleet is strategically located in the US power grid and the costs of abandoning these sites would be substantial.

c. Conclusion

It would be unwise to assume that existing coal-fired power stations will be easily withdrawn from the US generation mix. I am not suggesting that coal generation will not be affected. It will be. However, there are at least five key factors influencing the outcome: the relative prices of natural gas and coal; the overnight cost of building new plant; total demand growth; the CO2 prices; and the cost of replacing coal. The two things we do know are, that coal costs are likely to continue to be low and stable, and that replacing coal will be very expensive and unpopular in many states. Unless gas prices stay very low, CO2 prices are very high, overnight building costs fall and demand grows, there is a reasonable expectation that 'market forces' will lead to continued generation from existing coal-fired power stations.

Does that matter? One could argue that it does not, provided the US is meeting its CO2 emission targets: if there are cheaper ways to cut emissions, such as offsets, there is no need to cut CO2 emissions from coal. But this ignores three problems. The first is that this reflects that the emissions target is unambitious in the early years. Were the emissions targets more demanding, CO2 prices would be higher and coal plant would be under greater pressure to shut down or cut emissions. The second point is that WM is actually giving old and inefficient coal plant a new lease on life by taking the EPA out of the picture and discouraging the building of efficient new plant. If the aim were to transform the coal industry into a more modern one, it would make more sense to close down these old plants, or to repower or rebuild them altogether. Third, the US is sending a signal to other countries, in particular China, that says: 'don't worry about cutting emissions from your existing coal plants (unless we are buying them through our offset programme).' If China followed the same strategy as the US with respect to existing coal-fired power stations, the global emissions from coal would continue to grow and overwhelm all other mitigation efforts.

7. Proposals for US Legislation

In an effort to facilitate the transition to a low carbon economy, current draft legislation is too timid. It should be redrafted to be less tentative. There are two possible ways forward, which place a greater or lesser reliance on market forces.

a. Making the CO2 market work

One option is for the legislation to set emission targets that are tough enough, and CO2 price floors that are high enough, to induce the necessary innovation and investment in low carbon technology and conservation. In that case, non-price signals would have a less important role. Here are two proposals to make the market more effective in promoting low carbon technologies.

1. *Set a tougher emissions target for 2020.* Postponing emission cuts means that even more difficult cuts will be needed later and makes investors sceptical about whether government will be willing to impose cuts if they are really going to bite. Setting and meeting a more ambitious early target sends a more positive message. The US has set itself a relatively easy target. Achieving a 17% reduction by 2020 (compared to 2005) should now be relatively easy to achieve. The KB Bill raises the bar a bit by proposing a 20% reduction. Legislation should go further and adopt an objective equivalent to Japan's target of 25% by 2020, compared to 1990 emissions.
2. *US legislation should adopt a carbon tax or a higher minimum price in the cap-and-trade system.* I accept that there is a case for cap-and-trade on a number of grounds, in particular that it may be easier to induce developing countries to enter a global CO2 market. However, there is one overwhelming reason to prefer taxes if the objective is to promote investment in highly capital-intensive equipment: the volatility of cap-and-trade raises the cost of capital and will delay the adoption of technologies such as carbon capture and storage.[38] If a carbon tax is truly not viable, then an alternative is to narrow significantly the difference between the collar and the floor price for CO2 permits, ensuring a high enough floor to justify early investment in CCS and related low carbon technologies.
3. *Offsets should be lower.* As long as offsets are expected to be less expensive than emission reductions by covered entities, they will depress the CO2 price and weaken the incentive to invest in zero carbon technologies. Also, by allowing offsets equivalent to 30% of the covered emissions (equivalent to the entire EU ETS), WM has significantly reduced the pressure to reduce emissions in the US and has left some considerable uncertainty about the extent to which the offsets will be 'real'. The legislation should reduce reliance on offsets.

In the current political and economic situation, tougher domestic targets and high minimum CO2 prices seem unlikely. Even if the targets were more demanding, there is a serious question over whether the government would stick to them if they proved painful. By postponing the pain of emission reductions and transferring the cuts to other countries, the US has raised the question of whether it will ever truly accept any pain.

b. Non-price measures

I have a preference for the first approach, relying on price signals. However, if price signals are not going to be sharp enough and commitment is in doubt, the alternative is for the legislation to go further than it already does in recognizing the need to use non-price mechanisms to achieve the climate objective. The draft legislation already uses non-price mechanisms by introducing performance standards (effectively mandating CCS) for 'new' coal-fired plants. In the absence of credible and strong market signals, it should impose performance standards on existing power stations – which are the most significant source of CO2 emissions.

[38] Metin and Graves, Op Cit.

Below, I outline a plan for US legislation to bring it more in line with the objective of cutting coal-based emissions from existing power stations in the US and abroad.

1. *The legislation should provide a timetable for the introduction of performance standards on all coal plant, including a timetable for closure of plant that does not meet those standards.* The effect of WM is to give very old and inefficient coal plant a new lease on life by taking the EPA out of the picture and discouraging the building of new plant. To avoid this, the legislation should introduce performance standards that would apply to existing plant, not just new ones. It should include a timetable for closing plant that does not meet the performance standards – otherwise, the legislators will be open to heavy political pressure to bend the rules, if new plant is not built. For plants that are suitable for CCS retrofits (e.g. plants under 35 years old, over 300 MW), the timing and standards should be set in a similar way to those that have been set for new coal plants under WM. Where CCS is not suitable, the standards should be set in order to further encourage investment in efficiency retrofits, repowering (e.g. with gas) and co-firing with biomass. The performance standards and the timing of their introduction should allow existing plants to offer reserve support for a number of years, even if their running hours are limited. This would have a very little environmental cost, and would enable the system to save the cost of building new reserve capacity. The overall approach would clarify the regulatory framework that will apply to all coal-fired plant, providing incentives for investors to finance retrofitting existing coal-fired stations, or prepare to shut them down. It would clarify that the EPA's role would be to administer the performance standards set by the legislation. And it would send a signal to the rest of the world that the US intends to reduce emissions as soon as possible from existing coal-fired power stations.
2. *The legislation should also provide a timetable for the introduction of performance standards on natural gas plant*. Natural gas-fired plants are going to dominate generation expansion in the US, and indeed will be needed as back-up to growing amounts of renewable power. The US also appears to have 100+ years of adequate supply reserves, via shale gas, and it is highly unlikely that these will not be tapped. In order to achieve decarbonization of the electricity sector, CCS will be needed for the natural gas plants.
3. *The legislation should provide bonus emission permits or other funds to retrofit existing plant (with CCS or other carbon-reducing technology) in the US and abroad.* If the legislation does introduce emissions standards for existing coal and gas-fired stations, the case for funding is strongest. In any case, the funds should be allocated to retrofit existing plants (for large- scale demonstration and then more generally) in a similar way as for new coal-fired plants. US funding and technological support for the retrofitting of coal-fired power stations in China would be an excellent way to ensure that US companies were actively pursuing the right objective. Since China is the main market for the technology, it also makes good commercial sense for the US to be promoting collaboration in the development of CCS to retrofit plants in China.
4. *Additional investment in zero carbon technologies.* WM's reliance on CCS for coal is compounded by its failure to give enough incentive to invest in alternative new low carbon capacity. The legislation relies too heavily on the success of CCS. The legislation should have stronger measures in place (through the allocation of bonus emission permits, the setting of higher renewable targets, and through RD&D spend) to ensure that nuclear and renewable capacity is in place – especially if CCS fails to take off – rather than allowing old coal capacity to hang around and hope the new technology develops.

c. Some implications for international agreements

Ultimately, global emissions and concentration levels are what matters. This paper has focused exclusively on ways that domestic US legislation could support the effort to cut CO2 emissions from coal-fired plant. This would be a substantial contribution, sending the right signals to investors and to governments around the world. But it is, obviously, only a small part of the effort that is required to deal with the challenge of coal-based emissions from existing power stations around the world.

It is close to inconceivable that we can switch 100% of our electricity away from coal over the next couple of decades. Global reliance on that fuel, and the political reasons to continue supporting it in a few countries, are simply too great to expect coal use to end or fall dramatically. The US and China have an interest in finding a solution that does not spell the early end of the coal industry. While it takes two to tango, ultimately someone has to lead. The US has the opportunity to do so now. Ironically, it may find that China moves more quickly and that the US will fall behind.

A timid strategy towards coal will eventually require a heroic, probably infeasible one later because we will have foreshortened the timetable to withdraw carbon from the atmosphere. At some point, it becomes technically, if not economically and politically unrealistic if not impossible to cut emissions enough to be avoid the worst effects of climate change. At that stage, and indeed before, the world will be taking drastic measures, including the shutting down of conventional coal stations, and will be discussing sulphate seeding of the upper stratosphere and other forms of climate geo-engineering. At that point, conventional coal will be dead: we will not have taken the steps necessary to transform coal into an environmentally sustainable energy source. Ironically, if coal has a future, the necessary policy now is one of ‘tough love’.