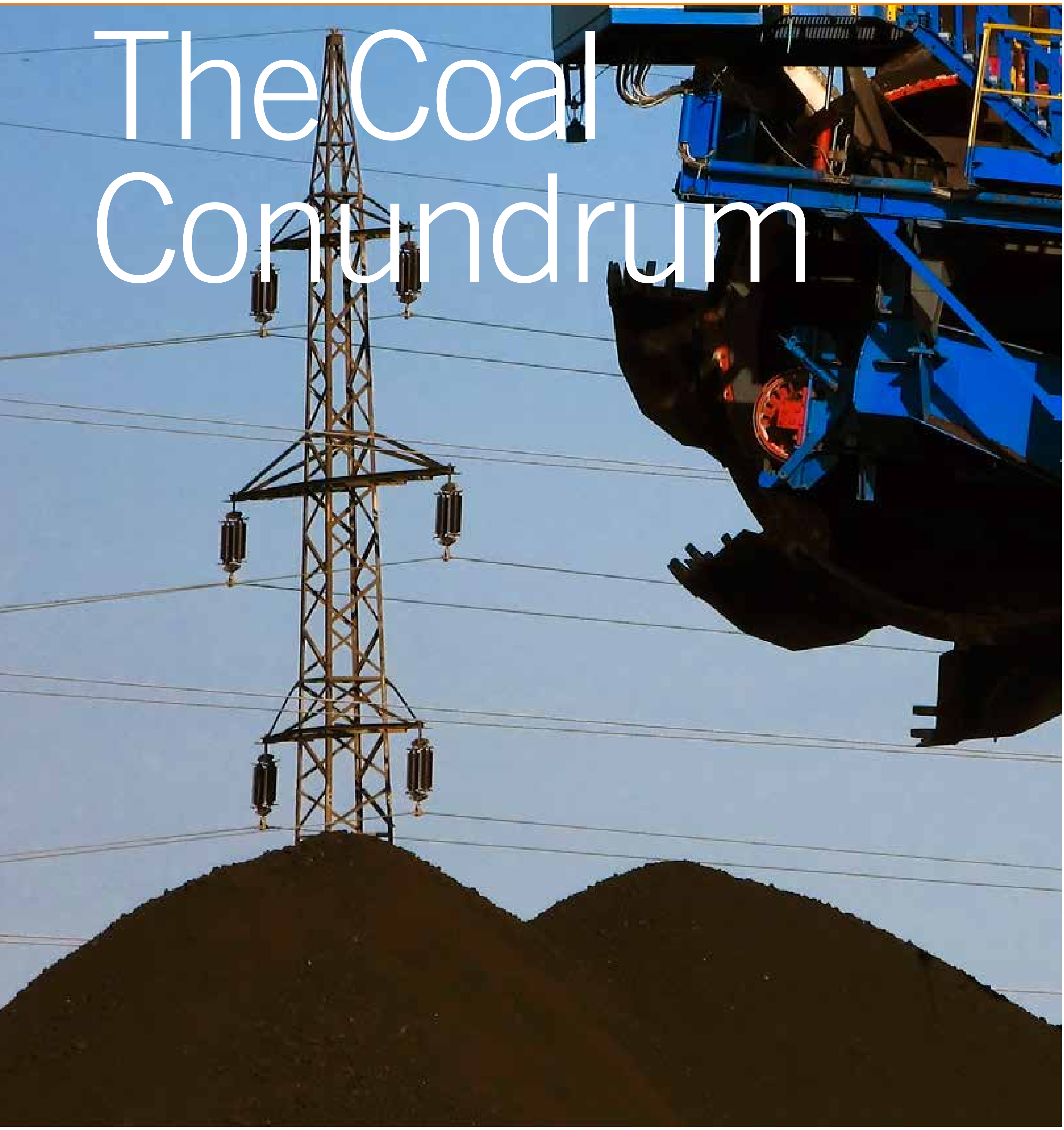
PÖYRY POINT OF VIEW - OCTOBER 2016

The Coal Conundrum



Does coal have a role in economy?

Addressing energy security, universal access to affordable energy and production in an environmentally sustainable way is one of the toughest challenges facing government and industry today. In this Point of View, we consider the role of coal in a lower carbon economy. Can we square the energy trilemma?

Energy policy considers three objectives in meeting energy demand referred to as the energy trilemma:

- **Security of supply**;
- **Affordability**; and,
- **Environmental protection**.

These objectives often compete and the focus on each changes over time depending on which is perceived as the most important.

For instance China and the US have recently ratified the Paris Agreement to limit global carbon emissions, reaffirming that climate change is a growing risk that needs to be urgently addressed.

Coal is recognised as relatively secure and cheap but dirty. In fact, looking at plant emissions, coal is the dirtiest of the main fuels available for power and heat generation in all like-for-like operating modes, including when in part load mode to support the intermittency of renewables.

In addition, as wind and solar increase their share of generation, coal plants have increased value, providing flexible, controllable electricity.

Against a background of concern over climate change and the polluting effects of unabated coal combustion, what is the current position of coal in the energy mix?

In the recent past coal use has increased dramatically in absolute terms and also in its share of total energy used (see Figure 1 and Figure 2).

FIGURE 1 – GLOBAL PRIMARY ENERGY MIX IN 2000 AND 2013[1]
Source: IEA World Energy Outlook

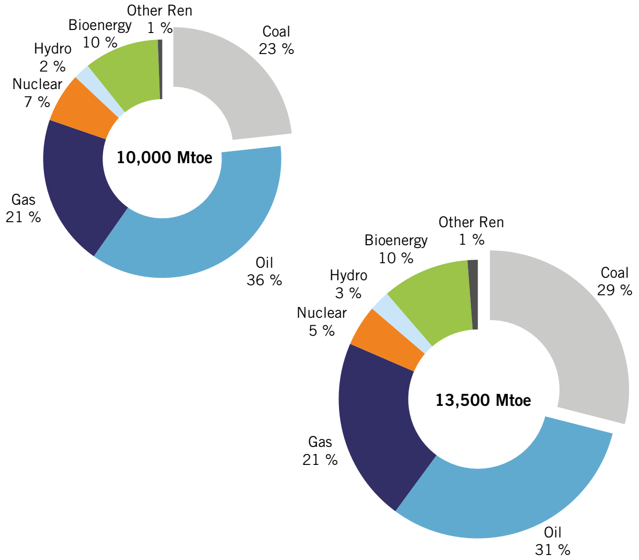
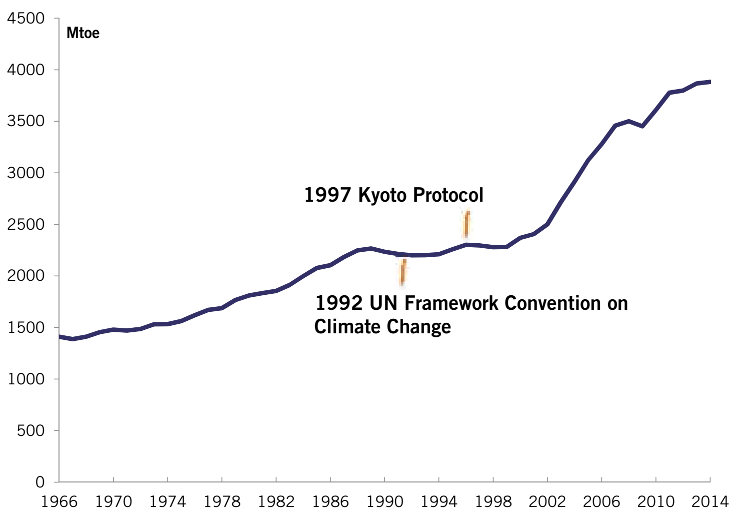


FIGURE 2 – GLOBAL COAL DEMAND 1966 TO 2014
Source : BP statistical review



n a lower carbon

The driver behind this increase in global energy demand and the increased use of coal has been the growing prosperity of developing countries, especially China and India. As their economies have grown so has their electricity demand, which has been met by increased coal-fired electricity generation.

As Figure 1 and 2 suggest, just at the time when our increasing understanding of climate change risks would dictate reducing coal demand and the resulting carbon dioxide released into the atmosphere, we have increased our use of coal dramatically.

THE FUTURE

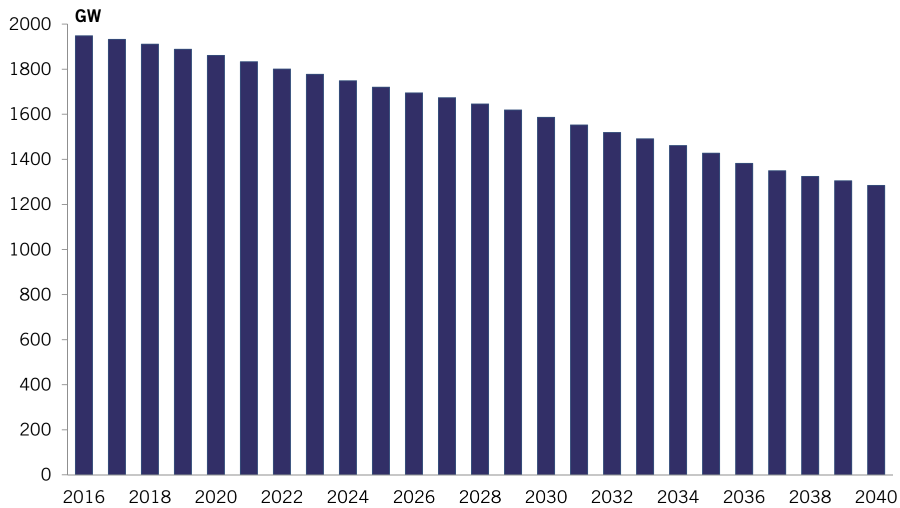
The general consensus is that energy demand will continue to increase. The global population is now 7.3 billion and projected to grow further, reaching close to 10 billion by 2050. An expanding population, combined with higher living standards in developing countries will drive increased energy demand, even when taking account of improvements in end-use efficiency. In order to meet the increasing demand will coal remain part of the mix?

The global coal fleet makes up around one third of total global electricity generation capacity and around 40% of total electricity generation. The global coal fleet is spread around the world with 45% of capacity in China, 16% in the US, 9% in India and 8% in Europe – the remainder being spread across many countries.

In Figure 3 we see a retirement profile for the existing global coal fleet. We assume a mid-range technical lifetime of 50 years. It is worth noting that several hundred GWs of new coal are under construction around the world and many more are in planning and these are not included in the figure.[2]

Figure 3 shows that unless something changes it is likely that the majority of coal-fired generation capacity will be with us for the foreseeable future.

FIGURE 3 – EXISTING GLOBAL COAL CAPACITY RETIREMENT PROFILE
Source: Global Data and Poyry



HOW CAN WE SQUARE THE ENERGY TRILEMMA?

With a large amount of coal capacity in operation today and an urgent need to reduce emissions to limit climate change risks the following options are available:

Option 1 – Shut down the existing coal fleet and replace with alternatives. This may be impractical at a large scale and difficult in some locations. However, for some older assets this can be an economic option where efficiency or operation is low.

Option 2 – Improve Efficiency. Efficiency of existing plants can be improved through refurbishment which lowers the amount of carbon dioxide produced per unit of energy output. Increasing the efficiency of the fleet is a good way to reduce emissions and this can be assessed as part of normal operations. With higher fuel costs, including a carbon cost where it exists, the economics of improving plant efficiency get better.

Option 3 – Switch to a lower carbon fuel. This approach involves utilising existing assets to co-fire with or convert to another fuel source, such as biomass.

Option 4 – Carbon Capture and Storage. The use of carbon capture and storage (CCS) would enable coal-fired assets to generate with a much reduced climate change impact.

In fact all 4 options will be needed to reduce emissions from the global coal fleet in the same way that all energy options will be needed to meet our growing energy demand. The options chosen for each plant/for each country will depend on a number of factors not least the geographical location and the alternatives available, for instance:

- Are there alternative low cost renewable options, e.g. solar or wind, that can replace the coal plants? Failing that is low cost natural gas available?
- Is sustainably sourced biomass in large volumes readily available nearby or can it be imported cost-effectively from regions with biomass surplus?
- Are suitable storage sites for carbon dioxide available within a reasonable distance?

Shutting down the existing coal fleet will not be feasible in many places. Improvements in efficiency will get us only so far. So what role can biomass and CCS play in the future?

BIOMASS CONVERSIONS

- Full conversion has taken place at a number of sites – most notably at 3 out of 6 units at Drax power station in the UK – which represents a total of 1.9GW. Drax was commissioned between 1974 and 1986, and the biomass conversion took place between 2013-15.
- Drax imports over 7mt of wood pellets each year, mainly from North America and Europe. Drax produces 11TWh of electricity per annum that is carbon free according to carbon accounting rules under the EU emissions trading scheme (although this is being consulted on and changes are expected for the next Phase of the ETS).
- The coal-to-biomass conversion of the 400MW Lynemouth Power station in the UK has just started and the station is expected to come back online by early 2019 at the latest. The Langerlo-Genk plant (420 MW) in Belgium is another example of a planned conversion of an existing coal power station to biomass.

BIOMASS TRANSITION

Biomass when pre-treated appropriately in the form of wood pellets can be used as a substitute for coal in all modern power stations. With limited investment standard pellets can be co-fired up to 10%. With further capital investment coal can be completely replaced by pellets.

Coal-to-biomass conversion projects offer great potential as this is a proven technology and capital expenditure can be 70-80% lower when compared to a new build biomass power station. And future developments, such as black pellets, may reduce conversion costs and allow for higher levels of co-firing.

Co-firing has taken place in various coal-fired power stations, mainly in Europe in the UK, Poland and the Netherlands, over the past decade. These co-firing activities were driven mainly by subsidies for renewable energy and the EU Emissions Trading Scheme (ETS).

For CO2 reduction to be realised in practice it is necessary that the biomass used is sustainably produced and sourced. This is an area of controversy and debate. Monitoring

and accreditation are important to ensure sustainability and to persuade the public and policy makers that support should be given. The UK has taken the lead in this sector and has implemented stringent sustainability standards for biomass to be used in energy generation.

Coal-to-biomass conversions also present a cost effective and quickly implementable opportunity for the ageing fleet of coal stations in the East and Northeast US, a region which presents a substantial sustainable biomass resource potential. Similarly, coal stations in Latin America and Asia could be decarbonised supported by sustainable fast growing forestry, such as energy crop plantations or agricultural residues like palm kernel shells (PKS).

Replacing coal with biomass will be an important part of the solution, offering the advantage of being able to provide reliable low carbon baseload energy for networks. **In addition to some form of carbon price or renewable incentive, two key enabling factors for this are the establishment of high yielding and affordable feedstock resources and the development of efficient global trade flows for biomass fuels**.

CARBON CAPTURE AND STORAGE – END DESTINATION?

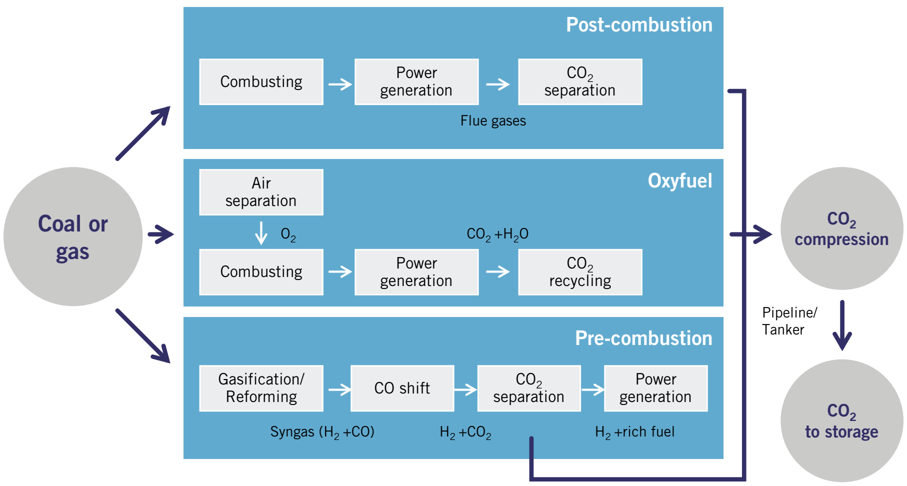
CCS can be thought of as a three step process. The first and usually most costly step is to capture the carbon from a process where it would otherwise be emitted. The second step is to safely transport the carbon, generally in the form of pressurised pure CO2, away from the place where it is generated. Finally, the CO2 must be permanently stored to prevent its atmospheric release, with injection into stable sub-surface geological structures the most likely route.

All of the individual processes involved in the three carbon capture technology options for power stations are well known and have been employed many times in different settings (although until very recently never at commercial scale in power generation). The technologies can be applied in slightly different ways to feedstocks of coal or gas (and potentially with sustainably sourced biomass to drive negative net emissions). Each technological approach has different pros and cons and will suit different applications. To address existing power plants though the post combustion route is currently the most suitable.

If we are to reduce global emissions in the long-term it is not just the power sector we need to consider. We also need to reduce the significant emissions from the steel, chemical and cement industries and the only option currently available for deep sectoral emissions reduction is CCS. The synergies for so-called industrial CCS with CCS on power generation are significant, arising primarily from the shared use of CO2 transport and storage infrastructure – this leads to large economies of scale and potential risk reduction for all parties.

There are three main technology options for the carbon capture step in power generation:

- **Post combustion** – in which the flue gas has carbon dioxide removed from it after the fossil fuel has been combusted;
- **Oxyfuel** – in which the combustion takes place in oxygen and CO2 (to moderate the flame) and the resulting flue gas is CO2 and water; and,
- **Pre-Combustion** – where the fossil fuel is transformed to a hydrogen rich fuel, with the carbon dioxide separated as part of the process.



The sub-surface geological storage of CO2 is recognised by the IPCC as highly likely to be a successful method of long-term storage of CO2. However the market for CO2 storage is still in its infancy despite individual success at sites such as Sleipner in Norway. Here the Norwegian state oil and gas company, Statoil, has been successfully extracting 1mt of CO2 pa from a natural gas field and reinjecting it into a nearby geological structure for permanent storage for the last 20 years[7].

SHOW ME THE MONEY

The key current issue for carbon capture in both the power and non-power industrial sectors remains one of economics.

The cost of power and industrial products created at CCS-enabled sites will be significantly greater than at sites that simply emit the carbon. This situation will remain as long as the direct or indirect cost of emitting carbon stays low. This is well demonstrated by the situation in the United States – carbon capture and transport is an established industry in certain areas but only where CO2 has a value, in the US case for Enhanced Oil Recovery. The additional step to permanently store the CO2 is not the primary goal and in many places it does not take place. In a future carbon-constrained world we may see the cost of fossil fuels, such as coal, dropping as demand falls away – this will help CCS compared to other low-carbon technologies but will not be sufficient on its own without a strong carbon price signal.

If a carbon price represents the ‘stick’ approach to developing CCS, an alternative ‘carrot’ route is more direct financial support. While renewable energy has enjoyed widespread support, ultimately paid for by consumers, the CCS industry has struggled to gain any kind of financial support for commercial scale projects anywhere in the world. This comes down to a fundamental issue – a lack of public and hence political support for the technology.

A FAILURE OF POLICY?

If CCS is to contribute to the future of coal there is an urgent need for practical progress in two areas:

- **The appraisal and development of CO2 storage sites.** The long lead-time and uncertainty around future CO2 volumes for any individual development (at least in the short-term) means that direct support is likely to be required; and
- **The development of an economic model** where carbon capture enabled power stations and industrial sites can compete with their carbon-emitting counterparts.

Governments have so far failed to take the required steps despite making tentative progress, particularly in North America and China.

THE ROLE FOR COAL

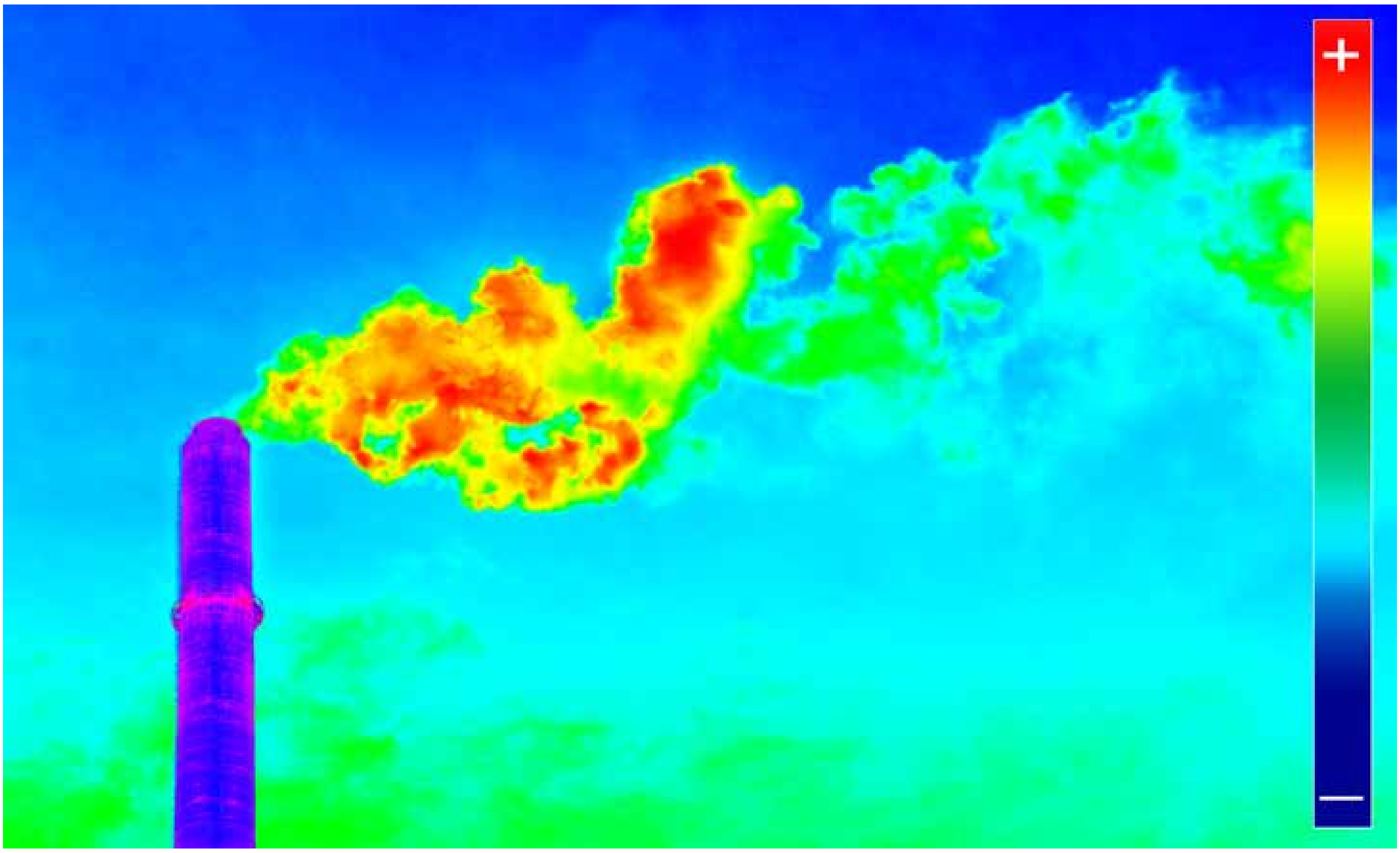
Coal is not about to disappear from our energy mix any time soon. And power stations that currently burn coal make up a large share of total global electricity and heat production.

At the same time, climate change risks are accumulating and are likely to gain more attention over the coming years.

Preparing for a carbon constrained world is of increasing priority for policy makers and companies alike. If we are to keep the lights on and at the same time avoid catastrophic climate change, CO2 emissions from the coal power station fleet have to be tackled and tackled fast.

Burning sustainable biomass in the existing coal fleet will be part of the solution – but CCS is necessary and development is currently far too slow.

1. Here bioenergy includes the traditional use of solid biomass and the modern use of bioenergy
2. The number of coal plants in planning has been reducing more recently. In addition, coal plants in China are reported to have lower than expected load factors. This is most likely due to lower than expected economic growth, rather than concerns over climate change.
3. See Poyry's Global Pellet Market Report for more details (hannes.lechner@poyry.com).
4. With transportation by pipe or ship if suitable geological structures are not present locally.
5. http://saskpowerccs.com/ccs-projects/boundary-dam-carbon-capture-project/
6. Bio-coke from, for instance Palm Kernel Shells is one possible alternative.
7. For comparison a 1GW coal-fired plant running baseload emits around 6mt CO2 pa.



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