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This issue of *Oxford Energy Forum* (OEF) looks at the Paris Agreement (which came out of COP21 – the 21st Conference of Parties under the United Nations Framework Convention on Climate Change) along with its implications for individual energy sources, for particular countries and regions, and for specific policy areas. Perhaps most striking is the range of views contained in the articles here and the disparity of impacts as between different sources, countries, and policy areas. Whereas in the last issue of *OEF* (where the focus was on electricity), there was much emphasis on the fundamental changes the industry is undergoing as a result of the rapid growth of low-carbon sources, and the similarity of the challenges in different parts of the world, the emphasis in this issue is on diversity. While some areas are seeing major changes and challenges, others are continuing with something little different from business-as-usual. The same applies to fuels; electricity is in the front line in most countries in relation to climate change policy, but for the oil and gas industries the challenges seem to be more to do with the medium- to longer-term. Perhaps as a result, investment markets seem distinctly uninterested in either the challenges or the opportunities offered by the low-carbon transition. Is this just realism or dangerous complacency about future developments?

Diversity is, of course, admirable in many respects but (given that we are dealing with an issue which is global and extends across the whole energy sector) it may simply indicate the failure of policy makers to face up to the challenges. The discrepancy between electricity and other energy sources is arguably symptomatic of a wider problem – that energy policy making is not keeping pace with environmental ambitions. At present, energy policy for decarbonization has a fairly narrow focus – support for renewable sources (particularly in electricity) and energy efficiency feature in most countries' plans. But these measures alone will not deliver the emissions reductions the Agreement says are needed, and the narrow focus could create distortions within the energy sector, add to the cost of the transition, and delay progress.

The suspicion must be that governments are concentrating on this narrow set of measures because they raise fewer problems, in particular in relation to consumer acceptance. Strategies for other sectors – for example heating and cooling – are only just starting to be developed in a few areas. Transport is proving resistant to decarbonization everywhere and the best that can be expected in this sector is 'jam tomorrow', in the form of the substantial penetration of electric vehicles, at some conveniently distant date. Non-renewable low-carbon sources seem to have stalled – nuclear is facing big political and economic challenges and is unlikely to prosper in current markets. Carbon Capture and Storage (CCS) is encountering practical, economic, and technical problems; previous optimistic expectations have not been realized.

Meanwhile, governments do not seem to have thought through the role that should be played by markets in decarbonization policy – another discrepancy is between

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the sort of policy recommended by many economists (global carbon taxes, for instance) and those adopted by policy makers. Even where carbon taxation plays a role, as in the UK, the approach is unsystematic. It is unsurprising that governments are relying so little on markets in their response to what has been described as the biggest market failure of all time, but the approach does contain the potential for distortions and inefficiencies. Overall, the impression is that governments have started with the relatively easy measures (renewables and energy efficiency) and have little idea where to go next.

It is this background which may have given rise to the complacency in some areas noted above. However, there are also reasons to question this complacency. The last issue of *OEF* may contain a salutary case study – developments in electricity have been much more rapid and (for incumbents) in many ways more painful than most expected, with huge losses of market value, stranded assets and technologies, and the need to develop new business models. It is also noteworthy that major economies, like China, have changed their stance significantly in recent years – to the extent that it now seems realistic to expect that China's emissions will peak within the next decade. So developments can take place faster and more fundamentally than many expect. In this respect, the importance of the Paris Agreement may be as much in its symbolism as in its details – it reflects a shift in global opinion which it could be short-sighted to ignore, even if the concrete results are not yet clear.

The first group of articles in this issue look at the agreement itself. *Mari Luomi* considers what it adds in institutional and financial terms, where it falls short (in particular in relation to what the science suggests is needed), and its lack of binding elements and procedural muscle. The main need now is effective implementation. However, the history in this area is not very encouraging and it will take time to gauge how far the agreement has been a success. *Scott Barrett* argues that the strong point of the agreement (that it was agreed by consensus) is also its Achilles heel. The outcome is less than what was needed and may not be achieved anyway. He explains this in terms of the problems of collective action, with reference to an exercise in experimental economics – in this experiment, groups chose ambitious, but still inadequate, collective targets and it was found that the review process did not succeed in its aim of increasing contributions aimed at reaching these targets. Barrett proposes some additional measures to secure better coordination. *Raphael J. Heffron* presents a personal view from a legal perspective. The main significance of the Paris Agreement to him is that it takes the focus of policy beyond 2020 and sends a signal to firms about the need to take action. Legal constraints on fossil fuel use are only likely to increase over time and the review process is likely to increase global transparency on the issue. The significance of the Paris Agreement is, to a large extent, as part of a wider process of changing global attitudes to energy.

A second group of articles look at the implications for the energy sector. *John Mitchell* considers the content of the Paris proposal, paying particular attention to its implications on the demand side – not just products and services, but also planning, infrastructure, and transport. The brunt of the changes required will be borne by the power sector in the near term – the challenges for oil and gas are less immediate, but this does not excuse complacency. There may be greater challenges to come, and meanwhile it is by no means clear whether gas will play the role of transition fuel. *David Robinson*, focusing on natural gas in Europe, develops this theme. In the short term, gas may benefit from COP21 as coal is squeezed out in electricity – a process helped along by policy measures restricting the use of coal which are likely to be reinforced in the wake of the Paris Agreement. However, gas will also face challenges, being increasingly regarded merely as back-up for intermittent renewables. In any event, the long-term prospects for gas look grim if policy makers really intend to meet their emissions reduction targets. Robinson argues that a strategy on gas infrastructure is needed. *Malcolm Grimston* considers whether nuclear's future is any clearer after Paris. It has a proven ability to deliver big emissions reductions; nonetheless many countries and activists are opposed, not always on solid grounds. However, the biggest current problem facing nuclear is probably economic. It is not clear whether it is possible to overcome the cost and risk barriers, at least in markets as they are constituted today.

The third group of articles look at particular countries and regions. *Sarah Ladislaw* considers US climate policy. The Climate Action Plan looks tough, but the measures taken so far may not be tough enough to reach the medium-term goals it sets, while political parties (and the US public) remain divided. There is a range of institutional and other complications which may work in either direction; Congress could prove a constraint, on the other hand, individual states may lead the way. A lot will depend on the forthcoming Presidential election.

Isabel Hilton points out how important China is to the process and how much its stance has developed since COP15 (the Copenhagen Climate Change Conference in 2009). There is now a real prospect that its emissions could peak within a decade and, although coal still dominates the energy mix, it seems to be in long-term decline. China's success in implementing its climate objectives will matter for the whole world. *Lavinia Hollanda* looks at the challenges faced by Latin America. In some ways they (or at least many countries in the region) have a favourable starting point – relatively low carbon intensity due to the high penetration of hydro power. However, there are also big challenges and Hollanda identifies financing in particular. Latin America is also rather weak in technology development and innovation. Overall, concerns about climate change in the region are rather different from those faced in Europe or the USA. *Anupama Sen* looks at India's climate and energy goals. The power sector is a key focus. Although there are fairly ambitious plans for the development of renewables, the reliance on coal, and the relatively low level of electrification mean that emissions in this sector are set to rise many fold. Unlike China, there is no prospect of emissions peaking in the foreseeable future, and climate and energy policy remain contradictory rather

than complementary. *David Buchan* analyses the challenges in Europe. Policy has hitherto concentrated on electricity and the sectors involved in the Emissions Trading Scheme. However, in future more attention will need to be given to other sectors and the barriers, particularly in relation to consumer acceptance, are much greater. Strategies are being developed in new areas – for example heating and cooling in buildings – but it is not yet clear how far they will affect individual member state strategies, or consumer behaviour, as they will need to do to be effective.

A final group of articles looks at some specific areas where the Paris Agreement could have an impact. *Andrew Howard* looks at investors' viewpoints. So far, climate change has not been a major driver of sentiment – the jury is still out on whether governments are prepared to take strong measures to achieve their objectives. For instance, the global impact of carbon pricing is equivalent to only about 50 cents per barrel of oil – an insignificant figure when set against the volatility of oil prices. Firmer action by governments would not necessarily lead to lower investment in high-carbon companies – it might simply reduce the uncertainty surrounding their valuation. *Frederick Lawrence* of the Independent Petroleum Association of America looks at the divestment debate from a producer's perspective – from that viewpoint it appears ineffective, and likely to cause more harm to the institutions engaging in divestment than the companies from which they are divesting. He argues that constructive engagement by these institutions would be a better way forward.

Paul Johnson considers the UK approach to carbon pricing. Many economists would argue that an effective and consistent carbon price would help minimize the cost of meeting carbon targets. However, UK policy has not been consistent over time or as between different forms of energy consumption. That adds to costs and reduces incentives by creating uncertainty about the future price trajectory. Overall, Johnson considers the UK approach hard to square with a commitment to reduce emissions at minimum cost. *Jos Dings* looks at policy for decarbonizing transport across the EU, and also finds it wanting. Most measures have either failed or disappointed. The promotion of renewable energy in transport in particular has been a huge policy mistake. Looking forward, however, Dings manages to see opportunities, particularly in energy efficiency and electrification. He concludes that although the clock is ticking, it is not yet too late to make progress. Finally, *Ben Caldecott* and colleagues look at how CCS fits into the coal value chain, drawing on a study undertaken by Oxford's Stranded Assets Programme. The study found that of the top 100 coal-fired utilities, two-thirds have no power stations meeting even fairly generous retrofitability criteria. Furthermore, coal-based generation fitted with CCS faces competition from other low-carbon sources like nuclear and renewables; overall the role of CCS in the thermal coal value chain is at best uncertain, at worst undesirable.

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Is the Paris Agreement a success and what does it mean for the energy sector?

Mari Luomi*

On 12 December 2015, the French President of the UN Climate Change Conference gavelled through the Paris Agreement in the presence of a few thousand country delegates. The conference room broke into euphoric cheers and applause as negotiators celebrated success in a task that just six years earlier had seemed all but impossible. Those who had been closely involved in the process described the Paris Agreement as the best possible outcome. Governments, investors, experts, and activists worldwide affirmed it had signalled the end of the fossil fuel era.

This short article examines these two affirmations. It asks: what did Paris do to deserve to be called a success, and where does it fall short? What does the Paris Agreement mean for the energy sector?

On the question of success, the article examines whether the Paris Agreement provides the necessary global regulatory mechanisms to prevent dangerous climate change. For negotiators who had seen several years of protracted negotiations and were desperate to avoid a similar collapse to that of Copenhagen in 2009, the definition of 'success' was inevitably lower than for climate scientists, civil society advocates, and people all around the world already feeling the negative impacts of climate change through abnormal weather patterns and increasing extreme weather events.

On energy, this article looks at what difference, if any, the Paris Agreement will make for the sector. How can an agreement that does not make a single reference to fossil fuels, nor any substantive reference to energy, push countries to decarbonize their energy supply and move towards more efficient and climate-resilient energy systems? While a major outcome from Paris undoubtedly was the strong signal it sent of collective political determination, a signal alone is insufficient if it is not sustained by long-term policies and regulations, backed up by investments and divestments.

What is the Paris Agreement?

From a diplomatic perspective, the Paris Agreement was the culmination of more than 20 years of negotiations. It represents a consensus among 195 governments on what the global regulatory framework for preventing dangerous climate change post-2020 should look like. According to many, the Agreement restored faith in the ability of the multilateral UN system to agree on collective solutions to global problems. In recent years, a growing number of voices have been calling for the formation of 'climate clubs' of major emitters that agree to take ambitious action in exchange for trade and other benefits, as being the only viable solution to achieving the required emissions reductions. The Paris conference showed that the time of UN diplomacy is not over; it can deliver results even through consensus (the *de facto* procedure in the UN climate negotiations).

As a multilateral treaty, the Paris Agreement scores high on legitimacy through its near-universal level of participation. It also sends a strong signal on political ambition, and has in-built mechanisms aimed at increasing ambition over time.

'AS A MULTILATERAL TREATY, THE PARIS AGREEMENT SCORES HIGH ON LEGITIMACY THROUGH ITS NEAR-UNIVERSAL LEVEL OF PARTICIPATION.'

From an international law perspective, the Paris Agreement consolidated a 'bottom-up' architecture for multilateral climate governance. In the words of climate law expert Daniel Bodansky Paris tied

> *'a treaty ribbon around … key elements of the Copenhagen Accord'*

('Reflections on the Paris Conference', *Opinio Juris*, 15 December 2015). It includes a system of nationally determined contributions (and their non-binding content), an extension of this system to all countries, and an affirmation of the pledge to mobilize US$100 billion in finance to developing countries by 2020.

This bottom-up system, in which countries themselves determine what they consider a fair and ambitious contribution is, however, significantly strengthened in the Paris Agreement. Its 'hybrid' approach introduces a number of regulatory elements, political mechanisms, and institutional structures that will be crucial in ensuring that countries' individual plans, and their implementation, add up to what is required by science.

What does the Paris Agreement add?

Firstly, the Paris Agreement sets global long-term goals for temperature and greenhouse gas (GHG) emissions. Parties to the Agreement subscribe to a collective goal of holding the global average temperature increase well below 2 °C (or even 1.5 °C), of reaching a global peaking of GHG emissions

as soon as possible, and of achieving emissions neutrality in the second half of this century.

Secondly, the Agreement establishes a system of national climate action plans ('nationally determined contributions', NDCs), the preparation, communication, and maintenance of which are obligatory to all countries. NDCs need to be communicated every five years and must include mitigation (emissions reduction) measures and represent a progression over the country's previous NDCs.

Thirdly, the agreement lays the foundations for a framework to incentivize increasingly ambitious climate action by countries. This includes a process and systems to track countries' progress towards their individual goals (transparency framework) and a process to periodically assess collective progress towards the long-term goals of the agreement (global stocktake).

In order to encourage developing countries to adopt increasingly ambitious mitigation targets and to support their adaptation efforts, the Paris Agreement enhances the existing institutional mechanisms for technology development and transfer, and for capacity building in developing countries under the UN Framework Convention on Climate Change (UNFCCC). It also provides assurances on climate finance by extending the US$100 billion commitment through 2025 and establishing a process to define a common accounting methodology for public finance – this definition remaining a source of contention between developed and developing countries.

Where does the Paris Agreement fall short?

As noted above, if restoring faith in multilateral diplomacy and saving the reputation of the UNFCCC as the leading global institution for climate governance are used as the criteria for success, Paris delivered extremely well. No doubt it also sent a strong political signal. However, the Agreement's key features also reveal a number of shortcomings, which may determine whether it succeeds as a climate agreement.

'…A HUGE GAP STILL REMAINS BETWEEN THE LEVEL OF ACTION COUNTRIES ARE WILLING TO COMMIT TO INTERNATIONALLY AND WHAT IS REQUIRED…'

Firstly, a huge gap still remains between the level of action countries are willing to commit to internationally and what is required according to science to avoid dangerous climate change. The celebration by many vulnerable developing countries of the hard-fought inclusion of a reference to 1.5 °C in the Agreement text is contrasted by the stark reality of the pledges that countries brought to Paris (according to most estimates these would lead to 3 °C of warming or more, if implemented). A key measure of success will therefore be how well, and how fast, the Agreement will incentivize more ambitious action.

Secondly, the binding elements of the Paris Agreement are largely procedural. Achieving broad participation came with the cost of allowing countries to self-determine the level, type, and scope of their national contributions. Only the process-related aspects (preparation, communication, maintenance) of the NDCs are binding. The exact content of the NDCs is left to countries to determine.

Thirdly, the Agreement lacks legal muscle to ensure countries comply with their pledges or to increase them to a level that science determines as sufficient to avoid disastrous climate change. While crucial in setting a common direction for all countries, the long-term goals of the Paris Agreement are in practice merely aspirational, given the impossibility of holding any country, or group of countries, accountable for non-compliance. Should a country fail to reach its goals, a committee of experts will examine the case in a facilitative and non-punitive manner. In the absence of a strong compliance mechanism, the power of the ambition mechanism is therefore mainly drawn from peer pressure – in other words political shaming and blaming.

What needs to happen now?

Paris resulted in a long to-do list for both the UNFCCC and national governments. Under the UNFCCC, climate negotiators and experts will spend the next five years developing the detailed rules and procedures that will form the basis for the functioning of the regulatory, political, and institutional frameworks supporting the Paris Agreement (transparency framework, global stocktake, accounting rules for finance, and rules for international emissions trading, among others).

In order to make the Paris Agreement operational by 2020, countries will need to ratify it, formalize their Paris pledges, and start preparing for their updated NDCs, which are due by 2020, with a target year of 2030. For entry into force, 55 countries representing at least 55 per cent of global GHG emissions will need to join. Boding well for this process, the USA and China (which jointly account for a more than a third of global emissions) announced in early April 2016 that they would aim to join the Agreement as early as possible in 2016.

The most crucial task, however, will be turning the countries' NDCs into on-the-ground action by translating them into public policies, programmes, and

investments. This work should start even before the Paris Agreement enters into force. Intergovernmental Panel on Climate Change (IPCC) emissions scenarios suggest that delaying more ambitious action increases both the costs and risks involved later on. If, instead of steady reductions, global GHG emissions are allowed to keep rising for the next 10–20 years, quick reductions will be needed thereafter to stay within 2 °C of warming. This would translate into higher costs and increase the likelihood of needing to resort to controversial geoengineering technologies – such as bioenergy with carbon capture and storage (BECCS).

Between 1970 and 2010, according to the IPCC, global GHG emissions increased by more than 80 per cent. Economic and population growth continue to drive the growth of fossil fuel consumption, which in turn is the main driver of climate change: currently responsible for two-thirds of human-made GHG emissions. Energy will therefore be at the centre of global mitigation efforts.

What does Paris mean for the energy sector?

Despite numerous analyses of the Paris Agreement from legal and political perspectives, less attention has been paid to its implications for global energy use patterns in the future. There are several possible reasons for this: firstly, energy is a highly politicized topic in the UNFCCC negotiations, which is why the Paris Agreement lacks clear references to it. The Paris Agreement also leaves it up to each country to decide how and where they will reduce their emissions. At the same time, energy will be a core component in practically all countries' climate plans. According to the World Resources Institute, 80 per cent of intended nationally determined contributions (INDCs) submitted by late October 2015 referenced clean energy.

'…ENERGY IS A HIGHLY POLITICIZED TOPIC IN THE UNFCCC NEGOTIATIONS, WHICH IS WHY THE PARIS AGREEMENT LACKS CLEAR REFERENCES TO IT.'

Secondly, the long-term goals of the Paris Agreement are not by any means breaking news for the energy industry. The pathway set for emissions to peak rapidly and reach net zero in the second half of this century will evidently require a major transformation of the entire global energy system. However, these collective emission goals merely reflect what science tells us, and the consequences of pursuing them are generally well known.

For example, the IPCC's Fifth Assessment Report from 2014 concluded that:

> *' … mitigation policy could devalue fossil fuel assets and reduce revenues for fossil fuel exporters, but differences between regions and fuels exist.'*

The report also confirmed that, as a result of mitigation action, coal and oil export revenues are likely to decrease, with less certain impacts on natural gas export revenues, and that the use of Carbon Capture and Storage (CCS) technologies would reduce adverse effects on the value of fossil fuel assets. What the Paris conference therefore did was confirm that countries are listening to science. This is nevertheless a powerful signal to the energy industries – if they are listening.

Thirdly, there is no track record of a link between UNFCCC outcomes and global emissions. The UNFCCC and its first legally binding treaty (the Kyoto Protocol) have not, so far, had a demonstrable net effect on global GHG emissions. However, this may be changing as, in March 2016, the International Energy Agency (IEA) reported that CO_2 emissions from the energy sector had remained constant from 2013 to 2015. This was the first time in 40 years that global emissions had stood still (or fallen) for reasons unrelated to an economic downturn. According to the IEA, the trend was led by changing energy consumption patterns in China and the USA: switching from coal to renewables in the former and from coal to natural gas in the latter. These changes were offset by emissions growth elsewhere in Asia, in the Middle East and, to some extent, in Europe.

The stalling of global energy emissions due to changes in just two countries shows how domestic actions by major emitters can have a significant impact on global emissions. Here, the periodic ambition and transparency mechanisms of the Paris Agreement can play a key role in building trust for increasingly ambitious action by all major economies.

Fourthly, oil markets have in recent times been more preoccupied with low prices, which are driven by factors largely unrelated to climate policy, namely a glut in supply. The jury is still out on whether the low oil prices are a curse or a blessing for ambitious climate action. On the negative side, low prices incentivize higher oil consumption and use of energy inefficient solutions, especially in the transport sector (where impacts may be felt by fuel-efficient vehicles, electric vehicles, and biofuels), but in some countries also in the electricity sector. The IEA estimates that if sustained, lower oil prices could discourage US$800 billion in energy efficiency investments through 2040, leading to higher GHG emissions.

On the positive side, low oil prices have already made it possible for many countries to implement badly needed fossil fuel subsidy reforms. In the oil industry, they have led to the postponing of capital expenditure in

production and exploration, possibly to a time in which environmental regulation or changed market conditions will make their use no longer viable. Low oil prices have also accelerated the determination with which many oil-producing countries, in particular in the Gulf, are pursuing their economic diversification efforts. The United Arab Emirates' post-oil strategy, together with plans in Saudi Arabia to sell shares of the national oil company to support economic growth and reform, are powerful signs of this.

Will Paris make a difference?

It is argued here that, in order to see the real potential of the Paris Agreement to support the needed global energy transformation, one must look beyond its actual and perceived shortcomings. These include its internal operational and structural weaknesses (the gap between pledges and science, and the weak enforcement mechanism), issues related to external perceptions (the UNFCCC's weak track record), and parallel energy trends (low oil prices).

'DESPITE ALL ITS SHORTCOMINGS, THE PARIS AGREEMENT, AS A UNIVERSAL CLIMATE AGREEMENT, REPRESENTS A REALISTIC COMPROMISE AND ACHIEVES MORE THAN MANY HAD EXPECTED.'

Post-2015, the question of whether the Paris Agreement will be successful or if it will spur change in the energy sector, is arguably synonymous to asking if national climate policies will be strengthened and implemented over time, and where energy investments will be directed as a result. Despite all its shortcomings, the Paris Agreement, as a universal climate agreement, represents a realistic compromise and achieves more than many had expected. The debate, going forward, should therefore not be about whether Paris succeeded or not, but about how to leverage the Agreement to support national-level implementation worldwide. Ultimately, future generations will not judge ours for whether the Paris Agreement included ambitious pledges, or even if it set up functional confidence-building and support mechanisms, but whether we, collectively, managed to cut our energy emissions quickly and deeply enough to keep global temperature rise at a safe level.

**The views expressed in this article are those of the author, and do not necessarily reflect the views of the Emirates Diplomatic Academy or the UAE Government.*

COP21: One step forward, a mile to go

Scott Barrett

At the Paris climate conference last December, all the world's countries were able to reach a consensus about a matter of profound importance. They agreed that climate change needs to be halted and that every country must play a role in halting it.

Why were countries able to reach a consensus? One reason, of course, is that all countries recognize the threat posed by climate change. But another reason is that, under the rules of the first climate treaty, adopted in Rio in 1992 (the United Nations Framework Convention on Climate Change, or UNFCCC) decisions by the parties *must* be agreed by consensus. As the new agreement was being negotiated under these same rules, opposition by any country could have sunk the effort – this is what happened in Copenhagen in 2009 at the previous make-or-break climate meeting. All countries agreed after this that they had no alternative but to try again.

'…THE MAIN OBLIGATIONS OF THE AGREEMENT ARE SELF-DETERMINED AND EXPLICITLY VOLUNTARY…'

Another reason why a consensus was reached in Paris is that the main obligations of the agreement are self-determined and explicitly voluntary (other obligations are collectively determined, but the agreement says that implementation of these obligations is to incorporate 'built-in flexibility'). Previous efforts to negotiate a climate treaty tried to get countries to do more than they were willing to do on their own, without providing any means for enforcing such obligations. If the means for enforcement are lacking, and a consensus is needed, then it's obvious how the negotiations should be structured: you have to ask countries to accept obligations that they are willing to accept. You can urge them to do more, but you cannot compel them to do more. And since the obligations are usually expressed in terms of outcomes that countries don't control directly (country-wide emissions), you have to accept that meeting these obligations is ultimately voluntary in order to provide an extra measure of reassurance.

This is not to say that the negotiations were tension-free. Although each country wants to be free to choose its own obligations, every country would like all *other* countries to do much

more than they are willing to do on their own. Moreover, every country knows that all countries together are better off if they all agree to do more than they are willing to do on their own. The problem is that no country is willing to do this unless given the reassurance that all other countries will do it. This is the main purpose of enforcement – to provide such reassurance. Unfortunately, when the means for enforcement is lacking, all that can happen is that counties urge others to do more, while at the same time insisting that their own obligations be self-determined and voluntary.

People who cheer the Paris Agreement see it as reducing emissions relative to a forecast of 'business-as-usual'. Indeed, the Secretariat to the UNFCCC produced an analysis of all the submitted 'intended nationally determined contributions' shortly before the Paris conference, and showed that, if countries fulfilled these pledges, emissions would likely dip slightly below 'business-as-usual'.

There are several things to note about this:

1 We will never observe business-as-usual (by definition, this is a future world that will never be realized since countries are now operating under the Paris Agreement). The Secretariat can do no more than try to infer what emissions would have been in the absence of the pledges.

2 Countries have incentives to limit their emissions unilaterally. Every country will be adversely affected by climate change – certainly in the longer term and with respect to 'abrupt and catastrophic' climate change – and so every country has an incentive to do something to limit its emissions. The problem, of course, is that countries have little incentive to reduce emissions for the benefit of other countries. We should expect all countries to do something, but we should not expect any country to do enough.

3 Pledges are almost always expressed in terms of a country's emissions, and yet countries do not adopt policies and measures to control their emissions directly. They adopt policies and measures to control their emissions indirectly. Even if countries adopt the policies they promise to adopt, there is no guarantee that the emission levels they have pledged will be met. For example, if emissions are expected to fall due to the adoption of new energy efficiency standards, the extent of the reduction will depend on the 'rebound effect', about which there can be significant uncertainty.

4 Future emissions will depend on factors that countries do not control, such as economic growth, technological advancements, and unanticipated shocks such as the tsunami that caused Japan to close its nuclear plants and Germany to phase out nuclear power.

5 Even if a particular country reduces its emissions, and keeps within its pledge, the consequence may only be to increase emissions elsewhere, because all countries are linked through global energy markets and trade.

'THE PROBLEM, OF COURSE, IS THAT COUNTRIES HAVE LITTLE INCENTIVE TO REDUCE EMISSIONS FOR THE BENEFIT OF OTHER COUNTRIES.'

The most important thing to understand about the pledges submitted in the lead up to Paris is that, even if they are all met, analysis by the Secretariat for the UNFCCC shows that global emissions will continue to increase through 2030. Such an outcome virtually guarantees that the overall goal agreed in Paris – to keep global mean temperature change (relative to pre-industrial levels) 'well below' 2 °C – will not be met.

How is it possible for countries to agree on a collective goal and then not adopt the policies needed to meet it? This is the essence of the collective action problem. All countries collectively have an incentive to meet the overall goal. Each country would be willing to take measures to play its part in meeting the overall goal – but only if assured that all other countries will play their part in meeting the goal. Of course, there is also the matter of countries needing to come to an agreement about the parts that each should play in this collective effort – these were all the things that were not agreed in Paris. As matters now stand, the only way in which the voluntary contributions pledged thus far could achieve the collective 2 °C goal would be if a 'miracle' occurred around 2030 – something like a technological breakthrough that caused global emissions to plummet around this time. Even then, according to another analysis by the Secretariat for the UNFCCC, the chances of staying within the 2 °C goal would be no better than 50–50.

Again, this assumes that countries do what they have pledged to do. Will they?

Perhaps the most important aspect of the Paris Agreement is the arrangement for transparency and review. The idea is that if countries knew they were going to be scrutinized, then they would take the steps needed to meet or exceed their pledges. But is this true? To determine the effect of such a process on behaviour, Astrid Dannenberg (of the University of Kassel in Germany) and I conducted a laboratory experiment involving real people playing for real money. The advantage of an experiment is that you can create the needed 'counterfactual'. That is, we can compare behaviour with and without a review process.

This is what we found: The review process causes groups to choose a

'OUR RESEARCH SUGGESTS THAT THE REVIEW PROCESS WILL AFFECT WHAT COUNTRIES SAY BUT NOT WHAT THEY DO.'

more ambitious collective target. However, the target they choose is still too weak relative to what is required to make the group as well off as possible. We also find that the review process causes the players to announce more ambitious pledges. However, when added up, these pledges fall short of the group's target. Finally, we find that the review process does not increase contributions. Moreover, contributions fall short of pledges. Hence, our research suggests that the review process will affect what countries say but not what they do. The analyses by the UNFCCC that I noted previously assume that countries will fulfil their voluntary pledges, but we can't be sure of this. Over the past 25 years, many countries have made pledges to reduce emissions and then failed to achieve them.

The real problem with the Paris Agreement is that it embodies the same approach that has been tried again and again – that of setting targets and timetables for emission limits at the national level, without providing a means for enforcement.

Are there ways in which a more ambitious agreement could be enforced? Recent research by William Nordhaus of Yale University shows that a club of like-minded countries could enforce more demanding obligations using a generalized tariff. However, the use of such a tariff could possibly spark retaliation – a possibility Nordhaus assumes away. Even if a trade war is avoided, Nordhaus's analysis shows that a tariff will lose its effectiveness once the price on carbon tops about US$50/t$CO_2$, which is a pretty low number compared to what is needed to bring about a transformation in the global energy system.

Plainly, the world isn't ready yet to contemplate such trade measures. Are there other options?

To my mind, the best thing about the Paris Agreement is that it doesn't forestall parallel approaches of the kind I have been recommending for 15 years – approaches that involve *coordination*.

One such approach is already underway. This is an effort to amend the Montreal Protocol (an agreement to protect the ozone layer) to limit hydrofluorocarbons (HFCs), a potent greenhouse gas. This approach will work because Montreal is designed very differently from any of the climate agreements. The climate agreements have all tried to limit the consumption of fossil fuels (meaning, the emissions that occur on a country's own territory). The Montreal Protocol is very different. It not only limits the consumption of chlorofluorocarbons (CFCs); it also limits the production of CFCs, arranges for rich countries to pay for the costs of compliance by poor countries, and bans trade in CFCs and products containing CFCs between parties and non-parties. As a result of this combination of measures, participation in this agreement has been full. CFCs have been phased out. And trade has never needed to be restricted.

There should now be an effort to identify other opportunities like this one. An obvious place to start is with negotiations under the International Civil Aviation Organization for international aviation, and under the International Maritime Organization for international maritime shipping. Both of these organizations should lead negotiations to establish agreements for technology standards that can improve the efficiency of transport. Enforcement in such agreements would involve ports and airports within the territories of every party, restricting access to vessels and planes to those that comply with the agreed standards.

Other opportunities exist in other sectors. For example, a change in the smelting process for making aluminium could eliminate the emission of perfluorocarbons (PFCs), another potent greenhouse gas. A new agreement would mandate that all new aluminium smelters adopt this technology by a particular year, and that existing plants adopt this technology by some future year. Financial transfers from rich countries would cover the compliance costs of poor countries. And all parties to this agreement would agree to import aluminium only from countries that participate in and comply with the agreement.

This approach of coordinating behaviour is piecemeal. It isn't fully cost-effective, and it won't, on its own, stabilize atmospheric concentrations. However, it is a conceit to believe that these objectives can somehow be achieved by a single global, overarching agreement.

Because none of these approaches is enough, a coalition of willing countries should also undertake joint research into 'game-changing' technologies, including the only true backstop technology for reducing emissions – an industrial technique for removing CO_2 directly from the air. Such a technology is likely to be very expensive, but the collective action needed to develop this technology and to apply it at very large scale is potentially easier than trying to change behaviour worldwide.

The Paris Agreement won't stabilize the climate, but we should work to get the most out of this Agreement, which means investing in its implementation. In addition to this, we should also

'THE PARIS AGREEMENT WON'T STABILIZE THE CLIMATE, BUT WE SHOULD WORK TO GET THE MOST OUT OF THIS AGREEMENT, WHICH MEANS INVESTING IN ITS IMPLEMENTATION.'

work now to build parallel agreements around Paris – agreements like an amended Montreal Protocol and similar efforts targeted at specific sectors and gases. We also need to contemplate more radical approaches – enforcement mechanisms like the one proposed by Nordhaus and technological remedies such as 'direct air capture'. The problem of climate change is unprecedented, and addressing it fully will require actions that go beyond the measures that negotiators have so far dared to contemplate.

The Implications of the Paris Agreement and climate change from a legal perspective

Raphael J. Heffron

The hot topic in energy research for many disciplines has become discussing the implications of the UNFCCC Paris Climate Change Conference (the 21st session of the Conference of the Parties, or Paris COP21). And while some heralded and stood like *Tubicenae* (trumpeters) in Ancient Rome to await the policy makers and their entourages returning from Paris with their pronouncement concerning climate change, lawyers, it can be said, were not rubbing their hands with glee. From a legal perspective, the effects of the Paris Agreement will take time to work their way into the three levels of energy law: international, national, and local.

'…THE EFFECTS OF THE PARIS AGREEMENT WILL TAKE TIME TO WORK THEIR WAY INTO THE THREE LEVELS OF ENERGY LAW: INTERNATIONAL, NATIONAL, AND LOCAL…'

It is also worth considering that while the Paris Agreement of 2015 is seen as a landmark in terms of climate change negotiations, in some sense we have been here before. Similar pronouncements have been made before and after climate change negotiations in the past. Some disciplines have moved on from this focus and have begun to see climate change differently. In this context, the real focus of many climate change scholars has been to follow the 'money trail'. There remains too much money in the fossil fuel industry. This is the big battle society is facing and a transformative shift, in terms of how we govern the energy sector and indeed the greater economy, is required.

Paris COP21 and the law

Paris, home to the latest climate change negotiations, is a city known for its stories of romance and is indeed a melting pot of leading literary figures, from Joyce to Beckett, to Camus and Sartre, to name but a few. It has given us a similar romantic tale about climate change. And just as Paris remains a city of romance and literature, it is likely that Paris COP21 will remain significant in the battle against climate change. More countries than ever before have agreed to take action on climate change. Paris COP21 has delivered real potential for change, with three of the world's largest carbon dioxide (CO_2) emitting countries, India, China, and the USA having initially agreed to be part of the Agreement – which will be signed between 22 April 2016 and 21 April 2017.

In considering the effect of the Paris COP21 negotiations, the real goal from a legal perspective is the aim of moving 'beyond 2020'. Law in terms of energy and climate change has been dominated by the year '2020' – the year when new targets for emissions, efficiency, and the contribution of renewable energy would be met under binding targets for many countries present at Paris COP21. While these countries have been focusing on meeting these targets – with mixed success in many cases – there has been little direction as to what will happen post-2020. The impact of Paris COP21 is that it has brought this *beyond 2020* debate more into focus.

Certainly, from a legal perspective there seems to be an acknowledgement that 'legal thinking' is essential in thinking *beyond 2020*. Policy makers and scholars in general now recognize the necessary development of new law to provide improved, and new, market structures for the energy sector so that Paris COP21 climate change goals can be realized. Lawyers need to play more of a role in achieving the next stage of climate change targets, for 2030. And perhaps in thinking of the wider energy and climate change community and their focus on energy transition scenarios, and of the energy scenarios of 2030, 2050, and 2080, law has been a forgotten part of the debate.

Paris COP21 and the 'silent legal signals'

Paris COP21 has placed climate change at the forefront of public consciousness by its achievement of more international cooperation than ever before on the issue. This is significant when we think of the indirect legal effects of Paris COP21. To explain this we can return to

the idea of following the *money trail* in the battle against climate change. We know that what society refers to as 'big business' is responsible for the majority of CO_2 emissions globally; Heede's 2014 study ('Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers 1854–2010', *Climatic Change*) states that 90 entities (mostly) companies are responsible for two-thirds of global CO_2 emissions. Hence, if these companies are held more to account and encouraged to move away from fossil fuel use, we may begin the significant and necessary transformation of the economy, and begin to realize the notion of a low-carbon economy.

In 2001, Noreena Hertz wrote an excellent book on the silent power and influence of big business on society – it was appropriately titled *The Silent Takeover: Global Capitalism and the Death of Democracy*. I believe that, aided and abetted by the international climate change agreements (and in particular their continued development resulting in Paris COP21 and its increase in international support), we are seeing a slow reduction of this *Silent Takeover* where energy is concerned. To some degree Paris COP21 confirms to these companies that the international community is intent on taking action and that the time for supporting (institutionally and financially, and directly and indirectly) these firms is coming to an end. In essence these firms have been sent a *silent legal signal* to begin playing their role in beginning the transformation to a low-carbon economy and Paris COP21 confirms this signal.

Indeed, the shift away from fossil fuels has been signalled to the international investment community for some time but Paris COP21 confirms this. The world's largest development bank, the European Investment Bank, has been investing more and more in international renewable energy projects – in part because it is legally obliged to follow EU energy policy objectives. Other funds, such as university endowment funds, have moved out of fossil fuel energy sources while even Norway's sovereign debt fund is divesting all its coal assets (see 'Norway fund could trigger wave of large fossil fuel divestments, say experts', *The Guardian*, 28 May 2015). Further, in the USA, coal assets have plummeted, losing nearly 85 per cent of their value in the last five years (see Stranded Assets and Thermal Coal: An analysis of environment-related risk exposure, Ben Caldecott, et al., Oxford Smith School, 2016). And what value will UK coal assets have following the recent announcement by the UK Government that all coal generation electricity assets would be closed by 2025?

'IN THE INTERNATIONAL INVESTMENT COMMUNITY THERE IS PERHAPS A REALIZATION THAT SOME FOSSIL FUEL ASSETS ARE NOW PRICED AT THEIR PEAK VALUE.'

In the international investment community there is perhaps a realization that some fossil fuel assets are now priced at their peak value. For example in the USA, Bill Koch lost approximately US$2 billion in the decline of coal prices in the last five years and admitted he did not exit the market at the right time. This understanding is now spreading to the rest of the fossil fuel community and in particular to the gas industry. Germany has had a gas plant built that has never been turned on. Carbon Capture and Storage (CCS), as a technology source for capturing CO_2 from gas plants, is looking further away than ever from commercial operation. And significantly TOTAL, the French energy giant, has already begun to sell some assets in gas (see 'French oil major Total to sell $900m of North Sea assets', *Financial Times*, 27 August 2015 and 'Total sells stake in North Sea gasfield to SSE in $900m deal', *Financial Times*, 29 July 2015). Indeed, is TOTAL ahead of the curve, and aware that now is the peak price period for gas assets?

Paris COP21 set to increase the legal burdens on fossil fuel use

What has, and is, turning these companies away from fossil fuel use? In a nutshell it is the increased legal burdens that are being placed on these companies when operating and/or developing fossil fuel assets. And Paris COP21 signals that these legal burdens are here to stay and set to increase. Consider the following legal trends internationally in the energy sector, which demonstrate the increased legal burdens on energy companies:

- *Coal mining* – operating companies have to show evidence they have the financial reserves to pay for full decommissioning.
- *Offshore oil and gas* – decommissioning costs are escalating; the threat of legislation to ensure that oil and gas companies have the financial reserves to pay for decommissioning is looming in many countries.
- *Fossil fuel electricity generation infrastructure* – in many countries, legislation is in place that new fossil fuel infrastructure can only be built if it is accompanied by CCS technology (it should be noted that there are variations on this, some countries focus on coal only, while others state only that they have to have the 'capture' technology built).
- *Provision of data* on CO_2 emissions, toxic pollutants, effects on local and national public health, and subsidy support.

The first three are self-evident, while the final one is perhaps the most interesting as it overlaps with Paris COP21; this is discussed in more detail in the next section.

The Paris COP21 five-year review and data production

Data production is enabling a new era – in terms of how we see and think of the energy sector and its effects – to be ushered in. More and more people are questioning why and how we support different energy sources. In this context, people are witnessing more of the external effects of energy, in particular the issue of poor public health – both the physical effects and conclusions reached from the data itself – in a variety of forms. India, China, and the USA all have this in common and it is therefore no surprise that they want action to some degree. In part, this results from the spread of information relating to energy data – this spread of data is well documented in popular science books. 'Energy' learning and teaching is increasing significantly and is itself now beginning to mature as probably the first major interdisciplinary research field at universities.

'THE FIVE-YEAR REVIEW PROCESS OF PARIS COP21 WILL … FORCE US TO REVIEW "THE DIRECTION" OF WHERE WE ARE GOING POST-2020.'

One of the significant aspects of Paris COP21 is its call for a review of progress and action every five years. While countries contemplate the final stages of whether they will meet their 2020 climate change targets, and some set the narrative of why they may not have achieved it, the climate and energy community will be engaged in a data production rush. This data, produced over the next five years, will contribute significantly to how we tackle climate change beyond 2020.

The five-year review process of Paris COP21 will, for certain, force us to review 'the direction' of where we are going post-2020. It will also encourage us to review the data produced to date and to think and explore more on the issues where more data may significantly influence public opinion. For just a few examples of this, consider the following:

- more data on subsidies for the energy sector is being produced and it is changing our opinion on support for fossil fuels (in other words, is renewable energy so expensive when we factor in subsidies to fossil fuels and the spiralling decommissioning costs?);
- more data on the public health consequences (both in terms of cost to the public health system and of physical impact on the person) of fossil fuels is changing the view on using fossil fuels in the long term; and
- more data is being produced, and will be required in the future, to build new energy infrastructure – such as that used in the Environmental Impact Assessment (EIA) documentation from 2017 – and this data is required not just by the public but also by banks who finance the projects.

The EIA process and its data production requirement are increasingly making fossil fuel energy infrastructure more difficult to build. It is likely that a lot of data for the five-year reviews under Paris COP21 will come from the EIA process. The *energy data rush* is about to go into overdrive and, worryingly for the fossil fuel industry, it seems destined to make a major contribution to the review of the true cost of fossil fuel infrastructure – a review that includes the full cost of harm from its externalities, and the subsidy support it receives.

Fossil fuels, the Emperor has no clothes

Paris COP21 highlights a new level of international cooperation on climate change. It represents the move to go beyond 2020, and law has a significant role to play in ensuring that the steps we need to take for that period are realized. Paris COP21 is sending clear signals to the investment community that there is a major threat to the future of the fossil fuel industry and that in the future it will be harder to justify building new fossil fuel infrastructure.

Indeed, for the success of global action against climate change, continued use of fossil fuels is the real challenge. Perhaps the Paris COP21 achievement is that it espouses the continued use of 'subtle' changes to fossil fuel energy sources that have dominated our society for so long. Economic markets should create incentives to move away from reliance on these sources, but considering their domination by fossil fuel sources, more subtle and slow reform is needed. Hopefully this is what we will see with the development of the Mission Innovation initiative – another Paris COP21 result – that is aiming to deploy renewable energy to developing world countries and beginning the process of moving these countries away from further reliance on fossil fuels.

Finally, the responsibility falls on lawyers to work on continuing to adapt and change the legislation that is currently beneficial to fossil fuel energy sources. They need to encourage – and continue – the state of undress of the Emperor, so that all will finally realize that the Emperor is, as in the 1837 story by Hans Christian Andersen, without clothes. In this reality, the greater achievement of Paris COP21 may be that it has *cemented* the idea internationally in public consciousness that a '*change*' – from business-as-usual and the continued increase in fossil fuel use – is needed, and it is the legal community which can ensure delivery of this change.

'…A "CHANGE" – FROM BUSINESS-AS-USUAL AND THE CONTINUED INCREASE IN FOSSIL FUEL USE – IS NEEDED, AND IT IS THE LEGAL COMMUNITY WHICH CAN ENSURE DELIVERY OF THIS CHANGE.'

The climate of Paris

John Mitchell

Humanity is the cuckoo in the nest of nature: supported by it but destroying it. Humans have always destroyed their environment in order to thrive and prosper; now there are many more humans and much less environment. Climate change is the latest in a series of confrontations where nature threatens to retaliate. There has been progress; the 'sustainable development' movement of the 1980s and international cooperation to protect 'the commons' threatened by the tragedy of overexploitation or random development, for example the UN Convention on the Law of the Sea (UNCLOS) 1982 (nine years to negotiate) and the Montreal Protocol on Ozone Depleting Substances (1989).

'HUMANS HAVE ALWAYS DESTROYED THEIR ENVIRONMENT IN ORDER TO THRIVE AND PROSPER; NOW THERE ARE MANY MORE HUMANS AND MUCH LESS ENVIRONMENT.'

The United Nations Framework Convention on Climate Change (Rio 1992) showed almost universal acceptance by governments of the concept that global warming and the threat of climate change merited international action. Disagreements about degree, responsibility, and burden sharing prevented satisfactory progress at Kyoto (1997). The magic of Paris is a big step towards a more promising way forward, building on the Obama–Wen Jiabao agreement in Copenhagen in 2009.

The keys to Paris

The Paris Agreement has two key mechanisms which Rio and Kyoto lacked.

1 *A substitution of bottom-up for top-down policy making* on climate mitigation.

By one of those feats of diplomatic acrobatics at which treaty makers excel, the Contracting Parties neither agree to, nor impose, emission limits on any country. There are *Intended Nationally Determined Contributions* (INDCs), put forward by individual governments for the period to 2030 (2025 in the case of the USA).

The INDCs are not themselves innovative. They reflect recent energy and climate policy developments. The language of the agreement carefully avoids any suggestion that the INDCs will be reviewed, or their policies changed, by collective action; it speaks in terms of common methodology and 'understanding', which may include explaining how each country considers that its INDC:

> *'… is fair and ambitious, in the light of its national circumstances, and how it contributes towards achieving the objective of the Convention'*

Implementation is at the discretion of each government. INDCs do not take even nominal effect until 2020, though they will influence planning and policy developments by government and industry.

2 A commitment by all countries to a *'stocktaking' review every five years* to assess progress/deviations versus the INDCs. The Intergovernmental Panel on Climate Change (IPCC) will conduct another review of scientific evidence and the best estimates of probable ranges of outcomes of future global warming. (Their 2014 reports formed the basis of the perceptions on which the Paris Agreement is founded).

Together, these constitute a very sophisticated and subtle form of what in earlier days was known as 'pledge and review' (rejected at Rio and Kyoto). It might now be described as *'intend and defend'*.

Money

Money matters; the Paris Agreement commits developed countries to find at least US$100 billion a year by 2025 for mitigation and adaptation in developing countries. For some countries, such as those in the EU, the sale of emission permits will generate flows of money outside the budgetary process. This can be used for climate change (and other) policies. Rules must be developed, and it will not be surprising if the flexible use of money helps ease some of the diplomatic obstacles to the next round of climate change negotiations. Some developing countries have made very clear that they expect significant contributions from developed countries towards their estimates of the very large costs of mitigation and adaptation.

Adaptation

The Paris Agreement commits the parties to give equal attention to *adaptation* and *mitigation*. There is a follow-up task: to develop methodologies and policies for suitable international action. While global measures are essential to mitigate climate change, adaptation measures are likely to be addressed mainly through flows of money and advice to developing and specifically threatened countries.

'THE PARIS AGREEMENT COMMITS THE PARTIES TO GIVE EQUAL ATTENTION TO *ADAPTATION* AND *MITIGATION*.'

Follow-ups

The Paris Agreement commits the United Nations Framework Convention on Climate Change (UNFCCC) bureaucracy to a tough diplomatic agenda. Many people will be employed in *technical work* on measuring emissions, conversions, and protocols to make the review process operational.

There will be similar, and probably more difficult, discussions about the treatment of emissions from *Land Use, Land-Use Change, and Forestry* (LULUCF). Some countries include these in their INDCs (because they are net carbon sinks), but 'below the line', because definitions are contentious and activities difficult to monitor.

Emissions trading, a key feature of the Kyoto protocol, is left floating in the Paris Agreement. The European Emissions Trading System (ETS) has been cleaned up and a mechanism for avoiding very low carbon prices created. There are regional emission trading systems in the USA and pilot schemes in China. These are likely to grow, as they can spread the costs of reduction to industries where reduction is cheapest. International trading, however, presents a set of administrative challenges which need not be addressed at this stage and this has been eschewed by the USA, the EU, and China.

Joint Implementation (JI) and the *Clean Development Mechanism* (CDM) – both features of Kyoto – are neither prominent in the Paris Agreement, nor are they negated. Some countries, notably the USA, the EU, and China do not propose to use new international instruments to count towards their own targets as Japan does. Japan can proceed bilaterally, but peer pressure in the next round of negotiations may well close down future use of these mechanisms, or introduce very strict regulations for validating the additionality of extraterritorial carbon savings.

Questions of regulating emissions from *international aviation* and *international shipping* are being addressed with the International Civil Aviation Operators Association (ICOA) and the International Maritime Organization (IMO).

Demand side

Change in demand is necessary to implement the INDCs, and in preparations to go further after 2030. There are no intentions to restrict the supply of fossil fuels except by reducing demand. Most INDCs rely on emissions growth slowing or reversing as economies shift away from manufacturing to less energy intensive services. This is an issue of development policy beyond the scope of the UNFCCC or the Paris Agreement, but it does include measures to promote technical efficiency and the adoption of good energy management practices. This challenges consumers and manufacturers of all equipment that uses energy, including buildings. The automobile industry has been under pressure for decades to improve efficiency and reduce emissions of other pollutants; it now has to reduce greenhouse gas (GHG) emissions. The US Supreme Court accepted (2007) that the Environmental Protection Agency (EPA) is empowered by the Clean Air Act (1990) to regulate greenhouse gas emissions from vehicles, and the EU has added GHGs to the list of controlled pollutants from vehicles. Regulations will emerge from agencies and courts that will seek to reduce the market for fossil fuels and create markets for products and services which avoid their use. The oil, gas, coal, and power industries will be required to restrict emissions from their own operations.

Changes on the demand side will go beyond simple products and services; the planning of city infrastructure and of transport systems will also change. This will be most evident in countries like China, where rapid economic growth means that the new is overtaking the old and there is time to avoid being locked into obsolescent transport systems like those of the USA and Europe.

Unresolved policies

There are a number of challenges for the think tanks and special advisers preparing for the stocktaking in 2018.

The headline issue for the advocacy groups is whether *the object of limiting the probability of more than 2* °C *warming should be more aggressively set at 1.5* °C. The next IPCC report may clarify what the difference in risks is, but meanwhile the argument is mostly about prudence; for the first couple of decades, the policies likely to emerge under a 2 °C regime versus a 1.5 °C regime are similar. The probabilities would change – aiming at a 1.5 °C maximum increases the probability that a 2 °C maximum will be achieved – and this is all about probabilities. The UNFCCC Secretariat has endorsed the view that the Paris INDCs will be likely to limit global warming to 2.7 °C (2.2 °C to 3.4 °C) by 2100. It is difficult to be precise. Organizations with climate, or climate and economic, models show a vast range of estimates. So much is unknown, not just about the economic factors underlying long-term projections, but also about the sensitivity of climate to levels of concentration of GHGs (see Energy and Climate Outlook 2015, MIT Joint Program of the Science and Policy of Global Change and Climate Change 2014 Synthesis Report, IPCC, 2014).

Another fundamental question is the *balance between early and late emission reductions*. There is general agreement that early reduction is best because it reduces the degree of

change that will be required later, given the demographic momentum driving increasing emissions. Early action will slow the accumulation of long-lived GHGs. It would also reduce the risk of building long-life assets and infrastructure to be stranded by more severe emission restrictions. While 2030 is the date for the INDC contributions listed in Paris, 2050 is regarded by many countries as an anchor for simplistic targets to decarbonize economies (for example by 50 per cent), while 2100 is regarded as the ultimate date by which almost total decarbonization must be achieved to limit the cumulative growth of emissions.

'…2100 IS REGARDED AS THE ULTIMATE DATE BY WHICH ALMOST TOTAL DECARBONIZATION MUST BE ACHIEVED TO LIMIT THE CUMULATIVE GROWTH OF EMISSIONS.'

However some believe that costs deferred are costs reduced so that loading much of the change into 2030–50 would be sensible. Technology may improve, so later changes (for example, massive use of carbon sequestration) become less expensive, or geo-engineering (mirrors in the sky) becomes feasible. 'Net negative emissions' might become possible, reducing cumulative CO_2 or at least pre-empting later CO_2 emissions.

The INDCs

The INDCs of many developing countries do not offer very specific policies, rather general intentions that do not compromise their growth aspirations. The idea of 'differentiated responsibilities' between developed and less-developed countries originates in the UNFCCC of 1992 and is held to be non-negotiable by developing countries. China, India, and other developing countries intend to *reduce their energy intensity of GDP*: China by 60–65 per cent, India by 30–35 per cent (below 2005 levels). Neither country has a commitment to reduce emissions from an historic baseline, unlike developed countries. India expects significant financial contributions from developed countries to reduce the expected and very large costs of their climate programme, particularly in the power sector.

In China, energy intensity will fall as the economy transitions to a 'new normal' (more growth in services, less in heavy industry), combined with programmes to improve efficiency in vehicles, industry, and buildings. The carbon intensity of energy will be reduced by mandating and subsidizing renewables for power generation; continuing nuclear expansion; and building fewer coal power stations.

Oil and gas demand in China will continue to grow to 2030 before peaking; emissions may continue to grow. In India too, the main driver for limiting emissions will be economic transformation – shifting out of agriculture into manufacturing, with higher energy intensity but more renewables. The argument for early adoption of efficiencies is particularly relevant to India, where a large proportion of future capital stock has not yet been built.

Other developing countries maintain their right to grow, but their INDCs do not always articulate how either their energy intensity, or the carbon content of their energy, is to be reduced.

The INDCs of developed countries reflect recent plans to reduce emissions from 2005: by 26–28 per cent for the USA by 2025, 25 per cent for Japan by 2030, and 30 per cent for the EU by 2030.

The power sector

In most major countries the INDCs show that *the power sector is due for most change*, and quickly. Direct government intervention, subsidies, and regulation will change the mix of fuels, compulsorily increasing the share of renewables with dispatch prioritization and subsidies using feed-in tariffs; coal use will be reduced by mandates or taxes. The precise combination will depend on local options and policies in which gas supply – especially imported gas – will be a high risk residual. Market structure will change to accommodate intermittent sources of supply, to provide increased competition, to dampen the price increase caused by greater use of renewables, and to increase resilience and security of supply.

Agenda for companies

The international agreements reached in Paris point very clearly to *more regulations and policies to control and reduce the emission of greenhouse gases*. These policies will reduce the demand for carbon-heavy fuel, and require strict controls on emissions of methane and other gases. Price expectations can no longer be based on assumptions of the rising costs of supplying ever-increasing quantities of fossil fuels. Companies (including state-owned companies) that are responsible for supplying fuels and gases will alter their investment plans accordingly. There will be new opportunities for manufacturers of vehicles and equipment, and for providers of services which avoid the use of carbon-heavy fuels.

Investors in companies on both the supply and consumption side may legitimately ask how they are planning to adapt their current business models to these changes. Pessimistic investors may sell shares, fearing that such companies cannot successfully adapt given that the direction is clear but the route is very uncertain.

'THE POWER SECTOR WILL BEAR THE BRUNT OF CHANGE IN THE FIRST DECADE OR TWO.'

The power sector will bear the brunt of change in the first decade or two. Power and gas companies need to adapt to increasing intervention, limits on their choice of fuel, and mandates to use more renewables. The power sector is equally challenged in developed countries (legacy assets) and developing countries (the need for investment to be made under conditions of uncertainty and increasing intervention). Political considerations cloud economic judgments (coal, nuclear, renewables) and the 'golden era of gas' as a transitional solution may prove elusive. Few countries have much oil in their power generation mix. The changes mainly affect development of gas production and investment in infrastructure routes which would bring gas, in competition with internationally priced coal, into export markets either yet to exist or defined by government policies. The switch towards bottom-up policies and local solutions, even within national borders, affects competition at each stage of the supply chain. Major oil companies investing in gas for export need to pay attention to the problems of the power sector, market-by-market.

For the oil industry, the INDCs to 2030 do not represent a significant early threat. The price collapse of 2014 clearly signalled the need to avoid overinvestment and high-cost upstream projects. The shifting balance of demand from the USA and Europe to Asia is not new, and will continue to challenge companies with developed country downstream businesses. The real challenge for the oil companies lies probably after 2030, when developments of battery technology coincide with an expansion of renewable electricity supply.

For advocates who are serious about limiting climate change, the rainbows on 2050 and 2100 horizons involve (among many complexities) decarbonizing electricity so that transport can be based on electric vehicles and public transport systems. There are major manufacturers of surface vehicles, ships, and aircraft who are already engaged in long-term planning to secure their situation in such a world. The oil industry shows little sign of similar efforts. The relative lack of new challenges on the oil side does not excuse complacency about the longer-term developments in transport and the more immediate disturbance of the power sector, the major market for gas.

COP21 and the future role of natural gas in the EU

David Robinson

This article considers the implications of COP21 for the natural gas industry, with a focus on the EU and Spain. The Paris Agreement represents a successful effort to avoid a complete breakdown of climate change negotiations. Although we cannot assume that the governments who signed the agreement will comply with their commitments, or deliver more ambitious commitments later, COP21 will influence public policy and corporate strategy. This is particularly important for the natural gas industry in the EU. It has the potential to contribute to decarbonization in the short to medium term, provided it wins the necessary policy support, especially to replace coal in the power sector. However, in the longer term and assuming the EU meets its ambitious emissions reduction targets by 2050, the future for natural gas looks problematic in the absence of technological innovations to abate emissions.

Natural gas may benefit from COP21 in the near to medium term

The Paris Agreement is potentially good news for the European natural gas industry. This is because natural gas can support decarbonization by replacing coal in power generation, providing back-up to intermittent renewables, and replacing more carbon-intensive petroleum products in certain transport and heating markets. Consequently, the industry considers itself to be at least a bridge to a low-carbon future. It is calling for policies to support natural gas because the current relative prices of fossil fuels, as well as many national government policies, currently favour oil and coal over natural gas.

'THE PARIS AGREEMENT IS POTENTIALLY GOOD NEWS FOR THE EUROPEAN NATURAL GAS INDUSTRY.'

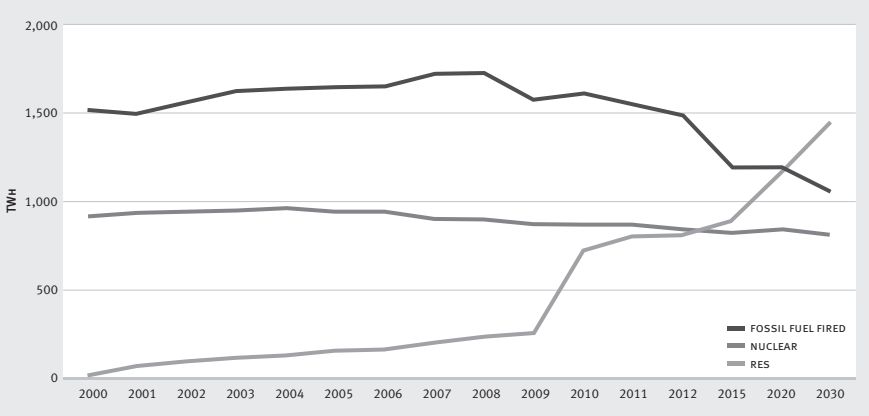
Replacing coal in the power sector

In Europe, electricity demand for natural gas fell by almost 60 bcm (more than 10 per cent) between 2010 and 2013. Indeed, electricity accounts for almost all of the reduction in the demand for natural gas in Europe

during that period. Furthermore, within the market for generation from fossil fuels, natural gas lost share to coal. The explanation includes relatively high and rising natural gas prices, low prices for CO_2 emission allowances, as well as low and falling prices of coal. Natural gas prices in Europe have subsequently fallen due to ample supply of Russian gas and LNG, low demand for natural gas, and the decline in oil prices (often the basis for indexing prices of natural gas). But coal prices are also falling. Consequently, natural gas has not yet won back market share from coal except in the UK, where there is a rising CO_2 tax floor which favours natural gas over coal.

Natural gas demand in the power sector has also been affected by the decline in electricity demand, which has fallen by over 3 per cent in the EU since 2008. This is partly the result of the recession, but it also reflects a structural change in the large OECD countries where the relative decline in the importance of heavy industry coincides with demand saturation and policies to promote energy conversation and energy efficiency.

So while replacing coal with natural gas in the power sector should be 'low-hanging fruit' as far as decarbonization is concerned, this is only happening in some EU countries and it largely reflects policy decisions rather than markets. For instance, the EU's Large Combustion Plant Directive and the Industrial Emissions Directive have contributed to the early closure of existing coal-fired power plants in the UK. The Paris Agreement will almost certainly reinforce these policies in EU countries, further tightening restrictions on coal-based generation and indirectly favouring natural gas, at least in the near to medium term. However, the evidence suggests that without additional policy support, at the EU and national level, natural gas will not be able to replace coal.



Generation by primary energy: 2030 outlook in the EU 27

Source: Eurelectric

Natural gas as a support to renewable power

The most significant challenge for natural gas (and to a lesser extent for coal) in the power sector to date has been from renewable energy, which has enjoyed significant public policy support. The figure 'Generation by primary energy: 2030 outlook in the EU 27' captures the significant increase in output from renewable energy sources (RES) compared to conventional power from fossil fuels and nuclear.

'AS LONG AS INTERMITTENCY CONTINUES TO BE A CONCERN, NATURAL GAS WILL PLAY A ROLE AS FLEXIBLE BACK-UP SUPPLY.'

The natural gas sector points out that it plays an important role when it comes to fostering the development of renewable energies, acting as a guarantee against their intermittency. As long as intermittency continues to be a concern, natural gas will play a role as flexible back-up supply. However, there are other sources of back-up, including demand response, interconnection, and flexible generation from other sources (such as hydro, other renewables, coal, and even nuclear in some cases). Natural gas-fired plants will have to compete with these other sources of flexibility.

The development of low-cost storage could reduce the value of flexibility from natural gas. However, it could be many years before battery technology is cheap enough, and has achieved the scale, (and attracted the investment), to replace gas in the job of balancing renewables. Furthermore, it could be many years before renewables can replace gas in more baseload service at a price that consumers will accept in their bills as gas is phased out.

Transport and heating opportunities

Beyond the power sector, there are some other potential bright spots for natural gas, in particular as a competitor to petroleum-based products in transport and, to a lesser extent, in heating. Onshore trucking is potentially an interesting market for natural gas, but progress to date has been slow. LNG as a marine bunker fuel shows more promise and could be an important market for natural gas in the 2020s. In some countries, such as Spain where diesel is an important heating fuel, natural gas has the potential to gain share in heating markets.

For these three reasons, Paris COP21 should help the natural gas sector. However, decarbonization via natural gas is not automatic. First, the relative prices of fossil fuels do not favour

natural gas. In the power sector, coal prices are much lower than gas prices on a per unit (kWh) basis; ironically, this is partly due to the fact that low-cost shale gas is replacing coal in the US power sector, leading to increased exports of coal from the USA and to lower world coal prices. Natural gas is also facing very low prices from petroleum products in transport and heating markets. Second, policy makers in some countries clearly favour coal over natural gas. Germany and Poland seem set to continue to use coal and lignite on a grand scale for some time to come. This dwarfs any discussion of gas versus renewables in these countries, or indeed any rational CO_2 abatement logic.

What policy support is required?

First a higher price of CO_2 emissions (such as a carbon tax or price) would clearly favour natural gas over both coal and oil products. To achieve that aim, fixing the EU ETS so that prices are higher and predictable is a priority for the natural gas sector; the introduction of carbon prices for the sectors not covered by the ETS should also be a priority. The importance of this sort of policy is evident in the UK, where the higher and rising CO_2 price floor is killing off coal quite quickly. A rising carbon price throughout Europe would be particularly welcome, and easier to introduce, while coal and oil prices are very low.

Second especially in the absence of adequate carbon prices, the EU should consider the idea of declining carbon intensity targets. The USA has introduced policies that mandate a reduction of carbon intensity for the power sector in the medium term (2025–30). This effectively requires a shift away from coal and encourages generation from lower-carbon sources, notably natural gas and renewable power. The US Clean Power Plan faces legal hurdles, notably from states that reject the authority of the Environmental Protection Agency (EPA) to impose such a plan. However, even in the absence of such a policy the economics are moving in the same direction, due to the very low cost of natural gas. In the EU, where natural gas prices are relatively high and where coal and carbon prices are low, a policy aimed at reducing the carbon intensity of the power sector would be worth considering.

'A HIGHER PRICE OF CO_2 EMISSIONS (SUCH AS A CARBON TAX OR PRICE) WOULD CLEARLY FAVOUR NATURAL GAS OVER BOTH COAL AND OIL PRODUCTS.'

The longer-term prospects for natural gas are grim

Even if natural gas can replace coal in the European power sector over the next 10–15 years, and replace oil products in heating and transport over a similar period, its long-term prospects are less promising in the absence of new technologies to abate carbon emissions. For the EU to meet its 2050 target of a reduction of 80–95 per cent of GHG emissions compared to 1990, most governments are planning on a virtually complete decarbonization of the electricity sector, and substantial replacement of fossil fuels in heating and in transport.

For instance, a recent study by the UK Energy Research Centre (UKERC) ('The future role of natural gas in the UK', February 2016) argues that gas is unlikely to act as a cost effective bridge to a low-carbon energy future. The study said that, without Carbon Capture and Storage (CCS), the scope for UK gas use in 2050 was little more than 10 per cent of its 2010 level. But, irrespective of whether CCS was developed, the report said that, to meet emissions reduction targets cost-effectively, gas use in power stations would decline after 2025, when all coal power stations are to shut. This would mean that gas-fired power stations built between now and then would need to operate on relatively low load factors, something that investors will doubtless take into account in their decision whether to invest in these power stations.

Other research sponsored by UKERC ('Decarbonising Heat', Nick Eyre, ECI/Oxford, February 2016) also points to a dramatic fall in natural gas use for the residential heating market in its three main policy scenarios – from about 230 TWh in 2010 to well below 100 TWh in 2050.

In Spain, a study by Deloitte offers a further indication of the challenges faced by natural gas. That study concludes that a reduction of GHG emissions by 80–95 per cent in 2050 would require that at least 90 per cent of electricity will be based on renewable electricity (compared to 38 per cent in 2015) with natural gas used only as back-up, that personal electric vehicles will have very high penetration, and that the heating market will also be substantially electrified. However, the study identifies two sources of new demand for natural gas, namely to replace petroleum products for heavy vehicles and maritime transport, as well as for part of the heating market. The result is that natural gas demand in 2050 is forecast to be similar to current levels.

For long-term growth of natural gas demand to be compatible with the avoidance of dangerous interference with the climate requires the development of technologies that are economically viable at scale to absorb and utilize or store CO_2 emissions. I have in mind direct air capture, as well as Carbon Capture and Storage or Utilization (CCS/CCU). We are a long way from meeting the requirement for these to be economically viable at scale.

Need for a new strategy and policy on infrastructure

Finally, I would add a note of caution about the implications for investment and the recovery of fixed costs in gas infrastructure. If the EU is serious about its 80+ per cent emissions reduction by 2050, the total EU gas market could be significantly smaller than at present, and it is in any case unlikely to grow by much. Yet investment timescales in gas, especially in gas infrastructure, are very long and investment may well be needed in order for gas to play a bridging role in the near to medium term in certain regions. This has two implications: one for industry and the other for policy makers.

'IF THE EU IS SERIOUS ABOUT ITS 80+ PER CENT EMISSIONS REDUCTION BY 2050, THE TOTAL EU GAS MARKET COULD BE SIGNIFICANTLY SMALLER THAN AT PRESENT.'

The gas industry needs to develop a coherent long-term strategy to reflect the likelihood of stranded network assets in certain regions. On the one hand, if the assets are fully amortized, they can be abandoned; what matters are forward-looking costs. On the other hand, it is worth considering alternative uses of pipeline, storage, and LNG infrastructure. Some companies are already thinking about this; for example, converting renewables into hydrogen gas, which can then be transported, stored, and blended with natural gas in existing infrastructure. If CCS becomes more significant, it may also be possible to use the gas infrastructure to transport and store CO_2, although this will depend on location and geology. More generally, the gas industry should be thinking about the longer-term uses of its network in a low-carbon world. As European gas production declines and if gas consumption also declines, infrastructure could be the industry's main asset.

It is also important for the industry to press effectively for *a clear public policy* to help investors decide whether to proceed with new investment in infrastructure. For example, the Spanish gas industry argues that due to its significant LNG assets, Spain could play a key role in providing continuity of European supply. Expanding the capacity of gas pipeline infrastructure between Spain and France could help bolster supply to France and allow other pipeline supplies to be diverted further eastwards.

However, for additional Spanish gas exports to reach central European markets would require additional infrastructure investment in France, as well as the interconnector investment between Spain and France. It may be less expensive to transport LNG to northern Europe than to build new interconnectors and additional pipelines through France. The question is therefore whether these new infrastructure investments (interconnectors and national grids) are economically justified, and who would bear the costs if the assets lost value due to the lack of utilization. This requires careful and independent study. But it also requires a clear statement of European policy with respect to the future role of natural gas in the EU's long-term decarbonization and energy strategy, along with measures to realize that policy.

In conclusion, for natural gas to support decarbonization in the short to medium term requires urgent policy support and planning, both at EU and national levels. In the longer term, in the absence of economically viable technologies to capture and use CO_2 emissions, the future for natural gas must be in question if the EU is serious about moving to a low-carbon energy system. Given the very long lead times needed for infrastructure investment, and the need to reduce emissions over the next two decades, a clearer strategy for the role of gas and how it fits into the transition needs to be developed to underpin investment.

Nuclear after Paris: any clearer?

Malcolm Grimston

One might have expected that the Paris Conference of Parties meeting (COP21) on climate change in December of last year might have placed a particular focus on nuclear power. For some years France has generated a higher proportion of its power from nuclear than any other country. This French version of Germany's Energiewende – tournant énergétique perhaps? – came along a quarter of a century before Germany's and, if judged in carbon reduction terms at least, was notably more successful. In comparison with its neighbour, Germany's energy and environmental policy (set out in the 1991 and 2000 Renewable Energy Acts), had had limited success in reducing greenhouse gas emissions, even before the 2011 post-Fukushima decision to close its nuclear plants.

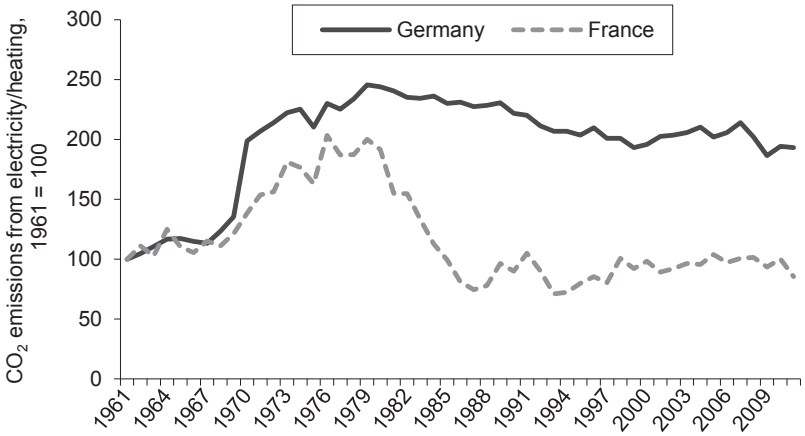
Releases from electricity and heating followed the same path in France and Germany until about 1980, after which

'…THE GROWING FRENCH NUCLEAR FLEET BROUGHT EMISSIONS DOWN TO LEVELS THAT WERE EFFECTIVELY THE SAME AS … THOSE OF THE EARLY 1960S.'

the growing French nuclear fleet brought emissions down to levels that were effectively the same as, or slightly below, those of the early 1960s. German emissions remained twice their level in 1961, falling less than 1.5 per cent in the decade after the 2000 Act. Emissions rose in four of the five years following Germany's decision to exit from nuclear: even during the warm summer of 2014, emissions failed to return to 2011 levels.

France led the 'dash for nuclear' (in part a response to the oil shocks of 1973 and 1979) from 1975 to 1995. For the only time in history so far, since the start of the industrial revolution, the global proportion of primary energy produced from non-fossil fuels increased significantly, from around 6 per cent in 1975 to 13 per cent in 1995; it has stubbornly stayed at this level despite the growth in renewables.

In the two peak years for nuclear installation so far – 1984 and 1985 – some 64,000 MW of nuclear capacity came on line, capable of producing around 500 TWh of power per year at a reasonable level of performance. Given today's global power demand (around 24,000 TWh), sustaining that rate of deployment for the following 30 years, all else being equal, would have resulted in a world that obtained well over half of its electricity from non-fossil sources by now, as opposed to barely one third.



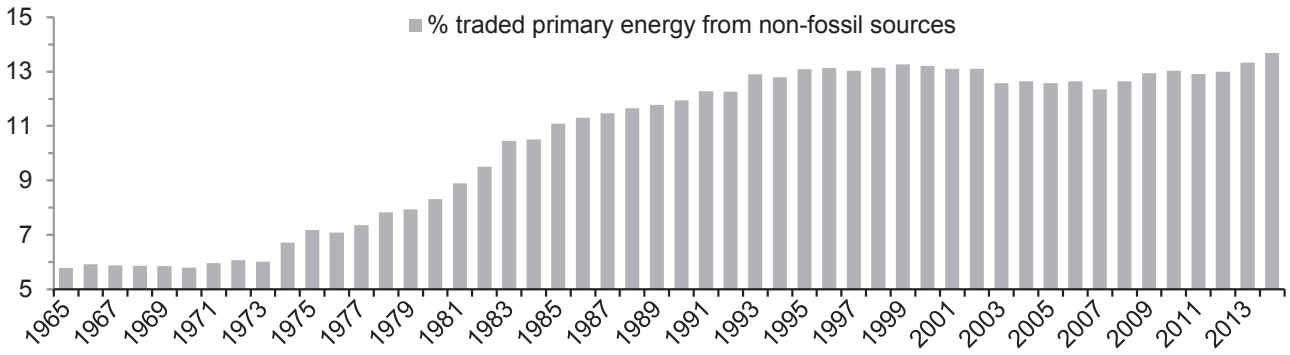
CO_2 emissions from electricity and heating, Germany and France (1961 = 100)

Source: 'Climate change knowledge portal', World Bank, 2014

Antinuclear activists were nonetheless successful at the key Kyoto COP meeting in 1997 (COP3) in excluding nuclear power from the 'Kyoto' mechanisms, notably the Clean Development Mechanism. An illustrative example of antinuclear tactics came in 2009 from the Worldwide Fund for Nature (WWF). In its 2009 G8 Climate Scorecards, the organization faced a difficulty – calculations based on actual greenhouse gas emissions from energy use kept placing countries like France and Sweden, with their large nuclear programmes, at the top in terms of reducing greenhouse gas emissions. WWF's response was an object lesson in Big Green science.

> *'WWF does not consider nuclear power to be a viable policy option … To reflect this, a policy approach that favours the use of nuclear power was assessed by assuming that electricity from nuclear energy was produced with gas.'*

Sure enough, by redefining 'very large volumes of carbon dioxide emissions' to include 'minuscule levels of radioactive releases' in such an



Percentage of global primary energy from non-fossil sources, 1965–2014

BP Statistical Review of World Energy, 2015

'ANTINUCLEAR ACTIVISTS WERE NONETHELESS SUCCESSFUL AT THE KEY KYOTO COP MEETING IN 1997 IN EXCLUDING NUCLEAR POWER FROM THE "KYOTO" MECHANISMS…'

arbitrary way WWF was able to give the impression that nuclear power was not a particularly effective way of reducing greenhouse gas emissions. (*G8 Climate Scorecards,* WWF-Allianz, July 2009).

In the early days of the Paris summit, in the words of one commentator, nuclear power 'struggled to find its voice'. Things warmed up somewhat when four of the world's top climate scientists (Ken Caldeira, Carnegie Institute; James Hansen, Columbia University, credited with getting climate change onto the US political agenda in 1988; Kerry Emanuel, MIT; and Tom Wigley, University of Adelaide) delivered a performing version of their celebrated 2013 letter calling on environmentalists to think again on the nuclear issue – something which increasing numbers have duly done. As Caldeira said:

> *'The climate doesn't care whether electricity comes from a wind turbine or a nuclear reactor. The climate just cares about carbon. I've come to see now that the magnitude of the problem is so great that we can't afford to leave technologies unused that can potentially help.'*

This did not go down well in all quarters. One Naomi Oreskes, a history professor, argued that anyone proposing deviation from a prescribed 100 per cent renewable approach should be classed a 'climate denier' – perhaps a harsh verdict on Hansen and his colleagues given their record ('There is a new form of climate denialism to look out for', *Guardian*, 16 December 2015). Oreskes seems to depend heavily on work by Mark Jacobson from Stanford, who claims that 139 countries can generate all the energy they need from wind, solar, and water power technologies by 2050. Like all such claims, they assume startling reductions in energy use – by 43 per cent in the UK, 36 per cent in China, 43 per cent in India. (Current World Energy Council estimates suggest a doubling in Chinese energy use and a 150 per cent increase in India's by 2035.) Historically, however, improvements in energy efficiency have often been associated with growth in energy demand, by stimulating demand.

The reasoning behind the 'energy efficiency argument' seems to be along these lines: if we had not developed the light bulb – first incandescent and more recently LED – then if viewed from space the earth would still be producing just as much artificial light but it would be coming largely from candles. On this assumption the development of electric lighting has indeed cut energy use enormously. The development of the jet engine has slashed energy use for long haul air travel because otherwise we would be undertaking some 15 billion passenger miles each year by turboprop or maybe even Gypsy Moth. One would need a lot of persuading to bet the planet and secure power supplies on such an argument – even the IPCC and the European Union now acknowledge the importance of these 'rebound effects'. It certainly cannot be claimed to be so self-evident that anyone who remains unconvinced can be regarded as 'denying' anything – except perhaps the value of blinkered thinking.

The justification for treating renewables more favourably than nuclear power has usually involved some invocation of the supposed 'maturity' of nuclear technology against the 'emergent' nature of the renewables. This is a peculiar argument. The ironically named 'new' renewables have been around almost as long as electricity as an energy vector. Edison opened his Pearl Street power station in 1882; the first electricity from solar photovoltaics was generated in 1884; from wind in 1887; from geothermal in 1904; from wave in 1910. Denmark, for example, had 30 MW of wind-generated electricity capacity by 1900. The dominant (and ultimately unsustainable) model of electricity generation in the late nineteenth and early twentieth centuries – localized small-scale renewable production embedded within the demand network – was swept away when national supergrids emerged from the 1920s and 1930s onward. Suddenly consumers could have electricity when they wanted it without the vast cost of battery storage. Demand soared. Hydro (almost) held its own against fossil fuels, as its power was generally available when it was needed, but the story of the middle years of the twentieth century was of fossil fuels, with all the associated geopolitical and environmental challenges they bring. The first nuclear-generated electricity did not come along until 1951.

Growing divisions within the environmental community may have been a factor in the change of tone in the agreement reached in Paris. The 32 page final document marks a significant shift away from a prescriptive approach driven by an imperative to promote certain technologies rather than to reduce carbon emissions. There is a single reference to:

> *'the need to promote universal access to sustainable energy in developing countries, in particular in Africa, through the enhanced deployment of renewable energy'*

but otherwise neither of the words 'nuclear' nor 'renewable' is to be

found. So in principle countries are free to approach their carbon reduction programmes in whatever way they see fit. For the relatively few players for whom reduction in climate change emissions is the top priority this will be welcome.

But it is a far cry from this move towards treating nuclear and renewables more equitably to assuming that a major nuclear revival is just round the corner. Especially in the five years since Fukushima, public perceptions and political opposition have remained an obstacle in several countries, most notably perhaps in Germany and Japan but also in, for example Italy, which rejected a return to nuclear in a 2011 referendum. (Elsewhere, including the USA, Canada, Scandinavia, eastern and central Europe, much of Asia–Pacific, and the UK, this is much less the case.) Political and public concerns can be damaging to nuclear prospects through direct political decisions to curtail the lives of reactors, by preventing their return to service, or by introducing tighter regulation, which can increase costs.

'IT IS COST THAT IS SINKING NUCLEAR POWER IN THE "OLD" NUCLEAR NATIONS OF WESTERN EUROPE AND NORTH AMERICA.'

And it is cost that is sinking nuclear power in the 'old' nuclear nations of western Europe and North America. Around the turn of the century the US Department of Energy was suggesting that new nuclear capacity should cost about US$1,500 per kW for the first-of-a-kind (£1,400 today, inflation corrected) and US$1,200 per kW for a programme of four or more. Even excluding financing costs, Hinkley Point C is expected to come in at around £16 billion for 3.3 GW, which works out at around £5,000 per kW. The new reactor at Flamanville in Normandy is currently six years late and around €7.2 billion over budget; Olkiluoto-3 in Finland is expected to be 10 years behind schedule and €5.5 billion over budget.

The UK government has done as much as could reasonably be expected to transfer a significant proportion of the inherent economic risk involved in nuclear investment from the investor to the electricity consumer. Though fuel costs are lower in nuclear stations than in Combined Cycle Gas Turbines, CCGT is much quicker and cheaper to build, and so is much less risky in a competitive market. Potential nuclear investors will require some very good reason to think that power prices will remain sufficiently high for several decades, to repay the initial investment and deliver an appropriate rate of return.

In centrally planned electricity systems this is reasonably straightforward, at least in theory; the plant is owned or operated by a monopolistic supplier with de facto lifetime contracts for its output, so any excess costs can be passed on to captive customers. Within a broadly competitive market framework, however, the risks associated with purely 'merchant' nuclear plants have proved too great. To stand any chance of attracting investment, then, government has to offer some long-term guarantees over the price at which the electrical output can be sold – in the UK this has taken the form of a 'strike price' of £92.50 per MWh (index linked from 2012 prices) which will run for the first 35 years of the plant's operation, coupled with loan guarantees on part of the initial investment. Yet despite these inducements, despite China offering to take a one-third stake in the project, the Final Investment Decision on Hinkley Point C has been delayed and delayed since EDF Chief Executive Vincent de Rivaz's statement in 2007 that:

> *'EDF will turn on its first nuclear plant in Britain before Christmas 2017 because it will be the right time.'*

The dash for nuclear has not entirely evaporated – China has plans to triple its nuclear capacity to 58 GW by 2020 and there are ambitious plans in India, for example, with several countries talking about entering the technology for the first time. If China's record for building plants within a reasonable budget and to time can be exported to other countries, then nuclear power's prospects would look considerably brighter. Attention is also turning to new approaches, the so called SMRs (Small Modular Reactors). In principle, SMRs could be built as one or two units or as modules in a bigger complex. The simplification of design, and increased reliance on passive rather than engineered safety systems, could significantly reduce the cost of nuclear plants without any negative implications for safety or plant reliability: such plants would rely on naturally occurring phenomena such as gravity, natural circulation, and condensation, guaranteeing (it is claimed) safe shutdown of the plant even in the highly unlikely event of an accident. The loss of economies of scale enjoyed by large units may, at least to an extent, be offset by the series economies which come from building larger numbers of identical smaller units. A bank of fifteen 100 MW units would be more flexible than a single 1,500 MW reactor, there being the option of switching some units off to follow load rather than trying to vary the output of single large units, which tend to be regarded as rather inflexible. Several SMRs are now operating across the world. But it would be a mistake to presume (in any technical field) that attractive concepts on paper can easily be translated into a large commercial programme.

At the heart of the power problem in the market economies lies a

'THE DASH FOR NUCLEAR HAS NOT ENTIRELY EVAPORATED.'

confusion that is still not resolved. Is electricity basically a commodity or is it a social/industrial service? If the former, then government's role should involve: setting up a stable market that corrects for externalities, notably in the environmental field perhaps through carbon taxes or tradable emission permits, preventing oligopoly, and allowing the market to make the investment it sees fit. If it is the latter, then government is effectively the guarantor of last resort. It might use market forces to help deliver on its goals, for example by offering competitive tenders for power station construction and operation, but ultimately it remains responsible for the fuel mix, the environmental outputs, and the security of supply. At present, it can be argued, we have the worst of both worlds. Government (or the power consumer) is in effect paying rates of return to the private sector to persuade private, or rather non-UK government owned, companies, to carry out public policy. Even what now look like very generous terms for Hinkley Point C have so far failed to persuade the French to make the investment required, even with Chinese backing.

So, if the government has that ultimate responsibility – and who can imagine any government of the day getting out unscathed if we could not power our hospitals, petrol pumps, street lighting, water distribution network, mobile communications and so on? – is it time for government to take back unequivocally the responsibility for constructing sufficient low-carbon generating capacity to face the new challenges? Once built, the plants could be sold on or franchised out, since markets do seem good at operating existing assets efficiently. Public sector rates of return would reduce the costs of the capital-intensive electricity sources significantly.

It is not, of course, certain that government would be any more reliable as a long-term partner to nuclear construction companies than the current short-term market is. It took a year to persuade the European Commission to allow the Hinkley Point C deal and appeals are still going through the system – in the absence of Brexit it would be a very difficult conversation that would lead to the UK regaining powers over all new plant construction. But the Hinkley C saga shows that the present approach does not work: the market simply cannot send firm signals to invest, even with the high levels of support now on offer. Unless this barrier can be overcome it may prove academic whether nuclear power has indeed come in from the cold as far as the fight against climate change is concerned.

US climate policy in a post-Paris context

Sarah O. Ladislaw

The USA's goal for the UN climate negotiations in Paris last December was to secure broad and meaningful participation from member countries and establish a long-term, durable framework for future actions to cope with a changing climate. Supporters of the Paris Climate Agreement tout its success for delivering on that goal, mobilizing emissions reduction efforts, and sending signals to catalyse additional finance and investment. However, the Agreement is also criticized for falling short of the action necessary to secure the 2 °C temperature rise limit and for lacking strong enforcement mechanisms. Going forward, the objective is to deliver on the commitments secured in Paris and find ways to enable even deeper emissions reductions and more robust adaptation measures that will be necessary to mitigate the climate risks.

'THE FUTURE OF US CLIMATE POLICY WILL BE DETERMINED BY THE OUTCOME OF THE 2016 PRESIDENTIAL ELECTION CYCLE.'

So what is the likely path forward for US climate policy in a post-Paris context? Many have argued that the future of US climate policy will be determined by the outcome of the 2016 presidential election cycle. This belief is supported by two underlying factors.

- First, in order for the USA to meet its near and medium-term emissions reduction targets, existing policy and regulatory measures must not only go forward, but additional emissions reduction efforts will be required. Moreover, meeting longer-term climate objectives will require the next administration to lay the groundwork for even more ambitious emission reduction.
- Second, Republican and Democratic presidential candidates have vastly different climate policies that would, if implemented, lead to different energy sector and emissions outcomes.

US targets are tough to reach, yet not enough

In its Intended Nationally Determined Contribution (INDC) submission, the

USA has pledged itself to the task of:

> *'reducing its greenhouse gas emissions by 26–28 per cent below its 2005 level in 2025 and to make best efforts to reduce its emissions by 28%.'*

This commitment builds on the USA's pre-existing goal to reduce emissions in the range of 17 per cent below 2005 levels by 2020. According to the latest estimates, US emissions were 6.5 per cent below 2005 levels in 2011. The 2014 US Climate Action Report, submitted by the US government to the UN Conference of Parties, estimates that current and planned activities laid out by the administration's Climate Action Plan (CAP) will:

> *'put the United States on a course to meet its goal of reducing emissions in the range of 17 per cent below 2005 levels by 2020.'*

This finding is predicated on the assumption that current and planned activities under the CAP will proceed as envisioned. Many analysts agree that the USA is within the realm of meeting its 2020 climate target.

When it comes to the 2025 target, however, the USA will have to take additional action at both the federal and state level to achieve 26–28 per cent emissions reductions (see the table 'Climate Action Plan: additional actions'). A quick survey of the studies indicates that existing and announced climate policies will generate somewhere on the order of 16–22 per cent reduction relative to 2005 levels by 2025. The wide range in estimates can be attributed to several key factors:

'MANY ANALYSTS AGREE THAT THE USA IS WITHIN THE REALM OF MEETING ITS 2020 CLIMATE TARGET.'

- uncertainty in the capacity of carbon sinks and the impact of land use related emissions;
- the emissions impact of existing policy and regulatory measures;
- the underlying assumption about things like renewable energy deployment costs, overall level of methane emissions, and the cost-effectiveness of efficiency measures; and
- baseline assumptions about economic growth, the relative cost of fuels, and timeline for implementing policies.

Several studies offer ways to strengthen or expand existing policy measures, as well as suggestions on how to implement new policies to deliver on future emissions. One study, conducted by the World Resources Institute, suggests that US emissions could be reduced by 30 per cent by 2025, and 38 per cent by 2030, using additional policy measures. Because support for climate policy in Congress is too weak to deliver on legislative action, many of these studies prioritize climate policy actions under existing executive branch authority. So in order to meet the US climate targets, the next administration must not only support existing and announced policies and regulatory measures, but also enact new policies to deliver additional reductions. Moreover, many of these studies note that reaching longer-term climate goals will require a much steeper emission reduction trajectory post-2025. Achieving greater emissions reductions by or before 2025 could help ensure a smoother pathway to those future emissions reduction targets.

Climate Action Plan: additional actions	
■ Clean Power Plan – greenhouse gas emissions standards on power sector ■ Doubling electricity from wind and solar ■ Energy efficiency in federal buildings and appliances ■ Methane emissions standards for new oil and gas sources ■ Revised heavy duty vehicle efficiency standards ■ Phase down hydrofluorocarbons (HFCs) ■ Protect and restore forests	■ Methane regulation from agriculture, coal mines, and existing oil and gas sources ■ Landfill regulation ■ New and strengthened federal appliance efficiency standards ■ Improved GHG and fuel efficiency standards for passenger vehicles and medium- and heavy-duty trucks ■ New GHG standards for industry ■ Emissions standards for new and existing natural gas systems ■ Reduced HFC consumption

Democrat and Republican candidates take different positions on climate change

Political parties in the USA continue to be divided over the issue of climate change. Two recent polls illustrate this divide. In June 2015 a Pew Research poll found that 87 per cent of Democrats and 69 per cent of Independents believe climate change is a serious issue, compared to only 44 per cent of Republicans. A more recent poll, conducted by Monmouth University in December 2015, found that:

> *'64% of Americans support the US government doing more to reduce the types of activities that lead to climate change'*

with 74 per cent of Democrats, 66 per cent of independents, and 47 per cent

'IN THE USA A GREAT DEAL OF ENERGY POLICY AUTHORITY RESTS WITHIN STATES.'

Democrat candidates	Republican candidates
■ Accept the existence of man-made climate change and support the imperative to act ■ Targets and goals for renewable power, carbon free-power, solar, and emissions reduction ■ Support extension of federal clean energy tax incentives and competitive clean energy grants ■ Support or advocate strengthening Clean Power Plan, EPA regulation of methane emissions ■ Increase environmental standards for or ban hydraulic fracturing ■ Oppose Keystone XL ■ Called for carbon tax, programs to support household energy efficiency and purchase of solar panels ■ Oppose certain areas for offshore drilling	■ Question whether manmade climate change is occurring and do not see it as a significant threat ■ Pledge to roll back EPA regulations including the Clean Power Plan or abolish the EPA ■ Support Keystone XL and other similar pipelines ■ Against energy subsidies ■ Support pro-production policies on oil, gas, ethanol
*Summary of campaign positions from campaign websites simplified to represent the range of views among candidates in the field.	

of Republicans supporting that position. Taking a deeper look at American public opinion on the issue, the country is even more divided when it comes to both how urgent climate change is relative to other priorities, and the precise measures they would support in an effort to combat climate change. Public opinion also varies a great deal on those issues relative to age, location, and ideological spectrum.

This divide is magnified by the presidential campaign both in terms of the candidates' stance on climate change and the relative importance placed on the issue by either party. Democratic candidates give climate change and the creation of a clean energy economy relatively high billing in their national platforms and have detailed policy proposals to support their positions. Republican candidates, in contrast, have outlined relatively few climate and energy-related policies and tend to talk about them only when asked or when providing examples of government overreach by the current administration (see the table 'Democrat candidates: Republican candidates'). Among the current candidates, the Democrats generally support strengthening the US commitment to emissions reduction in line with globally agreed upon goals, whereas the Republican candidates have, by and large, agreed to roll back existing emissions reduction efforts. This contrast has led many to assume that the climate and energy related outcomes from a new Democratic or Republic administration would be fundamentally different. While this assumption is true, by and large, it is also complicated by several factors that could possibly constrain any new administration.

Any future administration must deal with Congress

The composition and functioning of Congress will enable or constrain the next administration and its ability to use legislative measures to deal with climate change. In the recent past, divided government and a gridlocked Congress has proven to be a difficult environment for both advancing and repealing climate policies. The 2015 budget appropriations bill that cleared the way for crude oil exports, solar and wind tax credit extensions, and US contributions to global climate funds, stands in stark contrast to the virtual stalemate on climate and many other policies. This has, for some, raised the question of whether political trade-offs could exist on this issue in the next Congress – especially within the context of a broader tax reform debate. While the Obama administration has advanced climate policy in the absence of congressional action, future administrations will be forced to deal with Congress to reach the more ambitious edges of their platform, to fund or defund existing programmes and agencies, and to meet the US climate finance obligations.

Not all climate policy is made at the federal level

As noted earlier, one source of additional climate policy is through state-level activity. In the USA a great deal of energy policy authority rests within states. Indeed, states are largely in control of much of natural resource development (guided by federal safety and environmental standards), electricity sector regulations (renewable portfolio standards included), and transportation policies (including transportation infrastructure decisions). At present, several states are leading the way in some of the most transformative policies influencing the energy sector and contributing to the US emissions reduction target. These policies include changing the electric power market structure in places like New York, implementing and linking emissions trading systems (for example in the north-east and California), as well as many other examples. Several states

'IT WILL BE HARD FOR THE USA TO COMPLETELY REVERSE POSITION ON CLIMATE CHANGE IN THE NEXT ADMINISTRATION, BUT CERTAINLY NOT IMPOSSIBLE.'

have already established a leadership of their own on climate, by establishing robust domestic emissions reduction policies and even launching ambitious internationally coordinated subnational climate efforts – such as the recently launched Under 2 MOU which links 127 subnational jurisdictions in a pledge to reduce greenhouse gas emissions by 80–95 per cent by 2050. Therefore, even when federal policy is moving in one direction, or not at all, states have a role to play in plotting their own course.

Rolling back regulation is not easy, and the likely outcome of such efforts is uncertainty, which sends a mixed signal to investors

Several Republican candidates pledged to roll back many of the environmental policies put forward by the Obama administration – most notably the Clean Power Plan (CPP) which places emissions limits on new and existing power generation sources. The way forward on the CPP is bumpy no matter which way you go. Enacting the CPP will require the government to survive the current legal challenge put forward by 27 states on the grounds that the Environmental Protection Agency (EPA) lacks the legal authority to implement the regulation as constructed. This legal outcome will ultimately be settled by the Supreme Court sometime in the 2018 timeframe, and could involve remanding the CPP back to the EPA for alterations. To 'roll back' the CPP, as some candidates want to do, is no easy task either. The EPA would have to justify the reason for revoking the regulation and go through a new process to undermine the scientific, legal, and regulatory underpinning of the regulation as finalized. The agency would undoubtedly be sued in the process and the most effective and least time consuming course of action would be to slow walk or neglect putting into place new regulation. This uncertainty translates into a muddy investment signal for utilities, many of whom have decided to move forward with planning for the eventual implementation of the CPP as being the best possible way to mitigate the risks posed by that uncertainty.

Markets, technology, and economics matter

Policies are important but market dynamics, economic factors, and technology changes also shape the production and use of energy and will play deterministic roles in whether society can mitigate the effects of a changing climate. The effects of many climate policies are based on:

- the pace and scale of economic growth (note the impact that the 2008 global financial crisis had on emissions and climate policy),
- the relative prices of fuels (low natural gas prices have had a large impact on the energy fuel mix and emissions outcome in the USA in the last several years and low oil prices are similarly impacting the energy sector right now in terms of production, consumption, and vehicle purchasing patterns), and
- the political priorities given to various policies, based on economic conditions (for example, politicians are more likely to care about pro-oil, gas, and coal production policies in the USA when prices are high than when they are low).

The prerogatives of other countries matters too

The next administration will also be constrained, or enabled, by the community of countries with which it chooses to work and the importance those countries place on global climate action. Many have argued that it will be hard for a US administration that does not believe in addressing climate change to walk away from its global commitments without upsetting other countries. Given the sheer magnitude of policies, initiatives, and investments that have been mobilized to put momentum behind global climate action, it will be hard for the USA to completely reverse position on climate change in the next administration, but certainly not impossible. The question is whether or not other large countries will hold the USA accountable for such actions (an area where the Paris Agreement is not particularly robust) or proceed along the path they set forth on in Paris even without US participation.

It is safe to conclude that the USA is more likely to reach its existing climate targets with an administration similar to the current one, because reaching those commitments will require defence of existing policies as well as additional action. While Democrats are more inclined to pursue those policies than Republicans, the path forward is far more complicated than meets the eye and either party could face headwinds as it pursues its agenda.

Implications of COP21 for China

Isabel Hilton

Three months after the historic Paris Agreement affirmed the ambition of 195 countries to keep global average temperature rises below 2 °C, the world had an opportunity to assess how the efforts of China, the world's biggest greenhouse gas (GHG) emitter, will measure up to its promises, at the annual meeting of China's National People's Congress (NPC), in Beijing in March.

How quickly big emitters like China and India migrate to a low emissions development model will largely determine the outcomes of the process that the Paris Agreement has begun. As it stands, the agreement, based on voluntary national pledges from the participant countries, falls well short of what is required. Its future success will depend on how far the signatories are willing to ratchet up their respective national ambitions in the review mechanism that was built in to the package.

How far China and India are able to tighten their national objectives will be determined, in turn, by the hundreds of smaller decisions on energy use, transport, industrial policy, land use, and city planning that will be taken in each country over the next five years. That was reason enough to keep a close eye on the outcome of the long domestic negotiations that resulted in China's 13th Five Year Plan, approved in March by the annual meeting of the NPC.

The details will come later as the plan works its way through China's state machine. The outline that was unveiled in March sets the strategic economic objectives, and fixes a number of key targets. These are intended to determine the direction of the economy and the priorities that provinces and cities, as well as the key state ministries, must respect in their own economic planning.

'…THE WORLD'S LARGEST INDUSTRIAL ECONOMY IS CONTINUING … TOWARDS A LEANER, GREENER, MORE EFFICIENT, AND MORE SUSTAINABLE MODEL…'

Like the Paris Agreement, China's 13th Five Year Plan will not bring the world's average temperature rise below the 'safe' limit of 2 °C. But it does offer the reassurance that the world's largest industrial economy is continuing on a path, begun five years ago, towards a leaner, greener, more efficient, and more sustainable model, and that cleaning up the legacy of the previous 30 years – including its GHG emissions – remains a key priority.

Just a few years ago, China's behaviour in Copenhagen was among the many factors that contributed to the failure of COP15. By COP21, however, China had undergone some profound changes: the Chinese development model, with its high emissions, high investment, and low added value, was exhausted; China's leaders had been aware since the turn of the century that the time was approaching when rising labour costs, a shrinking workforce, and a cavalier attitude to the use of resources would deliver diminishing returns and slower growth. They also knew, if only from the example of neighbouring Japan, Taiwan, and South Korea, that the way through such difficult passages was to become leaner and more efficient, and to move up the value chain.

For China, the development and manufacture of low-carbon technologies became the key to maintaining prosperity in a carbon-constrained world. China could apply its unmatched experience of manufacturing at scale to lower the price of such goods as solar panels, and, through heavy investment in research and development, to become the technology leader in such sectors as low-carbon mobility, with the intention of supplying a growing export market. By the time the 13th Plan was approved, China was investing more in research and development per capita than was Europe. Deployed at home, low-carbon technologies would help to curb the pollution that was costing China 6 per cent of GDP every year and contributing to the government's credibility deficit. China had begun to see radical mitigation both as a necessity and as a huge opportunity. All other things being equal, it had a strong interest in a successful outcome to COP21.

'CHINA HAD BEGUN TO SEE RADICAL MITIGATION BOTH AS A NECESSITY AND AS A HUGE OPPORTUNITY.'

Managing an outcome that satisfies 195 very different countries is a huge and multifaceted task. If not carefully managed, it can go wrong with alarming speed. The French team, led by Laurent Fabius, conducted the process with impressive skill, determined to avoid a repeat of the Copenhagen collapse. In the two years before the conference, diplomats circulated around major capitals to make sure the French presidency of the COP understood each player's red lines and ambitions, and to identify any domestic political obstacles that could throw an agreement off course. The French were not in the business of surprises.

China, too, was anxious to avoid surprises, in particular any surprise that resembled the closing days of Copenhagen, when the then prime minister, Wen Jiabao, had to resort to subterfuge to avoid negotiating directly with President Obama, Angela

Merkel, and other leaders in the last ditch efforts to reach a deal. Not even the prime minister could modify a position that had been agreed by the collective leadership back home. Nor was there was any opportunity to repair the damage created by early toxic exchanges between the US and Chinese delegations.

The system the French designed – with voluntary pledges in advance and national leaders drafted in at the beginning to set the tone, instead of as a last minute rescue party for failing negotiations – removed much of the potential tension. Progress on climate cooperation between the USA and China in the years leading up to Paris removed even more.

In the domestic politics of China and the USA, the other plays a potent symbolic role: when Chinese imagine modernity and superpower status, images of the USA come to mind, along with a fear that the USA seeks to block China's path; when the USA imagines its own decline, China is usually blamed. The strategic rivalries between the rising and incumbent superpowers create tensions in a wide range of fields and geographies. But in climate policy, they have seen the virtue of cooperation.

In 2013, the US Secretary of State John Kerry and his Chinese counterpart, the State Councillor Yang Jiechi, announced a climate change working group within the USA–China strategic and economic dialogue. Progress was relatively swift: in addition to official level cooperation in such fields as smart grids, GHG accounting, and policy exchanges on transport and energy efficiency, President Obama and Xi Jinping made a public commitment in November 2014 to work towards an agreement in Paris. In November 2015, a further series of announcements and a satisfactory progress review gave added momentum to the mood of optimism that the French presidency saw as critical to a successful outcome.

The annual report of the USA–China Climate Change Working Group (CCWG) gave an account of more than 50 cases of constructive engagement on climate change, clean energy, and environment that underscored their growing climate cooperation – a relationship that was to bear fruit in the Paris talks. Even Su Wei, the characteristically deadpan head of the Chinese negotiating team, spoke with a new warmth of USA–China cooperation at a Paris side event.

Domestic politics in China also played positively into the Paris process. Xi Jinping, the general secretary of the Chinese Communist Party and president of China since 2012, has succeeded in gaining control of many aspects of state power, coupled with a long running anti-corruption campaign that has cowed some important rival centres of influence. These developments have raised concerns about the trend of Chinese politics, but the concomitant weakening of China's collective leadership may have clarified the task of China's negotiators, who could be confident that they could take their cue from Xi. And when negotiations threatened to go off track, a telephone call between Beijing and Washington could relieve the pressure.

'…SOME ANALYSTS PREDICT THAT CHINA'S EMISSIONS COULD PEAK AS EARLY AS 2025.'

After Paris, with China's good intentions on climate mitigation re-affirmed, attention shifted to implementation and the implications of China's promises for domestic and international energy. There is little doubt that China can fulfil its INDC pledges – some analysts predict that China's emissions could peak as early as 2025, well before the promised 2030 (see, for instance 'New study finds China's emissions likely to peak by 2025', LSE/Granthan Research Institute, 8 June 2015). Looking further ahead, several studies suggest that China could supply more than 60 per cent of its total energy needs, including transportation, from renewables by 2050. This would include 85 per cent of its electricity supply (see 'China 2050 High Renewable Energy Penetration Scenario and Roadmap Study', Energy Foundation China, 20 April 2015).

How far and how quickly China will be prepared to increase its ambition will depend on a number of factors, including the outcome of the wider political and economic uncertainties that the regime is facing. At its November 2015 plenary, the Chinese Communist Party announced five concepts – innovation, coordination, green development, opening up, and sharing – with which it intends to guide the next phase of China's development, aiming to restructure heavy industry, improve the environment, and enhance efficiency. In the outline 13th Plan, ten of the 13 mandatory targets relate to the environment, natural resources, climate mitigation, or ecosystems.

The most important energy related targets in the plan are the pledge to reduce energy intensity by 15 per cent compared with 2015; to reduce carbon intensity by 18 per cent, on a 2015 baseline; to cap total energy consumption at 5 billion tonnes of coal equivalent (the current level is 4.3 billion tonnes); and to increase the proportion of non-fossil fuels in primary energy consumption to 15 per cent. The 18 per cent carbon intensity reduction target would set China on track to reach, and in all likelihood surpass, the high end of its 2020 climate target of a 45 per cent carbon intensity reduction, on a 2005 baseline.

Coal, the big bad beast of China's energy mix, continues to dominate, but

it is in decline: coal use fell 2.9 per cent in 2014 and a further 3.7 per cent in 2015. Although the details of China's coal statistics are notoriously problematic, the trend seems clear: already China's coal-fired power stations are running below economic levels, with utilization rates characteristically below 50 per cent. But in one sign of a familiar dysfunction in China's policy implementation, even as rates of return on new coal plants were falling below the level necessary for the plant to pay for itself, and the national government talked of promoting the move out of coal, provincial and local governments continued to grant permissions for new coal generation in what risks becoming one of the world's larger stranded asset creation programmes.

According to a Greenpeace analysis, in 2015 China's central and provincial governments approved 210 new coal-fired power plants, with a collective capacity of 169 GW and potential emissions of around 780 million tonnes a year. However, given China's overall energy demand level and the fact that any new demand is likely to be met by renewables, hydro, or nuclear, even if the plants were built they are unlikely to run at anything close to full capacity. In March, in an effort to regain central control of coal plan approvals, the National Energy Administration (NEA) ordered 13 provincial governments to stop issuing approvals for new coal-fired power plants until the end of 2017 and instructed a further 15 provinces to stop building new coal power plants that have already been approved. It remains unclear how many of the plants approved in 2015 will be affected.

There is less confusion on coal supply: in December 2015, Xinhua News Agency reported that China planned to close 1,000 coal mines and suspend new capacity approvals until 2019, with an expected cull of 1.3 million jobs in the coal sector over the 13th Five Year Plan. Overall, China aims to reduce coal's share of primary energy in 2016 to 62.6 per cent. Over the longer term, some analysts have suggested that China could meet 80 per cent of its energy needs from non-fossil sources by 2050.

Under the 12th Five Year Plan, China surpassed its energy and carbon targets: between 2011 and the end of 2015, energy intensity fell by 18.2 per cent and carbon intensity declined 20 per cent. Slower economic growth and an accelerating decline in heavy industry should make the 13th Plan's carbon and energy intensity targets highly achievable. China's veteran special representative for climate change, Xie Zhenhua, assured an audience in Hong Kong in February ('China's climate envoy bullish on hitting reduction goal for 2020', *South China Morning Post*, 23 February 2016) that China would have no difficulty in hitting its 2020 targets of cutting carbon intensity by 50 per cent below 2005 levels, if China met its 13th Plan energy saving goals.

'IF CHINA SUCCEEDS, THE BENEFITS OF ITS TRANSITION WILL SPREAD WELL BEYOND CHINA. IF IT FAILS, THE IMPACTS WILL BE EQUALLY WIDELY FELT.'

If carbon intensity was cut by 50 per cent by 2020, according to Xie, China could easily peak emissions and cut carbon intensity by 60–65 per cent on 2005 levels by 2030, in line with China's ambition to build a green, service economy. The transition to 2030 would be eased, he said, with investments of 4.1 trillion Chinese Yuan Renminbi (US$628 billion) in green, low-carbon industries, with the creation of 69 million new jobs.

Over the coming year, planners at every level of China's government will put flesh on the bones of the 13th Plan. How smooth the process will be is uncertain: slower growth, popular discontent at job losses, and the difficulty of implementing reforms to the energy market will need to be dealt with. The temptation to continue with infrastructure investment will be strong, and already the plan has attracted criticism for its projected investment in expanding high speed rail and in building new airports. But if China succeeds, the benefits of its transition will spread well beyond China. If it fails, the impacts will be equally widely felt.

The post-Paris agenda: challenges ahead for Latin America

Lavinia Hollanda

The Paris Agreement indicates that in the coming years, the world is going to move to a low-carbon economy, and the energy sector should be responsible for promoting big changes in the global climate scenario. The terms of the agreement are comprehensive and ambitious, based on common but differentiated responsibilities among countries, and the energy guidelines and contribution targets of developed and developing countries differ in many points. This means that both the developed and developing world will have to make

'THE ENERGY MIX IN THE REGION CAN BE CONSIDERED RELATIVELY CLEAN…'

efforts to limit the increase in global temperatures to well below 2 °C above pre-industrial levels – and pursue efforts to achieve the 1.5 °C target. However, the contributions of different countries towards providing solutions will be diverse, and will take into consideration each country's historical and current emissions, as well as its ability to tackle climate change. After the successful results of COP21, each country now has a different – and perhaps more challenging – task of making the Paris Agreement real. In this context, what are the implications of the post-Paris scenario for the energy industry in Latin America?

Some aspects of Latin America and of its energy sector give the region an advantage in the transition to a low-carbon economy when compared to other parts of the world.

The energy mix in the region can be considered relatively clean compared to the global average participation of fossil fuels – some 70 per cent of the energy demand in the region is supplied by gas, oil, or coal, whereas in the world on average this percentage rises to 82 per cent. When considering solely the power sector, the high participation of hydropower – and, more recently, of the 'new' renewables (wind, solar, biomass) in some countries – brings fossil fuels contribution to approximately 60 per cent of electricity generation in the region, compared to the global average of 73 per cent (IADB based on IEA data, 2013). Going forward, an expected increase in demand, combined with social and environmental constraints on building additional capacity in hydropower plants, indicates that Latin American countries will need structural change in order to find a path that allows the region to consume more energy, at affordable prices, and in a more responsible way.

Latin America also abounds in natural resources – these could allow energy transition to take place within the region. However, the penetration of 'new' renewables (excluding hydropower) and biofuels in the energy mix varies greatly among the countries in the region. In *Brazil*, for instance, the installed capacity of wind generation has increased enormously in the past six years, from nearly zero in 2009 to more than 8.5 GW in 2016. Nevertheless, this represents only 6 per cent of Brazil's power generation. In *Argentina*, a country with significant potential for onshore wind generation, particularly in the Patagonia region ('Beyond Paris: Energy Transition in Latin America and the Caribbean', Institute of the Americas, 2016), wind power generation is nearly zero. In the case of solar generation, a comparison of irradiation maps of countries in the region with Germany, where currently 21 per cent of capacity comes from solar generation, indicates that there is much potential for growth in solar projects in Latin America. To illustrate this point, data from SolarGis shows that the maximum irradiation in Germany is around 40 per cent lower than the maximum irradiation in Brazil, for instance.

In the case of biofuels, Brazil is the world's largest sugarcane ethanol producer and a pioneer in this segment. Most of the country's current light vehicle fleet consists of flex fuel vehicles, and there is a government mandate that requires a 27.5 per cent ethanol mix to gasoline. In the past years, the biofuels sector in Brazil has suffered from harsh competition with oil products, which have been heavily subsidized by the government, mainly because of inflationary concerns. The decline in oil prices has given local governments in Brazil, and in other countries in Latin America, the opportunity to gradually eliminate such subsidies (allowing ethanol to regain competitiveness) and, potentially, to enhance further research in advanced biofuels.

However, in Argentina most of the energy sector relies on fossil fuels, mainly gas, while solar and wind account for less than 1 per cent of installed capacity (an additional 3 per cent comes from biomass, IADB Energy Database, 2013). A new Renewables Law, enacted in October 2015, establishes that 8 per cent of generation must come from renewables by the end of 2017, and 20 per cent by 2025. At the same time, Argentina has the largest gas reserves in the region, located in the Neuquén Basin (Vaca Muerta and Los Molles), with an estimated 20 billion barrels of shale oil and 583 trillion cubic metres of shale gas. Since imports of gas represent a significant proportion of the total domestic supply in countries like Mexico and Brazil, development of the Argentinean reserves could potentially allow natural gas to play a transition role in the region. In addition, the new government in Argentina has raised expectations about the progressive normalization of the macroeconomic scenario and the resumption of more favourable policies for foreign investments.

An additional asset for Latin America is its market size. The evaluation of the Global Competitiveness Index (GCI), calculated annually by the World Economic Forum, shows the relevance of some markets in the region. The index assesses the performance of 140 countries through the evaluation of 12 key pillars that drive competitiveness; these include institutions, infrastructure, macroeconomic environment, education and labour markets, innovation, and market size.

'LATIN AMERICA FACES GREAT CHALLENGES IN THE IMPLEMENTATION OF THE PARIS AGREEMENT.'

Concerning market size, there are seven Latin American countries which rank among the top 50 markets (such as Brazil in seventh position and Mexico ranking eleventh). Even if we consider a likely income reduction in the region in the coming years (loosely due to low commodity prices), some Latin American markets will remain globally relevant.

However, Latin America faces great challenges in the implementation of the Paris Agreement.

How will the transition be financed? This is probably the region's most immediate challenge as energy and climate change generally have strong links with a country's political and macroeconomic scenario – and this applies to Latin America. The participation of Latin America in the global supply of oil and gas is slightly below 5 per cent, mainly concentrated in Mexico, Venezuela, and Brazil, and to a lesser extent in Colombia and Argentina ('The Geopolitics of Oil and Gas The Role of Latin America', Lins et al., Catavento, February 2016). However, the region's economies are highly dependent on natural resources, with a great deal of revenues relying on commodities exports – oil and gas are particularly relevant in Mexico and Venezuela, and they have a significant impact in Bolivia, Ecuador, Argentina, and Brazil.

Export dependence and commodity price fluctuations Dependence on exports of natural resources has put some countries at the mercy of fluctuations in global commodities prices. Coupled with some questionable economic policies implemented in the past years, this has led to a deterioration in macroeconomic fundamentals and to turbulence in the political scenarios of most of the countries in the region. There have also been headwinds from abroad: key players in the commodities markets, particularly China, have been showing slower growth rates. Given these factors, it is unsurprising that most countries in the region reported GDP growth deceleration, or even contraction, in 2015 (the figure for Latin America and the Caribbean was –0.3 per cent, largely affected by Brazil's recession); perspectives for 2016 are also weak.

The region faces a trade-off between the short-term economic gains of developing existing fossil fuel resources (once global oil prices allow) and the longer-term benefits of transitioning to a less carbon intensive energy sector ('How can Latin America avoid being left behind?', Alicia Bárcena Ibarra, World Economic Forum, 18 January 2016). In either case, the region will need to attract significant investments in order both to overcome structural gaps and to invest in cleaner technologies. With high levels of debt and fiscal deficits, Latin American governments have very limited scope for maintaining the high levels of public spending seen over the past 10 years and are under enormous pressure to attract foreign investment.

'…FINANCING THE TRANSITION TOWARDS A LOWER-CARBON ECONOMY IN DEVELOPING COUNTRIES IS A SIGNIFICANT BARRIER TO OVERCOME.'

Where will the financing come from if Latin America's national governments are unable to provide the necessary financial resources to turn plans into action? The Paris Agreement has acknowledged that financing the transition towards a lower-carbon economy in developing countries is a significant barrier to overcome. Several financing mechanisms to mitigate and adapt to climate change have been made available for developing countries. These include resources from both public and private funds – an example of the latter is the Breakthrough Energy Coalition, an initiative backed by private individuals. However, other countries and regions more directly affected by extreme weather and climate-related events should have priority in receiving these funds (see 'Beyond Paris: Energy Transition in Latin America and the Caribbean'). As a result, the ability to attract private investments will be crucial in establishing the pace of energy transition in Latin America. The establishment of a predictable regulatory environment, with clear rules and strong institutions, is the key to unlocking foreign private investment in the region. Less government intervention in domestic markets should also help.

The ability of players in Latin America's energy industry to develop and deploy new and cleaner technologies will also be important in dictating how fast the transition will happen in the region. On the consumer side, with the expected increase in the region's urbanization rate, cities should be the locus of technological change and could foster innovation in urban transportation, water and waste management, and in the way energy is delivered to consumers. Moreover, innovation in the supply side, such as Carbon Capture and Storage (CCS) and efficiency improvements, will allow the energy industry to become greener.

However, Latin America as a region is not particularly well positioned in terms of innovation and technology development. A deeper analysis of the innovation pillar in the Global Competitiveness Index (GCI) illustrates the region's poor innovation capacity (see the table 'Economic and competitiveness indicators in Latin America' on page 32). When analysing

Economic and competitiveness indicators in Latin America – selected countries

Indicator	Brazil	Argentina	Venezuela	Mexico	Colombia
2015 GDP growth[1]	–3.8%	0.4%	–10%	2.5%	2.5%
2016 GDP growth (est.)[1]	–3.5%	–0.7%	–6%	2.6%	2.8%
Commodities exports[1] (% of total exports)	45.3%	49.8%	87.1%	11%2	58.5%
2013 renewables[3] (%)	57%	13%	39%	12%	52%
Rank in GCI (Global Competitiveness Index)[4]	75th	106th	131st	61st	66th
GCI – market size[4] (on scale 1–7)	5.6–7.0	4.6–5.5	4.6–5.5	5.6–7.0	3.6–4.5
GCI – innovation[4] (on scale 1–7)	2.6–3.5	2.6–3.5	0–2.5	2.6–3.5	2.6–3.5

1. 'World Economic Outlook 2016', FMI
2. Oil and oil products, INEGI, 2014. Mexico is not a large commodity exporter, but oil accounts for a significant part of government income (31% in 2014)
3. Electricity, including hydro and geothermal, IADB
4. World Economic Forum, Global Competitiveness Index 2015–2016. Ranks out of 140 economies and scores measured on a 1 to 7 scale

this factor, countries like Brazil, Chile, Colombia and Peru lose position in the general ranking, while countries like Mexico, Argentina and Bolivia maintain their relative positions. The main factors influencing negative results for innovation in the region relate to low patent registration and availability of scientists and engineers. In fact, the share taken by Latin America and the Caribbean in total global patent applications has been settled at a figure below 3 per cent since the 1990s ('How can Latin America avoid being left behind?', Alicia Bárcena Ibarra). In addition, despite the accomplishment of significantly increased school enrolment, and in years of education completed, it will be necessary to improve quality in some countries in order to further develop the skills and capabilities of the workforce for the post-Paris scenario. Perhaps the only exception relating to technology development in the region is deep and ultra-deep water technology in the oil and gas sector, where Brazil has been on the frontier with Cenpes (the research centre at Petrobras). Given adequate incentives, this knowledge can be applied to the development of cleaner technologies to this industry.

In summary, even considering its relatively clean energy mix, the use of clean technologies in further expansions of the energy sector will be important for reducing emissions in Latin America. For the region to overcome the political, macroeconomic, financial, and technological obstacles hindering it in its transition to a greener economy, it will be necessary to promote cooperation between the public and private sectors and develop a business environment capable of attracting foreign investment. To this end, governments must define policies that foster collaboration between different stakeholders and encourage agents to invest in low-carbon alternatives. A solid, stable, and transparent regulatory framework will also be pivotal in supporting investment and accelerating the transition.

'IT IS CLEAR THAT DEVELOPED AND DEVELOPING NATIONS HAVE QUITE DIFFERENT CONCERNS OVER CLIMATE CHANGE.'

It is clear that developed and developing nations have quite different concerns over climate change. Similarly, different countries and regions can be expected to experience energy transition at different paces. Discussion of peculiarities in each country's approach to energy transition in the Latin American region can help increase understanding of their individual energy policies, and create a coherent view of the relationship between energy, climate change, and the economic and social dimensions in the region. In the end, if we want to build a greener and more sustainable energy sector in Latin America, we had better start acting now.

India's climate and energy goals after COP21: contradictory or complementary?

Anupama Sen

The agreement reached at the 21st Conference of Parties (COP21) in Paris in December 2015 evoked mixed reactions in India. While its prime minister declared that the deal was a win for 'climate justice', the environment minister reportedly stated that the agreement could have been more ambitious, as the actions of developed nations were 'far below' their historical responsibilities. There was, however, a visible shift in India's stance at COP21

'…(PRIOR TO 2009) INDIA'S FOCUS WAS ON RESISTING INTERNATIONAL ATTEMPTS TO IMPOSE ANY EMISSIONS LIMITS THAT COULD CONSTRAIN ITS ENERGY POLICY.'

in comparison with previous climate summits. Arguably, this shift began in 2010 in Cancun, when India pledged its first climate target (to reduce the emissions intensity of GDP by 20–25 per cent by 2020 from 2005 levels, soon after China announced its emissions intensity target), and it was further defined at COP21.

The core of India's negotiating position has remained unchanged – relying on the principle of 'common but differentiated responsibility and respective capabilities' within the United Nations Framework Convention on Climate Change. This relates to its main domestic and international challenge which, as described in the *IEA World Energy Outlook 2015*, is to

> *'demonstrate serious intent to reduce emissions, while still preserving sufficient headroom to allow for economic growth'.*

While in the past (prior to 2009) India's focus was on resisting international attempts to impose any emissions limits that could constrain its energy policy, at COP21 it explicitly articulated its stance – namely, that given the limited amount of carbon space (or total amount of carbon that can be emitted before the 'safe' temperature threshold is breached), developing countries should be allocated a 'fair and equitable' share to enable them to pursue critical development and poverty alleviation goals. It simultaneously announced ambitious domestic targets on clean energy, albeit reiterating a proviso that these were contingent upon low-cost technological assistance from the developed world. Another key feature of this 'shift' was India's leadership (jointly with France) in rallying 120 (mostly developing) nations around an international solar alliance, purportedly to seek the financial assistance required to scale up the adoption of solar energy.

Taken at face value, these steps collectively hint towards the beginning of a hitherto unprecedented conflation of climate policy and economic development policy, in contrast to a previously perceived dichotomy between climate change mitigation and economic development (see 'Neither Brake Nor Accelerator: Assessing India's Climate Contribution', Navroz Dubash and Radhika Khosla, *Economic and Political Weekly*, 17 October 2015). Indeed, many of the potential characteristics of renewable energy – such as decentralized solar systems – present potential solutions to the problem of rural electrification, which is one of the centrepieces of the current government's policy pledges. However, a key question arises: is India's shift in its stance on climate and energy at COP21 consistent with the commitments in its Intended Nationally Determined Contribution (INDC)? In other words, are India's goals on climate and energy policy complementary, or contradictory?

India's twin climate targets – commitments versus aspirations

It is in fact important to note that India has *two* sets of climate-related policy targets. The first set is enshrined within its INDC and therefore constitutes firm international commitments. These are:

- To reduce the emissions intensity of GDP by 33–35 per cent from 2005 levels by 2030;
- To achieve 40 per cent of cumulative electric installed capacity from non-fossil fuel sources by 2030, with the help of technology transfer and low-cost international finance, including the Green Climate Fund; and,
- To create an additional carbon sink of 2.5–3.0 billion tonnes of CO_2 equivalent, through additional forest and tree cover by 2030.

The second set of targets reflects the Indian government's domestic policy intentions through its long-running National Action Plan on Climate Change (launched in 2008). These include:

- A five-fold increase in renewables installed capacity to 175 Gigawatts (GW) by 2022;
- Of the above, 100 GW from solar, 60 GW from wind, and the remainder from other sources; and,
- A 10 per cent reduction in total energy consumption (from current levels) by 2018–19.

Notably, the second set of targets has received greater publicity than the INDC targets, and they do not form a part of the INDC commitments; rather, they are listed in the INDC as part of recent government policy initiatives on climate change mitigation – they can therefore be construed as *domestic policy aspirations*, rather than *firm international commitments*.

Several broad assessments of India's INDC targets have been made since December 2015, and the consensus appears to be that they are achievable, but relatively conservative in ambition. For instance, in contrast with other large developing economies (Brazil, China, and South Africa) which had joined India to represent their collective interests in 2009, India's INDC retained its historical preference for an emissions intensity target, while at COP21 Brazil, China, and South Africa moved from emissions intensity targets towards absolute emissions targets. India's emissions intensity of GDP (measured in kilograms of CO_2 per 2011 PPP$ of GDP) is estimated to have fallen by around 7.5 per cent from 2005 levels (*World Bank World Development Indicators, 2015*).

However, India's INDC estimates that its energy intensity has declined by a much higher 17 per cent (given the dominance of fossil fuels, emissions intensity may have followed a similar trend). It is likely to continue to decline as India expands its National Mission on Energy Efficiency (see 'Energy Efficiency: low-hanging fruit for India', Anil Jain, *Oxford Energy Forum*, February 2015) and one assessment puts the likely emissions intensity of GDP at 41.5 per cent below 2005 levels by 2030 (*India Climate Action Tracker, 2015*).

'…NON-FOSSIL FUEL SOURCES ALREADY COMPRISE 30 PER CENT OF INDIA'S OVERALL INSTALLED CAPACITY…'

India's INDC pledge to expand non-fossil fuel installed electric capacity (including hydroelectric and nuclear) is similarly achievable, as non-fossil fuel sources already comprise 30 per cent of India's overall installed capacity – the majority of this 30 per cent being hydroelectricity, while within renewable energy (excluding hydroelectricity) wind takes the largest share. The *IEA New Policies Scenario (NPS) 2015* for instance, predicts that non-fossil fuel capacity will reach 46 per cent of installed capacity in 2040. At the same time, it is important to note that a target for installed capacity does not equate to a target for generation – particularly given India's low capacity utilization, its high transmission and distribution losses, and the inherent intermittency of renewables using current technologies. For instance, Dubash and Khosla, in 'Neither Brake Nor Accelerator', estimate that the target would translate into a 21–22 per cent share of generation, meaning that fossil fuels are likely to continue to dominate.

However it seems that the effectiveness of India's INDC targets, and the scaling up of a potential 'climate as development' narrative, will depend not just on the success of its domestic policy aspirations (specifically on the interactions with INDC commitments) but also on more granular measures, such as efficiency reforms in the electricity sector. The consensus from various assessments appears to be that the successful achievement of its domestic policy aspirations could result in India even exceeding its INDC emissions intensity and non-fossil fuel electricity capacity targets. However, estimates of this vary considerably (see 'India's Climate Pledge Suggests Significant Emissions Growth up to 2030', Sophie Yeo and Simon Evans, *Carbon Brief*, 2 October 2015).

The power sector – the biggest hope, but also the biggest constraint

India's installed generating capacity

Source	Percentage of total
Coal	61%
Oil	0.34%
Gas	8%
Nuclear	2%
Hydro	15%
Renewables	13%

The table 'India's installed generating capacity' gives the percentage composition of India's 289 GW of installed capacity in February 2016. Within renewables, solar and wind were 13 and 65 per cent, respectively.

According to the IEA, CO_2 emissions from electricity comprise the single largest proportion (44 per cent) of total CO_2 emissions from fuel combustion in India (*CO_2 Emissions from Fuel Combustion,* IEA, 2014). Given that roughly a third of its population lacks access to modern commercial energy, India's government in 2014 set a target of providing '24 × 7 electricity to all' by 2019. The viability of this target is contingent not just upon an expansion of installed capacity, but also on massive technical and financial reforms to the electricity sector. Given its dual emissions and development implications, the power sector, therefore, represents the biggest hope for a successful confluence of climate and energy policy, but at the same time, its biggest hurdle. The latter is characterized by *two fundamental problems relating to power sector reform*:

- First, India's electricity reform is largely based on the OECD model, where prices are eventually set based on system marginal cost. As electricity policy in India's federal structure lies with individual states, these are at different stages of reform. However, India is beginning to demonstrate problems similar to those seen currently in the OECD, where a system based on marginal cost pricing cannot cope with the intermittency of renewables, nor provide adequate long-term incentives for investment in desirable (that is, alternatives to coal) backup generation (see 'Divergent Paths to a Common Goal?', Anupama Sen, OIES paper EL10, May 2014). Attempts at incorporating renewables have run into problems. For instance, a 'renewables purchase obligation' (RPO) requires distribution utilities to purchase a certain proportion (set by state regulators) of electricity from renewables, or alternatively an equivalent amount in 'renewable electricity certificates' (each equating to 1 MWh) on India's two main power exchanges. However, the exchanges have reported a growing inventory of untraded certificates since the programme's inception. For instance, the Indian Electricity Exchange, which accounted for over 90 per cent of the domestic electricity trading market in 2015, reported that of 9.6 million certificates available in fiscal 2014/15, only 3.1 million had been traded (see 'Green certificates sale down 58% at 4.01 lakh in January', *Economic Times*, 27 January 2016)
- This leads to the second problem and a fundamental reason why India's previous attempts at reform failed: the insolvency of state distribution utilities,

'CO_2 EMISSIONS FROM ELECTRICITY COMPRISE THE SINGLE LARGEST PROPORTION (44 PER CENT) OF TOTAL CO_2 EMISSIONS FROM FUEL COMBUSTION IN INDIA.'

reflecting a failure to enforce cost-reflective pricing. This has meant that utilities are often unable to fulfil their RPOs. Policymakers are undoubtedly aware of these problems: three recent attempts have been made to restructure the debts of utilities. The latest reform, announced in November 2015, asks state governments to appropriate 75 per cent of distribution utilities' debts over a period of two years. Following this, the debts will be included as part of state fiscal deficits, thereby necessitating parallel measures to be taken by states to increase power sector tariffs and eliminate subsidies. The incentive to states to implement this reform is the awarding of priority in other federal funding – nine out of 29 states had signed up at the time of writing.

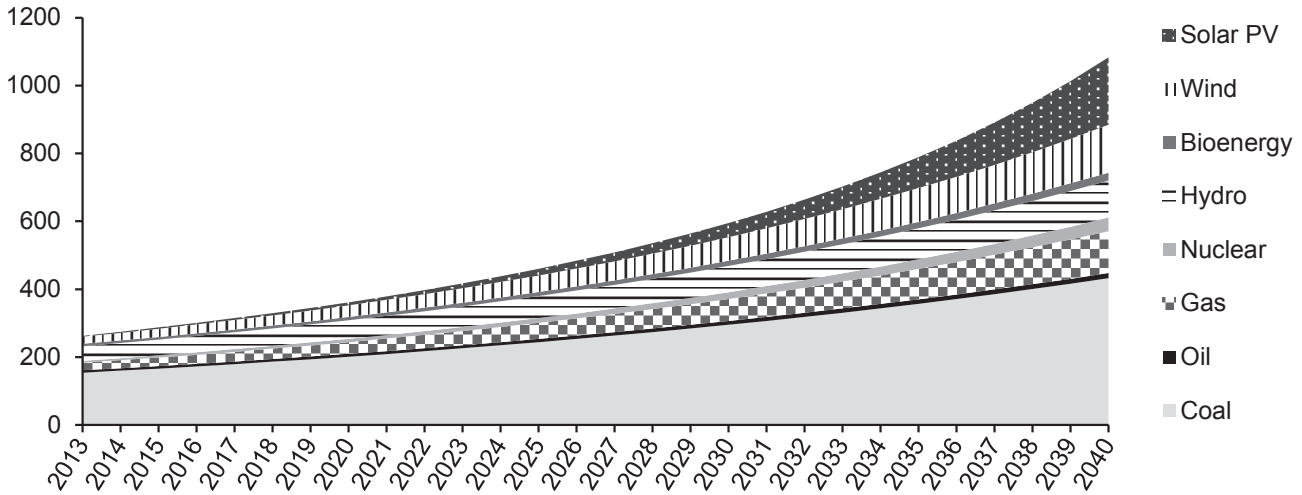
Subsidies have been successfully eliminated for energy products such as gasoline and diesel by liberalizing retail prices (accompanied by direct subsidy payments to eligible consumers through cash transfers). However, the position of petroleum products, where policy is made at federal level, is different from that of electricity, because electricity policy is a state subject; decision making for electricity is therefore fragmented and influenced by regional politics. India's INDC states that the government will enforce a 'renewables generation obligation' requiring fossil fuel generators to invest in solar plants or purchase electricity from renewables equivalent to 10 per cent of fossil fuel capacity. Although this moves the policy impact from the politically sensitive distribution sector to generation, and may help in adding capacity, it is unlikely to resolve the problem of cost-reflective pricing, which requires the building of a political consensus amongst states and greater enforcement powers for electricity regulators.

The unyielding role of coal

An alternative way of scaling up renewables within electricity is to disincentive coal, making it less attractive to consumers. However, this is where contradictions emerge. Aware of its pledge on universal electricity access and its wider ambitions on economic growth, India's government aims to triple domestic coal production to 1.5 billion tonnes by 2020 and, further, to meet this entirely from domestic resources which have a high ash content. Assessments show that these targets are ambitious but not impossible (see 'Indian Steam Coal Imports', Sylvie Cornot-Gandolphe, OIES paper CL3, March 2016). At the same time, it has announced domestic policy initiatives on 'clean coal', including:

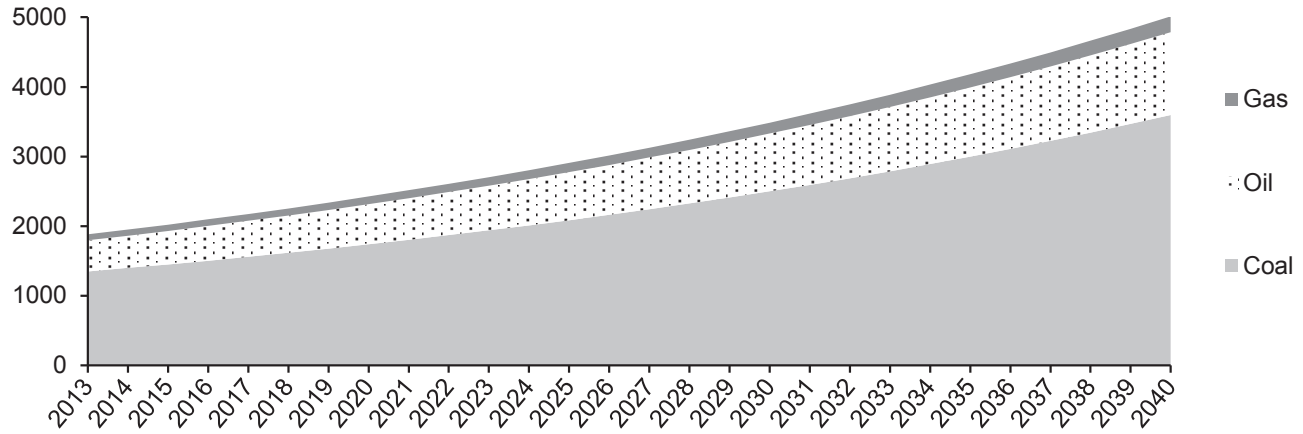
- Mandatory supercritical technologies for coal-fired power plants from 2017 (currently comprising only 16 per cent of the coal-fired fleet);
- The expansion of coal washeries (less than 20 per cent of coal is washed);
- Pricing based on auctions (Indian coal has at times been half the price of internationally traded coal);
- Environmental regulations on transportation of coal with high ash content; and,
- A 'coal cess', which has been doubled every year since its inception in 2014 (now roughly US$6/tonne).

However, by most assessments, and despite current policy measures, coal will continue to meet the major proportion of India's energy demand (set to



Trend in growth of installed capacity to 2040 (GW)

Source: Author's estimates using compound annual average growth rates from IEA World Energy Outlook, *2015*



CO_2 emissions to 2040 (million tonnes)

Source: IEA World Energy Outlook *CPS, 2015; Author*

increase by 2.5 times) to 2040 (see the figure 'Installed capacity to 2040' on page 35).

The *IEA World Energy Outlook* estimates that coal-fired capacity in the *NPS* will be 17 per cent lower than in the *Current Policies Scenario (CPS)*; in contrast, non-fossil fuel capacity will be 48 per cent higher in the *NPS* than *CPS* – but this is starting from a very low base, particularly for solar. In reality, solar is estimated in the IEA-NPS at 28 GW of capacity in 2020, 100 GW in 2030, and 182 GW in 2040, implying that India could fail to achieve its ambitious 2022 domestic solar target.

The resultant impact on emissions has been estimated by the IEA at around 5.2 billion tonnes of CO_2 in 2040 in the *NPS* (15 per cent lower than the *CPS*) – see the figure 'CO_2 emissions to 2040'. Although in absolute terms India would remain one of the largest emitters of CO_2, in per capita terms emissions would be around 3.4 tonnes (assuming UN population projections of 1.5 billion), up from 1.6 tonnes at present – placing it below predicted 2040 per capita emissions for the USA, China, and the EU ('India's Climate Pledge', Yeo and Evans, 2015).

'THE BIGGEST UNCERTAINTY IS, HOWEVER, NOT WHETHER INDIA'S CARBON EMISSIONS WILL CONTINUE TO GROW, BUT WHEN THEY WILL PEAK.'

Turning the coal tide

The biggest uncertainty is, however, not whether India's carbon emissions will continue to grow, but when they will peak. India has, thus far, resisted putting forward a target for this (as China has done), but its INDC states that it

> *'reserves the right to make further submissions as and when required'.*

A related uncertainty is over whether the path to peak emissions could be speeded up or moved to a lower trajectory. This is where India's proviso of

> *'access to low cost international finance and technology transfer'*

comes into play. It is likely to be the basis of future negotiations and of adjustments to India's INDC targets going forward through the 'update and ratchet' mechanism. India's INDC puts forward a preliminary estimate of US$2.5 trillion (2014 prices) as the cost of implementing enhanced climate actions to 2030 – higher than all other developing countries combined ('India's Climate Pledge', Yeo and Evans, 2015). In contrast, global renewable energy investments in 2016 were estimated at US$286 billion, the majority being in developing countries (*United Nations Environment Programme*). Although India prefaces its INDC contribution with 'sanguinity' about the availability of international finance, the weight of evidence is against such sanguinity (as noted in 'What do India's climate contributions mean, and are they implementable?', Lavanya Rajamani, *Economic Times*, 23 October 2015). There is an urgent need for greater clarity on how much of India's estimated cost can be funded domestically, and how much internationally.

India's climate and energy goals, as they currently stand, are still contradictory, but there is room for complementarity and for exploiting the growing synergies between the two. This has not been sufficiently explored by governments (and not just India's), fearful of yielding sovereignty over domestic policy. What may turn the tide in the next few years is the move towards decentralized solutions to energy access and development, along with rising public concerns over environmental issues such as abysmal urban air quality (this has recently caused a slew of litigation by citizens against India's administrative authorities), which could force climate and energy policy closer together.

Europe's climate policy – after Paris comes the harder part

David Buchan

The Paris climate agreement is a big comfort to the European Union. The fact that so many governments have come forward with at least some form of emission reduction plan leaves the EU feeling less lonely in the fight against climate change and less exposed to competitive threats from economies with no carbon constraints.

Indeed some EU governments have subsequently felt sufficiently buoyed by the outcome of Paris to urge the EU to increase the ambition of what it laid on the table at Paris. The final communique in Paris exceeded most expectations by promising action to keep the rise in global average temperatures, from pre-industrial levels, to 'well below 2 °C' and to 'pursue efforts' to hold the increase to 1.5 °C. As a result, at the March 2016 meeting of EU environment ministers, Germany, Austria, Portugal, and Luxembourg criticized the European Commission for being unwilling to revise upwards EU climate goals to reflect the increased ambition of the Paris accord. These governments, along with green groups, claimed that while the EU goal of a 40 per cent reduction of emissions by 2030 (from the 1990 level) might be compatible with a 2 °C temperature rise, it was inadequate to help the world achieve the lower 1.5 °C target. They also pointed to the fact that the 2030 emission reduction goal, set in 2014, was couched as 'at least 40 per cent'.

But the Commission is leaving the 2030 target unchanged – and for the good reason that in the current general political turmoil inside the EU, any adjustment might well be down rather than up. For the 2030 goals will be harder to achieve the 2020 targets.

'THE 2030 GOALS WILL BE HARDER TO ACHIEVE THE 2020 TARGETS.'

This is not so evident as regards the slightly less than half Europe's emissions that are produced by the 10,000 power generators and industrial operators covered by the Emissions Trading Scheme (ETS). Largely due to recession and slow growth in the eurozone, the EU will have no difficulty at all in meeting the sub-target of a 21 per cent decrease (from 2005 levels) in ETS emissions by 2020. The 2030 sub-target of a 43 per cent reduction in ETS emissions ought to be achievable, but progress here could be stymied by developments in three sectors of power generation:

- *Coal-fired generation plant.* Construction of new coal plant is still continuing in central and eastern Europe, chiefly in Poland, whose new nationalist and somewhat climate-sceptic government is making support for the mining sector a key part of its industrial and social policy, but also in the Czech Republic. In western Europe, a small amount of coal plant is still being built in Germany and the Netherlands, but in capacity terms this is dwarfed by the scale of coal plant closures in the UK, where the government has said all coal generation should shut down by 2025. The mirror image of this east–west divergence on coal is that more gas-fired generation is being built in western Europe than in eastern Europe, though the overall amount is small.
- *Renewable electricity.* There has been a slowdown in new renewable capacity in the UK and in several central and east European member states. The UK is withdrawing subsidy for onshore wind and, partly as a result, will probably miss its 2020 renewable target, as may Poland where the new government's pro-coal policies are bringing to a halt the sizeable increase in renewable capacity seen in recent years. Declining enthusiasm for renewables is evident elsewhere in the region, where Hungary, the Czech Republic, and Bulgaria failed to erect a single wind turbine last year. None of this is surprising, given that it was the UK and east European states which successfully lobbied for the EU to drop renewable energy targets for individual member states after 2020.
- *Nuclear power.* In terms of emissions reductions, the continuance of some new investment in coal generation and the slowing increase in renewables would matter less if there were a real prospect that Europe could at least maintain output of near zero-carbon nuclear power. At present the share of electricity produced from nuclear power is 27 per cent, which is the same portion of the electricity mix as that provided by renewables. In the latest of the 'indicative' nuclear programmes that are periodically required to be published under the Euratom Treaty, the European Commission 'estimates that the nuclear electricity generation capacity would decline by 2025'.

  This seems obvious, partly because by that date the last German reactor will have shut and France will have, according to its 2015 energy transition law, reduced the nuclear share of its electricity mix to 50 per cent, and partly because even if Electricité de France makes a final investment decision this year on a new UK reactor at Hinkley Point this will not start generating until 2025.

But the Commission's 'indicative' programme enters the realm of make believe in predicting that the decline in nuclear will reverse by 2030 and rise slightly to provide a 17–21 per cent share of the electricity mix by 2050. This assumes that, in addition to the reactors currently being built or expanded (as in France, Finland, and Slovakia), or under negotiation (as in the UK and Hungary), the nuclear projects still on the drawing board in Bulgaria, the Czech Republic, Lithuania, Poland, and Romania will all go ahead. Even with maximum life extensions of existing reactors, if the EU were to maintain a 20 per cent nuclear share of the electricity mix, by 2050 80 per cent of the output would have to be from new nuclear reactors built, on the Commission estimate, at a cost of €350–450 billion. This is, to put it politely, most implausible.

However, achievement of the 43 per cent emission reduction goal in the sectors covered by the ETS is possible:

- if the agreed reforms to the ETS produce a high carbon price,
- if this in turn favours gas over coal,
- if the cost of renewables continues to come down, and
- if this in turn brings the rate of subsidy for renewables down to a politically sustainable, and therefore stable, level.

Europe's decarbonization strategy is designed to start with the electricity sector that can then replace fossil fuels in heating and transport. Not only is the priority on decarbonizing electricity logical, it is also, in one sense, easier – it only requires behavioural change from a relatively small number of energy producers, not a multitude of energy consumers, as in the heating and transport sectors.

'EUROPE'S DECARBONIZATION STRATEGY IS DESIGNED TO START WITH THE ELECTRICITY SECTOR…'

It is this behavioural challenge that makes decarbonization particularly difficult in the sectors (chiefly transport, buildings, agriculture) of the European economy which are not covered by the ETS but which account for nearly 60 per cent of Europe's emissions. The challenge is somewhat eased by the fact that, in contrast to the one-carbon-price-hits-everyone regime of the ETS, the burden of decarbonizing the non-ETS sectors is adjusted to the member state's ability to bear it – higher targets for richer states, lower ones for poorer states. This burden-sharing – which the European Commission prefers to call 'effort sharing' – is not the most efficient form of emission reduction, because the most energy-wasteful countries are often the poorest – such as those in central and eastern Europe – but it has been chosen as being the most politically acceptable.

In the current EU energy and climate regime, non-ETS emissions are supposed to decline (from 2005 levels) by an overall 10 per cent by 2020. But within that ceiling, poorer states (the mainly smaller economies in eastern Europe) are allowed to increase their non-ETS emissions by up to 20 per cent by 2020 (from 2005 levels), while the richer ones (which include the five largest EU states that are all in western Europe) have to cut emissions by up to 20 per cent. Apart from three or four west European member states, most of the EU-28 will have no problem meeting their 2020 targets, and the 10 per cent overall non-ETS target will be easily met.

However, the post-2020 regime will be considerably tougher. The overall target for 2030 is a 30 per cent reduction (again on 2005 levels) in non-ETS emissions, and while differentiated targets remain for individual states, they range from a zero percentage increase for poorer states to a 40 per cent reduction for the richest. The Commission is shortly to propose where the legally binding targets for individual states should fit along this 0–40 percentage point spectrum. In the absence of radical relative changes in national income, it will presumably again see a state like Bulgaria getting the easiest target (such as just keeping its non-ETS emissions flat through the 2020s) and a state like Denmark having to cut its non-ETS emissions by up to 40 per cent (though for the 2030 regime there is the possibility of states with very stiff non-ETS targets getting some easing, in return for foregoing some of their ETS allowances).

'THE BIGGEST EMITTING SECTOR IS TRANSPORT, ACCOUNTING FOR A THIRD OF ALL NON-ETS EMISSIONS.'

The biggest emitting sector is transport, accounting for a third of all non-ETS emissions. It is also the most difficult to decarbonize (see 'Europe crawls towards low-carbon transport' by Jos Dings, page 46). The European Environment Agency (EEA) has made some projections: it foresees overall transport emissions falling by only 0.7 per cent by 2020, and staying steady, in the absence of any new policies, up to 2030.

By contrast, the EEA forecasts significant reductions in emissions from residential and commercial buildings (which at present account for 27 per cent of all non-ETS emissions), both up to 2020 and beyond. To accelerate progress in this area, the Commission has this year produced what it called its first ever strategy for heating and cooling in residential and commercial building, and in industry. If this is to work, it will involve not only tightening existing legislation on energy efficiency and the energy used in buildings, but also behavioural

changes such as, for instance, better cost-sharing arrangements between owners and tenants so that both reap the benefit of renovating buildings they own or inhabit. In the difficult task of reducing emissions outside the ETS, the Commission has at last identified one area in which it can, so to speak, push on an open door.

Taking the temperature

Andrew Howard

From a vantage point inside financial markets, it feels at times that investors are shouldering weightier expectations to lead the line in addressing climate change than they can deliver. At the time of writing, four of the 13 articles on the UN Framework Convention on Climate Change (UNFCCC) homepage describe the role of various climate investments in addressing the challenge. '*Financial flows*' is the first topic on its list of action areas.

High profile efforts such as the *Montreal Pledge* – which commits investors to measure and disclose the carbon footprints of their portfolios in order to demonstrate commitment to tackling climate change – have fuelled the rhetoric, despite their relatively small scale. The US$100 billion of assets managed by Montreal Pledge signatories equates to around 0.1 per cent of the world's professionally managed assets.

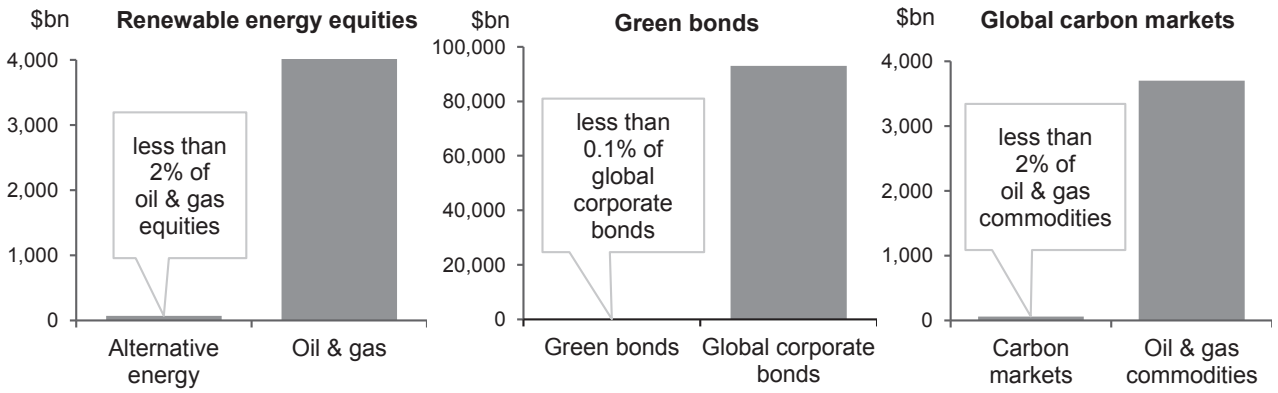
While there is no doubt that capital markets will be vital to facilitating the very significant investments needed to decarbonize the world's energy infrastructure and economy, financial markets will not blindly lead that transition. Investments will follow where economic and financial incentives lead, and at this point those incentives have not yielded an avalanche of investment in climate technologies or infrastructure.

'INVESTMENTS WILL FOLLOW WHERE ECONOMIC AND FINANCIAL INCENTIVES LEAD…'

The selection of charts ('Value of selected climate markets, relative to traditional equivalents') plotting the global value of investments that focus on clean energy or on climate solutions, relative to their fossil fuel counterparts, put the scale of climate-focused financial investment in context.

The small numbers seem at odds with many headlines. The IEA's latest *World Energy Outlook* states that 60 per cent of new power investment went into renewables in 2014, equating to 130 GW of renewables capacity. Although that figure equates to only around 60 per cent of investment in upstream oil and gas production, renewables play a far bigger role in the industry than in capital markets. The circle is largely squared by the relatively small share of that investment coming from public markets. The UN Environment Programme has estimated that while global new investment in renewable energy has risen by 20 per cent annually over the last decade, reaching US$270 billion in 2014, less than 10 per cent comes from public capital markets. Most is funded by companies' own cash flows or private vehicles.

This could change quickly. With a clearer regulatory and economic signal, rising investment could push the industry to mature quickly, reducing technical and execution risks and



Value of selected climate markets, relative to traditional equivalents

Source: Datastream, The Climate Group, Climate Bonds, Statista

improving the liquidity of available investments. As a study in the pace of change possible: US$500–600 billion was invested in the US shale industry during 2005–10, pushing its share in US energy supply to around 20 per cent from a standing start. Technological and regulatory changes created an economic opportunity into which capital flooded.

In this article, we look more closely at why investment has not been greater to date. Populist challenges attributing the industry's muted response to ignorance ('*they don't understand*'), myopia ('*they only care about the next quarter*'), or vague conspiracy theories all miss the mark and do nothing to help unpick solutions.

The job of an investor is to maximize the value of investments managed on behalf of clients, most of whom are, ultimately, the general public. The majority of professional investors have no mandate to pursue environmental agendas or to use their clients' money for social or political goals, however well intentioned. That is the impassionate lens through which financial markets look at climate change.

Through that lens, we can dissect in stages the reasons for the apparently limited financial market response to climate change, relative to the scale of the problem:

'CLIMATE CHANGE IS CLEARLY ON INVESTORS' RADAR SCREENS AND THE SCALE OF THE CHALLENGE HAS BEEN WELL PUBLICIZED.'

1 Are enough investors aware of the issue and does it seem likely to have a big enough effect on corporate values to worry about?
2 Does it look likely that regulators, governments, consumers, or another group will take meaningful action to address the threat?
3 Is there a logical way to work out how those actions will affect the values of individual companies or asset classes?

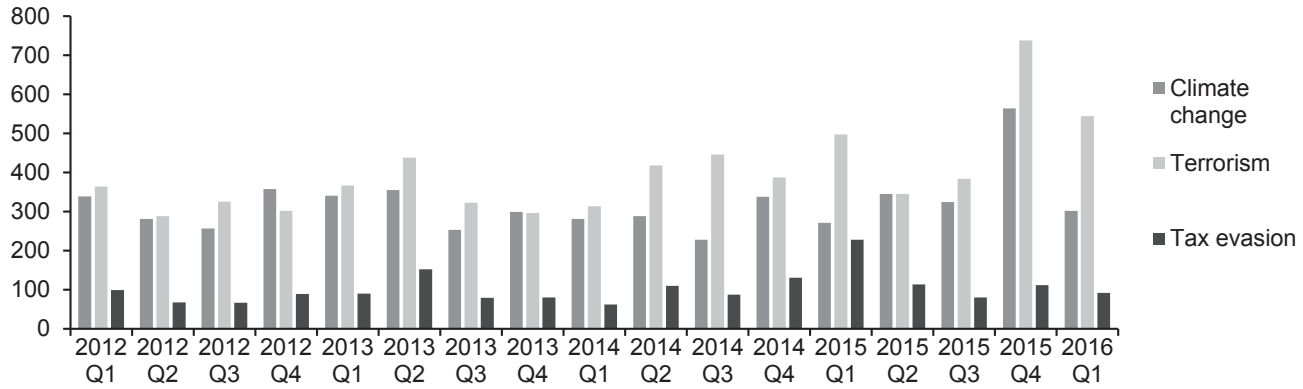
On the ***first*** question: climate change is clearly on investors' radar screens and the scale of the challenge has been well publicized. Over the last year, the *Financial Times* has run more stories on 'climate change' than on 'tax evasion', and only slightly fewer for 'climate change' than it has published on 'terrorism' (see the figure 'FT articles referring to selected topics'). Fewer than 10 per cent of those articles mention scepticism over the science or threat of climate change and none we found concluded that those sceptical arguments are valid.

On the ***second*** question: whether regulators, governments, consumers, or some other constituency will take steps to address the threat is less clear. Last year's agreement in Paris resulted in global leaders agreeing to take steps to limit the increase in the global average temperature to well below 2 °C above pre-industrial levels, and to pursue efforts to limit the temperature increase to 1.5 °C.

On the face of it, this is stern stuff. By our estimates, the targets published by individual countries prior to that point imply an emissions pathway consistent with temperature rises around 3.5 °C. The Paris Agreement should have been followed by governments queuing up to ratchet those national targets. They haven't.

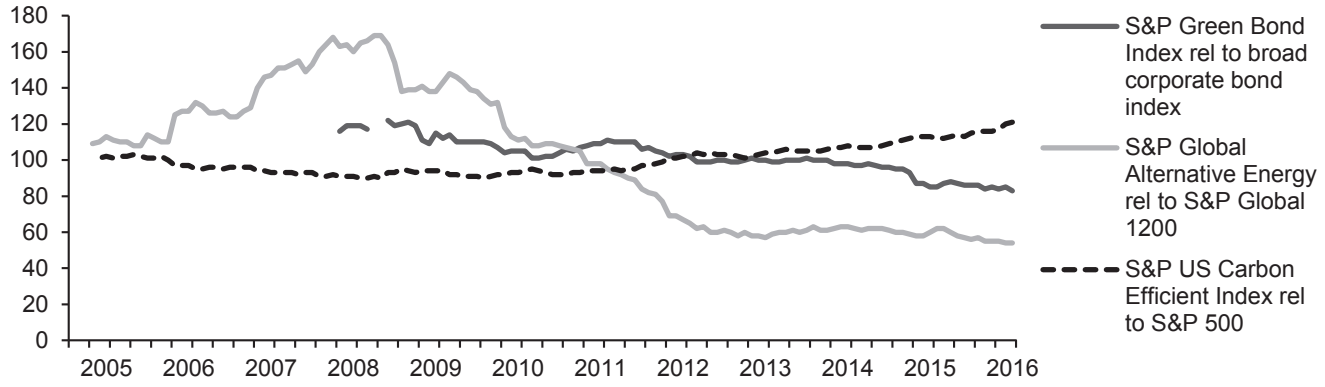
Financial markets will be driven by evidence that global ambitions to address the causes of climate change are grounded in a willingness to take practical regulatory steps. So far, the jury is out.

Carbon pricing is a key plank of most policymakers' climate toolkits, but it is yet to approach levels at which it might become financially meaningful. Dividing the global value of carbon markets by annual emissions yields a global average price around US$1 for each tonne of carbon emitted annually. At that level, the carbon



FT articles referring to selected topics

Source: Financial Times



Performances of selected carbon investments relative to comparable benchmarks

Source: Datastream

contained in a barrel of oil is worth under 50 cents, a figure smaller than the average daily change in the price of oil over the last few years. Any calculation of the effects of carbon pricing on companies' profitability or value relies either on a lot of decimal places, or the assumption that carbon prices will rise significantly, which in turn relies on regulators taking much sterner steps.

Although we start from a low base, it is also clear that political action is strengthening. A decade ago, the first carbon markets had just launched, whereas we estimate that today existing or planned carbon trading schemes will cover close to one-third of global emissions, albeit with relatively loose caps that lead to muted prices. Although the pace of change is unclear, most investors are clear that the trajectory is towards more stringent regulatory action.

'…WE ESTIMATE THAT TODAY EXISTING OR PLANNED CARBON TRADING SCHEMES WILL COVER CLOSE TO ONE-THIRD OF GLOBAL EMISSIONS…'

On the *third* question: if convictions in the likelihood of regulatory action continue to strengthen (as they are), ideas on how to translate that risk into investment decisions will become more critical. To date, proposals have focused on relatively blunt responses, often developed by environmental groups with limited financial expertise, which are logical first steps but which rarely provide sensible long-term solutions.

- *Carbon footprinting* measures the amount of carbon emitted by the companies an investor owns when he or she invests £1 in an investment fund. It says little about how rising carbon prices will impact the value of those companies, an altogether trickier question demanding knowledge of industry structures, pricing dynamics, and financial markets.
- *Clean energy funds* funnel investment into listed alternative energy technology companies. Most have performed poorly, reflecting both their sensitivity to changing regulation and the difficulties many sectors have faced in generating attractive levels of profitability, often weighed down by the excess capacity caused by heavy investment in relatively immature markets.
- *Fossil fuel divestment campaigns* generate compelling headlines, but the leap from reductions in fossil fuel use to underperformance by producers of those commodities misses the nuances of resource economics and the depressed valuations on which they trade.
- *Green bonds, carbon markets, or other emerging investments* have, so far, only scratched the surfaces of the broader asset markets of which they are parts, generally with disappointing performances to date (see the figure 'Performances of selected carbon investments relative to comparable benchmarks').

In principle, the availability of a deep enough pool of liquid investment opportunities will be important once those conditions are established. Illiquidity and the relatively high costs associated with finding and managing small investments have been challenges in the past. However, in practice, those barriers tend to fall quickly once capital builds momentum.

Assuming that political responses follow through on the commitments made by leaders in Paris last year, financial market attention will turn to solutions that assimilate the investment implications of tougher responses. The investment strategies that result may not line up with environmental groups' goals or political hopes for financial market intervention.

Implications will be more nuanced than the blunt approaches advocated to date; the biggest investment effects of climate policies are likely to be outside

the clean technology sectors that will provide many solutions. Rather than narrow investment in clean energy technologies, attractive opportunities are likely to emerge in other industries where companies can generate indirect competitive advantages through managing the indirect effects of regulation and consumer expectations on their costs, pricing, or growth.

'FINANCIAL MARKETS ARE UNIQUELY ADEPT AT HUNTING DOWN VALUE, BUT IT IS LIKELY TO EMERGE IN UNEXPECTED PLACES.'

Instead of reducing investments in all high-carbon companies, greater regulatory clarity may actually make it easier to value fossil fuel companies, even if they face dwindling growth. Financial markets are uniquely adept at hunting down value, but it is likely to emerge in unexpected places.

The divestment debate: a view from energy producers

Frederick J. Lawrence

Over the past year, nearly 30 UK universities have yielded to the pressure of climate activists and considered whether to rid their endowments of fossil fuel-related assets. The anti-fossil fuel camp will tell of the growing number of notable universities that have pledged to divest of such assets, with Glasgow, Sheffield, and Warwick among them. However, the lines of success are blurred when you look behind the headlines. Oxford, for example, reportedly divested its £3 billion endowment, when in fact it had committed to avoid investment in coal or oil sands only – both sectors in which it was not invested in the first instance. Not only does this raise the question '*What is true divestment*?', but moreover, *what are the motives behind the divestment movement*? There is little reason to believe that divestment will affect the bottom lines of the companies the activists hope to derail, or that it will produce a tangible solution to the climate challenges they wish to address.

'THERE IS LITTLE REASON TO BELIEVE THAT DIVESTMENT WILL AFFECT THE BOTTOM LINES OF THE COMPANIES THE ACTIVISTS HOPE TO DERAIL…'

Some leaders of the divestment movement accept that their efforts are primarily symbolic in nature. Stephen Heintz, president of the Rockefeller Brothers Fund (RBF), admitted in 2015 that the fund's decision to divest from many fossil fuel stocks was 'largely symbolic' and meant to incite others to change behaviour. But even the RBF couldn't commit itself to full divestment at first – it initially dropped only coal and oil sands stocks, which resulted in a less than 1 per cent decrease in the fund's fossil fuel exposure. Much like Oxford's decision, activists listed RBF in the win column, despite the fact that the organization continued to invest in oil and gas (a decision which was just recently expanded). The reality is that calls to action – even those intended as symbols – eventually need to be clearly definable, yet divestment proponents seem to be comfortable with loose guidelines over what divestment truly is. Why aren't car manufacturers, or banks holding debt of mining companies, considered to be as unsavoury as oil explorers? On the flip side, why shouldn't oil and gas firms investing in green technologies be encouraged to continue these pursuits?

Perhaps it's the parallels with boycotts of the past that give activists a false sense of confidence. The global reach of the divestment campaign has activists comparing their tactics to those deployed in the 1980s in protest against South African Apartheid. Yet even some of the proponents of climate change action admit that while divestment is focused on a worthy cause, when observed on the morality scale it clearly does not warrant the same attention as those issues eliciting divestment support in the past. When asked about how his involvement in introducing divestment bills in response to human rights violations in Iran and Sudan compares, former US Representative Barney Frank explained:

> *'Changing out of fossil fuels is important, but it doesn't have the same moral problem. […] Objecting to blatant violations of human rights is different than pushing for public policy change, even if a very worthy one.'*

Equally, such boycotts have proven to be ineffective time and again – even for the most worthy of causes. Professor Ivo Welch of the University of California – Los Angeles (UCLA) is a prominent voice on the effectiveness of boycotts adopted during Apartheid.

> *'Unfortunately, when we started measuring* [the effect of the boycott], *we found that it had no impact whatsoever'*

he told a popular American radio programme. He found that there was always a way to escape the boycott because there would always be another buyer in the market. Experts at the

Stranded Assets Programme of the University of Oxford's Smith School of Enterprise and the Environment (the 'Oxford Smith School') concluded in a 2013 report (Stranded assets and the fossil fuel divestment campaign: what does divestment mean for the valuation of fossil fuel assets?, Atif Ansar, Ben Caldecott, and James Tilbury, Oxford Smith School) that the same would be true in the case of fossil fuel divestment, as divested holdings

> *'are likely to find their way quickly to neutral investors'* [which could result in] *'unintended consequences'* (*Stranded assets and the fossil fuel divestment campaign*, p. 18).

Not only could the stock end up in less sympathetic hands, but the presence of another buyer would also mean a divestment strategy would have a nil effect on the bottom lines of the targeted companies.

'THE EXCLUSION OF THE FOSSIL FUEL INDUSTRY FROM A PORTFOLIO COULD RESULT IN SIGNIFICANT LOSSES IN RETURNS.'

Divestment may not have a material effect on fossil fuel companies, but it may very well have a significant financial impact on individual investor portfolios and on the performance of critical pension funds. There are obvious downsides to removing such a significant global sector from a portfolio. Oil and gas stocks in particular provide a level of risk and return not easily replicated – certainly not by simply replacing them with renewables stocks, as so many divestment proponents suggest. Two separate reports commissioned by IPAA concluded that the exclusion of the fossil fuel industry from a portfolio could result in significant losses in returns. University of Chicago Law School Professor Daniel Fischel found, in his 2015 report ('Fossil Fuel Divestment: A Costly and Ineffective Investment Strategy') that portfolios divested of energy equities produced returns 0.7 percentage points lower than ones that invested in energy on an absolute basis, representing a 23 per cent loss over a 50 year time period ('Fossil Fuel Divestment', p. 10). Europe Economics concluded a similar percentage point loss, and found that if sustaining lower returns was not an option, then an investor would have to take on more than 20 per cent extra risk in their investment portfolio (Costs to Investors of Boycotting Fossil Fuels, Andrew Lilico, et al., 2015, p. 13).

Professor Fischel added another dimension to the debate: management fees involved in complying with divestment policies could squander any potential gains in returns. Any investor knows that the more personal attention their portfolio requires, the higher the management fees that are likely to be applied. While there is an increasing number of specialized funds and 'climate conscious' tools on offer, there is no standardized strategy for divesting a fund of fossil fuels. Instead, investors must identify the specific securities to be divested from – a service which comes at a cost. As fossil fuel companies evolve and new investment opportunities arise, there will be ongoing compliance costs required to stay ahead of the curve. The Leonardo DiCaprios of the world may be able to absorb such a cost, but a university with only a £191 million endowment, like that of Heriot-Watt, for example, should think twice about the cost–benefit of the decision to divest – especially when there is no clear reward.

However, the current low-oil price environment has bolstered the divestment argument, albeit artificially. After all, isn't the plunging oil price a signal of a failing industry? Not in the slightest, and even some activists admit it. Journalist and 350.org Board member Naomi Klein admitted in a recent interview that fossil fuel-based industries have

> *'just lost their best argument'* [in the oil price drop, but confessed that] *'They won't lose it for long. So that's another reason to pound away at it.'*

But even if an investor is fortunate enough not to have to worry about returns, there are other issues at stake when considering a position on divestment. Of course, deciding to divest your own earnings based on your personal beliefs is your prerogative. But leveraging a university endowment in the name of a moral cause – one which has no clear benefit to the operation of the university – cannot be seen as prudent. In the case of Harvard University, 35 per cent of its operating budget comes from the endowment – that's US$13 billion that could in theory be leveraged for political points for the climate activist camp. However, Harvard president Drew Faust made the university into a case study of how to consider the plight of concerned students and alumni, and ultimately concluded that

> *'the endowment is a resource, not an instrument to impel social or political change.'*

As Hertford College lecturer Clive Hambler wrote in a recent letter to *The Independent*, Professor Sir Richard Southwood, former Vice-Chancellor at Oxford, said that a university should not take an official position on an environmental topic. Instead, the university exists to foster debate, not to cement a position and thereby suppress academic free speech. This reverence for opposing views may be foreign to many corporate interests, but that's what makes the academic community so important to public discourse, and why maintaining its

integrity should be a priority over scoring political points.

Simply put, a political statement does not equate to useful action. But what divestment activists often discount is the role that the fossil fuel industry can play in aiding a smooth energy transition around the world. That transition begins with an acknowledgement by key decision makers of our widespread dependence on fossil fuels, and a recognition that divestment is hypocritical in the face of that reality. According to the US Energy Information Administration (EIA), global consumption of petroleum and other liquid fuels grew by 1.4 million barrels per day in 2015, and they predict fossil fuels will still supply almost 80 per cent of the world's energy by 2040. Ms Faust, among others, included this observation in her rationale for Harvard not to divest, saying

> *'it is hard for me to reconcile that reliance* [on fossil fuel-based energy] *with a refusal to countenance any relationship with these companies through our investments.'*

Looking ahead, a significant amount of expertise sits with oil and gas companies that could prove integral to the world's energy transition – the framework of which is being developed today. For example, ExxonMobil has a working interest in more than one-third of the world's existing carbon capture capacity (much of it used for Enhanced Oil Recovery). In 2014, as reported in the company's Corporate Citizenship report, the company captured more than six million tonnes of CO_2. Such contributions have not gone unnoticed by Oxford Martin's Net Carbon Zero Initiative, which observed in its 2015 report that:

'…A SIGNIFICANT AMOUNT OF EXPERTISE SITS WITH OIL AND GAS COMPANIES THAT COULD PROVE INTEGRAL TO THE WORLD'S ENERGY TRANSITION…'

> *'Should large-scale carbon dioxide disposal eventually be required to stabilise climate, many of the skills and expertise required may be found or developed within the oil, gas and fossil fuel utility sectors' (Working Principles for Investment in Fossil Fuels,* Oxford Martin School, 2015, p. 2).

'COMMUNICATION WITH MANAGEMENT TEAMS CAN BE MORE EFFECTIVE BEFORE USING THE "TRUMP CARD" OF DIVESTMENT.'

This isn't to say that the oil and gas industry does not acknowledge its role in carbon generation, but it believes there is a better way to achieve the end goal of reducing carbon emissions, by pooling our resources and working together rather than in silos. As researchers at Oxford's Stranded Assets programme concluded, since divestment would likely not affect the bottom lines of the companies activists wish to reach,

> *'neutral debt or equity investors have little cause to shun fossil fuel companies' (Stranded assets and the fossil fuel divestment campaign,* p. 12*).*

Instead, they found, communication with management teams can be more effective before using the 'trump card' of divestment. There are signs of this bearing fruit as well. Shareholder engagement with oil and gas majors BP and Shell led to the companies committing to adjust their business models in accordance with international pledges to limit global warming. Constructive engagement of this sort is a better way forward than divestment, both for investors and for the climate itself.

Carbon pricing in the United Kingdom

Paul Johnson

Nick Stern argued in his influential review that action to mitigate climate change could be carried out at modest cost but that

> *'costs will be higher if … policy-makers fail to make the most of economic instruments that allow emissions to be reduced whenever, wherever and however it is cheapest to do so.'*

One of the key instruments – but not the only one – is of course the imposition of a carbon price.

An effective carbon price which minimizes costs would have a number of important features:

1 The carbon price should be consistent across different forms of emissions;

2 Policy should be stable and predictable to allow producers and consumers to plan their investments and consumption appropriately;

3 Many would argue that the carbon price should rise over time as the marginal cost of each unit of carbon emitted rises.

Ideally the carbon price should also be consistent internationally since it doesn't matter where the emissions take place. That's why international

trading schemes such as the EU Emissions Trading Scheme (ETS) ought to have a prominent role to play. The way in which pricing interacts with a range of other policies will also matter. This is not an issue that can be solved by pricing alone.

'UK POLICY ON CARBON PRICING DOESN'T COME CLOSE TO MEETING THESE BASIC PREREQUISITES FOR EFFECTIVE POLICY.'

Almost needless to say, UK policy on carbon pricing doesn't come close to meeting these basic prerequisites for effective policy. Prices vary dramatically according to the source of emissions and the nature of the consumer. Policy has been notably unstable, providing little certainty for either consumers or industry. In the case of road fuel the effective carbon price has been falling rather than rising. The failure of the EU ETS to bind has made these domestic policies, and policy failings, especially important.

Consistent pricing

The proceeds of environmental levies such as the renewables obligation, contracts for difference, and feed-in tariffs are forecast by the Office for Budget Responsibility to double from about £6 billion in 2015/16 to over £12 billion in 2020/21. In addition, receipts from the Climate Change Levy (CCL) are due to rise from £1.8 billion to £2.2 billion. These are increasingly significant economically. But they do not add up to a consistent carbon price. There are numerous policies, for example, which add to the cost of electricity consumption, but few of these costs are imposed on gas consumption – for which the effective carbon price is close to zero. In fact once one accounts for the fact that VAT for domestic fuels (both gas and electricity) is charged at only 5 per cent, rather than at the standard 20 per cent rate, gas consumption by households is effectively subsidized. There is a negative carbon price.

The treatment of gas and electricity is becoming more unequal over time as new market arrangements designed to subsidize renewable electricity generation result in a rising price of electricity. Ignoring the implicit VAT subsidy, work by researchers at the Institute for Fiscal Studies, published in 2013, suggested that by 2020 the implicit carbon price faced by households would be well over £100 per tonne of CO_2 for electricity consumption – ten times the implicit carbon price for gas consumption. Given the relatively rapid rate of decarbonization of electricity production the price signals are increasingly worrisome – favouring use of carbon-emitting gas over the use of non carbon-emitting electricity.

There are differences in prices also according to end user, with businesses facing a range of additional pricing policies and significantly higher carbon prices than households. It is hard to see any rationale for this beyond a view that it is politically easier to increase charges on business energy consumption than on households. There are also differences between businesses of different sizes and types. Like households, businesses face higher implicit taxes on electricity than on gas, though the Budget 2016 announcement that the ratio between CCL rates for electricity and gas will be rebalanced from 2.5:1 to 1:1 will be a small movement in the right direction.

Even without going through the alphabet soup of different taxes, charges, and initiatives that make up these different carbon prices it is clear that pricing policy is not consistent. The priority for change should surely be to narrow the differential between the treatment of gas and electricity by finding a consistent basis for taxing gas use.

'POLICY IS NOT COHERENT IN THE WAY IT TREATS CARBON IN DIFFERENT FORMS OF ENERGY CONSUMPTION, AND NOR IS IT CONSISTENT OVER TIME.'

Consistent policy

Policy is not coherent in the way it treats carbon in different forms of energy consumption, and nor is it consistent over time. This inconsistency creates costs and reduces incentives to respond to price signals given uncertainty over how long they will persist for.

Take for example the carbon price support rate. This was introduced in April 2013 specifically to top up the EU ETS carbon price to meet the carbon price floor set by the government. It was intended both to raise the carbon price faced by those covered by the ETS and to create certainty over the carbon price. To do that it set a carbon price floor going forward to 2018. In the face of ETS prices well below intended levels this was, arguably, a defensible policy. There is, of course, the question of its relationship with the ETS itself and the fact that, to the extent that it reduced emissions in the tradable sector in the UK, it would allow more emissions elsewhere in Europe. But as a domestic policy it had some merit.

In the Budget just one year later the plans for a rising price floor were shelved, and a new floor level, not increasing over time, was announced. This sort of reverse clearly undermines the purpose of the policy.

More recently, in Budget 2015, the government announced that the CCL exemption for renewably sourced electricity would be removed. Self-evidently this removes the price incentive for businesses to source low-carbon electricity as well as representing a sudden change in policy direction. That it appeared in

the Budget 'scorecard' as rectifying an 'imbalance' in the tax system, and hence counted towards achieving £5 billion in revenue from 'avoidance and tax planning, evasion and compliance, and imbalances in the tax system', may tell us something about the policy making process.

A more welcome change, though a change nonetheless, will be the abolition of the Carbon Reduction Commitment energy efficiency scheme announced in Budget 2016, to take effect from 2019, with revenue recouped from a higher CCL. This will simplify an horrifically complex set of policies – themselves a testament to earlier policy failure.

Taxes on motorists

While most of the policy action has been on energy it remains the case that the biggest environmental tax by far is that on petrol and diesel. From a fiscal point of view this brings in nearly £30 billion a year – far more important than all other environmental taxes and levies combined. Of course this is not just a carbon tax since much the biggest externality created by driving is congestion, and the rates of tax are well in excess of anything that could be justified by carbon emissions alone.

'…THE BIGGEST ENVIRONMENTAL TAX BY FAR IS THAT ON PETROL AND DIESEL.'

This is another area of inconsistent pricing policy though. The real tax rate per litre of fuel – and hence per unit of emission – has been falling since 2010 and is currently at its lowest level in 20 years, but given the changes in petrol prices and fuel efficiency, the cost of driving now is lower than it was even longer ago than this. This is a policy choice that looks odd in the context of growing congestion and carbon costs. It is hard to know what the right tax level should be on road fuel, but it should certainly be rising over time. This is also a policy choice which has not been made explicitly or on a long-term basis. Tax increases have been announced and subsequently abandoned with monotonous regularity.

Taxes on car ownership have also been reformed substantially; increasing Vehicle Excise Duty (VED) in the first year of registration for high emitting vehicles, but with a flat rate VED payment in each subsequent year at a level unrelated to CO_2 emissions. In part, the reform reflected the extent to which an increasing fraction of new cars were falling into zero and lower-rated VED bands as emissions levels have fallen. Policy needs to adapt to such change. It also reflects a belief in the importance of up front incentives.

In conclusion

Carbon emissions in the UK are on a downward path. Electricity decarbonization is happening relatively swiftly. Average emissions from vehicles are falling. The first two carbon budgets on the route to the UK's 2050 target will be more than met. The lack of coherence in pricing, though, risks stalling this progress and making future progress more expensive than it need be. Following policies which subsidize gas consumption, penalize business over households, and reduce the cost of petrol consumption are hard to square with a commitment to reduce emissions at minimum economic cost.

Europe crawls towards low-carbon transport

Jos Dings

On the back of the Paris climate deal and record high global temperatures, Europe is slowly crawling towards a 2030 low-carbon strategy for transport. Later this year the European Commission is supposed to present a strategy paper, followed by concrete policy initiatives over the next year or so. This article looks into what Europe has done so far in the context of 2020 initiatives and what the key lessons are for the forthcoming action with timeline 2030.

What transport emissions are and where they will go

European Environment Agency numbers (data from the EEA document 'Greenhouse gas emissions from transport') indicate that in 2013 European Union transport greenhouse gas (GHG) emissions (including aviation and shipping) were 1,161 million tonnes of CO_2 equivalent. This is 20 per cent up from 1990 levels. Transport is the only sector which has seen emissions rise in the past quarter of a century, to the point that it currently represents 28 per cent of the EU's overall GHG emissions. However, on a positive note, transport emissions peaked in 2007; 2013 emissions are 12 per cent down from that pre-global financial crisis level of 1,314 million tonnes. It should be noted that these transport numbers only include emissions from combustion

'TRANSPORT IS THE ONLY SECTOR WHICH HAS SEEN EMISSIONS RISE IN THE PAST QUARTER OF A CENTURY…'

of fossil hydrocarbons – mostly diesel, petrol, kerosene, and heavy fuel oil. Upstream emissions from the production of all energy sources used for transport, including electricity and all emissions from biofuels, are excluded. Especially the latter is a serious omission, as this piece will show.

In October 2014 EU leaders agreed that sectors outside the Emissions Trading Scheme (ETS) should reduce their GHG emissions by 30 per cent compared with 2005 levels. Transport is the biggest of these non-ETS sectors, followed by buildings and agriculture. Assuming that transport should also contribute with a 30 per cent reduction, this means that surface transport should reduce its emissions by 23 per cent from 2013 levels. Against a baseline scenario expecting stabilization, this is no small task. And if the five-year 'review-and-tighten' process enshrined in the Paris deal takes effect in Europe too, we should plan for hitting lower numbers in 2030.

Unsurprisingly the refining sector is feeling the pinch of lower demand for its products; since 2009, 22 refineries in Europe have closed, leaving 84 in operation. Hitting European reduction targets would surely mean closing another 15 or 20 by 2030; an inevitable consequence of success.

However, using less oil is an undisputed net economic boon for a continent 90 per cent dependent on imports, the value of which represented €300 billion in 2013 or 2.5 per cent of EU GDP.

In any case, if the world takes its Paris pledges seriously, low oil prices are here to stay, not because of oversupply but lack of demand. Low oil prices are not an excuse for inaction – they are a consequence of success.

Can Europe take credit for the emissions drop since 2007?

The short answer is – only a very little bit, because most of the policies implemented either failed or disappointed. The long answer follows below.

'MANUFACTURERS ACHIEVED THE VAST MAJORITY OF OFFICIAL CO_2 CUTS SIMPLY THROUGH EXPLOITING LOOPHOLES IN THE TEST CYCLE.'

Without doubt, the potentially most effective policy Europe has adopted is the regulation to reduce CO_2 emissions from cars to 95 g/km in 2021 – which is 40 per cent below the 2007 level of 158 g/km.

It is also the first disappointment. Between 2009 and 2014, the year the regulation was adopted, *official* average CO_2 emissions of new cars dropped from 146 to 123 g/km, a sizeable 16 per cent cut in five years. Sadly though, *real-world* fuel consumption (hence CO_2 emissions) from new cars dropped by only 3–4 per cent, from 173 to 167 g/km, according to figures aggregated from 11 databases of logged fuel consumption of individual car models (see 'Mind the Gap 2015: Closing the chasm between test and real-world car CO_2 emissions', Transport & Environment, 28 September 2015). This less-than-1 per cent per year efficiency improvement is lower than what had been achieved before legislation (1–1.5 per cent). The gap between official and real-world fuel consumption has grown to 40 per cent and for some recently introduced models it is even 50 per cent. Manufacturers achieved the vast majority of official CO_2 cuts simply through exploiting loopholes in the test cycle.

The test procedure will change in 2017, and it will close quite a few of the largest loopholes. But under pressure from the industry, the effect of the loopholes will still be carried over in the new test through a much (15–20 per cent) weaker 2021 CO_2 standard. So we currently have a reasonable standard on a poor test; we will end up with a poor standard on a reasonable test. Real-world CO_2 is expected to drop over the next five years to 140–145 g/km in 2021; a far cry from the expected 110 g/km when it was introduced. Cars in 2021 will only be some 18 per cent more efficient than in 2009; much more is possible, even at negative societal cost.

'RENEWABLE ENERGY POLICY IN TRANSPORT HAS SO FAR BEEN AN OUTRIGHT FAILURE.'

On trucks, Europe has not yet achieved anything in terms of CO_2 legislation; fuel efficiency has been stagnant ('Europe's lost decade of truck fuel economy', Transport & Environment, 2 December 2015) for 20 years now, meaning that emissions grow along with vehicles miles travelled.

In terms of modal shift, stagnation is the word again; changes have been very limited apart from a big loss in share of rail freight in the 1990s. Since then, gains in some west European countries have been offset by strong losses in many east European member states.

A good trend, though, has been the progressive introduction of kilometre charges for lorries; this already covers 15 countries, the latest being Belgium on 1 April 2016. There is strong evidence ('Price sensitivity of European road freight transport', Significance and CE Delft, June 2010) that such charges encourage fuller and cleaner lorries, shorter distances, and modal shift to rail.

Renewable energy policy in transport has so far been an outright failure. Almost all of the current 5.5 per cent renewable energy in transport is biofuels; and some 75 per cent of these biofuels is made up of biodiesel from virgin vegetable oil. Unobtrusively, on 10 March the European Commission

uploaded an explosive report ('The land use change impact of biofuels consumed in the EU', ECOFYS, 27 August 2015) on the damning climate impact of such fuels. The report only looks at emissions from land-use changes, such as forest clearing, ploughing, and peat draining resulting from biofuels consumption in Europe. This type of emissions, for biodiesel alone, is already some 30 per cent higher than the full lifecycle emissions of fossil diesel. Add in direct emissions – from tractors, fertilizers, and the like – and lifecycle biodiesel emissions are 80 per cent (!) higher than those of fossil diesel ('Globiom: the basis for biofuel policy post-2020', Transport & Environment, April 2020). This further strengthens findings from an earlier study ('Assessing the Land Use Change Consequences of European Biofuel Policies', October 2011) for the Commission. Biofuels used in Europe currently increase, not reduce, transport GHG emissions and the picture will not change until 2020. Notwithstanding this, all biofuels are still counted as having zero emissions, giving governments all over Europe a reason to mandate or subsidize them: it helps them meet their climate obligations, on paper. A huge policy mistake and a huge accounting error that needs to be fixed as soon as possible.

'SHIPPING EMISSIONS HAVE DROPPED STRONGLY, BY 23 PER CENT SINCE THEIR 2007 PEAK.'

Shipping emissions have dropped strongly, by 23 per cent since their 2007 peak. This has little to do with trade which is close to pre-crisis levels, or with better ships ('Historical Trends in Ship Design Efficiency, The Impact of Hull Form on Efficiency', CE Delft, March 2016), but has everything to do with high fuel prices and fleet overcapacity, both of which give strong incentives for so-called 'slow steaming' – sailing more slowly, giving big savings in fuel consumption. Aviation emissions are close to pre-crisis levels; possibly the inclusion of the sector in the EU ETS for intra-EU flights has made a modest impact in controlling emissions but ETS carbon prices that equate to 1–2 cents per litre of kerosene are unlikely to have made a major difference.

In short – EU climate policy in transport has made precious little difference yet. Most of the 12 per cent drop in emissions between 2007 and 2013 has to do with lower economic activity and high oil prices.

But much can be done if only we learn lessons and use opportunities

The good news is that Europe has laid some useful foundations for further actions and that prospects for change are better than they were.

By far the most important change in the energy, climate, and transport landscape since the financial crisis has been the precipitous drop in the prices of solar and wind power and in the cost of batteries. Solar panel prices have dropped by some 85 per cent in the past seven years; wind prices by some 60 per cent.

Cars and surface passenger transport

Recently Bloomberg released a report ('Electric Vehicles to be 35% of Global New Car Sales by 2040', Bloomberg New Energy Finance, 25 February 2016) on the future of electric vehicles (EVs) – stating that the price of batteries had dropped by two-thirds since 2010. This equates to a drop of 20 per cent per year; close to a revolution. These are stunning numbers and the end is not in sight, leading Bloomberg to predict a 'Kodak moment' for internal combustion vehicles at some point in the 2020s. In China, 52,000 electric cars were sold ('Electric Vehicle Sales Continue to be Unstoppable in China – Up 170%', Inside EVs, March 2016) in January and February 2016. This is on track to smash Europe's 59,000 ('Alternative Fuel Vehicle registrations: +20.0% in 2015; +21.1% in Q4', European Automobile Manufacturers Association, 5 February 2016) in the whole of 2015 by a factor of five or so.

And of course there was the event every mainstream newspaper and website covered – Tesla's unveiling of its electric Model 3 leading to – by mid-April – an eye watering 400,000 pre-orders from enthusiasts who had to stump up US$1,000 for the honour of being first in line to pay US$35,000 for a car at a point almost two years from now.

Will Europe capitalize on this opportunity or not? That's the big question. In Norway the share of EVs in new car sales is close to 30 per cent; in Bulgaria exactly one (1) EV was sold in the last quarter of 2015. This shows that policy matters enormously.

'…ONE IN EVERY TWO VEHICLES SOLD IN EUROPE IS A DIESEL; ELSEWHERE IT IS ONE IN 20.'

For now, the continent seems, even in the wake of the VW diesel scandal, to cling to diesel as its prime technology, slowing down the transition to much more promising hybridization and electrification avenues. Europe gives diesel cars a fuel tax break worth €27 billion ('Europe's tax deals for diesel', Transport & Environment, 23 October 2015), something no other region does. As a result, one in every two vehicles sold in Europe is a diesel; elsewhere it is one in 20. Diesel cars have some 10–15 per cent lower CO_2 emissions compared with a same-size regular petrol car, but cost around €2,000 more; the comparison is therefore

one of apples and oranges. Investing that money in hybridizing a petrol drivetrain gives 25–30 per cent CO_2 benefits. Stimulating diesel is a very costly climate policy and isolates our carmakers on the world stage – even leaving aside the air quality problems we face as a result of 20 years of diesels dodging their emissions tests.

Japan has the lead in hybrids and, together with South Korea, in batteries; China and California are much more aggressive in promoting electric vehicles and Tesla is the undisputed leader in EVs. Europe needs to turn its defensive attitude on electrification into an awareness that there is no choice; if we don't act Asia and Silicon Valley will rule the roost in 2030.

A key policy instrument is ambitious CO_2 standards for new cars for 2025 and an associated 'flexible mandate' for ultra-low-carbon vehicles. That – supplemented with real-world testing to avoid a new round of exploitation of testing flexibilities – will convince Europe's carmakers that there is indeed no choice but to invest in fuel efficiency and breakthrough technologies, after so many years of wavering.

'Electrification' is not just about electric cars. It is also about making Europe's fragmented market work for the use of electric vehicles. With growing distances driven on a charge, international standardization of plugs and payment systems is urgently necessary.

The rise of smaller electric vehicles, including ebikes, is a tremendous opportunity to fill the huge current void between cars (often way too heavy and large for the task at hand) and bikes.

More broadly, electrification goes hand in hand with the sharing economy; an electric vehicle, after all, is expensive to buy and cheap to use, and hence an ideal asset for sharing. Electric vehicles can hence play an important role in delinking car use from ownership; an important precondition for smarter mobility with a much better match between demand and supply.

And the electric mode we have, rail transport, can be more smartly used. Booking a rail ticket for a trip that covers more than one company is close to impossible. No EU-wide booking sites exist that offer multimodal booking; simply because the railway undertakings, in contrast with airlines, do not share the necessary data with each other or with third-party providers. As a result people by default book air tickets for longer distances. Mandating the sharing of necessary data is surely a policy that should be thought through, especially for undertakings that receive public money for their services (most do).

Freight

Freight transport should not be overlooked; in 2030 it will represent some 40 per cent of surface transport emissions.

'NUMEROUS MARKET FAILURES HOLD BACK THE SUPPLY OF, AND DEMAND FOR, BETTER LORRIES.'

For trucks, we urgently need CO_2 standards too, to break the two decades of efficiency stagnation mentioned earlier. Numerous market failures hold back the supply of, and demand for, better lorries; standards can break these failures. The EU is thinking of adopting a regulation to start monitoring truck CO_2 emissions; the USA is in the process of adopting Stage 2 fuel efficiency standards and the expectation is that US trucks will be more economical than European ones within a decade. This is a real threat to the dominant 40 per cent share of the world's truck market that EU manufacturers have today. Again Europe is sliding from a standard maker to a standard taker.

And Europe needs to think urgently on what zero-carbon freight looks like. Is it trolley trucks with catenary lines on the main motorway network, with diesel and/or batteries as backup for the last (dozens of) miles? Is it hydrogen made from sustainable electricity? Is it 'power-to-liquid'? Biodiesel will surely not be available in the quantities required; vegetable oil-based biodiesel simply needs to be phased out as we have seen. Discussion on this vital topic is lacking.

The impact of truck policies can be reinforced by differentiating kilometre charges for the CO_2 emissions of the truck. Hauliers can then be certain that a truck certified for better fuel consumption and lower or zero CO_2 will produce a good payback, if not in fuel savings, then in lower road tolls. The Commission should make a proposal to mandate such a differentiation.

Aviation and shipping

A study ('Emission Reduction Targets for International Aviation and Shipping', November 2015) for the European Parliament throws up the challenge squarely:

> *'If, as in the past, the ambition of these sectors continues to fall behind efforts in other sectors and if action to combat climate change is further postponed, their CO_2 emission shares in global CO_2 emissions may rise substantially to 22% for international aviation and 17% for maritime transport by 2050, or almost 40% of global CO_2 emissions if both sectors are considered together.'*

Paris left aviation and shipping unmentioned, leaving the current situation of inaction intact; a gaping hole in the Agreement.

Aviation remains one of the biggest anomalies in transport policy. It is

the most carbon-intensive mode of transport and the fastest-growing one, yet it enjoys well-documented exemptions from fuel tax as well as from VAT on tickets; together these exemptions amount to some €30 billion a year. The inclusion of intra-EU flights in the EU ETS was a very modest start to remedying this situation; yet the fury this modest measure unleashed amongst the world's airlines was again an illustration of how used the sector is to special treatment and privileges.

This fury has led the International Civil Aviation Organization (ICAO), a UN body, to say it wants to 'develop' a global market-based measure; in October its Assembly will vote on whether it will pass, and in what form. It is already clear that carbon offsets will be its mainstay; just as Europe has rightly decided not to use them for compliance with its climate targets. At the very least, Europe should make sure that any global action complements, not replaces, the ETS. The ICAO also recently adopted a CO_2 standard for new aircraft; unfortunately it will make no difference to emissions ('International Civil Aviation Organization CO_2 standard for new aircraft', International Council on Clean Transportation, 9 February 2016).

In shipping one important challenge is to close the massive gap between efficient and inefficient ships, and to ensure that the huge potential for further efficiencies, including speed and power reduction, is used. The current so-called 'Energy Efficiency Design Index' for 2020 and 2030 fails to do this ('Historical trends in ship design efficiency 2016', CE Delft, 1 April 2016) and needs to be tightened; it is truly a low-hanging fruit.

'BOTH THE AVIATION AND SHIPPING SECTORS NEED TO FIND A ZERO-CARBON ENERGY SOURCE URGENTLY.'

Both the aviation and shipping sectors need to find a zero-carbon energy source urgently. Airlines have been saying that biofuels will be part of the solution; however, they have resisted any binding measure towards that effect. Apart from that, availability of sufficient truly sustainable bioenergy is very challenging.

Options such as power-to-liquid need to be looked at urgently; but without a serious policy to mandate or incentivize such better fuels, fossil kerosene and marine fuel oil and gas oil will remain the mainstay for a long time.

Conclusion

Transport has, so far, been quite resistant to efforts towards decarbonization. EU policies adopted in the first climate package (for 2020) have, almost without exception, either disappointed (for example CO_2 standards) or failed (biofuels). This is not so much due to the lack of technical options – study after study has demonstrated the potential for significant cuts at low or even negative cost. The challenge is a political one – between the resistance to change of the car, truck, oil, aviation, and shipping industries, and the inability or unwillingness of Europe's institutions (including, and especially, the Council of Member States!) to overcome that resistance.

As a result Europe is in real danger of losing its lead to the USA and Asia – not to mention failing to deliver on the Paris deal. The good news is that Europe can draw plenty of lessons from its first efforts for its second (2030) climate package and that, more than ever, there are opportunities for progress, especially in the fields of energy efficiency and electrification. It's not yet too late, but the clock is ticking.

Carbon Capture and Storage in the thermal coal value chain

Ben Caldecott, Lucas Kruitwagen, and Irem Kok

Carbon Capture and Storage (CCS) has a role to play in deep, economy-wide decarbonization, with potential application in the mitigation of industry and power sector emissions and late century negative emissions. Its high cost and low deployment to date has, however, made it a critical uncertainty in climate and energy technology scenarios. Recent work by the Stranded Assets Programme of the University of Oxford's Smith School of Enterprise and the Environment (the 'Oxford Smith School') has identified the limited role CCS might play in mitigating environment-related risk in the thermal coal value chain. We present the findings of this report and comment on the role CCS might play in the thermal coal value chain as a greenhouse gas (GHG) mitigation technology for coal-fired power stations and for emerging coal-processing technologies.

Scenario inclusion

Several scenarios include coal-fired CCS as a requisite technology for cost-efficient mitigation of power sector emissions. The IEA's Energy Technology Perspectives 2015 (ETP) and *World Energy Outlook 2015 (WEO)*

'…14 CCS-EQUIPPED POWER STATIONS ARE CURRENTLY PLANNED TO OPERATE BY 2025…'

respectively project power sector CCS deployment of 2.7 and 3 Gt/yr by 2040 in their 2 °C warming-compatible scenarios. The first CCS-equipped power station with Mt-scale CO_2 capture was completed in 2014. The Global CCS Institute reports that 14 CCS-equipped power stations are currently planned to operate by 2025, with combined capture of approximately 23 Mt/yr ('Large Scale CCS Projects', Global CCS Institute). Achieving the IEA's 2 °C-warming projections will require continued deployment of CCS capacity at an annual growth rate of approximately 37 per cent between 2025 and 2040. The IPCC's Fifth Assessment Report (AR5), of 2014, projects CCS deployment of between 7 and 17 Gt/yr by 2050 in a cost effective 2 °C-warming scenario. In scenarios without substantial deployment of CCS, the IPCC's AR5 projects that agriculture, afforestation, and other land use (AFOLU) will contribute significantly to net-negative emissions in the middle and latter portions of this century. The Oxford Smith School has also estimated the potential of negative-emissions technologies to extend carbon budgets through 2100 (see Stranded Carbon Assets and Negative Emissions Technologies, Ben Caldecott et al., Oxford Smith School, 2015).

Less understood is the role CCS might play in the mitigation of emissions from coal processing technologies (CPTs) – a collective name for coal-to-liquids (CTL), coal-to-gas (CTG), and underground coal gasification (UCG) technologies. CPTs often involve an interim gasification step – ideal for pre-combustion carbon capture. There are additional synergies between UCG and CCS, as CO_2 can be stored in the coal cavity after extraction and gasification (see 'Coal gasification: The clean energy of the future?', Richard Anderson, BBC News, 14 April 2014).

A limitation of the 2 °C warming-compatible scenarios currently employed is that geological storage is often assumed to be abundant and of uniform high quality. Geological CO_2 storage options have been described in the IPCC special report Carbon Dioxide Capture and Storage (IPCC, 2005), and by the Global Energy Technology Strategy (GETS) programme in Carbon Dioxide Capture and Geologic Storage (J.J. Dooley et al., 2006). Deep saline formations, depleted oil and gas fields, saline-filled basalt formations, unmineable coal seams, salt caverns, and organic shale formations are all suitable for geological CO_2 storage, where permeability and porosity allow CO_2 to be stored in empty pockets in the rock (see Carbon Dioxide Capture and Geologic Storage).

Although geological storage of CO_2 could be carried out in a range of geological formations with sedimentary basins, including both onshore and offshore formations, the IPCC's special report Carbon Dioxide Capture and Storage notes that some of these sedimentary formations are too shallow or have too low permeability, and carry the risk of hydrate ice crystallization, thermal fracturing of cement seals, mobilization of fault lines, and the formation of underground fractures, all of which can lead to CO_2 leakage ('Carbon capture and storage: how green can black be?', R. Stuart Haszeldine, *Science Magazine*, 2009). The availability of safe and suitable geological storage capacity is a critical factor in estimating the potential of CO_2 storage as an effective global mitigation strategy. However, it is difficult to estimate the exact storage capacity of saline formations due to variability of geological data, which has not been well established in regions lying outside of major oil and gas provinces ('Carbon dioxide capture and geological storage', Sam Holloway, Philosophical Transactions of Royal Society, 2007).

'THE AVAILABILITY OF SAFE AND SUITABLE GEOLOGICAL STORAGE CAPACITY IS A CRITICAL FACTOR IN ESTIMATING THE POTENTIAL OF CO_2 STORAGE…'

Moreover, the technical capacity for geological storage does not necessarily amount to economic storage capacity, which is affected by issues of technical feasibility, safety, and environmental impacts (such as potential leakage), as well as public opposition to nearby gas storage facilities (Carbon Dioxide Capture and Storage). The availability of high-quality geological storage resource and the associated costs of CO_2 transport and storage is one of the drivers of the economics of CCS. The IEA's Energy Technology Perspectives 2015 estimates that the cost of transporting and storing CO_2 might range from US$1/t to US$100/t; the IPCC's Fifth Assessment Report uses a central estimate of US$10/t.

Findings from 'Stranded Assets and Thermal Coal'

The Oxford Smith School recently published an extensive study of environment-related risks in the thermal coal value chain (see Stranded Assets and Thermal Coal: An analysis of environment-related risk exposure, Ben Caldecott, et al., Oxford Smith School, 2016). The study developed extensive asset-level datasets for:

- the top 100 coal-fired power utilities,
- the top 20 thermal coal miners with ≥30 per cent revenue from thermal coal, and
- the top 30 CPT companies.

(These were collectively known as the 'top thermal coal value chain companies'.) Hypotheses of how different environment-related risk factors could affect the value of assets in the thermal coal value chain were developed and appropriate measures for these risks identified (see the table 'Local Risk Hypotheses (LRHs) and National Risk Hypotheses (NRHs)' and Stranded Assets and Thermal Coal for full references). Local Risk Hypotheses ('U' and 'P' for 'utility' and 'coal processing technology' respectively) are assessed at the local level and whereas National Risk Hypotheses affect all assets in the country in a similar way. LRH-U1, for example, hypothesises risk exposure for coal-fired power stations proportional to the carbon intensity of generated electricity, on a kg.CO_2/MWh basis. Each asset was then measured against each risk and this exposure data was aggregated company by company, enabling a comparison of company portfolios.

One of the hypotheses developed and examined is the suitability of coal-fired power stations and CPT plants for CCS retrofit. The hypothesis is that coal-fired power stations and CPT plants not suitable for the retrofit of CCS technology might be at more risk of premature closure. Such power stations do not have the option of CCS retrofit in the case of strong GHG mitigation requirements, enforced either with targeted policy or with carbon pricing.

Local Risk Hypotheses (LRHs) and National Risk Hypotheses (NRHs)		
	Name of environment-related risk	**Reference to dataset for risk exposure analysis**
Coal-fired power utilities		
LRH-U1	Carbon intensity	CARMA/CoalSwarm/WEPP/Oxford Smith School
LRH-U2	Plant age	CARMA/CoalSwarm/WEPP
LRH-U3	Local air pollution	Boys et al. (2015)/NASA's SEDAC
LRH-U4	Water stress	WRI's Aqueduct
LRH-U5	Quality of coal	CoalSwarm/WEPP
LRH-U6	CCS retrofitability	CARMA/CoalSwarm/WEPP/Geogreen
LRH-U7	Future heat stress	IPCC AR5
NRH-U1	Electricity demand outlook	IEA
NRH-U2	'Utility death spiral'	Oxford Smith School
NRH-U3	Renewables resource	Lu et al. (2009)/ McKinsey & Co/SolarGIS
NRH-U4	Renewables policy support	EY's Renewables Attractiveness Index
NRH-U5	Renewables generation outlook	BP/REN21
NRH-U6	Gas resource	BP/IEA
NRH-U7	Gas generation outlook	IEA
NRH-U8	Falling utilization rates	Oxford Smith School
NRH-U9	Regulatory water stress	WRI's Aqueduct
NRH-U10	CCS legal environment	Global CCS Institute
Coal processing technology companies		
LRH-P1	Plant age	World Gasification Database
LRH-P2	Water stress	WRI's Aqueduct
LRH-P3	CCS retrofitability	World Gasification Database/GeoGreen
NRH-P1	CPT policy support	Oxford Smith School
NRH-P2	Oil and gas demand outlook	IEA
NRH-P3	Oil and gas indigenous resources	BP
NRH-P4	Other local environmental	Oxford Smith School
NRH-P5	Regulatory water stress	WRI's Aqueduct
NRH-P6	CCS policy outlook	Global CCS Institute

In 2012, the IEA examined the global fleet of power stations suitable for retrofit with CCS (CCS Retrofit: Analysis of the Globally-installed Power Plant Fleet, IEA, 2012). The IEA developed criteria sets based on plant age, efficiency, and size. In Stranded Assets and Thermal Coal this methodology was repeated with an added fourth criterion: proximity to a suitable geological reservoir. A geographical dataset of geological reservoir suitability was obtained from CCS consultancy Geogreen, with permission of the IEA Greenhouse Gas R&D Programme.

In order to be deemed retrofitable with CCS, a power station must meet the mid-level criteria of the 2012 IEA study noted above (CCS Retrofit) being:

- less than 20 years old,
- emitting less than 1 tCO_2/MWh, and
- having a nominal generating capacity greater than 100 MW.

These screening criteria identify plants which are the best candidates for investment in CCS technology: they are the highest value (having long remaining lives and high efficiency) and are large enough to enable economies of scale in technology deployment. Adding geological proximity, the power station must be located within 40 km of a 'suitable' or 'highly suitable' geological reservoir – sedimentary basins or continental margins with well understood geology (Global Storage Resources Gap Analysis for Policy Makers, Geogreen, 2011). The proximity threshold of 40 km was first chosen as a screening criterion by the USA's National Energy Technology Laboratory (Coal-Fired Power Plants in the United States: Examination of the Costs of Retrofitting with CO_2 Capture Technology (2011)), with the implicit assumption that this distance avoided prohibitive CO_2 transport costs.

The retrofitable and non-retrofitable assets are then aggregated by generating capacity to develop a company-level opinion of exposure to CCS retrofitability in coal-fired power stations.

Of the top 100 coal-fired power utilities listed in the figure 'CCS retrofitability (coal-fired power utilities)', 65 had no assets deemed 'retrofitable'. Many of these same utilities have indicated that they believe CCS retrofits are possible for their coal fleets and give them a route to being compatible with a low-carbon future (see 'Carbon Capture and Storage: A Vital Tool to Help Tackle Climate Change', E.ON SE, 2016; Public Engagement on Enel's CCS Projects, Enel S.p.A., 2011).

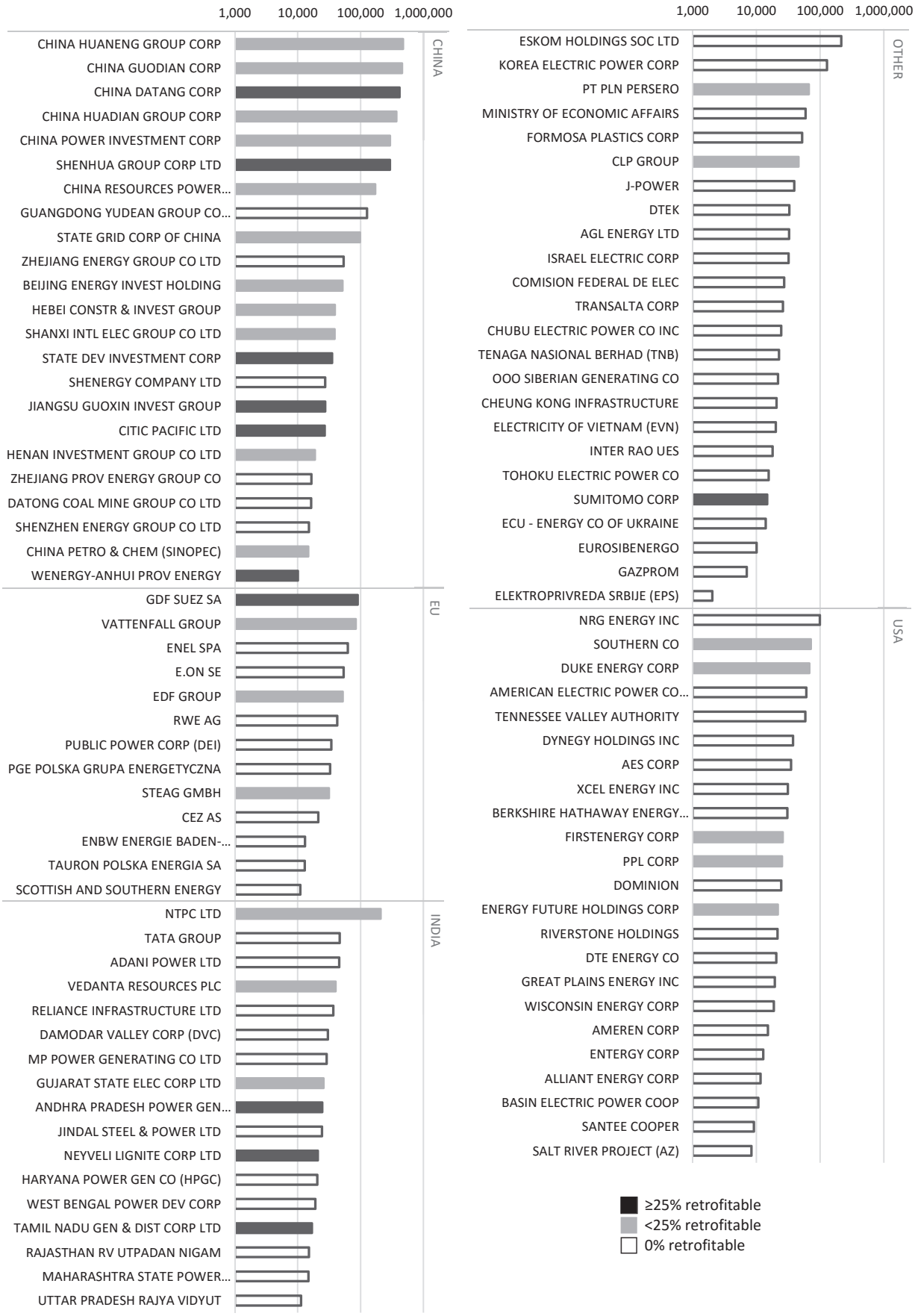
'…CCS RETROFIT PROJECTS WILL NOT BE SUFFICIENT TO ENSURE RESILIENCE TO A CARBON-CONSTRAINED FUTURE FOR MANY COAL-FIRED POWER UTILITIES.'

Others have initiated CCS retrofit projects but have met substantial barriers and setbacks, with notable examples including RWE AG's Hurth project ('RWE Goldenbergwerk Fact Sheet: Carbon Dioxide Capture and Storage Project', MIT, 2015), American Electric Power Co. Inc.'s Mountaineer project ('Utility Shelves Ambitious Plan to Limit Carbon', Matthew Wald and John Broder, *The New York Times*, 2011), and SSE plc's Peterhead project ('UK cancels pioneering £1 bn carbon capture and storage competition', Damian Carrington, The Guardian, 2015). The figure 'CCS retrofitability (coal-fired power utilities)' shows the retrofitability and coal-fired power generation of all top 100 coal-fired power utilities. Our analysis suggests that CCS retrofit projects will not be sufficient to ensure resilience to a carbon-constrained future for many coal-fired power utilities.

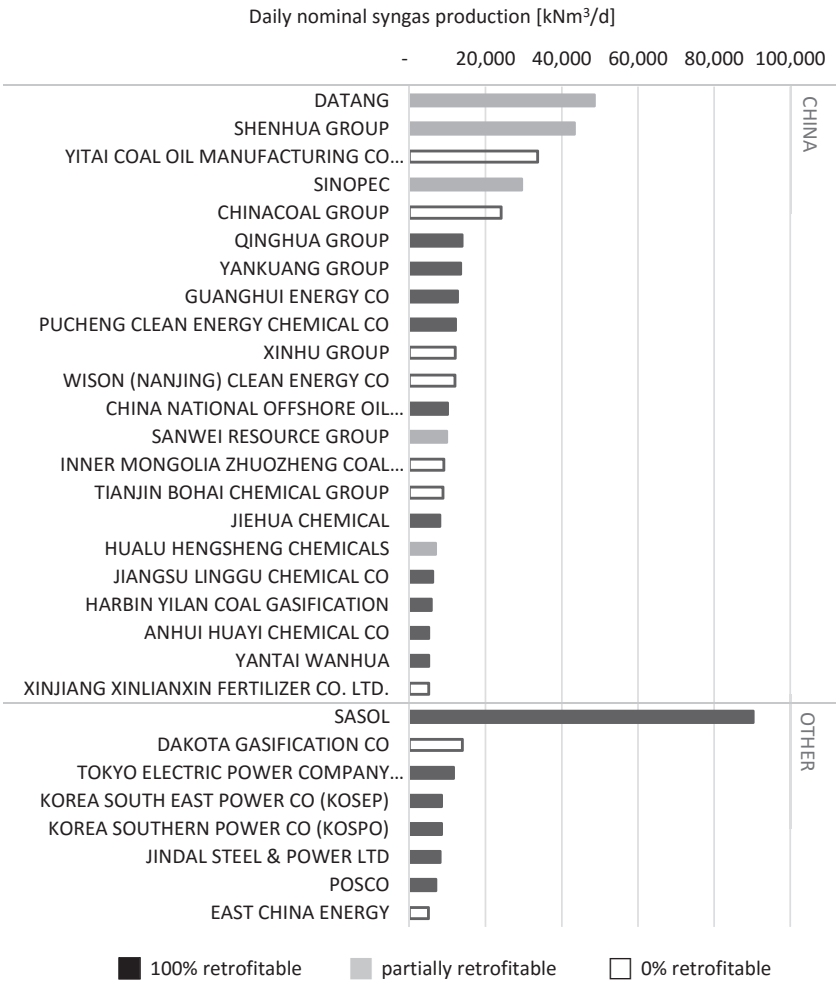
Stranded Assets and Thermal Coal developed a similar methodology for examining the CCS retrofitability of CPT companies. CPT plants within 40 km of a 'suitable' or 'highly suitable' reservoir are considered retrofitable. Of the top 30 CPT companies, nine had no assets deemed retrofitable. The figure 'CCS retrofitability (coal-processing technology companies)' shows the CCS retrofitability of the top 30 CPT companies.

A number of qualitative observations of environment-related risks related to UCG and CCS were also made. UCG and CCS have a synergistic relationship in that CO_2 can be directly stored in geological voids created by the gasification process. The amount of CO_2 that can be stored is, however, ultimately limited; the volume of by-product CO_2 from syngas creation is four or five times greater than the void volume created in the coal seam ('Water management issues in the underground gasification of coal and subsequent use of the voids for long-term CO_2 storage', Younger et al., IMWA, 2010; 'The feasibility of in situ geological sequestration of supercritical CO_2 coupled to underground coal gasification', David Schiffrin, *Energy and Environmental Science*, 2015).

Further, CO_2 storage cannot occur concurrently with the gasification process in many geologies ('TOPS: technology options for coupled underground coal gasification and CO_2 capture and storage', Durucan et al., *Energy* Procedia, 2014). David Schiffrin (in The feasibility of in situ geological sequestration) warns that heating and extraction during UCG generate significant thermal stresses in the coal voids, which could lead to roof collapse and CO_2 leakage. To avoid roof collapse and leakage, the void must be within depths below 800 to 1000 metres; with the right temperature and pressure, the CO_2 density would then be high enough to limit the storage volume required ('Review of underground gasification technologies and carbon capture', Stuart Self et al., *International Journal of Energy and Environmental Engineering*, 3, 1–8, 2012). Additionally, a careful site selection is required to



CCS retrofitability (coal-fired power utilities)



CCS retrofitability (coal-processing technology companies)

avoid potential water contamination and depletion risks associated with future UCG-CCS operations (Water management issues in the underground gasification of coal', Younger et al., 2010). Finally, Durucan et al. ('TOPS: technology options', 2014) observe that potential interactions between injected CO_2 and coal gasification products could further complicate CO_2 storage.

Analysis of findings

Of the top 100 coal-fired power utilities, two-thirds have no power stations meeting our generous retrofitability criteria. The EU and the USA have more companies that have no retrofitable power stations, and of those that do, less than 30 per cent of their coal-fired capacity is retrofitable. Retrofit with CCS seems an unlikely option for the mitigation of emissions from existing coal-fired power stations in the USA and the EU. We can also argue that CCS retrofitability has not been a strong criterion for choices in the location of coal-fired power stations. Optimal access to coal resource or shipping infrastructure and electricity transmission infrastructure have more likely driven location decisions for coal-fired generating stations, despite the hope that new power stations are 'CCS ready'.

Power stations in China are relatively more retrofitable with CCS than EU and US companies. These power stations, all things being equal, are relatively more resilient to asset stranding in the case of ambitious power sector mitigation targets.

Of the top 30 CPT companies, 22 are Chinese. Most have some, if not complete, CCS retrofitability potential, including giants Datang, Sinopec, and Shenhua Group. Most non-Chinese CPT companies are also completely retrofitable, including the three South Korean companies in the top 30, and the senior CPT company Sasol. CCS implementation could be a mitigation option for these companies, although there are a very large number of key uncertainties that would stymie this.

Policy makers must consider the limited availability of economic geological storage resource in designs to incentivize the rapid development and deployment of CCS. In the power sector, coal-fired power stations are unlikely to be the benefactors of such policy, given that they produce twice as much CO_2 per unit of electricity as gas-fired power (see the IPCC's Fifth Assessment Report) while fulfilling the same grid needs of dispatchable and flexible power.

Further, CCS-equipped power generation must compete with nuclear power and renewables as a low-carbon generating option. The latter has demonstrated clear and consistent cost reduction, making it cost-competitive in many locations, a trend Bloomberg New Energy Finance indicates is set to continue ('Wind and solar boost cost-competitiveness versus fossil fuels', BNEF, 2015). Scarce economic storage resource would be better allocated to addressing 'hard to treat' residual emissions from agriculture, industry, and aviation, which have fewer mitigation options.

The potential role of CCS in helping tackle industrial emissions, and of being a key part of negative emission technologies in the latter half of the century, bear no prescriptive role for the coal value chain in CCS deployment. We find that the role of CCS in the thermal coal value chain is at best uncertain, due to its stunted deployment, and at worst undesirable, due to the low value of coal-derived carbon relative to other carbon sources.

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