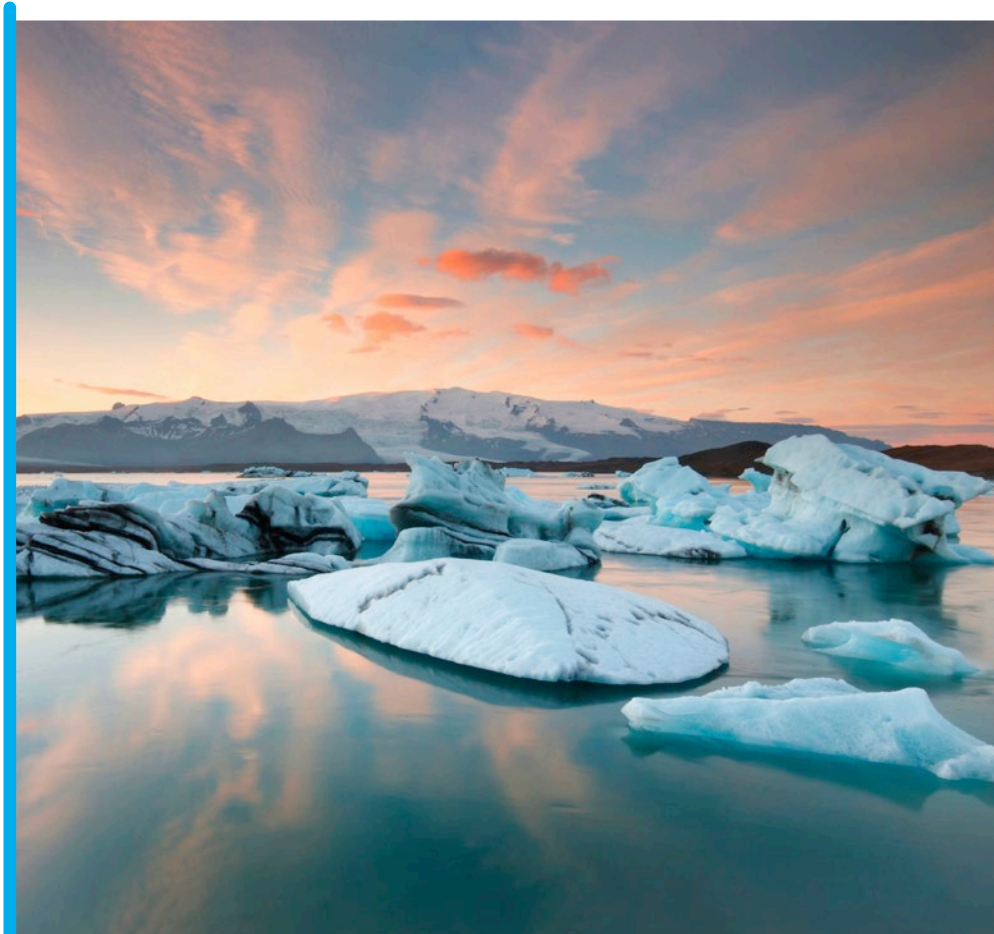
Equity Research
24 November 2015

#climatechange

Climate Change: Warming up for COP-21



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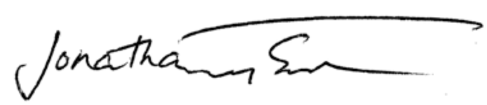
We are pleased to bring you the first equity research report launched under **#themes**, a new initiative aimed at organizing our best content around the most relevant market themes facing investors. Our aim is to enable investors to keep up to date and involved with the debates and market impact trends as they develop; while being able to easily identify and access this content under our #themes branding.

Barclays Research is increasingly seeking to cover the most topical events driving markets from a cross-sector and/or cross-asset perspective. This report on climate change is an example of this approach and can be found under **#climatechange** on Barclays Live, where we will also be housing future thematic content on this topic. In the report we combine the expertise of Mark Lewis, our Head of European Utilities Equity Research, together with that of Lydia Rainforth and James Stettler, who respectively lead our European Oil & Gas, and Industrials, Equity Research Teams.

We encourage you to explore the #themes section on Barclays Live and to look out for our future #themes publications and special media. We welcome your feedback.



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FOREWORD

The 21st session of the Conference of the Parties (COP-21) to the United Nations Framework Convention on Climate Change (UNFCCC) in Paris is the latest in a series of annual meetings that began with COP-1 in Berlin in 1995, when the international community first started to address the policy implications of the emerging consensus on the science of climate change. The stakes in Paris are high: the ultimate objective is to arrive at a credible path towards limiting greenhouse-gas emissions that will enable the world to restrict the increase in the average global temperature to no more than 2°C above pre-industrial levels – a goal the UNFCCC member states signed up to at COP-16 in Mexico in 2010.

COP-21 also comes at a time when the economic and investment implications of climate change are attracting increasing attention. The International Energy Agency (IEA) has been modelling the impact of different climate-policy scenarios on the energy sector for a number of years, but financial and regulatory authorities are now starting to consider the broader economic and financial ramifications of climate change, as demonstrated by the recent interventions by the Bank of England regarding the risk climate change poses to financial stability. At the same time, the financial risk posed to investors is also increasingly in the spotlight, as evidenced by the growing number of investor initiatives around carbon benchmarking, portfolio decarbonisation, and even outright divestment of fossil-fuel holdings.

The original hope for COP-21 was that via the national emissions plans submitted ahead of the COP, the world would move onto a trajectory consistent with a 2°C average temperature increase above pre-industrial levels. However, from the plans so far submitted, it is clear that COP-21 will not itself be able to deliver a 2°C path. As a result, a successful outcome would in our view be one that: (i) gives credible backing to the deliverability of the national emissions plans; and (ii) gives hope for a subsequent tightening of these plans such that the prospect of a 2°C deal at a later date remains alive beyond Paris via a credible periodic review process.

In its recently published World Energy Outlook 2015, the IEA estimates that under an energy-and-climate policy framework consistent with a 2°C trajectory, investment in low-carbon energy sources and energy efficiency out to 2040 would be $14trn higher than under its base-case scenario; by contrast, required investments in fossil-fuel energy sources would be $6.4trn lower, as would the prices for, and volumes of, fossil fuels sold. On our calculations, the IEA data imply that the fossil-fuel industry would stand to lose $34trn in revenues over 2014-2040 under a 2°C policy scenario, with the oil industry accounting for $22.4trn of this, gas for $5.5trn, and coal for $5.8trn.

From an investor standpoint, we think a strong outcome at COP-21 would boost the long-term fundamentals of the capital-goods and low-carbon power-generation sectors while weakening the long-term fundamentals of fossil-fuel industries. At the same time, such an outcome would in our view also boost both financial regulators' interest in climate risk and growing investor initiatives around portfolio de-carbonisation.

Mark Lewis
Barclays Power & Utilities Research

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We would like to thank the IEA for permission to use data from the recently published *World Energy Outlook 2015*.

OVERVIEW

COP-21: What's at stake and will we get a meaningful deal?

COP-21 will take place in Paris from 30 November to 11 December. Organized by the United Nations Framework Convention on Climate Change (UNFCCC), the objective of COP-21 is to arrive at a global agreement on greenhouse-gas (GHG) emissions that will ultimately limit the increase in the average global temperature to no more than 2°C above pre-industrial levels.

We already know that the national emissions plans (Intended Nationally Determined Contributions, or INDCs) submitted by each country ahead of the COP will not in themselves be enough to move the world onto a trajectory consistent with a 2°C average temperature increase. As a result, a successful outcome in our view would be one that (i) gives credible backing to the deliverability of the INDCs, and (ii) gives hope for a subsequent tightening of the INDCs beyond COP-21 such that the prospect of a 2°C deal at a later date remains alive via a credible periodic review process.

There are reasons to think COP-21 can deliver a strong outcome

In our view there are three main factors that suggest COP-21, could deliver a more meaningful outcome than the last comparable summit (COP-15 in Copenhagen in 2009).

1. The US and China are much better synchronised this time around

China and the US are the world's largest emitters, and tension between the two has been a long-standing ritual at previous COPs, not least COP-15 in Copenhagen where disagreement between the two was one of the reasons for that summit's ultimate failure. However, a bilateral agreement signed between President Obama and President Xi Jinping last November has transformed the relationship between the two countries on this issue.

2. INDCs cover 80-85% of all emissions, far more than Kyoto Protocol ever did

The level of coverage and engagement displayed in the INDCs is much higher than what has been achieved under the top-down approach of the Kyoto Protocol. We estimate that under the first Kyoto commitment period covering 2008-12, the countries that signed up to emissions targets accounted for only 30% of the global total, compared with the 80-85% covered by the countries that have so far submitted INDCs. The bottom-up approach in the INDCs is also inherently more flexible, which makes the politics easier.

3. Renewable-energy costs have fallen dramatically since COP-15 in 2009

The cost of the major renewable-energy technologies has fallen sharply since the failure of COP-15 in Copenhagen, and this transforms the context of discussions over future mitigation costs. It also means that with or without a meaningful deal in Paris, the world will be transitioning towards a more sustainable energy system over the next few decades.

But there are also reasons to be sceptical about what Paris can deliver

However, we also see three reasons to be cautious about the outcome.

1. The INDCs burn through three quarters of remaining 2°C budget by 2030

Even though the INDCs represent a big step forward, the energy-consumption pattern they imply would burn through 75% of the carbon budget likely consistent with a 2°C world by 2030 (748Gt/1,000Gt). Even under the looser scenario consistent with only a 50% chance of achieving a 2°C outcome, the INDCs consume 58% of the remaining carbon budget by 2030 (748Gt/1,300Gt).

2. Financing remains a major sticking point

It is hard to know how negotiations over climate financing will play out in Paris and whether this issue could ultimately prevent a successful outcome, but at the very least we think the level of ambition and urgency on the part of the leading developed countries will have to be increased if developing countries are going to agree to a meaningful deal at COP-21.

3. How to prioritise given so many other pressing global challenges?

Global leaders have many other pressing issues to worry about at the moment, with security at the top of the list following the recent terrorist attacks in Paris. Of course, global leaders are used to juggling many complex issues at the same time, and this backdrop may even help bring global leaders together, but equally it could distract attention and hence result in a weaker deal than might otherwise have been the case.

Global leaders will now assemble in Paris against a very sombre background

The timing and location of this particular COP is now inevitably freighted with tension and poignancy following the recent terror attacks in Paris. Whether this ultimately helps world leaders to find common cause on climate remains to be seen, but we think the key to achieving a successful outcome at COP-21 lies in the political will for a deal shown by the heads of government who will be assembling in Paris at the beginning of the talks.

In this respect, we think it is significant that the French government has inverted the usual order of proceedings for the COP by convening the heads-of-government meeting at the beginning of the two-week summit rather than the end (this was arranged well before the terror attacks of 13 November). This could help provide impetus to the detailed technical negotiations over the following two weeks.

We also think there are two developments in recent weeks worth highlighting:

1. French President François Hollande visited China at the beginning of this month and made a joint declaration with his Chinese counterpart, Xi Jinping, that emphasised the importance that both countries attach to securing a meaningful deal in Paris. Crucially, the two presidents fully endorsed the principle of securing a process at COP-21 that will allow the implementation of the INDCs to be effectively monitored and subsequently tightened so that a 2°C deal can remain within play beyond COP-21;

2. When U.S. President Barack Obama rejected the Keystone XL pipeline earlier this month, he explicitly linked this decision with climate change and with the need of the US to show global leadership on this issue ahead of COP-21. This indicates that President Obama views a meaningful deal in Paris as a priority for his own political legacy.

While in no way guaranteeing a successful outcome at COP-21 in themselves, we think these developments do at least show that there seems to be the kind of political will necessary amongst the world's two largest emitters, and the host country, to secure a meaningful deal at COP-21 that can then be revisited and strengthened in future negotiations.

It now remains to be seen how things play out.

COP-21 can help accelerate the global energy transition already underway

Whether or not COP-21 meets the criteria for a successful outcome as we have defined these above, we would emphasize that the falling cost of renewable energies and the savings to be made from improving energy efficiency are already driving a global energy transition that will put traditional energy providers under increasing pressure over the next two decades. A successful policy outcome at COP-21 could help accelerate this transition significantly.

As a result, we think the fossil-fuel industry can no longer afford to ignore the issue of carbon risk, and that a transparent stress-testing of its business model against the risk of a 450-ppm world would be the best way of kick-starting a dialogue with investors and other stakeholders over a meaningful risk-mitigation process. In this report we look at these risks in so far as they relate to investments in, and demand for, fossil fuels over the next couple of decades.

Investment upside for clean energy and energy efficiency

GHG-emissions from energy account for over two-thirds of the anthropogenic total, and this is why the INDCs are so focused on measures designed to reduce energy emissions, and why the International Energy Agency (IEA) has been so prominent in devising practical policy scenarios in recent years to help advise on the energy transition required to put the world on a 2°C trajectory.

In its updated scenario analysis published earlier this month in the World Energy Outlook 2015, the IEA's modelling of an energy path consistent with a 2°C world displays a sharp divergence with its base-case scenario, even though the agency's updated base-case scenario out to 2040 does take account (albeit cautiously) of the INDCs submitted ahead of the COP.

The share of fossil fuels in the energy mix is much lower under the IEA's carbon-constrained scenario consistent with 2°C (the 450-Scenario, or 450S) than it is under the IEA's base-case scenario (the New Policies Scenario, or NPS), and so too, as a result, are fossil-fuel investments and prices. By contrast, the share of renewables is much higher under the 450S, as is the emphasis on energy efficiency.

Overall, total fossil-fuel investments under the 450S are $6.4trn lower under the 450S than they are under the NPS, as shown in Figures 1 and 2.[1]

FIGURE 1

Fossil-fuel investment under the IEA's NPS, 2014-40 (2014 $trn)

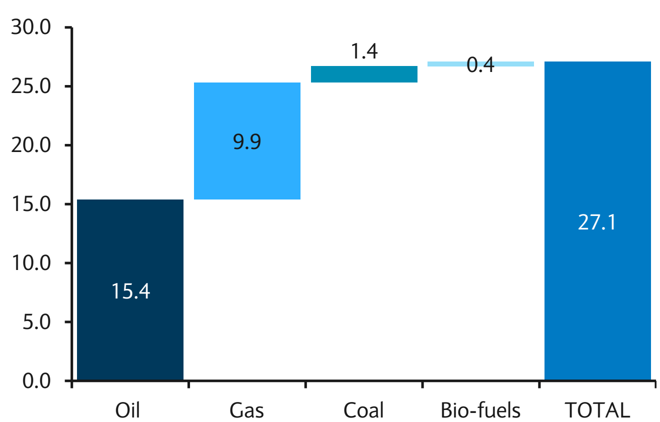

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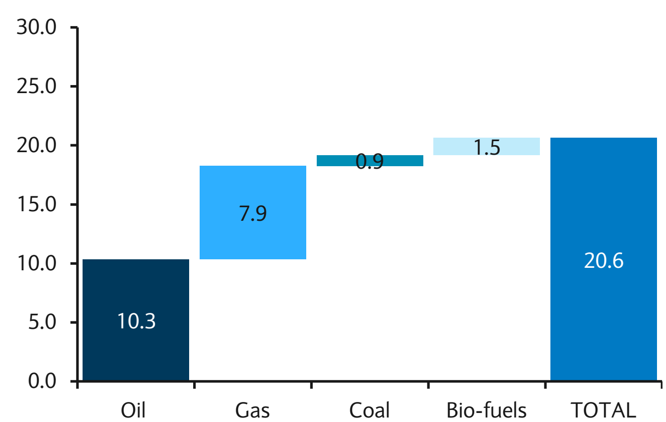
FIGURE 2

Fossil-fuel investment under the IEA's 450S, 2014-40 (2014 $trn)



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By contrast, investments in low-carbon energy sources and energy efficiency are some $14trn higher.

Figures 3 and 4 show the investments in power supply under the IEA's NPS and 450S respectively. Investments in renewable energy are $3.4trn higher under the 450S ($10.4trn versus $7trn under the NPS), and in nuclear $0.6trn higher ($2.1trn versus $1.5trn).

[1] Note that all financial figures quoted from the IEA's WEO 2015 throughout this report are given in constant 2014 US$, and are therefore always in real terms.

FIGURE 3

Power-supply investment under the IEA's NPS, 2014-40 (2014 $trn)

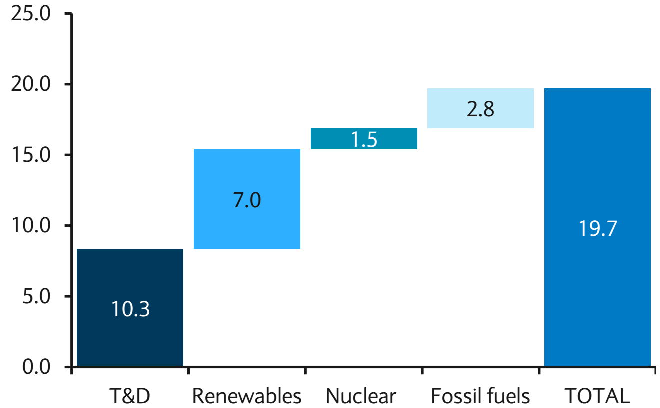

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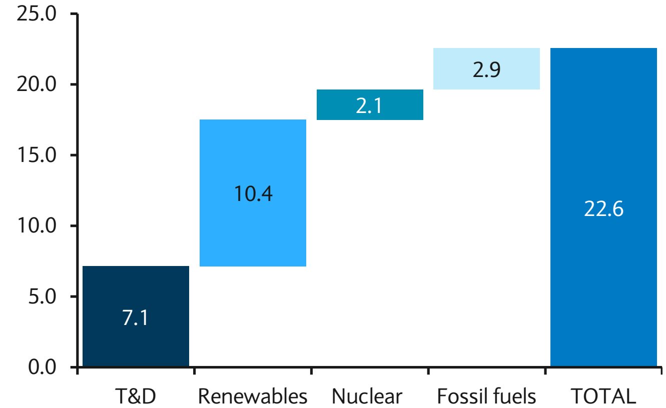
FIGURE 4

Power-supply investment under the IEA's 450S, 2014-40 (2014 $trn)



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Figures 5 and 6 show the investments in energy efficiency under the IEA's NPS and 450S respectively. Total energy-efficiency investment over 2015-40 is $10trn higher under the 450S than the NPS, driven mainly by buildings ($4.4trn higher) and transport ($4trn higher).

FIGURE 5

Energy-efficiency investment under the IEA's NPS, 2014-40 (2014 $trn)

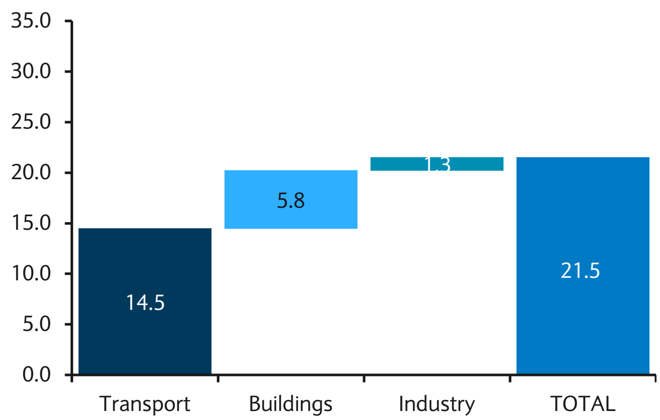

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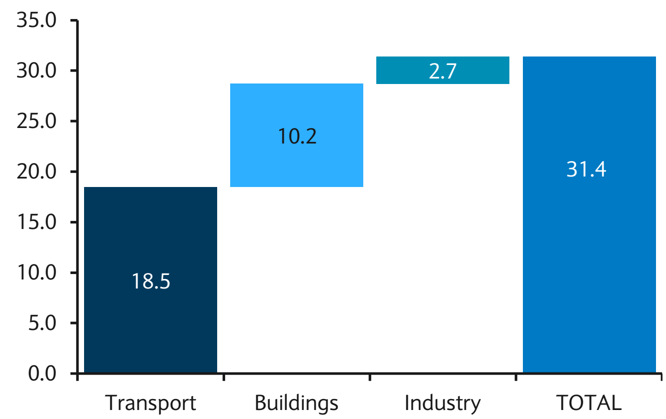
FIGURE 6

Energy-efficiency investment under the IEA's 450S, 2014-40 (2014 $trn)



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As noted above, COP-21 in itself will not deliver a 2°C deal, but a strong agreement in Paris next month could nonetheless keep that aspiration alive, with what are clearly far-reaching implications for future investments across the energy sector.

In particular, the obvious risk that the divergence in required fossil-fuel investments between the global energy system's current trajectory and a trajectory consistent with a 2°C world throws up is that fossil-fuel companies might end up with stranded assets if policymakers move towards a much more carbon-constrained policy framework than they are currently assuming.

Moreover, given the sheer size of the investments we are talking about here, it would not require a policy outcome fully in line with a 2°C world for the appropriate investment profile to change significantly. In other words, if COP-21 ultimately results in a policy framework by 2020 that puts the world on a trajectory midway between the NPS and the 450S, then this would also imply a need for significantly lower fossil-fuel investments and much higher clean-energy investments than the trajectory the world is on at the moment.[2]

The message for fossil-fuel companies is that they will need to be increasingly cautious regarding future investments in high-cost, high-carbon projects, as these are the ones most vulnerable to future stranding under any future policy tightening of the carbon constraint.[3]

Fossil-fuel revenues of up to $34trn at risk in a 2°C world

In a carbon-constrained world consistent with a 2°C outcome, we estimate that the fossil-fuel industry would stand to lose $34trn (in constant 2014 $) of gross revenues over the next two-and-a-half decades relative to the current trajectory. We derive at this number by comparing the IEA's base-case scenario for global energy trends out to 2040 (the NPS) with its 450-Scenario (its scenario consistent with a 2°C world).

Under the IEA's 450-Scenario (450S), both the demand for and the prices of fossil fuels would fall as policies were put in place to restrict CO_2 emissions from energy, which diverge sharply under the two scenarios.

In terms of the volume impact of these policy measures relative to the NPS, we estimate that cumulative demand for fossil fuels over the next two decades under the 450S would be lower by 48,000m tonnes of oil equivalent (48 gigatonnes, or Gtoe). This equates to four years of fossil-fuel demand at the current rate of consumption, with coal accounting for 50% of this difference, oil c.30%, and gas c.20%.

Cumulative oil demand (crude oil plus natural-gas liquids) over 2014-40 under the 450S is lower by 109bn barrels (bbls) than under the NPS, cumulative gas demand by 10.6trn cubic metres (tcm), and cumulative coal demand by 36bn tonnes of coal equivalent (tce). Figures 7 and 8 show our estimates of the difference in cumulative demand in billion tonnes of oil equivalent between the two scenarios.

[2] We do not enter into the debate around stranded assets in this report but we do refer to it in passing when looking at the Bank of England's recent intervention on this subject in Section 1 below. For those interested, there is a large and growing literature on this subject, which was pioneered by the NGO Carbon Tracker with its 2011 report *Unburnable Carbon*. The Governor of the Bank of England, Mark Carney, has been using the lexicology of unburnable carbon and stranded assets since his first intervention on this subject in October 2014.

[3] Note that we do not see a risk of asset stranding to the vast majority of the oil-and-gas sector's proved (1P) reserves. However, for the investments they make going forward we think they will need to be very alive to the risk of asset-stranding under a tighter climate-policy scenario.

FIGURE 7

Barclays estimate of cumulative fossil-fuel demand under the IEA's NPS, 2014-40 (Gtoe)

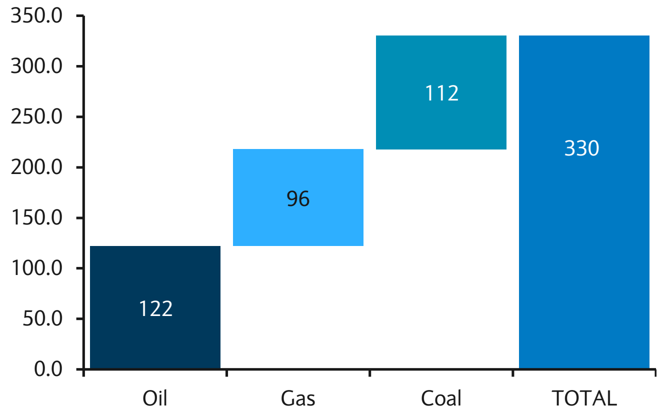

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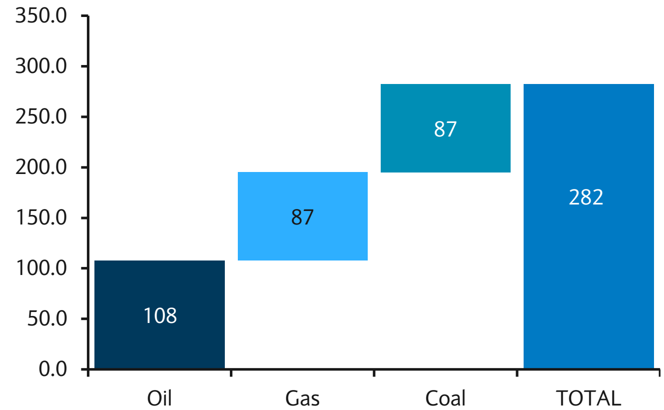
FIGURE 8

Barclays estimate of cumulative fossil-fuel demand under the IEA's 450S, 2014-40 (Gtoe)



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The IEA projects that prices would be lower for all fossil-fuels under the 450S than under the NPS, reflecting this lower demand. Under the 450S, our calculations based on the IEA forecasts sees oil prices averaging $88/bbl (in constant 2014 $) over 2014-40 compared with $103/bbl under the NPS, and coal $79/tonne under the 450S versus $97/tonne under the NPS. For gas, the picture is more complicated as prices vary greatly across the world, but in all regions prices are on average lower under the 450S than under the NPS.

On our estimates, the net impact of these volume and price effects under the 450S would be to reduce the revenues of the oil industry by $22.4trn over the 2014-40 timeframe, those of the gas industry by $5.5trn, and those of the coal industry by $5.8trn (again, all in constant 2014 $). In total, we estimate that fossil-fuel revenues would be $34trn lower at $103trn versus $137trn.

Figures 9 and 10 show our estimates of the difference in cumulative revenues between the two scenarios.

FIGURE 9

Barclays estimate of cumulative fossil-fuel revenues under the IEA's NPS, 2014-40 (constant 2014 $trn)

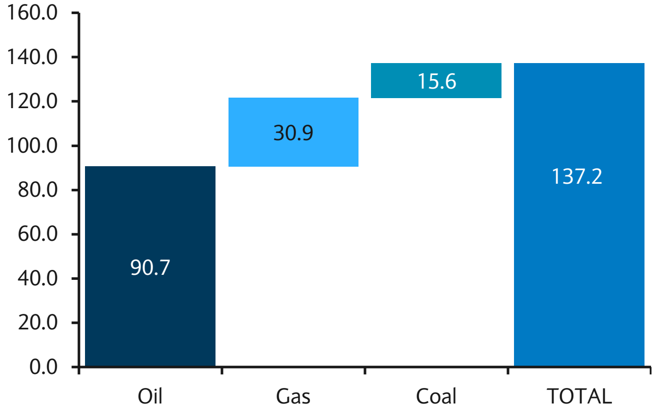

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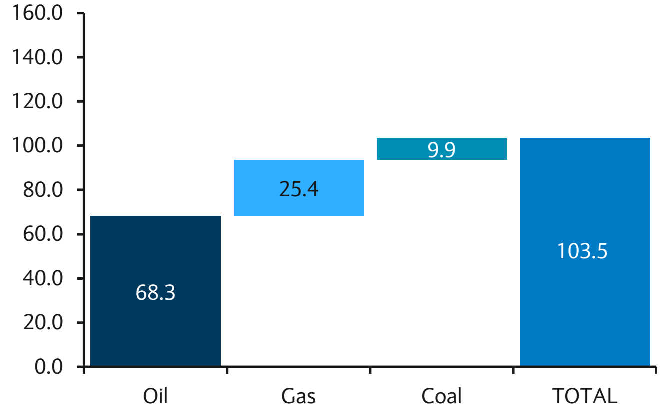
FIGURE 10

Barclays estimate of cumulative fossil-fuel revenues under the IEA's 450S, 2014-40 (constant 2014 $trn)



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The IEA's 450S is primarily intended to help policymakers make informed choices to put the global energy system on a sustainable pathway consistent with what the climate science says is both necessary and possible if the world is to stand a chance of mitigating the worst impacts of climate change.

At the same time, though, we think that comparing the very different outcomes for the fossil-fuel industry under the NPS and the 450S can also help investors.

Specifically, we think that this kind of comparative scenario analysis can help investors reach a clearer understanding of the magnitude of the risks that fossil-fuel companies face in a world where the threat of a much more carbon-constrained policy framework is only likely to increase in the future.

COP-21 and capital goods: relative winners and losers

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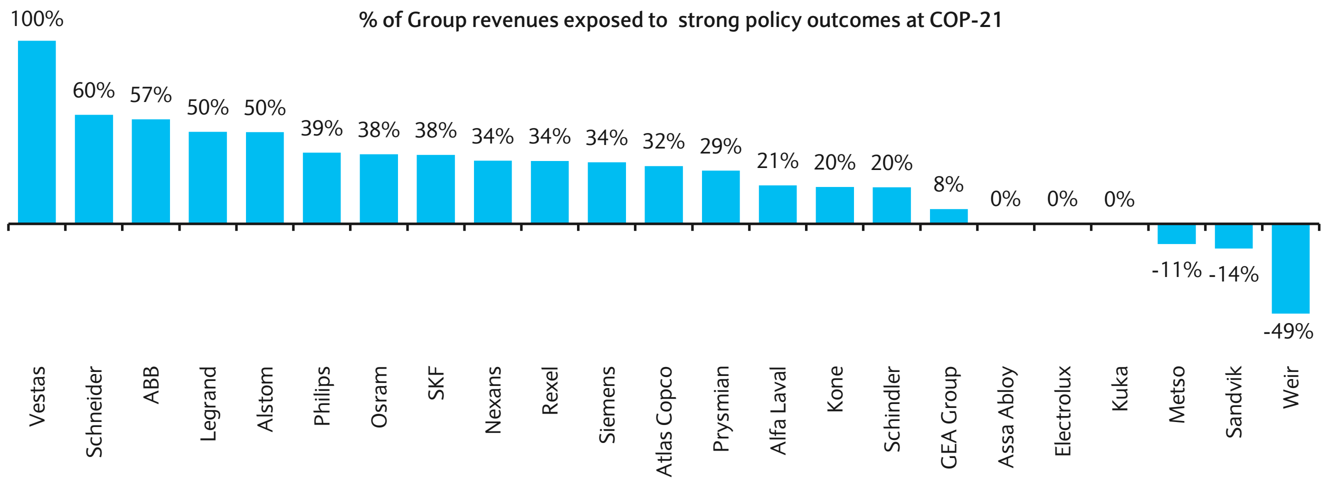
In this report we aim to highlight the opportunities and risks for the sector from a successful policy outcome. Based on industry exposure to which we ascribe a weighting on positive or negative impact, Vestas, Schneider and ABB emerge as winners. This is driven by a high exposure to renewable energy and energy efficiency. In contrast, we see Weir, Sandvik and Metso as net losers based on their exposure to the oil & gas markets. Under our framework, Siemens wins in renewables, rail & industry, but loses in fossil as well as in oil & gas.

FIGURE 11

Vestas, Schneider and ABB the winners, Weir, Sandvik and Metso the losers



Source: Barclays Research

FIGURE 11A

Barclays end market weightings ascribed to a successful policy outcome

End market	Barclays weighting	Drivers	Key companies
Renewable energy	+100%	Greatest beneficiary in power generation	Vestas, Siemens
Motors & drives	+100%	Most significant product category to reduce energy consumption in industry	ABB, Schneider, Siemens
Transmission/Distribution equipment	+100%	Beneficiary of increased renewables penetration	ABB, Siemens
Lighting	+80%	Strong growth in (lower margin) LEDs and accelerated phase-out of (higher margin) conventional lighting,	Osram, Philips
Low voltage equipment	+50%	Clear beneficiary in lighting/HVAC controls, limited impact in the area of safety, e.g. circuit breakers	Legrand, Schneider, ABB, Siemens
Rail	+50%	Most efficient mode of transportation	Alstom, Siemens
Mining	0%	Carbon policy may constrain long-term macro growth. Offset from energy efficiency investments	Atlas Copco, Sandvik, Metso, Weir
Automotive	-50%	Lower unit demand, offset: greater push towards light-weighting and more energy efficient drive-train	SKF, Atlas Copco, Kuka, ABB
Fossil Power	-50%	Growth in global electricity demand negatively impacted, shift out of fossil fuels, offset: shift from coal to gas	Siemens
Oil & gas	-100%	Negative: lower oil consumption, positive: higher demand for gas energy efficiency investments	Weir, Siemens, ABB, Schneider

Source: Barclays Research

COP-21 and integrated oils: relative winners and losers

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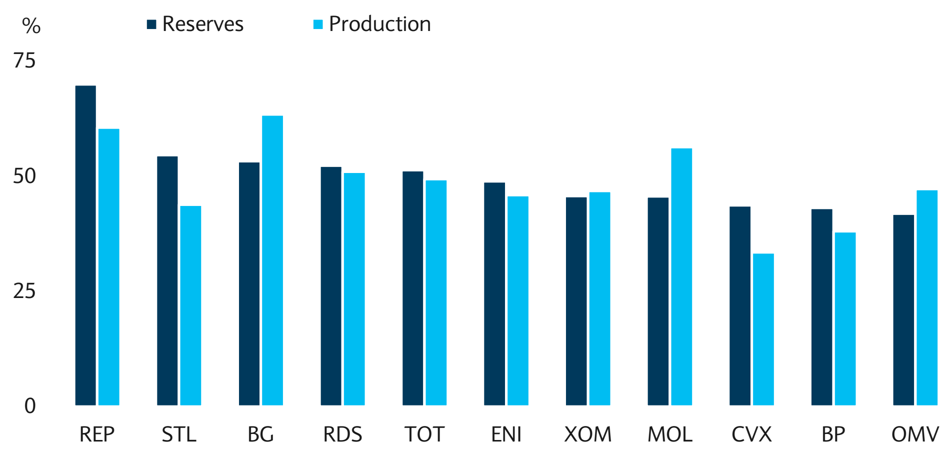
The easy conclusion to make is that a move towards a lower-carbon economy is a significant negative for the oil and gas industry: implied fossil fuel demand will be lower than it would be without policy changes, and such "decarbonisation" is likely to put pressure on oil and gas valuations. However, although we acknowledge that a co-ordinated policy response would reduce oil and gas demand compared to the current trajectory, we see oil and gas companies as materially undervalued based on any of the scenarios presented to 2040, all of which see energy demand grow. In order to deliver enough production to meet even the lowest of these demand forecasts, significant investment will be required and in order to incentivise this, oil prices need to be higher than currently and we expect a meaningful recovery over the coming three years. From a longer term perspective it is clear to us that the oil & gas industry is set to play a significant role in helping with the transition towards a lower-carbon economy, with technology both improving the availability of resources and reducing the cost of delivery for both conventional and renewable fuels.

In our view the easiest and quickest method to meaningfully reduce carbon emissions in the power sector is through the increased use of natural gas within the energy mix, particularly relative to coal. If policy evolves in such a way to support increased use of natural gas, we see this as a long-term positive for those with the largest exposure. Within our coverage universe our analysis shows the key beneficiaries as the newly combined Royal Dutch Shell-BG Group and Statoil. Royal Dutch Shell remains our Top Pick and we rate the shares Overweight with a 2850p per share price target. Within the transport sector we expect to see an increased role for third-generation bio-fuels and Finland-based Neste is a leader within this industry and we rate the stock Overweight with a EUR30 price target.

The chart below shows the proportion of natural gas for both production and reserves as of end-2014. On average for the companies shown below natural gas represents 50% of reserves and 49% of existing production.

FIGURE 12

Natural gas as proportion of production and reserves



Source: Barclays Research

Repsol has higher than average exposure to natural gas, though this has changed slightly post Talisman and this is largely Latin American gas. Statoil and the combined Shell-BG group also have greater than average exposure, although the differences we see as small in the long term context.

Structure of this report

This report is divided into five main sections.

1. COP-21: the essential background

This section reviews the history of the global policy response to climate change with a view to putting COP-21 into context. As such, it looks in some detail at the science, politics, and economics of climate change, and reviews the essential features of the INDCs, and the political momentum over the last few months building up to Paris. It also considers briefly the recent interventions by the Bank of England regarding the risk climate change poses to financial stability, and the growing number of investor initiatives around carbon benchmarking, portfolio decarbonisation, and outright divestment of fossil-fuel holdings.

2. The IEA scenarios: different degrees of carbon constraint

This section sets out the main differences between the IEA's NPS and 450S. The share of fossil fuels in the mix is much lower under the 450S than it is under the NPS, and so too, as a result, are fossil-fuel investments and prices. By contrast, the share of renewable energy is much higher under the 450S, as is the emphasis on energy efficiency. Overall, total fossil-fuel investments under the 450S are some $6.4trn lower under the 450S, while investments in low-carbon energy sources and energy efficiency are some $14trn higher.

3. Scoping the long-term risk to fossil-fuel revenues

We estimate that the net impact of the volume and price effects assumed under the 450S would be to reduce the projected revenues of the upstream fossil-fuel industry globally relative to the NPS by $33.7trn (in constant 2014 $) over 2014-40. This breaks down as $22.4trn of lost revenues from lower sales of oil, $5.5trn from lower sales of natural gas, and $5.8trn from lower sales of coal.

Of course, this is a hypothetical worst case based on a sensitivity analysis of the IEA's policy-based scenarios, but that does not mean that these are numbers the fossil-fuel industry can simply choose to ignore. On the contrary, we think that based on this worst-case analysis fossil-fuel companies need to think long and hard about how they respond to a rapidly changing energy landscape, as with or without a formal 2°C trajectory the ongoing energy transition from fossil fuels to zero- and low-carbon energy sources with a much greater emphasis on more efficient consumption could otherwise undercut their business models.

4. The implications for the capital-goods sector

Based on industry exposure to which James Stettler ascribes a weighting on positive or negative impact from a strong policy outcome, Vestas, Schneider and ABB (all OW) emerge as winners. This is driven by a high exposure to renewable energy and energy efficiency. On the flip side, he sees Weir (EW), Sandvik (EW) and Metso (OW) as net losers based on their exposure to the oil & gas markets. Siemens wins in renewables, rail & industry, but loses in fossil and oil & gas.

5. The implications for the oil-and-gas sector

Within the Oil & Gas sector, Lydia Rainforth believes a strong policy outcome would favour those companies with greater than average exposure to natural gas and third-generation bio-fuels. In terms of gas exposure the combined Royal Dutch Shell-BG Group (both OW) and Statoil (EW) emerge as key beneficiaries. In the biofuel space she sees Finland-based Neste as a leader within this industry, rated Overweight.

COP-21: THE ESSENTIAL BACKGROUND

The COP-21 conference in Paris is the latest in a series of annual meetings that began with COP-1 in Berlin in 1995 as the international community first started to address the policy implications of the emerging consensus on the science of climate change. The stakes are high, as the ultimate objective is to find a credible pathway towards the 2°C target all UNFCCC member states signed up to at COP-16 in Mexico in 2010.

COP-21 also comes at a time when the economic and investment implications of climate change are attracting increasing attention. The IEA has been modelling the impact of different climate-policy scenarios on the energy sector for a number of years, but financial and regulatory authorities are now starting to consider the broader economic and financial ramifications of climate change, as demonstrated by the recent interventions by the Bank of England regarding the risk climate change poses to financial stability.

At the same time, the financial risk posed by climate change to investors is also now increasingly in the spotlight, as evidenced by the growing number of investor initiatives around carbon benchmarking, portfolio decarbonisation, and even outright divestment of fossil-fuel holdings.

The science and politics of climate change

Concerted international action to address the issue of climate change dates back to the setting up of *the Intergovernmental Panel on Climate Change* (IPCC) in 1988. This was then followed by the establishment of *the UNFCCC* in 1992.

The scientific framework for global climate talks: the IPCC

The IPCC was established in 1988 by the World Meteorological Organisation and the United Nations Environment Programme with a view to assessing all the scientific, technical and socio-economic information relevant for the understanding of climate change, and of the options for adapting to and mitigating its effects.

Since it was founded, the IPCC has published *five comprehensive studies on the science of climate change*, known as assessment reports. The IPCC's first Assessment Report (AR1) was published in 1990, and its fifth and most recent (AR5) in 2014. In summary, the IPCC approach as developed since 1990 through the periodic assessment reports notes the empirical link between the increase in the concentration of these GHG emissions in the earth's atmosphere since pre-industrial times on the one hand, and the average increase in the earth's global temperature over the same period on the other. [4]

The IPCC rates six GHGs/groups of GHGs in terms of an index that measures their global warming potential (GWP) relative to carbon dioxide (emissions are therefore often measured in terms of tonnes of carbon-dioxide equivalent, or CO_2e).

So, carbon dioxide has a GWP of 1, methane of 23, and so on, all the way up to sulphur hexafluoride, which is 22,200 times more powerful than carbon dioxide in terms of its impact, when released into the atmosphere, on the earth's temperature (Figure 13 below).

[4] The evidence compiled by the IPCC over the last 25 years is extremely comprehensive but it is not our brief in this report to review the IPCC literature. For our purposes here it is enough to note that the IPCC's very detailed reporting on the science of climate change as set out in its periodic assessment reports since 1990 has informed global policy action through the UNFCCC by establishing the link between increasing concentrations of greenhouse gases in the atmosphere since the onset of industrialization and a rise in the average global temperature over the same period. For those interested in a more detailed review of the science behind climate change, and how the IPCC's approach has evolved over time, the best starting point is the *IPCC's own website on its assessment reports*.

FIGURE 13

Global Warming Potential of Greenhouse Gases

Greenhouse gas	GWP
Carbon doxide (CO_2)	1
Methane (CH_4)	23
Nitrous oxide (N_2O)	296
Hydrofluorocarbons (HFCs)	120-12,000
Perfluorocarbons (PFCs)	5,700-11,900
Sulphur hexafluoride (SF_6)	22,200

Source: UNFCCC

And the IPCC conclusion is that the required policy response is first slowing the rate of increase in, and then reducing the absolute level of, annual global emissions of these greenhouse gases.

The political framework for global climate talks: the IPCC

At the same time as the IPCC has been accumulating scientific evidence and refining its modelling and conclusions over the last two decades, the issue of climate change has assumed an increasingly high political profile, with the UNFCCC established as the agency to coordinate global climate action. The text underpinning the UNFCCC was adopted in May 1992 at the UN's headquarters in New York and then presented to the UN conference on Environment and Development held in Rio de Janeiro in June 1992.

The Convention itself entered into force in March 1994, and now has 196 countries signed up to it (comprising all UN members plus the EU). From *Article 2 of the UNFCCC*, which is entitled simply 'Objective', the ultimate purpose of the Convention is clearly defined, and is quoted in full below:

*"The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, **stabilization of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.** Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner." (Our emphasis)*

"The ultimate objective of this Convention is stabilization of greenhouse-gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." UNFCCC founding text, 1992

In other words, taking its cue from the scientific evidence compiled by the IPCC, the UNFCCC has set its overriding objective as limiting the impact of human activity on the eco-system of the planet via the stabilization of GHG-concentration levels in the atmosphere, whilst at the same time allowing for sustainable economic growth.

The target: Stabilizing GHG concentrations at 450ppm for a 2°C outcome

The IPCC published its *Assessment Report 5 (AR5)* over the course of 2013-14, and the findings were then summarized in the *Synthesis Report of AR 5*, which included a *Summary for Policymakers* to help inform policy decisions both ahead of COP-21 and beyond.

AR5 concludes that: GHG emissions from human activities have been the main driver of observed increases in the average global surface temperature since pre-industrial times, and especially since the mid-20th century. This is clear from page 4 of the *AR5 Summary for Policymakers*:

"Anthropogenic greenhouse-gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever. This has led to atmospheric concentrations of carbon dioxide, methane, and nitrous oxide that are unprecedented in at least the last 800,000 years. Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are ***extremely likely*** *to have been the dominant cause of the observed warming since the mid-20th century."* (Emphasis in original)

> "Limiting climate change would require substantial and sustained reductions in greenhouse-gas emissions which, together with adaptation, can limit climate-change risks."
> IPCC Fifth Assessment Report, 2014

The Fifth Assessment Report goes on to say that in order to limit the worst impacts of climate change, substantial reductions in GHG emissions will be needed (Ibid, page 8):

"Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems. ***Limiting climate change would require substantial and sustained reductions in greenhouse-gas emissions which, together with adaptation, can limit climate-change risks****."* (Our emphasis)

This raises two questions:

(i) What level of temperature increase versus pre-industrial levels is consistent with Article 2 of the Convention's text quoted above (i.e. with preventing *'dangerous anthropogenic interference with the climate system'*)?

(ii) What level of greenhouse-gas concentration is consistent with this level of temperature increase?

COP-16 adopted a 2°C target, implying a GHG-concentration level of 450ppm

At *COP-16 in December 2010 in Cancun, Mexico*, all member countries of the UNFCCC committed to restricting the increase in the average surface global temperature *"to a maximum 2°C above pre-industrial levels, and to consider lowering that maximum to 1.5°C degrees in the near future"*.

The reasons underlying the choice of a 2°C target (with the possibility of reducing this to 1.5°C at some future point) ultimately date back to the 1970s and encompass political as well as scientific considerations, but the commitment to a 2°C target signed up to by all UNFCCC member states in 2010 has meant that every COP since Cancun has ultimately been intended to advance the policy framework to achieve this outcome.

With regard to the GHG-concentration level consistent with this temperature target, the IPCC reiterated in AR5 last year that 450 parts per million (ppm) of CO_2e is consistent with a scenario likely to restrict warming to no more than 2°C over the rest of this century. This is clearly stated on page 20 of the *AR5 Summary for Policymakers*:

"*Emissions scenarios leading to CO_2-equivalent concentrations in 2100 of about 450ppm or lower are **likely** to maintain warming below 2°C over the 21st century relative to pre-industrial levels. These scenarios are characterized by 40% to 70% global anthropogenic GHG-emissions reductions by 2050 compared to 2010, and emissions levels near zero or below in 2100.*" (Emphasis in original)

So how has the 2°C target to which all UNFCCC member states have signed up translate into these states' planned contributions to COP-21?

From top-down to bottom-up: the INDCs and COP-21

Following COP-16 in Mexico, it was decided at *COP-17 in Durban in 2011* that the UNFCCC would aim to achieve an over-arching climate agreement at COP-21 in 2015 in the form of '*a protocol, another legal instrument, or an agreed outcome with legal force under the Convention applicable to all parties*'. It was also decided in Durban that the agreement to be finalized at COP-21 would take legal effect from 2020.

It was then further decided at COP-19 in Warsaw in 2013 that the process for achieving a global agreement in 2015 would be based on a bottom-up rather than a top-down approach, with countries submitting their own Intended Nationally Determined Contributions (INDCs) in the months leading up to the Paris COP. This was a marked change from the previous approach of attempting to secure a top-down climate agreement whereby countries would sign up to legally binding emissions-reduction targets. This reflected the political reality – which became apparent at the end of COP-15 in Copenhagen in 2009 – that top-down UN treaties with legally binding emissions-reductions targets are by their nature very difficult to agree upon and enforce.[5]

In short, since the outcome of COP-19 in 2013, countries have been working on their INDCs for submission ahead of the forthcoming Paris COP, with the implicit rationale being that the sum total of all the INDCs submitted should provide a pathway to putting the world onto a 2°C trajectory beyond 2020.

So with COP-21 now imminent, what do the INDCs tell us about the level of global ambition on climate change, and is the outlook for a successful outcome in Paris positive or negative?

Expectations for COP-21: what would constitute a successful outcome?

Expectations management is always very important ahead of any major international climate negotiation, not least owing to the widespread sense of disappointment after the Copenhagen COP in 2009, which was the last time there was such a build-up to a COP as this one in Paris. In one sense, the expectations management has already been better than it was at Copenhagen owing to the nature of the process itself this time around. This is for two main reasons:

[5] *The Kyoto Protocol*, which was signed in 1997 and took effect over the period 2008-12, was the top-down climate deal negotiated at COP-3 in Kyoto, Japan. However, only industrialized countries were obliged to reduce their emissions on an absolute basis, with developing countries encouraged to reduce their emissions on a relative basis via participation in projects credited under the *Clean Development Mechanism*. Following the *widely perceived failure of COP-15 in Copenhagen*, an extension of the Kyoto Protocol into a so-called second commitment period covering 2013-20 was *subsequently agreed at COP-18 in Doha in 2012*, but this extension was agreed without the participation of a number of the countries that had signed up to the original Kyoto Protocol, and hence fell far short of the top-down deal that had originally been envisaged at COP-15 in Copenhagen. This explains why the negotiations from COP-19 in Warsaw onwards have focused on a bottom-up approach.

(i) Rather than attempting to deliver a major new top-down agreement with the full legal force of an international treaty (as the COP-15 summit in Copenhagen was trying to do), COP-21 is effectively attempting to deliver a more flexible arrangement – '*a protocol, another legal instrument, or an agreed outcome with legal force under the Convention applicable to all parties*' – making it much easier to accommodate the political sensitivities of certain jurisdictions (most notably the United States);

(ii) As it is already clear from the INDCs submitted that COP-21 will not itself be able to deliver a 2°C trajectory, Paris is not being seen as a make-or-break moment in itself (as Copenhagen very much was), but rather as an opportunity to begin a process that could then deliver a 2°C trajectory at a later date.

This being said, it is still far from certain that COP-21 can deliver an outcome that will be perceived as a success, and in our view a successful outcome requires: (i) credible backing with regard to the deliverability of the INDCs; and (ii) credible backing for a subsequent tightening of the INDCs such that the prospect of a 2°C deal remains alive beyond Paris.

And as world leaders prepare to gather in Paris, there are grounds for both optimism and pessimism regarding their ability to fulfil these two criteria.

COP-21: the grounds for thinking a strong outcome is possible

In our view there are three main factors that suggest COP-21 could deliver a strong policy outcome, particularly as compared with Copenhagen in 2009.

1. The US and China are much better synchronised this time around

One of the major obstacles to a deal in Copenhagen in 2009 was the disagreement between the industrialized countries on the one hand (particularly the United States), and the developing countries on the other (particularly China).

> "The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof." Article 3, paragraph 1, UNFCCC treaty, 1992

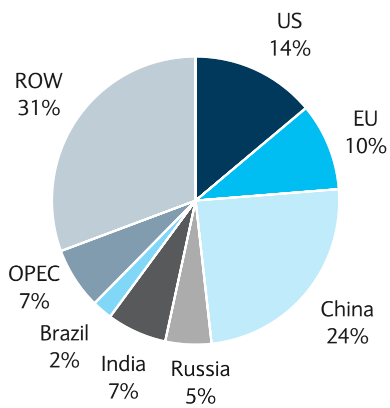
In itself this was nothing new, as the difficulty in reaching a global top-down agreement has always centred on how much of the burden for reducing emissions should be accepted by the developing countries given that most of the emissions historically have by definition come from the industrialized countries.

This was recognized in *the text of the 1992 UNFCCC treaty*, which established the concept of '*common but differentiated responsibilities*' to take account of the fact that developed countries had an obligation to take the lead on addressing climate change.

By 2009 and the Copenhagen COP, however, China had become the world's largest emitter, and as can be seen from Figure 14 and Figure 15 the most up-to-date figures available (2012) show that China on its own now accounts for the same volume of annual GHG emissions as the US and the EU combined.

FIGURE 14

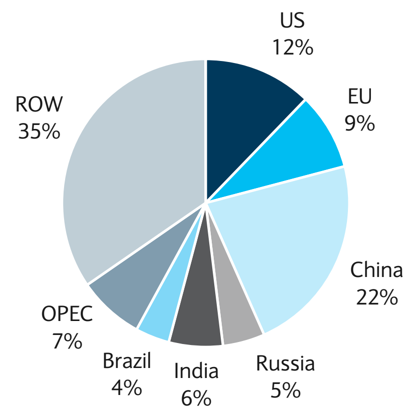
Breakdown of GHG emissions by major emitters (excluding Land-Use Change and Forestry), 2012



Source: World Resources Institute

FIGURE 15

Breakdown of GHG emissions by major emitters (including Land-Use Change and Forestry), 2012



Source: World Resources Institute

Against this backdrop, the tension over how the burden of responsibility for reducing emissions that effectively derailed COP-15 in Copenhagen might have proved even more insurmountable at COP-21, especially as India and certain other developing countries have only increased their share of global emissions since 2009. However, President Obama and President Xi Jinping made a joint declaration in Beijing in November 2014 that commits both countries to greater emissions reductions than either had previously been willing to agree to. In the case of the United States, President Obama committed to a reduction of 26-28% in GHG emissions by 2025 versus 2005, while in the case of China, President Xi Jinping committed Chinese GHG emissions to peaking by no later than 2030, and then falling in absolute terms beyond that date.

> "America is leading on climate change by working with other big emitters like China to encourage and announce new commitments to reduce harmful greenhouse gas emissions." President Barack Obama, November 2015

President Xi Jinping also committed China to sourcing 20% of its energy from non-fossil-fuel sources by 2030. These new targets went beyond earlier commitments, as the US previously had the objective of reducing GHG emissions by 17% by 2020 (versus 2005 levels), while China had previously talked only of reducing emissions relative to a business-as-usual baseline, resisting until this bilateral announcement any commitment to absolute reductions.

As such, the commitments by President Obama and President Xi Jinping were a significant development in advance of Paris, and the terms of the bilateral US-China deal were subsequently reflected in the two countries' respective INDCs.

Subsequent to the announcement between Presidents Obama and Xi Jinping last year, both leaders have fleshed out further their plans for reducing emission over time. For President Obama, the centrepiece of his strategy for addressing climate change is the *Clean Power Plan* announced in August of this year, while President Xi Jinping announced in September – while on a state visit to the United States – that *China would introduce a nationwide cap-and-trade system for carbon emissions from 2017*.

The Vatican and Climate Change: Pope Francis Issues an Encyclical

In addition to the breakthrough bilateral diplomacy on climate change between the United States and China over the last year, another significant diplomatic intervention in the last few months has come from a different kind of global leader: Pope Francis. In May 2015 the Vatican issued a *Papal Encyclical on climate change entitled Laudato Si*, which reiterated the scientific basis of climate change and emphasized the moral imperative to address it.

Paragraph 23 of the Encyclical is a bald statement on the science, and reads like a paragraph from one of the IPCC's assessment reports:

"A number of scientific studies indicate that most global warming in recent decades is due to the great concentration of greenhouse gases (carbon dioxide, methane, nitrogen oxides and others) released mainly as a result of human activity. As these gases build up in the atmosphere, they hamper the escape of heat produced by sunlight at the earth's surface. The problem is aggravated by a model of development based on the intensive use of fossil fuels, which is at the heart of the worldwide energy system."

And Paragraph 26 is a call to effective practical action to reduce emissions

"There is an urgent need to develop policies so that, in the next few years, the emission of carbon dioxide and other highly polluting gases can be drastically reduced, for example, substituting for fossil fuels and developing sources of renewable energy. (...) There is still a need to develop adequate storage technologies."

The Pope's call to action – *reiterated in his speech to the United Nations in September* – received very widespread attention, and this has increased the pressure on the world's political leaders to deliver a successful outcome at COP-21.

> "Climate change is a global problem with grave implications: environmental, social, economic, political and for the distribution of goods. It represents one of the principal challenges facing humanity in our day." Papal Encyclical of Pope Francis, May 2015

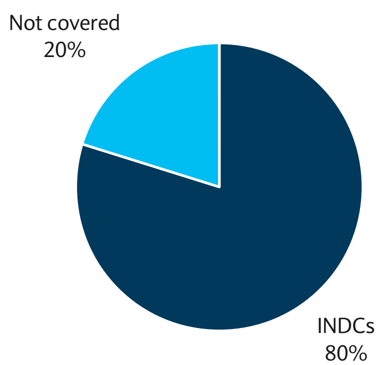
In short, the bilateral moves on climate change set out by the US and Chinese presidents over the last 12 months, while in no way on their own guaranteeing a successful outcome for COP-21, are nonetheless a very significant development, and represent a sea change in climate engagement by the world's two largest emitters as compared with their approach ahead of COP-15 in Copenhagen in 2009.

2. INDCs cover 80-85% of global emissions, far more than Kyoto Protocol

As of 1 October 2015, 119 INDCs had been submitted to the UNFCCC covering the plans of 146 countries. The INDCs set out the measures each country plans to implement by 2030 as their contribution to fighting climate change.[6]

FIGURE 16

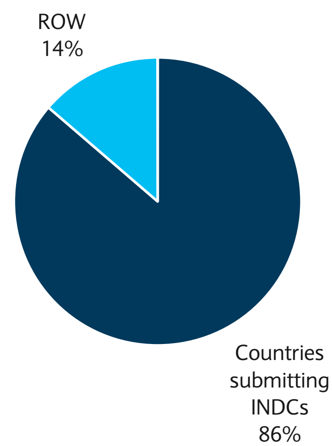
Amount of 2010 global emissions covered by measures set out in INDCs (incl. LULUCF)



Source: UNFCCC

FIGURE 17

Amount of 2010 global emissions accounted for by countries that have submitted INDCs (incl. LULUCF)

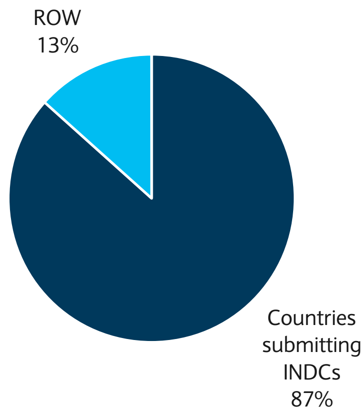


Source: UNFCCC

The UNFCCC analysis estimates that when added together the measures in the INDCs cover 80% of total global 2010 GHG-emissions (Figure 16) and that the total emissions of all the countries having submitted INDCs cover 86% of all 2010 emissions (Figure 17).

FIGURE 18

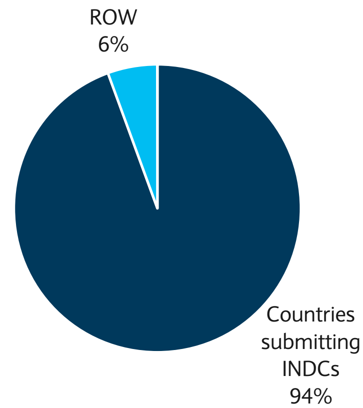
Amount of 2010 global population accounted for by countries that have submitted INDCs



Source: UNFCCC

FIGURE 19

Amount of 2010 global GDP accounted for by countries that have submitted INDCs

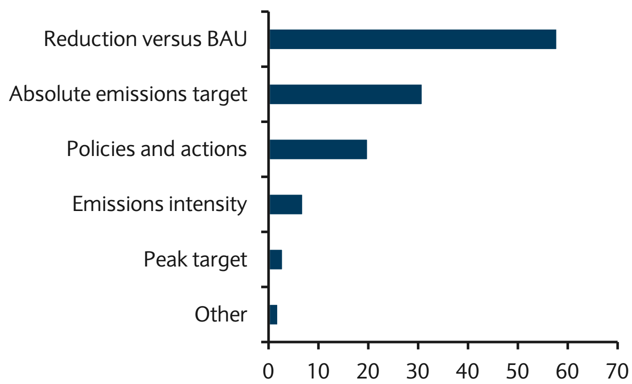


Source: UNFCCC

[6] In our summary here we have drawn on the detailed analyses of the INDCs published by the two relevant UN agencies: the UNFCCC'S *Synthesis report on the aggregate effect of the INDCs* published on 30 October, and UNEP's *Emissions Gap Report 2015*, published on 6 November, All industrialized countries' INDCs are unconditional, as are those of many developing countries. Other developing countries have submitted INDCs that are conditional on other factors (external assistance with financing for example), and the UNFCCC estimates that these conditional plans account for approximately 25% of the total emissions reductions targeted across all of the INDCs in aggregate.

FIGURE 20

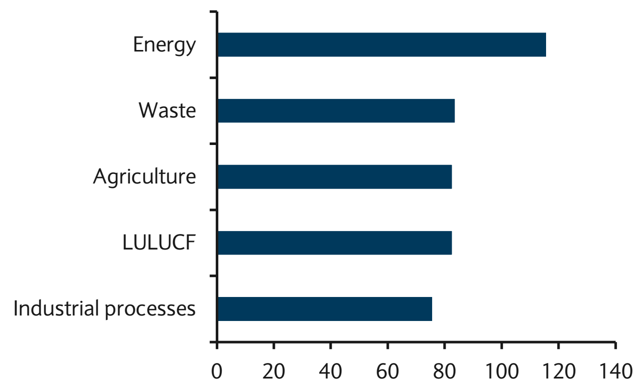
Mitigation targets in INDCs submitted by 1 October 2015



Source: UNFCCC

FIGURE 21

Sectors covered by the INDCs submitted by 1 October 2015



Source: UNFCCC

On the UNFCC's calculations, the countries submitting INDCs account for 87% of the world's 2010 population, and 94% of 2010 global GDP (Figures 18 and 19). Figure 20 shows the breakdown of mitigation targets included in the INDCs submitted by 1 October, and Figure 21 the sectors targeted for policy action. The most common form of mitigation target adopted in the INDCs is a relative target versus a business-as-usual (BAU) reference case (58/119 INDCs), followed by absolute reduction targets (31/119). As far as the sectors covered are concerned, nearly all of the INDCs are targeting the energy sector (116/119), underlining the dominant role of energy in terms of GHG emissions.[7]

Figure 22 shows the headline emissions-reduction targets of the INDCs submitted by the world's 10 largest GHG emitters. Six countries – the US, the EU, Russia, Japan, Canada, and Brazil – have absolute emissions-reduction targets, while China and India have opted for emissions-intensity targets, and South Korea and Mexico for relative reductions versus BAU.

FIGURE 22

INDC submissions to COP-21 of top 10 emitters of GHGs (excluding LULUCF)

Country	Targets in INDCs
China	Peak GHG emissions by 2030 or earlier and reduce carbon intensity of GDP by 60-65% below their 2005 levels by 2030
US	Reduce net GHG emissions by 26-28% below 2005 levels by 2025
EU	Reduce EU domestic GHG emissions by at least 40% below 1990 levels by 2030
India	Reduce the emissions intensity of GDP by 25-30% below 1990 levels by 2030
Russia	Reduce anthropogenic GHG emissions by 25-30% below 1990 levels by 2030 subject to the maximum possible absorptive capacity of forests
Japan	Reduce energy-related CO_2 emissions by 25%, reduce non-energy CO_2 emissions by 6.7%, CH_4 by 12.3%, and fluorinated gases by 25.1% compared with 2013 levels by 2030
South Korea	Reduce GHG emissions by 37% by 2030 compared with BAU
Canada	Reduce GHG emissions by 30% below 2005 levels by 2030
Brazil	Reduce GHG emissions by 37% compared with 2005 levels by 2025
Mexico	Reduce GHG and short-lived climate-pollutant emissions unconditionally by 25% by 2030 with respect to BAU

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015)

[7] We look at this in greater detail in the next main section below, *The IEA Scenarios: Different Degrees of Carbon Constraint*.

"The weight of the energy sector in global GHG emissions means that any agreement reached at COP-21 must have the energy sector at its core." International Energy Agency, World Energy Outlook, November 2015

The level of coverage and engagement displayed in the INDCs is much higher than what has been achieved under the top-down approach of the Kyoto Protocol. Taking *the 2012 GHG-emissions numbers compiled by the World Resources Institute*, we estimate that under the first Kyoto commitment period covering 2008-12, the countries that signed up to emissions targets accounted for only 30% of the global total, compared with the 86% covered by the countries that have so far submitted INDCs (as shown in Figure 17 above).

Moreover, given that the US never ratified Kyoto and Canada withdrew, we estimate that in the end the total world emissions covered under the first Kyoto commitment period came to only 16%. Under the second Kyoto period (2013-20), and again taking the WRI's 2012 numbers, we estimate the amount of global emissions covered at an even lower 12%.

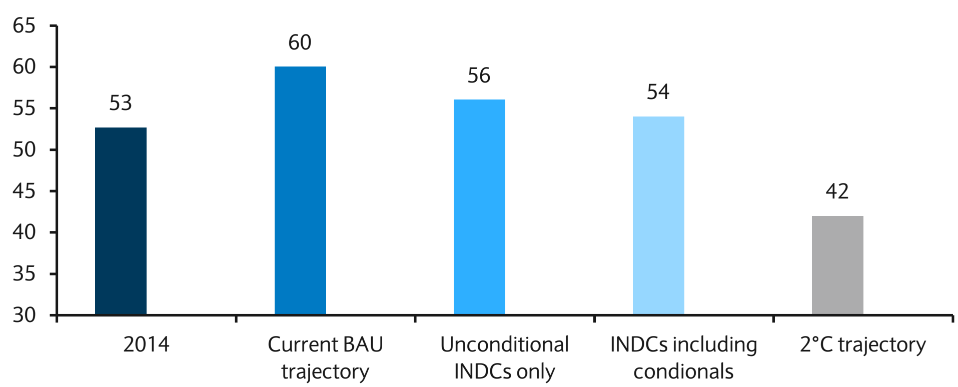
In short, the first reason the INDCs give grounds for thinking COP-21 can deliver a strong policy outcome is that they demonstrate an unprecedented level of engagement for mitigating global GHG emissions, covering as they do roughly five times the level of global emissions that were ultimately covered under the first Kyoto commitment period, and seven times the level covered under the second.

The second reason is that UNEP estimates that the implementation of the INDCs will lead to a reduction in global emissions of 4-6 billion tonnes (gigatonnes, or Gt) of CO_2e by 2030 versus the current business-as-usual trajectory.

As shown in Figure 23, annual global GHG-emissions are estimated to reach 60Gt by 2030 on a BAU basis, but UNEP estimates this would fall to 56Gt with the full implementation of all INDCs, and to 54Gt including the conditional measures on top.

FIGURE 23

Projected GHG-emissions by 2030 versus 2014 actual under different scenarios (Gt)*



Source: UNEP; *The figure given for 2030 under each scenario is the middle of an estimated emissions range

> "The INDCs have the capability of limiting the forecast temperature rise to around 2.7 degrees Celsius by 2100, by no means enough but a lot lower than the estimated four, five, or more degrees of warming projected by many prior to the INDCs." Christiana Figueres, UNFCCC Executive Director, October 2015

This represents a significant step towards the ultimate goal of a 2°C trajectory, with the recent *UNEP Emissions Gap 2015* report estimating that full implementation of all INDCs would likely be consistent with warming of 3-3.5% or less by the end of this century, compared with a much higher temperature range of 4-7% under the business-as-usual trajectory. That said, and as both the UNFCCC and UNEP acknowledge, the INDCs still fall a long way short of a 2°C trajectory, getting the world only one third of the way to plugging the so-called emissions gap – 6Gt out of a total 18Gt – between business-as-usual emissions in 2030 of 60Gt on the one hand, and the 42Gt consistent with a 2°C trajectory on the other.[8]

Another way at looking at this is to take the IEA's analysis of future energy and emissions trends under its two key scenarios – the base-case scenario known as the New Policies Scenario (NPS) and the scenario consistent with 2°C known as the 450-Scenario (450S) – and compare the difference between the IEA's 2014 and 2015 modelling of these scenarios in the respective 2014 and 2015 World Energy Outlook (WEO) publications.

As shown in Figure 24, we estimate that the emissions gap between the 2014 and 2015 analyses is lower by 24Gt in the 2015 WEO (which takes the INDCs into account in its NPS, albeit on a limited basis) than it is in the 2014 WEO (which pre-dated the INDCs). The reduction of 24Gt in the emissions gap attributable to the INDC is a significant step, but as can be seen it reduces the gap to the 450S by only about one-tenth of what is required.[9]

FIGURE 24

Barclays estimate of cumulative CO_2 emissions from energy over 2015-40 under the IEA's NPS and 450S as set out in the 2014 and 2015 WEO publications (Gt)

	NPS	450S	Emissions gap
2014 WEO	934	682	**-252**
2015 WEO	909	681	**-228**
Difference	**-25**	**-1**	**24**

Source: Based on IEA data from the World Energy Outlook © OECD/ IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

In short, while undoubtedly a significant development, the INDCs can only be seen as the first drafts of measures and policies that will need tightening in future climate negotiations beyond Paris if the world is ultimately to remain within a 2°C budget.

[8] In particular given that two thirds of the emissions gap to 2030 is left unfilled by the INDCs, the UNFCC estimates that the world still burns through three quarters of the remaining carbon budget compatible with a 2°C world by 2030, We discuss this point in greater detail below.

[9] We analyze the IEA's 2015 WEO scenarios in much greater detail below in the following two main sections of this report, but the IEA emphasizes that it has taken a 'cautious' approach to modeling the impact of the INDCs, such that if the full implementation of all INDCs were assumed the reduction in the emissions gap would be greater than 24Gt and more in line with the one-third reduction in the emissions gap estimated by UNEP.

3. Renewable-energy costs have fallen dramatically since COP-15 in 2009

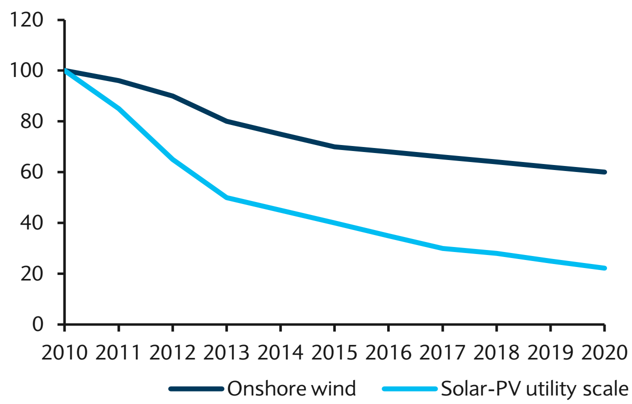
The cost of the major renewable-energy technologies has fallen sharply since COP-15 back in 2009, and this transforms the context of discussions over future mitigation costs.

The IEA's *2015 Renewable Energy Medium-Term Market Report* shows just how much the cost of onshore-wind and utility scale solar-PV generation has fallen over the last five years, and by how much more costs could fall by 2020 under IEA assumptions.

Figure 25 shows the historic reduction in the costs of these technologies since 2010 and projected further cost reductions out to 2020, and Figure 26 the same data but on an absolute cost-of-generation in real terms (constant 2014 $/MWh).

FIGURE 25

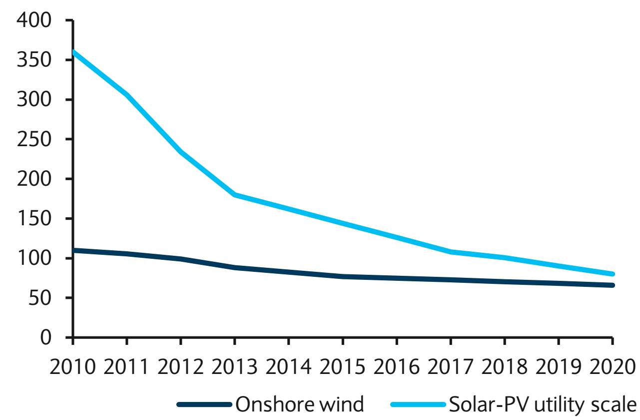
Indexed change in the LCOE for onshore wind and Solar-PV at utility scale, with 2010 reference value of 100*



Source: IEA; *The values shown are indicative estimates of the global weighted average LCOE based on the IEA's Medium-Term Market Report deployment forecast, and may not represent specific developments in a given market.

FIGURE 26

Historic and projected change in the LCOE for onshore wind and Solar-PV at utility scale (constant 2014 $/MWh)*



Source: IEA; * The values shown are indicative estimates of the global weighted average LCOE based on the IEA's Medium-Term Market Report deployment forecast, and may not represent specific developments in a given market.

The falling cost of renewables means that the IEA already expects their share in the global energy mix to increase sharply over 2014-40 even without the extra policy measures that would be required to achieve a 2°C pathway.

FIGURE 27

Renewables in total primary-energy demand (PED) under the IEA's NPS, 2014-40 (mtoe)

	2013	2020	2030	2040	Increase by 2040 over 2013
TOTAL PED	13,559	14,743	16,349	17,934	*32.3%*
o/w Renewables	1,863	2240	2,785	3,346	*79.6%*
% of renewables in PED	*13.7%*	*15.2%*	*17.0%*	*18.7%*	

Source: IEA World Energy Outlook 2015 (© OECD/IEA 2015)

Under the IEA's NPS (Figure 27), production of renewable energy increases by 80% over the IEA's forecast period (to (3,346mtoe from 1,863mtoe), whilst primary-energy demand overall increase by only 32%. As a result, renewables increase their share in the mix to 19% by 2040 from 14% in 2013.

In short, the much more competitive economics of renewables relative to fossil fuels in 2015 than was the case in 2009 are a second reason to think that countries might now be more willing to sign up to a strong policy outcome at COP-21.

COP-21: the grounds for thinking COP-21 will struggle to deliver a strong outcome

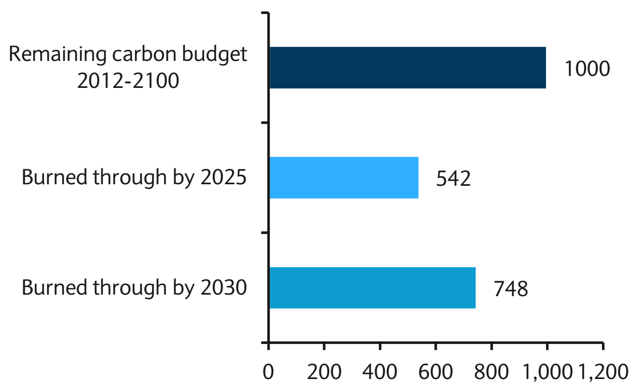
In terms of the obstacles to a strong outcome, we would highlight three main points.

1. The INDCs burn through three-quarters of remaining 2°C budget by 2030

The IPCC's Fifth Assessment Report posited a carbon budget consistent with achieving a 2°C world. The calculation starts from the total amount of cumulative emissions of all GHGs consistent with this target and then deducts the amount already emitted since 1870. After allowing for the emissions of other GHGs, the IPCC estimates the total amount of cumulative CO_2 emissions from 1870 onwards that is likely compatible with a 2°C outcome[10] at 2,900Gt, of which 1,900Gt were already burned over 1870-2011, thereby leaving a residual budget of 1,000Gt from 2012 onwards.[11] Under a scenario with only a 50% chance of achieving a 2°C outcome, the IPCC gives a higher remaining carbon budget of 1,300Gt.

FIGURE 28

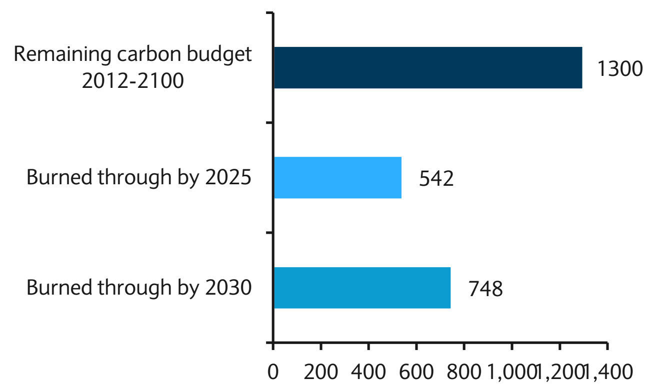
Communicated INDCs' implied consumption of IPCC carbon budget likely consistent (>66% chance) with 2°C



Source: UNFCCC, IPCC

FIGURE 29

Communicated INDCs' implied consumption of IPCC carbon budget with 50% chance of being consistent with 2°C



Source: UNFCCC, IPCC

Figures 28 and 29 show the UNFCC's estimates of the extent to which these respective budgets over 2012-2100 are consumed by 2025 and 2030 under the communicated INDCs. As can be seen, under the tighter scenario that is likely consistent with a 2°C world (i.e. >66% chance), 54% of the remaining carbon budget (542Gt/1,000Gt) is consumed by 2025, and 75% by 2030. Even under the looser scenario consistent with only a 50% chance of achieving a 2°C outcome (Figure 14), the INDCs consume 42% of the remaining budget by 2025 (542Gt/1,300Gt), and 58% by 2030 (748Gt/1,300Gt).

This means that although the INDCs undoubtedly represent a significant step forward against business-as-usual projections, they will clearly need to be tightened up significantly at a later date if a 2°C world is to remain within reach. And getting widespread agreement on the process to review the implementation of the INDCs and to tighten them further in the future could be a significant political challenge.

As the UNFCCC itself notes, this is where the discussions around the monitoring-and-review process of the INDCs at COP-21 will be so crucial:

[10] In the IPCC terminology, 'likely' is taken to mean having a >66% chance.

[11] For those interested in a more detailed analysis of the IPCCs carbon-budget calculations, the *Stockholm Environment Institute's detailed analysis* is extremely useful.

"The new climate-change agreement to be agreed in Paris can anchor the INDCs in terms of recognition, accountability and adequate support that will encourage the extra, required ambition to emerge."

And the question of *'adequate support'* – for which read financing – raises a second obstacle to a strong policy outcome at COP-21.

2. Financing remains a major sticking point

The question of financial support for developing countries is a long-standing one in international climate negotiations, especially since COP-15 in Copenhagen when the world's wealthier countries committed to establishing a *Green Climate Fund* (GCF), which was subsequently enacted at COP-16 in Mexico. The commitment given under the GCF was that wealthier countries would ramp up annual financial flows to developing countries to assist with the fight against climate change to $100bn per year by 2020.

However, progress towards this target has been the subject of increasing strain between the developed and developing world in the run-up to Paris, *with prominent NGOs warning* that it will be impossible to secure a meaningful deal at COP-21 unless developing countries believe the question of climate financing is being seriously addressed.

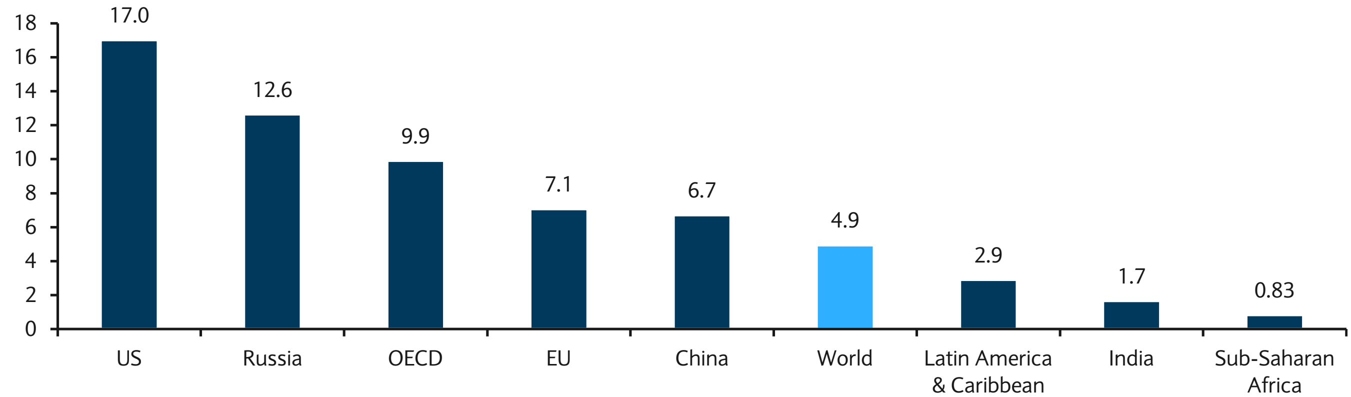
> "We can take nothing for granted with the COP, anything is possible. Some might say 'it can happen later at another conference'. But if it does not happen at Paris, it will not happen later, it will be too late for the world." President Francois Hollande, September 2015

The host of COP-21, President François Hollande, is well aware of *the potential for this issue to undermine the success of the Paris summit*, and in a speech to the United Nations in September he pledged to increase France's own contribution to the GCF by €2bn per year by 2020, bringing France's annual contribution by that date to €5bn.

One of the main reasons for this tension between developed and developing countries is that per-capita emissions for developing countries are generally much lower than those of developed countries (Figure 30).

FIGURE 30

Per-capita GHG emissions of selected countries versus world average, 2011 (metric tonnes)



Source: World Bank

As can be seen, even China – despite now being the world's largest GHG emitter in absolute terms – has significantly lower per-capita emissions than the US, Russia, the OECD, and the EU, while Latin America and the Caribbean, India, and Sub-Saharan Africa are all well below the global average.

This disparity between per-capita emissions on the one hand, and average income levels on the other, is the ultimate source of the strain between industrialized and developing countries over climate financing. After all, developing countries by definition have not contributed to climate change to anything like the same extent as industrialized countries, and their overwhelming economic objective is to raise the average standard of living of their citizens. If they are to eschew the fossil-fuel driven route to development and higher living standards pursued by the industrialized world, then they quite understandably insist that they receive adequate financial, technical, and logistical assistance.

It is hard to know how negotiations over climate financing will play out in Paris and whether this issue could ultimately prevent a strong outcome, but at the very least we think the level of ambition and urgency on the part of the leading developed countries will have to be increased at COP-21 if developing countries are going to agree to a meaningful deal.

3. How to prioritise given so many other pressing global challenges?

The final issue that we see as a potential obstacle to a strong outcome in Paris is the simple fact that global leaders have many other pressing issues to worry about at the moment, ranging from the state of the global economy to global and regional security issues. Of course, global leaders are used to juggling many complex issues at the same time, but this particular COP comes at a time of heightened geo-political tension in general and an unprecedented level of tension in Paris following the recent terrorist attacks.

A concerted exercise in global leadership is required if the strongest possible deal is to be struck in Paris. It is difficult to predict whether recent events might strengthen or weaken global leaders' resolve to reach an agreement.

The economics of climate change: risk awareness growing

The economic impact of climate change impinge most directly on the energy industry, and we discuss the implications of a 2°C trajectory on the energy sector in greater detail in the next two main sections of this report.

At the same time, though, financial regulators and investors are also becoming increasingly sensitised to the risks they face from climate change. In particular, the Governor of the Bank of England, Mark Carney, has been increasingly vocal on the broader economic risks posed by climate change, and the G20 group of countries is now potentially poised to examine climate risk in greater detail under China's presidency in 2016.

The Bank of England and the Financial Stability Board enter the debate

In *a widely reported intervention at the World Bank in October 2014*, Mark Carney stated that the vast majority of hydrocarbon reserves are unburnable if the world wants to avoid the worst effects of climate change.

The Bank of England Governor's remarks were made in the context of a discussion on *integrated reporting*, which is the idea that in addition to disclosing information on current issues impacting their operating and financial performance companies should also analyse and disclose their exposure to longer-term risks that might have an impact on their future performance, especially where policy is likely to change over time.

The Governor gave climate change as a prime example of such a long-term risk where policy would likely become tighter over time.

> The challenges currently posed by climate change pale in significance with what might come. Once climate change becomes a defining issue for financial stability, it may already be too late." Mark Carney, Bank of England Governor, September 2015

More recently, Governor Carney made *a speech to the London insurance market* in September 2015 called *"Breaking the tragedy of the Horizon"*. The speech was widely reported in *the business and financial media*, and stated that *"any efficient market reaction to climate-change risks as well as the technologies and policies to address them must be founded on transparency of information"*.

In addition to being the Governor of the Bank of England, Mark Carney is also Chairman of the Financial Stability Board (FSB), and following on from Governor Carney's speech in September the *FSB has now formally proposed to the G20 that a disclosure task force be set up on climate-related risks*, and that it be modelled on the FSB's existing Enhanced Disclosure Task Force.

It remains to be seen how the G20 will respond to this proposal, but COP-21 obviously offers an opportunity for both the leaders of G20 countries and for the UNFCCC more broadly to endorse the idea. Concerted global regulatory pressure for greater disclosure from companies on the risks they face from climate change would enable shareholders and other stakeholders to make better informed decisions, and thereby further reinforce investor initiatives around portfolio decarbonisation. It will therefore be worth keeping a close eye on the G20's response to this issue.

Investor decarbonisation initiatives growing

The increasing focus on the risks surrounding the impact of climate change on the incumbent energy sector have prompted an increasing focus on the part of institutional and sovereign investment funds on the carbon intensity of their portfolios.

These initiatives centre on three main activities:

- **Measuring portfolio carbon risk:** A good example of this is the *Montreal Pledge*, an initiative supported by the United Nations Environment Programme Finance Initiative (UNEPPFI) and the Principles for Responsible Investment.
- **Decarbonising portfolios:** A good example of this is the *Portfolio Decarbonisation Coalition*, a joint initiative between the UNEPFI and institutional investors.
- **Divesting from fossil-fuel holdings:** Calls for and decisions to proceed with, the outright divestment of fossil-fuels have been led by academic, faith-based, and charitable foundations (*Divest-Invest* being a good example), but *institutional* and *sovereign investment funds* are also starting to divest from fossil fuels, especially coal.

Conclusion: World leaders key to success of COP-21

We think a successful outcome to COP-21 will hinge on countries' willingness to accept both: (i) regular reviews of how the implementation of their INDCs is proceeding beyond COP-21; and (ii) a process that would allow for the tightening of the targets in their INDCs at a later date. We also think that the key to achieving such an outcome lies to a large extent in the political will for a deal shown by the heads of government who will be assembling in Paris at the beginning of the talks.

> "It is essential that the Paris Agreement adopt a dynamic approach in which ambitions, the mobilization of climate finance and other forms of cooperation can be adjusted upwards at regular intervals." Achim Steiner, UNEP Executive Director, November 2015

First, France's President Hollande visited China at the beginning of this month and made a joint declaration with his Chinese counterpart, Xi Jinping that emphasised the importance that both countries attach to securing a meaningful deal in Paris. *The full 21-point declaration* is available on the French Government's website, and covers all of the main points we have reviewed above concerning the ultimate objective and the modalities for achieving this, as explained in Point 2 of the joint declaration:

"President Xi Jinping and President François Hollande strengthen their resolve to work together and with leaders of all other countries to reach an ambitious and legally binding Paris agreement on the basis of equity and reflecting the principle of common but differentiated responsibilities and respective capabilities, in light of different national circumstances, mindful of the below 2°C global temperature goal."

Crucially, the two presidents fully endorsed the principle of securing a process at COP-21 that will allow the implementation of the INDCs to be effectively monitored and subsequently tightened so that a 2°C deal can remain within play beyond COP-21:

"Both sides also agree that the Paris agreement shall include provisions for Parties to formulate, communicate, implement and regularly update their nationally determined contributions. They support taking stock every five years and in a comprehensive manner of overall progress made towards reaching the agreed long-term goals. The results of this stock-take will inform Parties in regularly enhancing their actions in a nationally determined manner."

"China and France stress the importance of shifting the global economy onto a low carbon path in the course of this century, at a rhythm consistent with strong economic growth and equitable social development, and the below 2°C global temperature goal." President Jinping & President Hollande, Beijing, 2 November 2015

The second recent development adding momentum to the build-up to COP-21 is President Obama's decision on 6 November to reject the Keystone XL pipeline. *In his statement rejecting the pipeline as published on the White House website*, President Obama explicitly linked his decision with climate change and with the need of the United States to show global leadership on this issue ahead of COP-21 in Paris. This indicates that President Obama views a meaningful deal in Paris as a priority for his own political legacy.

We think these developments, while in no way guaranteeing a successful outcome in themselves, do at least show that there seems to be the kind of political will necessary amongst the world's two largest emitters, and the host country, to secure a meaningful deal at COP-21 that can then be revisited and strengthened in future negotiations. It now remains to be seen how things play out.

So much for the background to COP-21, but what about the potential impact on the energy sector as the sector most directly affected by a tightening of global climate policies?

THE IEA SCENARIOS: DIFFERENT DEGREES OF CARBON CONSTRAINT

GHG emissions from energy are by far the most important single component, accounting for over two-thirds of the anthropogenic total. This is why the INDCs are so focused on measures designed to reduce energy emissions, and why the IEA has been so prominent in devising practical policy scenarios in recent years to help advise on the energy transition required to put the world on a 2°C trajectory.

In its updated scenario analysis published earlier this month in the World Energy Outlook 2015, the IEA's modelling of an energy path consistent with a 2°C world displays a sharp divergence with its base-case scenario (even though the agency's updated base-case scenario out to 2040 does take account to varying degrees of different countries' INDCs).

The share of fossil fuels in the energy mix is much lower under the IEA's carbon-constrained scenario consistent with 2°C (the 450-Scenario) than it is under the IEA's base-case scenario (the New Policies Scenario), and so too, as a result, are fossil-fuel investments and prices. By contrast, the share of renewables is much higher under the 450S, as is the emphasis on energy efficiency. Overall, total fossil-fuel investments under the 450S are $6.4trn lower under the 450S, while investments in low-carbon energy sources and energy efficiency are some $14trn higher.

As we have already said above, COP-21 in itself will not deliver a 2°C deal, but a strong agreement in Paris next month could nonetheless keep that aspiration alive, with far-reaching implications for future investments across the energy sector.

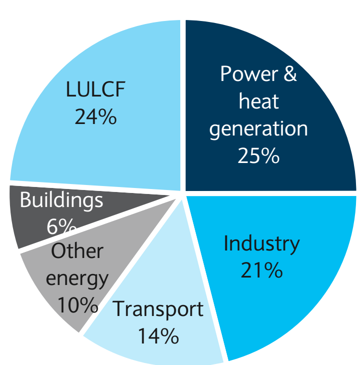
Global energy emissions in context

Figure 31 shows the breakdown of total anthropogenic GHG-emissions by activity in 2010, and Figure 32 the breakdown of CO_2 emissions energy in 2012. Energy accounts for nearly 70% of global GHG emissions, and 90% of total energy emissions are CO_2.

This explains why decarbonising the global energy system is so crucial, and why the outcome of COP-21 will be so important as far as the signals for the future of different energy sources are concerned.

FIGURE 31

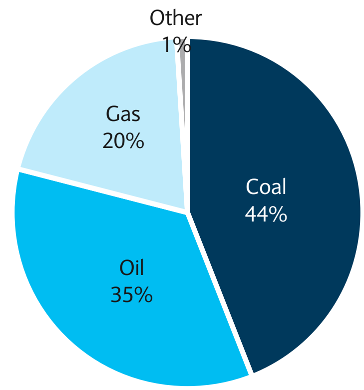
Breakdown of global anthropogenic emissions by source, 2010 (49Gt in total)



Source: IPCC, Fifth Assessment Report

FIGURE 32

World CO_2 emissions from energy, 2012



Source: IEA, CO_2 Emissions from Fuel Combustion 2014

The IEA's WEO: modelling the impact of the INDCs and the 450-Scenario

The IEA first modelled the impact of a policy framework designed to achieve a 2°C trajectory in its *World Energy Outlook 2010* in order to help policymakers towards the most efficient way of achieving the target their governments signed up to at COP-16 in Cancun. The IEA calls this their 450-Scenario, after the IPCC's recommendation that GHG-concentrations in the atmosphere be stabilised at 450ppm for a 2°C outcome.

The 450S is in effect a practical sensitivity analysis against the agency's base-case scenario for energy markets out to 2040 – known as the New Policies Scenario (NPS) – that enables policymakers to gauge the gap between the world's current energy and emissions trajectory on the one hand, and the trajectory that would be necessary to achieve a 2°C outcome on the other.

In the 2015 World Energy Outlook (2015 WEO) published earlier this month, the IEA updated its NPS to incorporate its estimate of the impact the INDCs submitted ahead of COP-21 will have on global energy production and consumption patterns. However, the NPS in this year's WEO does not assume the full implementation of the INDCs, and includes in its impact analysis only those measures in INDCs that are supported by what the IEA views as feasible policies.

What this means is that there is still a significant gap – as there has been in every WEO published since 2010 – between the emissions profile projected under the NPS on the one hand, and the 450S on the other, although the INDCs have contributed to narrowing this emissions gap versus the one projected last year in the 2014 WEO.

In addition to the value it holds for policymakers, the IEA's scenarios framework is extremely useful for energy companies and investors as they try to understand the implications of an increasingly carbon-constrained world. In this section and the next we analyse the difference between the NPS and 450S in terms of some key metrics for companies and investors (energy investments and revenues out to 2040), with a view to drawing out what is ultimately at stake at COP-21 on a long-term basis.

The IEA's policy-modelling framework

The IEA's *2015 World Energy Outlook* (2015 WEO) published earlier this month contains three scenarios for global energy-market trends out to 2040. These scenarios are:

- The New-Policies Scenario (NPS): This is the IEA's base-case scenario for global energy and emissions trends out to 2040. The NPS models *"the policies and implementing measures that had been adopted as of mid-2015"* (2015 WEO: p.31). This means it also incorporates the energy-related aspects of the INDCs that had been submitted by 1 October, "*albeit in a cautious manner"* (2015 WEO: p.57);

- The 450-Scenario (450): This models the energy path consistent with a global policy framework aimed at restricting GHG emissions to 450pmm of CO_2e. As such *"it depicts a pathway to the 2°C climate goal that can be achieved by fostering technologies that are close to becoming available at commercial scale"* (2015 WEO: p. 31);

- The Current Policies Scenario (CPS): This is the business-as-usual scenario, as it *"takes into account only policies enacted as of mid-2015"* (2015 WEO: p.31) and hence assumes no further tightening of energy or climate policies over the next two decades. As the CPS assumes no changes at all to current policies over the next two decades we do not consider it in our analysis here.

Figures 33 and 34 show the IEA's NPS and 450S respectively over 2015-2040.

Global primary energy demand stood at 13,558m tonnes of oil equivalent (mtoe) in 2013, and under the NPS this increases by 32% by 2040 versus 2013 to 17,935mtoe. The demand for fossil-fuel energy increases by 21% (to13,388mtoe from 11,049mtoe). Output from renewable-energy sources grows by 80%, and covers 19% of global demand by 2040 compared with 14% in 2013.

FIGURE 33

Global primary-energy demand (mtoe) and CO_2 emissions (Gt) under the IEA's NPS

	NPS				Change 2040 v 2013	
	2000	**2013**	**2020**	**2040**	**mtoe**	**%**
Oil	3,669	4,219	4,461	4,735	516	*12.2%*
Gas	2,067	2,901	3,178	4,239	1,338	*46.1%*
Coal	2,343	3,929	4,033	4,414	485	*12.3%*
Total FFs	**8,079**	**11,049**	**11,672**	**13,388**	**2,339**	***21.2%***
Nuclear	676	646	831	1201	555	85.9%
Hydro	225	326	383	531	205	62.9%
Bio-energy	1,023	1,376	1,541	1,878	502	36.5%
Other renewables	60	161	316	937	776	482.0%
Total renewables	**1,308**	**1,863**	**2,240**	**3,346**	**1,483**	***79.6%***
TOTAL WORLD PED (mtoe)	**10,063**	**13,558**	**14,743**	**17,935**	**4,377**	***32.3%***
Total CO_2 emissions (Gt)	***23.2***	***31.6***	***33.1***	***36.7***	***5.0***	***16.1%***

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015)

Under the 450S, global demand increases by a much lower 12% to 15,197mtoe, with the demand for fossil fuels falling by 17% to 9,181mtoe). Renewable energy more than doubles in absolute terms to 4,389mtoe in 2040 from 1,863mtoe in 2013, increasing its relative share of demand from 14% in 2013 to 29% in 2040.

FIGURE 34

Global primary-energy demand (mtoe) and CO_2 emissions (Gt) under the IEA's 450S

	450S				Change 2040 v 2013	
	2000	**2013**	**2020**	**2040**	**mtoe**	**%**
Oil	3,669	4,219	4,356	3,351	-868	*-20.6%*
Gas	2,067	2,901	3,112	3,335	434	*15.0%*
Coal	2,343	3,929	3,752	2,495	-1,434	*-36.5%*
Total FFs	**8,079**	**11,049**	**11,220**	**9,181**	**-1,868**	***-16.9%***
Nuclear	676	646	839	1,627	981	*151.9%*
Hydro	225	326	384	588	262	*80.4%*
Bio-energy	1,023	1,376	1,532	2,331	955	*69.4%*
Other renewables	60	161	332	1,470	1,309	*813.0%*
Total renewables	**1,308**	**1,863**	**2,248**	**4,389**	**2,526**	***135.6%***
TOTAL WORLD PED (mtoe)	**10,063**	**13,558**	**14,307**	**15,197**	**1,639**	***12.1%***
Total CO_2 emissions (Gt)	***23.2***	***31.6***	***31.5***	***18.8***	***-13***	***-40.5%***

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015)

In short, the rate of growth in demand is much lower under the 450S (12%) than under the NPS (32%), and the composition of demand is also very different.

The delta in the energy mix: 450S sees much quicker energy transition

Under the NPS the demand for all fossil fuels continues to rise over the next two decades, while under the 450S the demand for both coal and oil declines, with gas the only fossil fuel to see an increase.

Looking at the cumulative impact over the entire period 2014-40, we estimate that relative to the NPS demand for fossil fuels under the 450S would be lower by 48,000mtoe (48Gtoe), which is equivalent to four years of fossil-fuel demand at the 2013 rate of consumption.

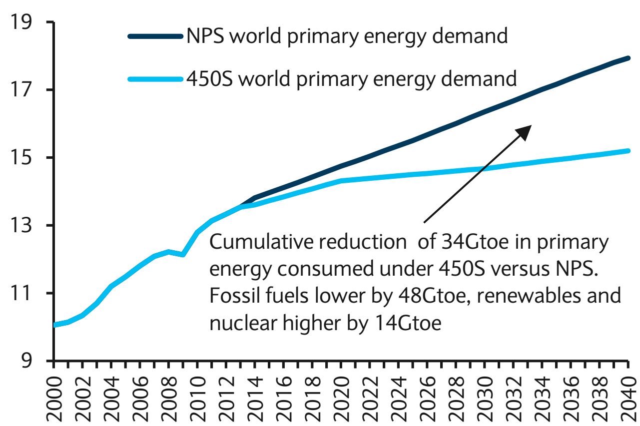
By contrast, we estimate that the contributions from renewables and nuclear are higher by a cumulative 10Gtoe and 4Gtoe respectively, such that zero and low-carbon energy sources increase by a cumulative 14Gtoe under the 450S relative to the NPS.

Accordingly, we estimate that total global primary energy demand is lower by a cumulative 34Gtoe under the 450S than it is under the NPS (Figure 35).

As a result of this change in the energy mix, 2040 energy emissions under the NPS are 18Gt higher than under the 450-Scenario (37Gt and 19Gt respectively). On our calculations, this means that CO_2 emissions under the 450S are lower by a cumulative 228Gt versus the NPS over 2015-40 at 681Gt and 909Gt respectively (Figure 36).

FIGURE 35

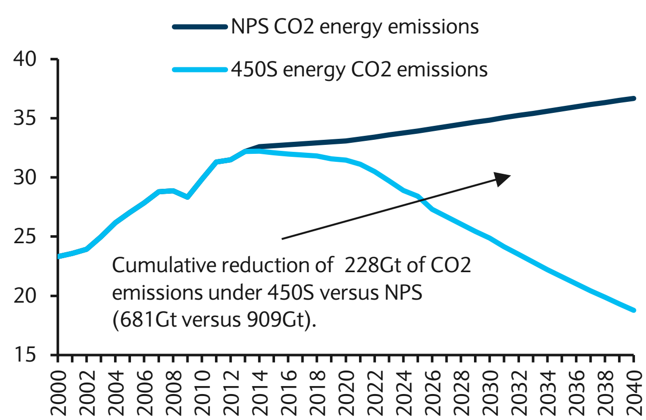
Barclays' estimate of world primary energy demand under NPS and 450S (mtoe)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

FIGURE 36

Barclays' estimate of world CO_2 energy emissions under NPS and 450S (Gt)



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Breaking down the change in primary-energy demand by source in the 450S versus the NPS (Figure 37), we see fossil fuels lower by 48Gtoe, but reneawbles higher by 10Gtoe and nuclear higher by 4Gtoe.

Aggregating all of the emissions savings achieved under the 450S relative to the NPS, we estimate that reduced demand for coal accounts for 58% of total CO_2 savings from energy over the period, oil for 25%, and gas for 17% (Figure 38).

Figures 39 and 40 then show our estimate of the breakdown of total cumulative primary-energy demand over 2015-40 under the NPS and 450S respectively.

FIGURE 37

Barclays' estimate of delta in total cumulative energy demand between NPS and 450S by fuel source, 2015-40 (Gtoe)

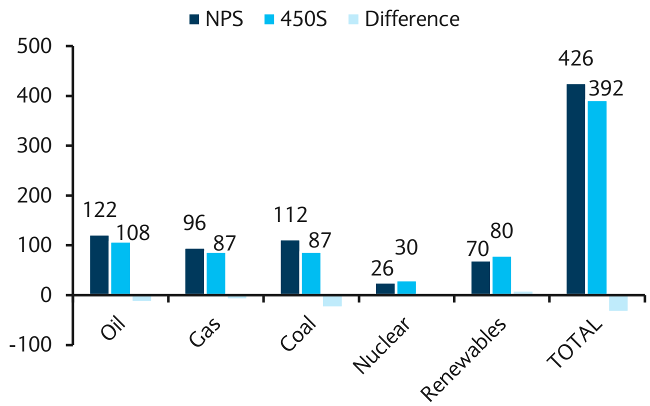

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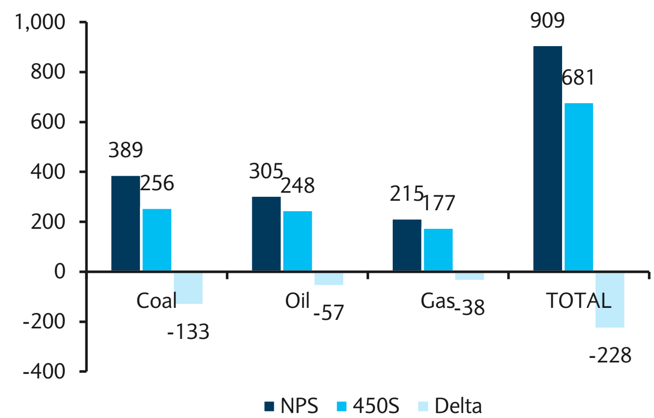
FIGURE 38

Barclays' estimate of delta in total cumulative emissions from fossil-fuels between NPS and 450S by fuel source, 2015-40 (Gt)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: *www.iea.org/t&c/termsandconditions*. Also based on Barclays Research estimates

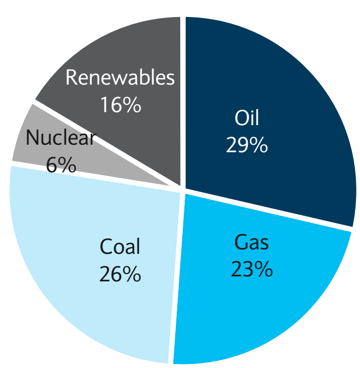
Under the NPS, we estimate that fossil fuels account for 78% (330Gtoe) of total cumulative demand over 2015-40, renewables 16% (70Gtoe), and nuclear 6% (26Gtoe).

Under the 450S, we estimate that the share of fossil fuels in total cumulative demand is lower at 71% (282Gtoe), and zero- and low-carbon sources higher, with renewables accounting for 20% (80Gtoe) and nuclear for 8% (30Gtoe).

This stark difference between the two scenarios in terms of global fossil-fuel demand and CO_2 emissions reflects the much tougher energy-and-climate policy framework assumed under the 450S.

FIGURE 39

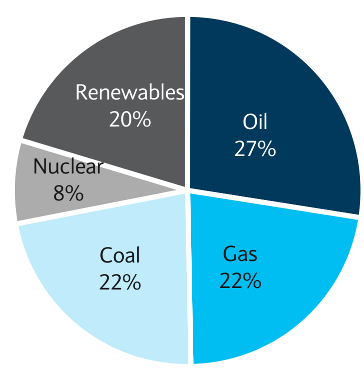
Barclays' estimate of breakdowm of cumulative primary-energy demand under NPS, 2015-40



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

FIGURE 40

Barclays' estimate of breakdowm of cumulative primary-energy demand under 450S, 2015-40



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: *www.iea.org/t&c/termsandconditions*. Also based on Barclays Research estimates

Tightening the carbon constraint: assumptions under 450S

The substantial reduction in global fossil-fuel demand and CO_2 emissions modelled by the IEA under its 450S pre-supposes a radically more carbon-constrained policy framework than under the NPS.

The NPS and the 450S: closing the emissions gap

A major driver of the shift away from fossil fuels under the 450-Scenario is the introduction of higher and more widespread carbon pricing across the world than under the NPS. Figure 41 shows the IEA's assumptions for carbon pricing globally under both scenarios, again in real terms (i.e. constant 2014 $).

FIGURE 41

Assumed CO_2 prices for selected countries/regions under IEA scenarios (2014 $/tonne)

	Region	Sectors	2020	2030	2040
New Policies Scenario	EU	Power, industry, aviation	22	37	50
	Chile	Power	6	12	20
	Korea	Power and industry	22	37	50
	China	Power and industry	10	23	35
	South Africa	Power and industry	7	15	24
450-Scenario	US & Canada	Power and industry	20	100	140
	EU	Power, industry, aviation	22	100	140
	Japan	Power and industry	20	100	140
	Korea	Power and industry	22	100	140
	Australia & New Zealand	Power and industry	20	100	140
	China, Russia, Brazil, South Africa	Power and industry	10	75	125

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015)

Under the NPS, prices reach $50/t by 2040 in the EU and South Korea, $35/t in China, $24/t in South Africa, and $20/t in Chile. However, there is no carbon pricing in the United States, Canada, or Australia, even by 2035. Under the 450S, by contrast, the IEA projects that carbon prices of $20/tonne would be necessary by 2020 across the entire developed world (including the US, Canada, and Australia), $100/tonne by 2030, and $140/t by 2040. The 450S also assumes that in addition to China and South Africa, other large non-OECD countries such as Russia and Brazil will be pricing CO_2 emissions at a rate of $125/t by 2040.

In addition to higher and more widespread carbon pricing, the 450S envisages a number of more specific policies tailored for different parts of the global energy system. These measures complement and/or reinforce the carbon-pricing overlay that pervades the global energy system under the 450S. Particularly important in this respect are (i) energy-efficiency measures and (ii) support for the large-scale deployment of low-carbon power-generation technologies above and beyond renewables (especially CCS but also nuclear). Both of these policy recommendations would also be naturally reinforced by higher and more widespread carbon pricing. Phasing out fossil-fuel subsidies – worth nearly $500bn in 2014 – and reducing methane emissions from oil-and-gas production are further important measures under the 450S.

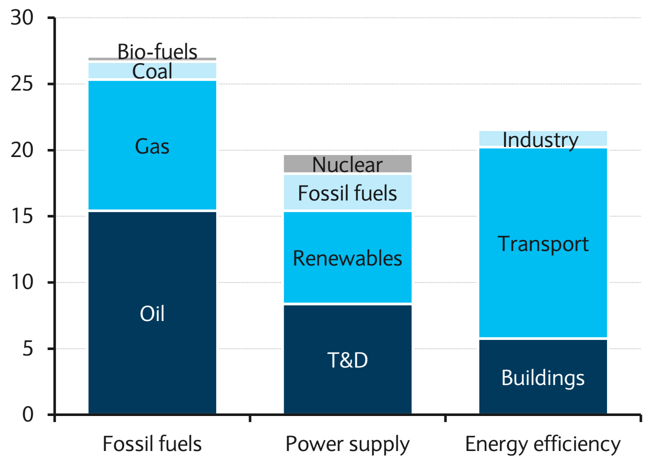
In short, the 450S envisages an accelerated shift towards a substantially lower share of fossil fuels in the global energy mix out to 2040, with renewables increasing their share very significantly and overall demand much lower owing to more efficient consumption patterns. All of which implies very different investment choices between the NPS and the 450S.

Low-carbon investment much higher under 450S

Figures 42 and 43 show the breakdown of investment across the global energy system over 2015-40 under the NPS and 450S respectively, as broken down between the three main components: fossil fuels, power supply (including transmission and distribution, or T&D), and energy efficiency.[12]

FIGURE 42

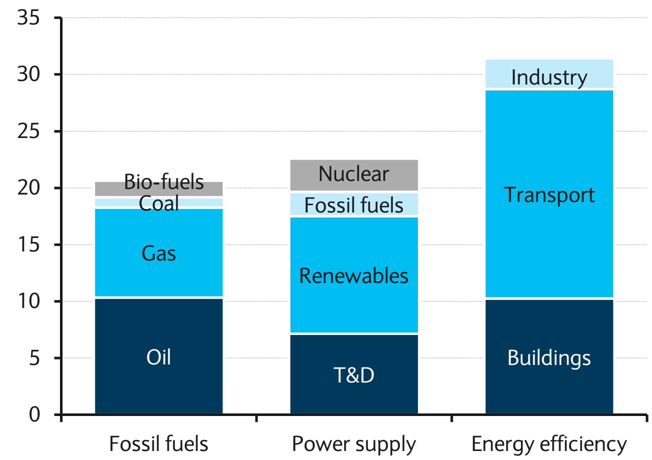
Energy investment under NPS, 2015-40 (2014 $trn)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research

FIGURE 43

Energy investment under 450S, 2015-40 (2014 $trn)

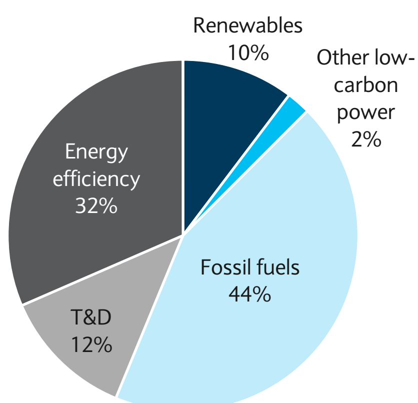


Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research

The difference in the scale of investment between the two scenarios is not that great, with the NPS requiring $68trn of capex over 2015-40 and the 450S $75trn. However, the difference in the composition of the investment is very stark (Figures 4and 45).

FIGURE 44

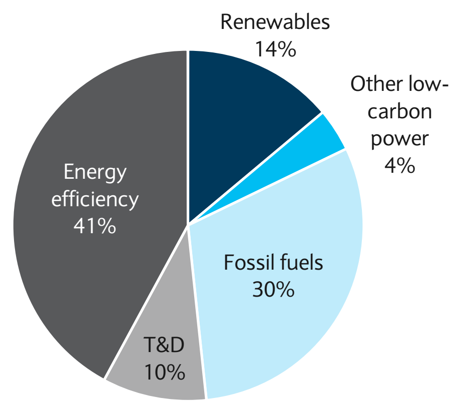
Shares of different components in total energy investment over 2015-40 under the NPS



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research

FIGURE 45

Shares of different components in total energy investment over 2015-40 under the 450S



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research

[12] The IEA defines energy-efficiency investment (WEO 2015: p.60) as *"the expenditure on a physical good or service that delivers the equivalent energy service and leads to future energy savings, compared with the energy demand expected otherwise"*.

As can be seen, fossil fuels (including fossil-fuel power generation) account for 44% of total investment under the NPS ($30trn), but under the 450S this falls to 30% ($23trn), a drop of 7$trn. By contrast, investments in energy efficiency are higher by $10trn under the 450S versus the NPS ($31trn and $21trn respectively). Similarly, investment in renewables and other low-carbon forms of generation are nearly $5trn higher under the 450S, reaching $13.3trn compared with $8.5trn under the NPS (renewables are $3.4trn higher under the 450S, and nuclear $1.4trn higher).

In short, a tightening of the global policy framework designed to engineer a 2°C trajectory would require a very radical shift in investment patterns, with total capex in low-carbon power and energy efficiency some $14trn higher, and in fossil-fuels $6.4trn lower, compared with the IEA's base-case scenario.

Fossil-fuel pricing lower under 450S

Figure 46 shows the IEA's projections for fossil-fuel prices in real terms (constant 2014 $) out to 2040 under the NPS. Given the rising demand for all fossil fuels over the period, and hence the need for the marginal unit supplied to come from ever higher up the respective industry's cost curve, the prices for all fuels are projected to rise over the next two decades (with the exception of gas prices in Asia).

Oil prices are projected to rise by 32% in real terms over the period, reaching $128/bbl in 2035 compared with $97/bbl in 2014. Gas prices, which unlike those for oil and coal vary greatly by region, are assumed to rise by 70% in the US, and by 33% in the EU, but to fall by 13% in Japan as the Asian market benefits from increasing supplies of LNG from the Middle East, Australia, and North America. Coal prices rise by 38%, reaching $110/tonne in 2040 versus $78/tonne in 2014.

FIGURE 46

Fossil-fuel import prices for selected countries/regions under NPS (constant 2014 $)

	Unit	2014	2020	2030	2040	Average price 2014-40
Oil	bbl	**97**	80	113	**128**	**103**
Natural gas						
US	mmbtu	4.4	4.7	6.2	7.5	5.6
Europe	mmbtu	9.3	7.8	11.2	12.4	10.0
Japan	mmbtu	16.2	11	13	14.1	13.1
Steam coal	tonne	***78***	*94*	*102*	***108***	**97**

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015). Average prices as calculated by Barclays Research

Figure 47 then shows the same projections out to 2040 under the 450S.

FIGURE 47

Fossil-fuel import prices for selected countries/regions under 450S (constant 2014 $)

	Unit	2014	2020	2030	2040	Average price 2014-40
Oil	bbl	**97**	77	97	**85**	**88**
Natural gas						
US	mmbtu	4.4	4.5	5.7	7.5	5.4
Europe	mmbtu	9.3	7.5	9.4	11.4	9.1
Japan	mmbtu	16.2	10.7	11.8	12.4	12.3
Steam coal	tonne	***78***	*80*	*79*	***77***	**79**

Source: IEA, World Energy Outlook 2015 (© OECD/IEA 2015). Average prices as calculated by Barclays Research

Given the falling demand for oil and coal over the period under the 450S, and the lower demand for gas than under the NPS, the prices for all fuels are projected to fall over the next two decades (except gas prices in the US and the EU). Oil prices are assumed to fall by 13% in real terms, dropping to $85/bbl in 2040 compared with $97/bbl in 2014. Gas prices are 70% and 33% higher by 2040 in the US and the EU respectively, but 13% lower in Japan. Coal prices are flat over the period, and are projected to be $79/tonne in 2040 compared with $78/tonne in 2014.

Oil prices average $88/bbl over 2014-40 versus $103/bbl under the NPS, and coal $79/tonne versus $97/tonne. US gas prices are on average 3% lower under the 450S over the period, EU prices 9% lower, and Japanese prices 6% lower.

Clear that COP-21 will not deliver a 2°C trajectory, but still…

The 450S is a hypothetical modelling scenario primarily meant to inform policymakers in the run-up to COP-21, and in this respect, it offers them a hard-headed and practical path to achieving sustained long-term reductions in global CO_2 emissions.

Of course, modelling a pathway and achieving a deal in global climate negotiations are two very different things, and as we noted above it is already clear that COP-21 will not in itself deliver a 2°C outcome. To take just one example, achieving the kind of carbon-pricing levels on a widespread global basis set out in the IEA's 450S poses very significant political obstacles (even if – as discussed earlier – there are some encouraging signs in this area, not least China's aspiration to establish a nationwide carbon-trading scheme in 2017).

> "If there is any energy company in the world which thinks that climate change policies will not affect their business strategies, they are making a grave mistake." Fatih Birol, Executive Director, IEA, September 2015

However, the fact that COP-21 in itself is clearly not going to put the world on a 2°C track does not mean that fossil-fuel companies can simply carry on with business as usual and ignore the implications of the IEA's 450-ppm pathway. On the contrary, we think fossil-fuel companies should at the very least be stress-testing their business models against a significant tightening of global climate policy over the next two decades.

In this respect, it follows from everything we have said above that it is not only investments in fossil-fuel assets that are at risk from ever tighter climate policies in the future, but also the revenues of the oil, gas, and coal industries. After all, lower volumes of fossil fuels consumed at lower average prices have the potential to reduce the sales of oil, gas, and coal over the coming decades.

It is to a more detailed consideration of this point that we now turn as we examine the revenue implications for the oil, gas, and coal industries of the IEA's 450S.

COP-21: SCOPING THE LONG-TERM RISK TO FOSSIL-FUEL REVENUES

Our analysis of the implied difference in cumulative volumes of fossil fuels sold under the 450S relative to the NPS at the lower average prices this entails results in an estimated $34trn of lost revenues for the upstream-oil, gas, and coal industries over 2015-40.

Of course, this is a hypothetical worst case based on a sensitivity analysis of the IEA's policy-based scenarios, but that does not mean that these are numbers the fossil-fuel industry can simply choose to ignore. On the contrary, we think that based on this worst-case analysis fossil-fuel companies need to think long and hard about how they respond to a rapidly changing energy landscape, as with or without a formal 2°C trajectory the ongoing energy transition from fossil fuels to zero- and low-carbon energy sources with a much greater emphasis on more efficient consumption could otherwise undercut their business models.

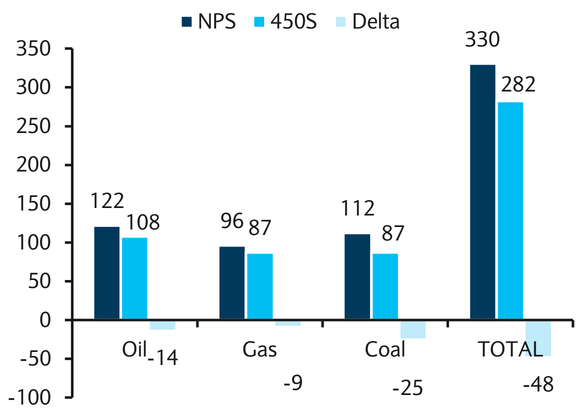
$34trn of fossil-fuel revenues at stake over 2015-40

Figure 48 shows our estimate of the difference in cumulative fossil-fuel volumes sold under the NPS and 450S over 2015-40, as broken down between oil, gas, and coal, and Figure 49 our estimate of the difference in cumulative upstream fossil-fuel revenues.

We calculate that the net impact of the volume and price effects assumed under the 450S would be to reduce the projected revenues of the upstream fossil-fuel industry globally relative to the NPS by $33.7trn (in constant 2014 $) over 2015-40. This breaks down as $22.4trn of lost revenues from lower sales of oil, $5.5trn from lower sales of natural gas, and $5.8trn from lower sales of coal.

FIGURE 48

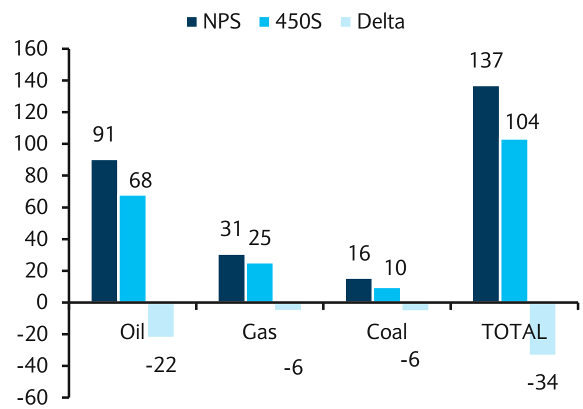
Barclays' estimate of delta in cumulative volumes of fossil fuels sold under 450S relative to NPS, 2014-40 (mtoe)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

FIGURE 49

Barclays' estimate of delta in cumulative revenues of upstream fossil-fuel industry, 450S v NPS, 2014-40 (constant 2014 $trn)



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Oil industry most exposed, with $22trn at stake

We calculate that the net impact of the volume and price effects assumed under the 450S would be to reduce the projected revenues of the global upstream-oil industry relative to the NPS by $22.4trn (in constant 2014 $) over 2014-40. This breaks down as $16.4trn of lost revenue from lower sales of conventional crude oil, $3trn from lower sales of natural-gas liquids (NGLs), and $3trn from lower sales of unconventional crude.

We calculate global upstream-oil revenues at $90.7trn under the NPS

Figure 50 shows the actual volume of oil demand by category in 2014 and the projected volume of demand in 2020, 2030, and 2040 under the NPS. The final column then shows our estimate of total cumulative demand over 2014-40 To calculate the cumulative volumes, we first break the 2014-40 period down into three sub-periods: 2014-20, 2021-30, and 2031-40. We then calculate an average annual demand volume over each of these sub-periods, which then enables us to derive the implied cumulative volumes over each of these three sub-periods. Aggregating the total of the three sub-periods then gives us our estimate of cumulative global demand over the entire 2014-40 period.[13]

On this basis, we calculate total demand for petroleum liquids over 2014-50 at 939bn barrels, comprising 665bn barrels of crude oil, 162bn barrels of natural-gas liquids (NGLs), and 113bn barrels of unconventional crude oil.

FIGURE 50

Barclays' estimate of cumulative global oil demand under the IEA's NPS, 2014-40 (mbd; total demand over 2014-40 in bn bbls)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL OIL	**87.3**	**93.4**	**97.2**	**100.5**	**95.3**	**939.4**
Crude oil	67.7	67.3	67.9	66.8	**67.5**	**665.0**
NGLs	13.3	15.2	17.2	19.2	**16.4**	**162.0**
Unconventional	6.3	10.9	12.1	14.5	**11.4**	**112.5**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; *For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

Figure 51 then shows our estimates for total revenues to the oil industry over 2014-40. To calculate these numbers we take the IEA's price assumptions for oil under the NPS for 2014, 2020, 2030, and 2040, so as to calculate average annual prices for each of our three sub-periods (2014-2020, 2021-30, and 2031-40).[14]

Multiplying the average annual prices for each of our sub-periods by the average annual volumes we have calculated for each sub-period then enables us to derive the implied average annual revenues over each sub-period. We then aggregate these three numbers to derive our estimated total cumulative revenues over the entire 2014-40 period.[15].

[13] We use exactly the same methodology below to estimate demand volumes for oil under the 450S, and for gas and coal under both the NPS and the 450S.
[14] The IEA price projections for the NPS in each of these years are shown in Figure 46 above.
[15] We use exactly the same methodology below to estimate revenues for oil under the 450S, and revenues bor gas and coal under bioth the NPS and the 450S.

(Note that For NGLs, we assume a price equivalent to 70% of the IEA's crude-oil price in each year, and for unconventional crude a price equivalent to 85% of the IEA's crude-oil price.[16])

On this basis, we derive annual revenues for the upstream oil industry of $2.9trn in 2014, $2.5trn in 2020, $3.7trn in 2030, and $4.3trn in 2040. This gives a weighted annual average revenue number over 2014-40 of $3.4trn.

FIGURE 51

Barclays' estimate of cumulative global upstream oil-industry revenues under the IEA's NPS, 2014-40 (constant 2014 $bn)

	2014	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL OIL REVENUES	**2,916**	**2,546**	**3,721**	**4,325**	**3,358**	**90,670**
Crude oil	2,397	1,965	2,801	3,121	**2,544**	**68,693**
NGLs	330	311	497	628	**441**	**11,897**
Unconventional	190	271	424	576	**373**	**10,080**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

The final column then shows our estimate of total cumulative revenues for the upstream oil industry over 2014-40 using a simple linear interpolation of our estimates for 2014, 2020, 2030, and 2040. On this basis, we derive total cumulative revenues of $90.7trn, comprising $68.7trn from crude oil, $11.9trn from NGLs, and $10.1trn from unconventional crude.

Under 450S we estimate revenues to be $21.3trn lower at $68.3trn

Figures 51 and 52 show total oil demand and total upstream oil revenues over 2014-40 respectively under the 450S.

As shown in Figure 52, using the same methodology as in the case of Figure 50 above, we calculate total demand for petroleum liquids over 2014-40 at 830bn barrels, comprising 592bn barrels of conventional crude, 143bn barrels of NGLs, and 95bn barrels of unconventional crude.

FIGURE 52

Barclays' estimate of cumulative global oil demand under the IEA's 450S, 2014-40 (mbd; total demand over 2014-40 in bn bbls)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL OIL	**87.3**	**91.4**	**83.3**	**71.9**	**84.3**	**830.4**
Crude oil	67.7	66.2	58.3	48.1	60.1	**592.5**
NGLs	13.3	14.5	15.1	14.2	14.5	**143.0**
Unconventional	6.3	10.7	9.9	9.6	9.6	**94.9**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; *For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

[16] The reason we discount the price for NGLs is that NGLs contain less energy per barrel than crude oil. NGLs typically contain 4.4 Gigajoules of energy per barrel compared with 6.3GJ/bbl for crude oil. The reason we discount the price for unconventional crude is that much of the unconventional crude sold today – e.g. US light-tight oil or so-called shale oil, and Canadian oil sands - sells at a discount in the market to conventional crude for a number of reasons, for example because it is landlocked, or because it does not meet refinery specifications.

As set out in Figure 53, using the same methodology as in the case of Figure 51 above, we derive annual revenues for the upstream oil industry under the 450S of $2.9trn in 2014, $2.4trn in 2020, $2.7trn in 2030, and $2trn in 2040. This gives a weighted annual average revenue number over 2014-40 of $2.5trn.[17]

The final column then shows our estimate of total cumulative revenues for the upstream oil industry under the 450S over 2014-40 using the same approach described above under the NPS.

On this basis, we derive total cumulative revenues of $68.3trn, comprising $52.3trn from conventional crude, $8.9trn from NGLs, and $7.1trn from unconventional crude.

FIGURE 53

Barclays' estimate of cumulative global upstream oil-industry revenues under 450S, 2014-40 (constant 2014 $bn)

	2014	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL OIL REVENUES	**2,916**	**2,401**	**2,736**	**2,054**	**2,528**	**68,254**
Crude oil	2,397	1,861	2,064	1,492	1,937	**52,312**
NGLs	330	285	374	308	328	**8,862**
Unconventional	190	256	298	253	262	**7,080**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

This means that using our methodology the implied loss to the upstream oil-industry under the 450S in terms of revenues forgone would be $22.4trn.

Lower revenues from crude oil account for $16.8trn of $22.4trn difference

Figure 54 shows our calculation of the breakdown of upstream-oil industry revenues forgone under the 450S relative to the NPS by source. Revenues from conventional crude oil are lower by $16.4trn, from NGLs by $3trn, and from unconventional crude by $3trn.

FIGURE 54

Barclays' estimate of cumulative upstream-oil industry revenues under 450S versus NPS over 2014-40(2014 $bn)

	NPS	450S	Revenues forgone under 450S
Crude oil	68,693	52,312	-16,381
NGLs	11,897	8,862	-3,035
Unconventional crude oil	10,080	7,080	-3,000
TOTAL	**90,670**	**68,254**	**-22,416**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

In short, given the lower volumes sold at lower prices, we estimate that the implementation of a policy framework consistent with a 2°C outcome would put $22.4trn of global upstream-oil industry revenues at risk over 2014-40 relative to the IEA's base-case scenario.

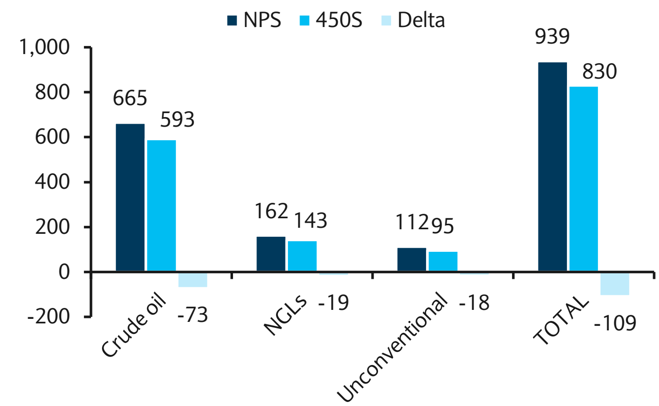
Figure 55 shows our estimate of the difference in cumulative volumes of oil sold under the NPS and 450S over 2015-40, as broken down between conventional crude oil, NGLs, and unconventional crude. Figure 56 shows our estimate of the difference in cumulative

[17] The IEA price projections for the 450S that we use to derive our revenue numbers here are shown in Figure 45 above.

revenues from oil sold under the NPS and 450S over 2014-40, as broken down between conventional crude oil, NGLs, and unconventional crude.

FIGURE 55

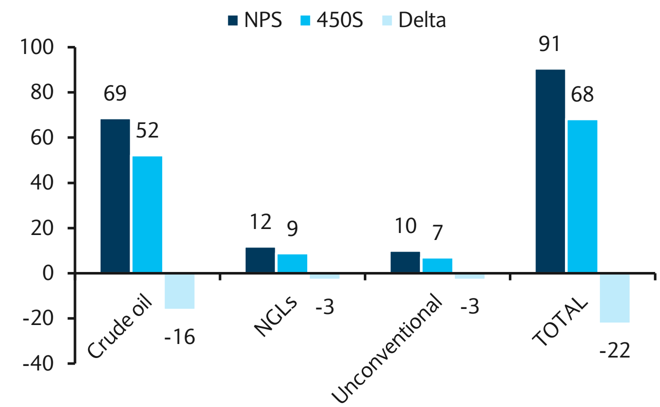
Barclays' estimate of delta in total cumulative oil demand between NPS and 450S, 2014-40 (bn bbls)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

FIGURE 56

Barclays' estimate of delta in total cumulative upstream oil revenues between NPS and 450S, 2014-40 (2014 $trn)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Conventional crude oil accounts for 67% of the difference by volume (73bn bbls out of a total delta of 109bn bbls), but a higher 73% of the difference in value ($16.4trn out of a total $22.3trn). This is explained by the greater intrinsic value of conventional crude over NGLs and unconventional crude.

Gas industry less exposed, but $5.5trn of revenues at risk

As already explained above, gas prices currently vary greatly by region, and although the differences between North American, European, and Japanese prices diminish somewhat over the IEA's forecast period, gas is still projected to be much cheaper in North America by 2040 than in Europe and Japan under both the NPS and the 450S.

The IEA does not give price assumptions for other regions under either the NPS or the 450S, which means that in order to estimate the impact of lower demand projected under the 450S in the rest of the world (ROW), we have to make more speculative price estimates.

As a result, here we first look at the implications of the 450S on the OECD countries (excluding Australia, New Zealand, and South Korea) in terms of the revenues at risk, and then attempt to estimate the impact of the 450S on the gas industry's revenues in the ROW.

Overall, we estimate that the net impact of the volume and price effects assumed under the 450S for the upstream-gas industry in the OECD (excluding Australia, New Zealand, and South Korea) would be to reduce revenues relative to the NPS by $2.2trn (in constant 2014 $) over 2014-40.

This breaks down as $900bn of lost revenue in North America, $1trn in Europe, and $200bn in Japan. For the ROW, our estimates are by their nature more speculative, but taking what we think is a conservative view we see a further $3.4trn of revenues at risk for the gas industry over 2015-40.

In total, then, we estimate that up to $5.5trn of revenues would be at risk for the upstream-gas industry over the next two decades under a global climate-policy framework consistent with a 450-ppm world.

We calculate upstream-gas revenues at $12.5trn in OECD under the NPS

Figure 57 shows natural-gas demand by OECD region (excluding Australia, New Zealand, and South Korea) in 2014, and the projected volume of demand in 2040 under the NPS. The final column then shows our estimate of total cumulative demand over 2014-40 using the same method we described above for oil.

On this basis, we estimate total demand over 2014-40 at 44.5 trillion cubic metres (tcm), comprising 28tcmbn in OECD North America, 14tcm in OECD Europe, and nearly 3tcm in Japan.

FIGURE 57

Barclays' estimate of cumulative gas demand in OECD North America & Europe and Japan under NPS, 2014-40 (bcm)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL	**1,563**	**1,599**	**1,667**	**1,757**	**1,649**	**44,515**
North America	924	1,001	1,038	1,125	1,028	**27,746**
Europe	512	496	526	528	515	**13,908**
Japan	127	102	103	104	106	**2,862**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates;* For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

Figure 58 then shows the IEA's gas-price assumptions over 2014-40 for North America, Europe, and Japan, and our estimated weighted average price over the period, but this time as priced in terms of constant 2014 $ per thousand cubic metres.[18]

FIGURE 58

Gas prices, OECD North America & Europe and Japan under NPS, 2014-40 (2014 $/kcm)

	2014	2020	2030	2040	Barclays' estimate of weighted average price 2014-40
North America	161	172	228	275	**210**
Europe	341	286	411	455	**371**
Japan	595	404	477	517	**477**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

As already explained above, gas prices vary greatly between these regions, and although these regional price differences are projected to diminish over the period, the IEA still projects significantly higher gas prices in than in Europe and Japan than in North America over the next two decades.

Figure 59 then shows our estimates for total revenues to the gas industry in these regions over 2014-40. To calculate these numbers we again use the approach described above for oil, multiplying our average annual demand volumes for each of our sub-periods derived

[18] We have converted the gas prices shown in Figure 58 above from $/mmbtu into $/kcm.

from the numbers in Figure 57 by the average annual prices for each of these sub-periods that result from the values shown in Figure 58.

On this basis, we derive annual revenues for the upstream gas industry in OECD North America, OECD Europe, and Japan of $399bn in 2014, rising to $604bn by 2040 and averaging $461bn annually over the period.

FIGURE 59

Barclays' estimate of cumulative upstream gas revenues, OECD North America & Europe & Japan under NPS (2014 $bn)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL	**399**	**356**	**502**	**604**	**461**	**12,455**
North America	149	173	236	310	**218**	**5,898**
Europe	175	142	216	240	**192**	**5,181**
Japan	76	41	49	54	**51**	**1,375**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; * For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

This gives total cumulative revenues for the upstream gas industry in these regions over 2014-40 of $12.5trn, comprising $5.9trn for OECD North America, $5.2trn for OECD Europe, and $1.4trn for Japan.

450S implies OECD industry revenues $2.2trn lower at $10.3trn

Figure 60 shows natural-gas demand by OECD region (excluding Australia, New Zealand, and South Korea) in 2014, and the projected volume of demand in 2040 under the 450S. The final column then shows our estimate of total cumulative demand over 2014-40 using the same method as we used for the NPS above.

On this basis, we estimate total demand over 2014-40 at 40.1tcm, comprising 25tcm in OECD North America, 12.4tcm in OECD Europe, and 2.6tcm in Japan.

FIGURE 60

Barclays' estimate of cumulative gas demand in OECD North America & Europe and Japan under 450S, 2014-40 (bcm)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL	**1,563**	**1,577**	**1,486**	**1,281**	***1,487***	**40,136**
North America	924	992	933	821	**930**	**25,104**
Europe	512	483	464	378	**460**	**12,423**
Japan	127	102	89	81	**97**	**2,609**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; *For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

Figure 61 then shows the IEA's gas-price assumptions under the 450S over 2014-40 for these regions (again in constant 2014 $/kcm).[19] Although prices are lower across the board than under the NPS, the same pattern can be observed, with North American prices still much lower than those in Europe and Japan over the entire 2014-40 period.

[19] Again, we have here converted the gas prices shown in Figure 61 above from $/mmbtu into $/kcm.

FIGURE 61

Gas prices, OECD North America & Europe and Japan under 450S, 2014-40 (2014 $/kcm)

	2014	2020	2030	2040	Barclays' estimated weighted average price 2014-40
North America	161	165	209	275	**201**
Europe	341	275	345	418	**336**
Japan	595	393	433	455	**445**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Figure 62 then shows our estimates for total revenues to the gas industry in these regions over 2014-40. To calculate these numbers we use the same approach as described above, multiplying our demand volumes for each of our sub-periods derived from the numbers in Figure 60 against the average prices for the same sub-periods that result from the values shown in Figure 61.

On this basis, we derive annual revenues for the upstream gas industry in OECD North America, OECD Europe, and Japan of $399bn in 2014, rising to $421bn by 2040 and averaging $382bn annually over the period.

FIGURE 62

Barclays' estimate of cumulative upstream gas revenues, OECD North America & Europe & Japan under 450S (2014 $bn)

	2014	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL	**399**	**337**	**394**	**421**	**382**	**10,303**
North America	149	164	195	226	**185**	**4,996**
Europe	175	133	160	158	**153**	**4,132**
Japan	76	40	39	37	**44**	**1,176**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

This gives total cumulative revenues for in these regions over 2014-40 of $10.3trn, comprising $5trn for OECD North America, $4.1trn for OECD Europe, and $1.2trn for Japan.

Lower revenues in Europe account for 50% of $2.2trn difference

Figure 63 shows our calculation of the breakdown of upstream-gas industry revenues forgone under the 450S relative to the NPS by OECD region. Revenues from North America are lower by $900bn, from Europe by $1.1trn, and from Japan by $200bn.

FIGURE 63

Barclays' estimate of cumulative upstream-gas industry revenues under 450S versus NPS over 2014-40 (2014 $bn)

	NPS	450S	Revenues forgone under 450S
North America	5,898	4,996	-902
Europe	5,181	4,132	-1,050
Japan	1,375	1,176	-199
TOTAL	**12,455**	**10,303**	**-2,151**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

This means that using our methodology the implied aggregate loss to the upstream-gas industry under the 450S in terms of revenues forgone in the OECD regions would be $2.2trn.

We estimate that revenues forgone in ROW would be $3.4trn

Estimating the revenues that the gas industry would stand to lose under the 450S in regions for which the IEA makes no price forecasts is by definition more speculative, but we can nonetheless make what we think is a reasonable attempt. To do this, we begin by looking at the sales volumes forgone in the ROW outside the OECD regions already covered above (note, however, that although Australia, New Zealand, and South Korea are all in the OECD, we have included them here rather than above as the IEA does not give separate gas-price estimates for these countries as it does for the US, Europe, and Japan).

Figure 64 shows that our estimate for the total sales volume forgone under the 450S relative to the NPS is 6.3tcm, which breaks down as 674bcm of imports into China and India, 250bcm of demand in Australia, New Zealand, and South Korea, and 5.3tcm of demand for all other non-OECD countries combined.

FIGURE 64

Barclays' estimate of cumulative gas demand under 450S versus NPS over 2014-40 in ROW (bcm)

	NPS	450S	Volumes forgone under 450S
China & India imports	6,772	6,098	-674
Australia, NZ, S. Korea	2,845	2,593	-250
All other non-OECD global demand	61,508	56,174	-5,333
TOTAL	**71,124**	**64,867**	**-6,257**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

The next step is to identify which regions are net importers of gas at benchmarked international prices, or price gas in their domestic markets at benchmarked international prices. For Asia, China and India account for approximately two-thirds of the total demand over the period (c.50% and c.15% respectively), and in these markets we estimate that 40% of total demand is imported (both countries imported c.30% off their needs in 2013, but the IEA expects this figure to increase out to 2040).Using these assumptions enables us to estimate total revenues from upstream gas sales in the ROW.

We estimate that total revenues in the ROW under the NPS would be $18.5trn

We assume that Chinese and Indian imports are priced between the IEA's Japanese and European import prices, which equates to an average price over the period of $430/kcm (in constant 2014 $). The other countries either importing (South Korea) or pricing at or ever closer to international benchmarks over the 2014-40 period are Australia and New Zealand.

For these countries we again assume an average price over the period of $430/kcm. For the remaining ROW we assume prices average a much lower $230/kcm, reflecting the large share of low-cost producers (especially in the Middle East and parts of Eurasia) here.

On this basis, we derive total revenues from gas sales in the ROW under the NPS at $18.5trn (Figure 65).

FIGURE 65

Barclays' estimate of total estimated ROW upstream-gas revenues under NPS, 2014-40 (constant 2014 $bn)

	Volumes sold	Assumed price ($/kcm)	Cumulative revenues, 2015-40
China and India imports	6,772	430	2,941
Australia, NZ, South Korea	2,845	430	1,223
All other non-OECD global demand	61,508	230	14,315
TOTAL	**71,124**		**18,479**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

We estimate that total revenues in the ROW under the 450S would be $15.1trn

Under the 450S we again assume that Chinese and Indian imports are priced between the IEA's Japanese and European import prices, as are prices in Australia, New Zealand, and South Korea. Under this scenario the average price over the period in these regions is $390/kcm (in constant 2014 $). For the remaining ROW we assume lower average prices over the period of $210/kcm. On this basis, we derive total revenues from gas sales in the ROW under the 450S at $15.1trn (Figure 66).

FIGURE 66

Barclays' estimate of total ROW upstream-gas revenues under 450S, 2014-40 (constant 2014 $bn)

	Volumes sold	Assumed price ($/kcm)	Cumulative revenues, 2015-40
China and India imports	6,098	390	2,385
Australia, NZ, South Korea	2,595	390	1,016
All other non-OECD global demand	56,174	210	11,687
TOTAL	**64,867**		**15,088**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Comparing the revenues from upstream-gas sales across these regions under the two scenarios, we derive revenues at risk of $3.4trn (Figure 67).

FIGURE 67

Barclays' estimate of ROW upstream-gas revenues lost under 450S, 2014-40 (constant 2014 $bn)

	NPS	450S	Revenues forgone under 450S
China & India imports	2,941	2,385	-556
Australia, NZ, S. Korea	1,223	1,016	-206
All other non-OECD global demand	14,315	11,687	-2,628
TOTAL	**18,479**	**15,088**	**-3,391**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Only a small part of this is in Australia, New Zealand, and South Korea, with the vast majority being in the non-OECD regions.

Lower revenues of $5.5trn under 450S

Aggregating our estimates for the OECD and non-OECD components of demand as set out above, Figure 68 shows our estimates of the difference between volumes of gas sold and revenues earned under the NPS and 450S.

In total, we estimate that the revenues at risk for the upstream-gas industry under the 450S relative to the NPS would be $5.5trn. This breaks down as $2.1trn in the OECD countries (excluding Australia, New Zealand, and South Korea), and $3.4trn in the non-OECD countries (but including Australia, New Zealand, and South Korea).

FIGURE 68

Barclays' estimate of upstream-gas volumes and revenues forgone under 450S compared with NPS, 2014-40

	Volumes sold under NPS (bcm)	Volume sold under 450S (bcm)	Revenues forgone (2014 $bn)
OECD*	44,515	40,136	-2,151
Non-OECD**	71,119	64,867	-3,391
TOTAL	**115,635**	**105,003**	**-5,542**

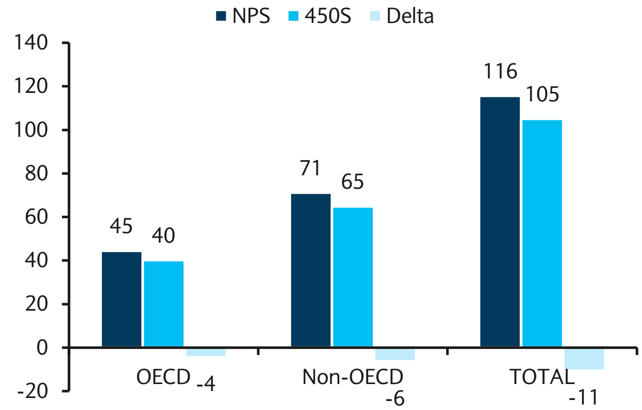
Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; *excl. Australia, New Zealand, and South Korea; ** incl. Australia, New Zealand, and South Korea

We think that our estimate of the revenues forgone in the ROW is likely on the conservative side given that we have assumed significantly lower average pricing for most of the Asian countries outside China and India, and for the whole of African and Latin America, when in reality there are other non-OECD countries in all these regions that import gas at internationally benchmarked prices.

Figure 69 summarises our estimate of the difference in cumulative volumes of gas sold under the NPS and 450S over 2045-40, as broken down between the OECD and non-OECD regions, and Figure 70 our estimate of the difference in cumulative revenues from gas sold on the same basis.

FIGURE 69

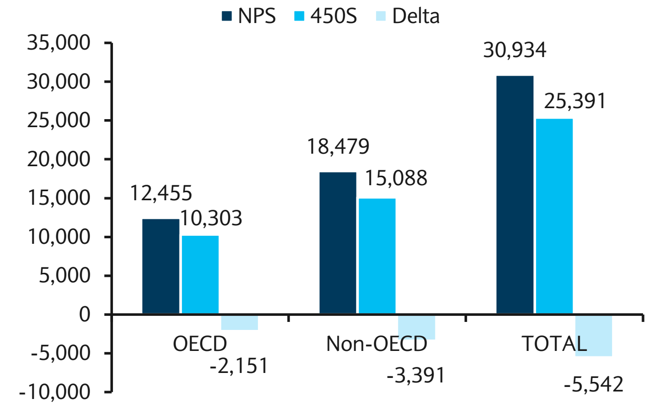
Barclays' estimate of delta in total cumulative upstream-gas demand between NPS and 450S, 2014-40 (bn bbls)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates. Note that Australia, New Zealand, and South Korea are included under non-OECD here.

FIGURE 70

Barclays' estimate of delta in total cumulative upstream-gas revenues between NPS and 450S, 2014-40 (2014 $bn)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates. Note that Australia, New Zealand, and South Korea are included under non-OECD here.

In short, despite being much less affected than the oil industry by a policy framework consistent with a 2°C outcome, we estimate that the gas industry would still face significantly lower revenues in a more carbon-constrained world.

Coal industry has $5.8trn of revenues at stake over 2014-40

We calculate that the net impact of the volume and price effects assumed under the 450S would be to reduce the projected revenues of the global upstream coal industry relative to the NPS by $5.8trn over 2014-40. This breaks down as $5trn of lost steam-coal revenues, $800bn of lost coking-coal revenues, and $23bn of lost lignite revenues.

We calculate global upstream-coal revenues at $14.6trn under the NPS

Figure 71 shows coal demand by category in 2013 and the projected volume of demand in 2040 under the NPS. The final column then shows our estimate of total cumulative demand over 2014-40 using the same method described above for oil. On this basis, we estimate total demand over 2014-40 at 161bn tonnes, comprising 129bn tonnes of steam coal, 24bn tonnes of coking coal, and nearly 8bn tonnes of lignite (also known as brown coal).

FIGURE 71

Barclays' estimate of cumulative global coal demand under NPS, 2014-40 (mtce)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL COAL	**5,723**	**5,762**	**6,027**	**6,305**	**5,955**	**160,797**
Steam coal	4,471	4,523	4,870	5,266	4,782	**129,116**
Coking coal	953	929	880	785	887	**23,958**
Lignite	299	310	277	254	286	**7,722**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; * For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

Figure 72 then shows our estimates for total revenues to the upstream-coal industry over 2014-40. To calculate these numbers we first take the volumes for each year as given by the IEA, and then multiply these either by the steam-coal price assumed in each of these years by the IEA (the case for steam coal), or by a price at a premium to the IEA number (the case for coking coal) or a discount (the case for lignite).[20]

For coking coal, we assume a price equivalent to 125% of the IEA's steam-coal price in each year (coking coal trades at a premium to steam coal), and for lignite a price of $15/tonne in 2014, falling to $9/tonne by 2040 (there is no traded market in lignite, so we have estimated the 2014 price from the *US Energy Information Administration's website* and then assumed a falling price out to 2040 in line with the IEA's projected falling demand.

FIGURE 72

Barclays' estimate of cumulative global upstream coal-industry revenues under NPS, 2014-40 (constant 2014 $bn)

	2014	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL COAL REVENUES	**446**	**538**	**612**	**677**	**579**	***15,640***
Steam coal	349	425	497	569	468	**12,643**
Coking coal	93	109	112	106	108	**2,905**
Lignite	4	4	3	2	579	**92**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

[20] The IEA price projections for the NPS in each of these years are shown in Figure 46 above.

On this basis, we derive annual revenues for the upstream coal industry of $446bn in 2014, rising to $677bn in 2040, and averaging 579 per year over the 2014-40 period. The final column then shows our estimate of total cumulative revenues over 2014-40 using our approach described above. We derive total cumulative revenues of $15.6trn, comprising $12.6trn for steam coal, $2.9trn for coking coal, and $92 for lignite.

But under 450S we estimate revenues to be $5.8trn lower at $9.9trn

Figure 73 shows our estimate of total coal demand over 2014-40 under the 450S. We calculate total demand for coal over 2014-40 at 125bn tonnes, comprising 97bn tonnes of steam coal, 21.5bn tonnes of coking coal, and 6bn tonnes of lignite.

FIGURE 73

Barclays' estimate of cumulative global coal demand under 450S, 2014-40 (mtce)

	2014*	2020	2030	2040	Weighted annual average 2014-40	Total Demand 2014-40
TOTAL COAL	**5,723**	**5,360**	**4,128**	**3,565**	**4,619**	**124,720**
Steam coal	*4,471*	*4,175*	*3,198*	*2,813*	***3,600***	***97,201***
Coking coal	*953*	*903*	*751*	*601*	***797***	***21,530***
Lignite	*299*	*282*	*179*	*151*	***222***	***5,990***

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates; * For the purposes of our analysis here we assume 2014 sales at the same level as the 2013 volumes given in the 2015 WEO.

Figure 74 then shows our estimates for total revenues to the upstream-coal industry over 2014-40 under the 450S. To calculate these numbers we first take the volumes for each year as given by the IEA, and then multiply these either by the steam-coal price assumed in each of these years by the IEA (the case for steam coal), or by a price at a premium to the IEA number (the case for coking coal) or a discount (the case for lignite).[21]

Again, we assume a price equivalent to 125% of the IEA's steam-coal price in each year and for lignite a price of $15/tonne in 2014, falling to $8/tonne by 2040 (our projection is slightly lower in each year for lignite under the 450S than under the NPS, in keeping with the lower demand profile under the 450S).

FIGURE 74

Barclays' estimate of cumulative global upstream coal-industry revenues under NPS, 2014-40 (constant 2014 $bn)

	2014	2020	2030	2040	Weighted annual average 2014-40	Total Revenues 2014-40
TOTAL COAL REVENUES	**446**	**428**	**329**	**276**	**365**	**9,863**
Steam coal	349	334	253	217	**284**	**7,671**
Coking coal	93	90	74	58	**79**	**2,124**
Lignite	4	3	2	1	**3**	**68**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Using the same methodology as above, we derive annual revenues for the upstream coal industry under the 450S of $446bn in 2014, falling to $276bn in 2040 and averaging $365bn over the forecast period. Using our simple linear-interpolation method again, we

[21] The IEA price projections for the 450S that we use to derive our revenue numbers here shown in Figure 47 above.

derive total cumulative revenues of $9.9trn, comprising $7.8trn from steam coal, $2.1trn from coking coal, and $68bn from lignite.

Lower revenues from steam coal account for $5trn of $5.8trn difference

Figure 75 shows our calculation of the breakdown of upstream-coal industry revenues forgone under the 450S relative to the NPS by source. We estimate the total implied loss to the upstream coal industry under the 450S in terms of revenues forgone would be $5.8trn. This breaks down as $5trn of lost steam-coal revenues, $715bn of lost coking-coal revenues, and $800bn of lost coking-coal revenues, and $23bn of lost lignite revenues

FIGURE 75

Barclays' estimate of cumulative upstream-coal industry revenues under 450S versus NPS over 2014-40 (2014 $bn)

	NPS	450S	Revenues forgone under 450S
Steam coal	12,643	7,671	-4,973
Coking coal	2,905	2,124	-781
Lignite	92	68	-23
TOTAL	**15,640**	**9,863**	**-5,777**

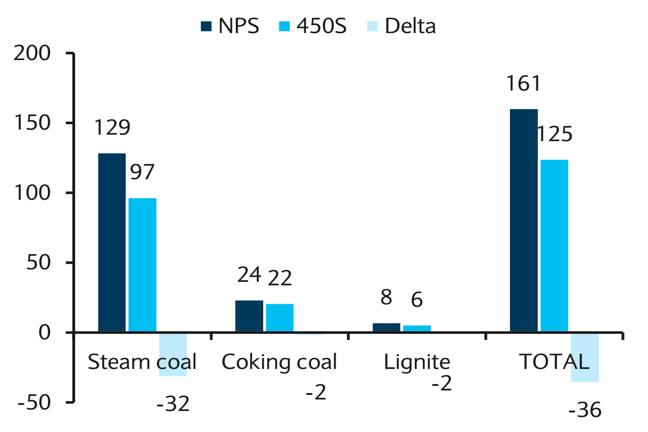
Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

In short, given the lower volumes sold at lower prices, we estimate that the implementation of a policy framework consistent with a 2°C outcome would put $5.8trn of global upstream-coal industry revenues at risk over 2014-40 relative to the IEA's base-case scenario.

Figure 76 summarises our estimate of the difference in cumulative volumes of coal sold under the NPS and 450S over 2014-40, as broken down between the different sources, and Figure 77 our estimate of the difference in cumulative revenues on the same basis.

FIGURE 76

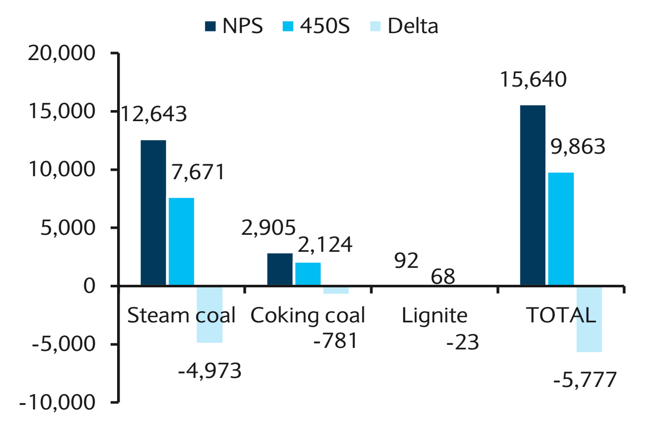
Barclays' estimate of delta in total cumulative coal demand between NPS and 450S, 2014-40 (bn bbls)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

FIGURE 77

Barclays' estimate of delta in total cumulative coal revenues between NPS and 450S, 2014-40 (2014 $bn)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

$34trn of fossil-fuel revenues at risk in a 450-ppm world

Figure 78 brings together our estimates for the revenues forgone by the upstream oil, gas, and coal industries under the IEA's 450S compared with the NPS. The total amount comes to $34trn, with oil accounting for 70% of this difference, gas 12%, and coal 18%.

FIGURE 78

Barclays' estimate of total fossil-fuel revenues forgone under 450S versus NPS, 2014-40 (constant 2014 $bn)

	Volumes under NPS (mtoe)	Volumes under 450S (mtoe)	Difference (mtoe)	Revenues forgone under 450S
Oil	122,006	107,845	-14,160	-22,416
Gas	96,046	87,212	-8,834	-5,542
Coal	112,445	87,217	-25,228	-5,777
TOTAL	**330,497**	**282,274**	**-48,223**	**-33,735**

Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates

Oil demand is lower by a cumulative 14.2bn tonnes under the 450S, and with lower average prices as well this results in revenues forgone of $22.4trn.

Gas demand is lower by 8.8bntoe, and combined with lower prices this results in lost revenues of $5.5trn.

Finally, for coal, demand is lower by 25.2bn toe and lower average prices means that on our estimates the industry would stand to lose $5.8trn of revenues under a global policy framework consistent with a 450-ppm world.

In short, on our estimates based on the IEA's modelling the global fossil-fuel industry would stand to lose $34trn of revenues under a policy framework designed to achieve a 2°C outcome.

COP-21 AND CAPITAL GOODS: CAP GOODS A WINNER

European Capital Goods
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A successful policy outcome triggering $13.5tn of investments by 2030 should be a long-term positive for the European capital goods sector. On the following page we map our companies' exposure to the main drivers of clean power generation and energy efficiency. We highlight Vestas, Schneider and ABB as the greatest potential winners. While Siemens should benefit in Wind, Automation and Mobility, we see greater headwinds in Power & Gas.

COP-21 in Paris: The national emissions plans - known as 'Intended Nationally Determined Contributions' (INDCs) - submitted by 150 countries, represent an important first step that could drive investments of $13.5 trillion through 2030 (IEA estimates). A successful outcome of COP-21 would, in our view, be an agreement that (i) gives credible backing to the deliverability of the INDCs, and (ii) gives hope for a subsequent tightening of the INDCs in order to achieve a "2° C" deal at a later date. We acknowledge that the link between government commitments, investments and company growth has been tenuous in the past. However, we believe more bottom-up commitments and a stricter enforcement mechanism should be positive for the sector.

Strongest boost to clean energy: With 40% of INDC emissions plans targeting a greater penetration of renewables, Vestas (OW, TP SEK485) stands out as one of the greatest potential winners in our view. Wind today represents less than 5% of global electricity generation. But it is now approaching grid parity in many circumstances and we see the potential for penetration to reach 10%+ by 2030. Additional policy measures could accelerate this process. There are no direct solar plays in our universe, but we expect ABB's big push into inverters should bear fruit under a strong policy outcome.

Large gains from energy efficiency: 33% of submissions target greater investments in energy efficiency across industry, buildings and transport. Under its central scenario, the IEA calculates an $8 trillion investment need to 2030. We see ABB (OW, CHF23), Schneider (OW, TP €62) and Legrand (EW, TP €48) as the greatest beneficiaries in this area. Amongst the mechanicals, we view Atlas Copco (OW, TP SEK245) and SKF (OW, TP SEK165) as the greatest potential winners.

Greener transport: The rail industry – representing one of the most energy efficient modes of transport – should see additional support under a strong policy outcome. We see Alstom (OW, TP €33), now a pure play on this end market, as a key beneficiary.

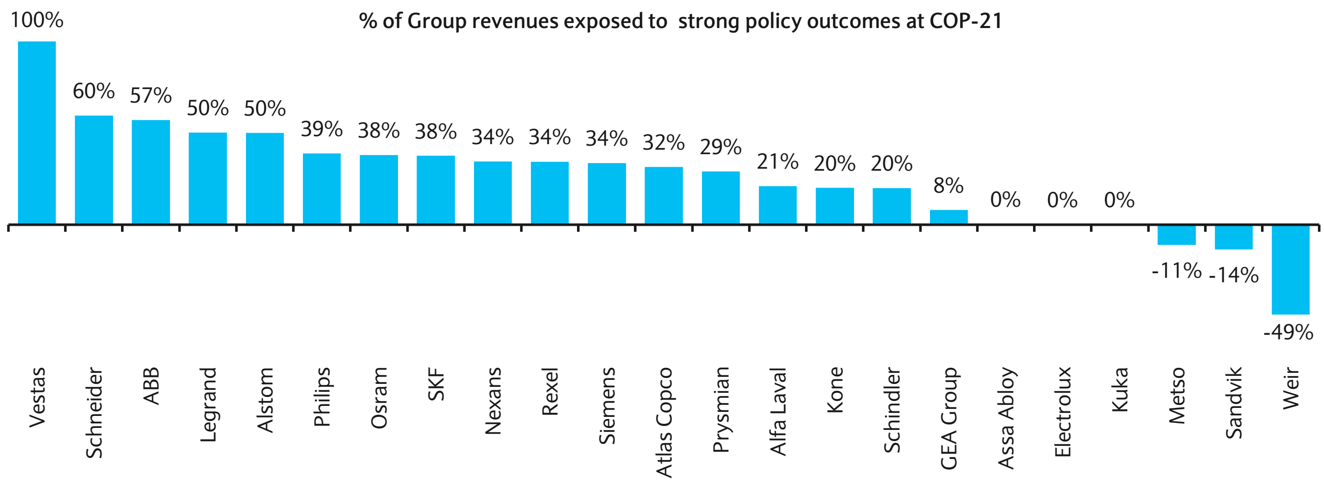
Industries at risk: More focus on energy efficiency would reduce electricity demand, especially in mature markets, compared to historical levels. At the same time, the share of fossil generation is set to decline under the INDC scenario. While gas should continue to benefit relative to coal, we see Siemens as a net loser in the Power & Gas division. With lower incremental demand growth for oil and gas, we also see risks for the equipment vendors such as Weir (EW, TP GBp 1,250) and Siemens (EW, TP €90).

COP-21: relative winners and losers

In this section we aim to highlight the opportunities and risks for the sector from a successful policy outcome. Based on industry exposure to which we ascribe a weighting on positive or negative impact, Vestas, Schneider and ABB emerge as winners. This is driven by a high exposure to renewable energy and energy efficiency. In contrast, we see Weir, Sandvik and Metso as net losers based on their exposure to the oil & gas markets. Under our framework, Siemens wins in renewables, rail & industry, but loses in fossil as well as in oil & gas.

FIGURE 79

Vestas, Schneider and ABB the winners, Weir, Sandvik and Metso the losers



Source: Barclays Research

FIGURE 80

Barclays end market weightings ascribed to a successful policy outcome

End market	Barclays weighting	Drivers	Key companies
Renewable energy	+100%	Greatest beneficiary in power generation	Vestas, Siemens
Motors & drives	+100%	Most significant product category to reduce energy consumption in industry	ABB, Schneider, Siemens
Transmission/Distribution equipment	+100%	Beneficiary of increased renewables penetration	ABB, Siemens
Lighting	+80%	Strong growth in (lower margin) LEDs and accelerated phase-out of (higher margin) conventional lighting,	Osram, Philips
Low voltage equipment	+50%	Clear beneficiary in lighting/HVAC controls, limited impact in the area of safety, e.g. circuit breakers	Legrand, Schneider, ABB, Siemens
Rail	+50%	Most efficient mode of transportation	Alstom, Siemens
Mining	0%	Carbon policy may constrain long-term macro growth. Offset from energy efficiency investments	Atlas Copco, Sandvik, Metso, Weir
Automotive	-50%	Lower unit demand, offset: greater push towards light-weighting and more energy efficient drive-train	SKF, Atlas Copco, Kuka, ABB
Fossil Power	-50%	Growth in global electricity demand negatively impacted, shift out of fossil fuels, offset: shift from coal to gas	Siemens
Oil & gas	-100%	Negative: lower oil consumption, positive: higher demand for gas energy efficiency investments	Weir, Siemens, ABB, Schneider

Source: Barclays Research

Supporting revenues in a low/no growth world

Since 2013, organic revenue growth for the European Capital Goods sector has remained sub 2%, reflecting the sharp slowdown in mining, oil & gas, emerging markets and most recently US industrial spending. A strong policy outcome would support incremental growth in renewables and energy efficiency. While difficult to quantify with a great degree of accuracy, we believe the impact on our top-rated stocks would be significant.

Clear benefit for renewables

A sustained increase in spending on renewable energy – building on the strength seen over the past two years – would clearly support the build-out of wind, in our view, and our OW call on Vestas. As calculated by the IEA's World Energy Outlook (November 2015), wind energy output in 2025 would rise by 18% under the 'New Policies' scenario vs. the baseline current policies scenarios. Taking into account the policies required to limit global warming to 2°C (the '450 Scenario') wind output in 2025 would increase 38% vs. the current policy scenario.

Quantifying the investment opportunity in energy efficiency is more difficult

The IEA forecasts a rise in energy efficiency spending from $380bn p.a. over the next five years to $920bn p.a. from 2035 through 2040 under the New Policies scenarios. Currently, the transport sector accounts for 60% of spending, followed by 36% for buildings and only 4% in industry. According to Schneider estimates (CMD presentation, February 2014), around 80% of the economic potential of energy efficiency measures in buildings/data centres and infrastructure remains currently untapped.

FIGURE 81

Fossil fuels are far more subsidized than renewables - lower oil price an opportunity

Fuel subsidies ($bn, 2014)	
Fossil fuel - Without 2009-14 reforms	610
Fossil fuel	490
Renewables	112
Biofuels	23

Source: IEA and Barclays

Mixed impact on fossil power generation

The impact from a successful policy outcome would be twofold in our view. One the one hand, lower electricity demand growth (According to the IEA, *energy efficiency has already cut consumption growth by two thirds over the past decade with more to come*) and a shift towards renewables would reduce demand for fossil fuel power even further. On the other, the displacement of coal and the need for more back-up power (at least until more economical energy storage technology is developed) should support a further gain in share for gas-fired capacity, which accounts for a significant proportion of Siemens' Power & Gas divisional revenues.

While the US is moving in this direction (supported by cheap shale gas), this has yet to really benefit the 3 major global gas turbine suppliers (GE, Siemens and Mitsubishi Hitachi Power Systems). Industry overcapacity - built up across the industry in anticipation of even higher demand – has led to *significant pricing pressure*, exacerbated by European energy policy which for now has destroyed profitability for gas-fired plants. **In sum we believe that the net impact will be negative which explains our -50% weighting ascribed to fossil power**.

Climate pledges and planned actions

The 150 countries that have submitted pledges for COP-21 (21st session of the Conference of the Parties) under the 'Intended Nationally Determined Contributions' or INDCs represent 90% of global economic activity and account for close to 80% of global fossil fuel production. Half of the submissions include explicit energy-focused targets. A full implementation would require the energy sector to invest $13.5 trillion through 2030. According to IEA's central scenario, global energy demand would grow by only 1% p.a., half the average annual rate seen since 1990.

Submitted plans could drive investments of €900bn p.a.

The plans submitted would be consistent with an average global temperature increase of around 2.7°C by 2100. While falling short of the ultimate target of limiting the increase to 2°C, they would represent a solid base to build upon.

A full implementation of the unconditional pledges submitted by mid-October would require the energy sector to invest **$13.5 trillion in energy efficiency and non-carbon technologies from 2015 through 2030**. This is equivalent to $900bn of spending per annum.

Increased renewables deployment (40% of submissions)

According to the IEA, over 60% of projected investments in power generation under the pledges made would be in renewable energy with wind accounting for one third, solar (mainly PV) for around 30% and 25% in hydro. In our view, the greatest winner of the stocks we cover would be **Vestas**.

Improved energy efficiency (33% of submissions)

Around $8.3 trillion is required through 2030 to improve energy efficiency across the transport, building and industry sectors. Many of the companies under our coverage should benefit from this, above all **ABB**, **Schneider**, **Legrand** and **Siemens** in terms of efficiency in industry (esp. motors) and buildings. Rail should be a clear beneficiary of a greener transport strategy (**Alstom** and **Siemens**).

Over the past decade, energy efficiency has cut global electricity demand growth by two thirds (0.7% annual growth vs. 2.0%) and the IEA predicts that policies under the 'New Scenario' could cut global primary energy demand by 6% in 2040 compared with the current policy scenario. The payback time associated with additional energy efficiency measures under the 'New Policies' scenario through 2030 is estimated by the IEA at around 2 years in North America and Europe and closer to 1 year in both China and India.

> 'Two thirds of the economic potential to improve energy efficiency remains untapped' - Schneider

Other measures: e.g. closing energy inefficient coal plants

Other measures submitted include the reduction in use of energy inefficient coal plants, lowering methane emissions from oil and gas production, fossil fuel subsidy reform or carbon pricing. The IEA notes that other solutions required for a transformation of the energy sector are rarely mentioned. These include nuclear power, carbon capture and storage as well as alternative vehicles (advanced biofuels, electric).

Power generation: Lower demand growth, more renewables

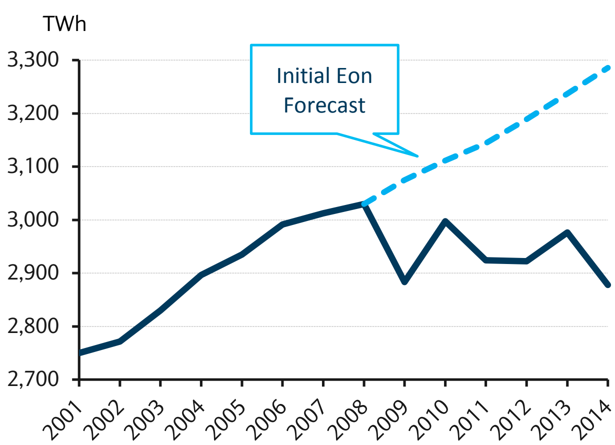
The power sector is seeing the greatest changes ever. Lower demand growth in mature markets is coupled with a rapid change in the mix. Between 2015 and 2040, the IEA estimates that 3,600 GW of renewable capacity will be added. Meanwhile the decarbonisation of power generation continues with gas-fired capacity displacing coal across many markets. We see the winners in the renewable energy segment while we expect the fossil fuel market to remain challenging despite growth in gas.

Mature market electricity demand growth slowdown

Since 2008, electricity demand in Europe has declined by 5%. While partly explained by lower economic growth, energy efficiency has had a significant impact. The picture is not too dissimilar in the US, where the historical link between GDP and electricity demand growth has been broken. With an even greater push for energy efficiency across mature markets and China, we expect this trend to continue. Offsetting the expected decline in overall mature market energy, demand will continue to grow in emerging markets.

FIGURE 82

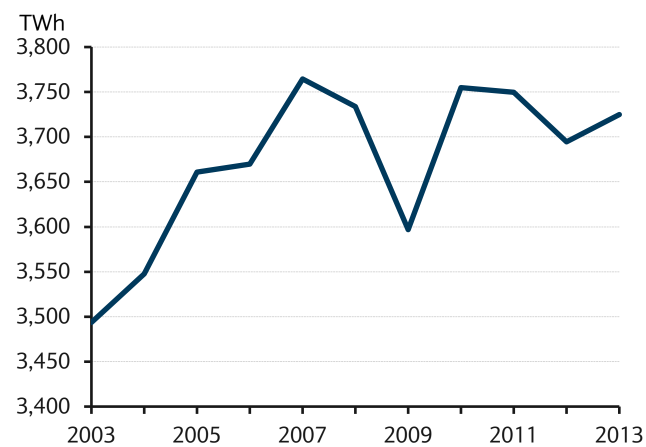
European electricity demand - in decline



Source: E.on 2008 investor presentation, Barclays Research

FIGURE 83

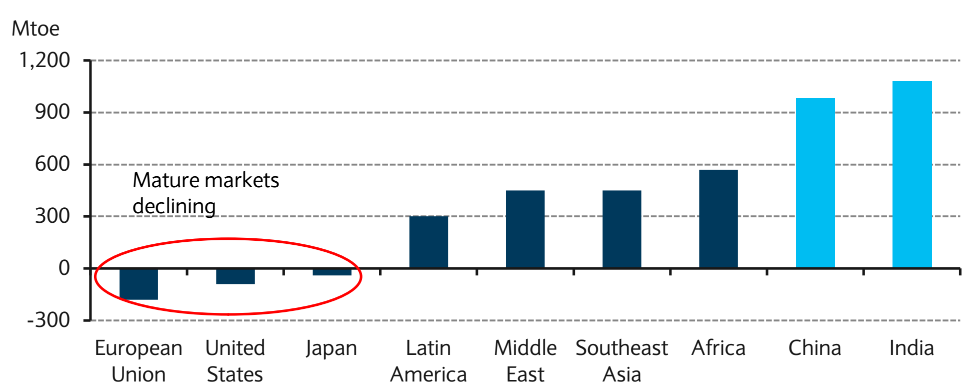
US electricity demand – ex growth



Source: EIA

FIGURE 84

Overall energy demand driven by emerging markets, led by India



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More renewables: Vestas, Siemens, ABB

Renewables (ex-hydro) accounted for just 3% of the global electricity generation mix in 2014 and are expected to rise to 20% by 2030, according to the IEA, even under the current policy scenario. Capacity additions reached a record high of 130 GW in 2014 and, according to IEA estimates, could account for 60% of new capacity additions over the coming 15 years, becoming the largest source of global power generation ahead of coal by 2030.

Energy transition in full swing

In 2014, renewables contributed almost half of the world's power generation capacity additions and - according to the IEA - have already become the second-largest source of electricity after coal. Based on its power generation outlook to 2040, the IEA forecasts that renewables will overtake coal in 2030 as the largest power source. **India**, which is forecast to see the greatest energy demand increase over this timeframe, is seeking to expand renewables. According to the Economic Times (16 November), the Power Minister believes that a 2022 renewables target of 175 GW is necessary.

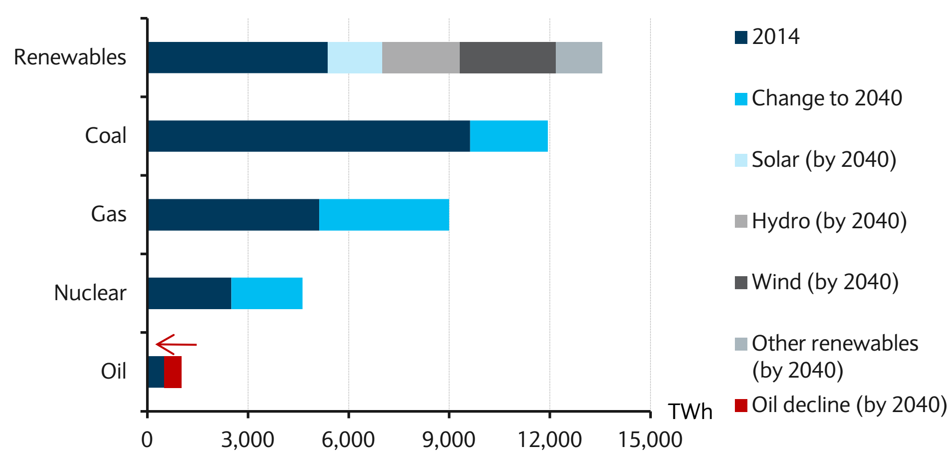
> Renewables accounted for close to half of new global capacity additions in 2014 and now represent the seond largest source of electricity after coal.

Between 2015 and 2030, **renewable capacity is projected to reach 60% of total investments in power generation**, according to IEA estimates, with **one third in wind**, **~30% in solar** and **~25% in hydro**. After renewables, **gas** is forecast to see the greatest level of growth, as shown in the chart below.

Under the IEA scenario which factors in the climate pledges made, global carbon emissions from electricity generation should start to stabilize as global electricity generation – driven by emerging markets - continues to grow in line with past levels. This despite the fact that India is forecast to continue to add significant coal capacity (estimated at ~800 MTce through 2040).

FIGURE 85

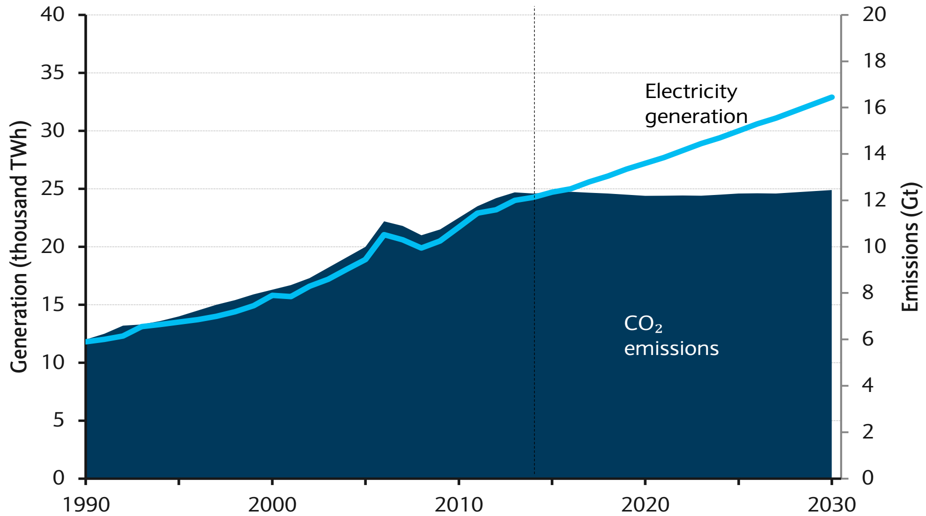
Global electricity generation by source: Forecast changes from 2014 to 2040*



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates. * driven by existing policy support

FIGURE 86

World electricity generation versus related CO2 emissions* – conscious decoupling



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. Also based on Barclays Research estimates * based on climate pledges made

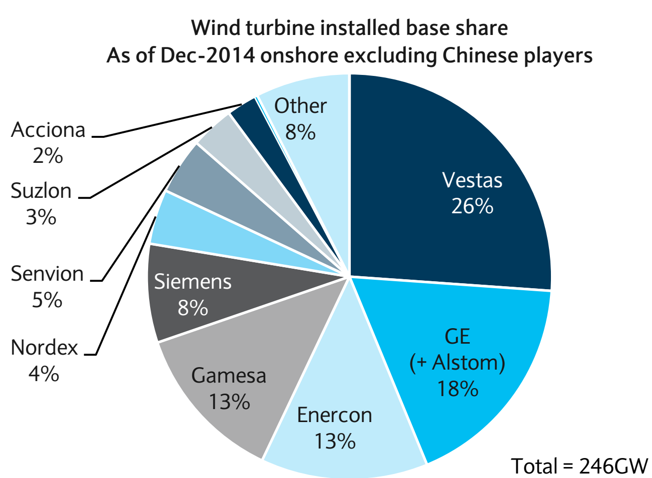
Wind Energy – approaching grid parity on-shore

With an installed base of 370 GW (out of a total world capacity of 5,500 GW, according to the IEA, wind energy has been the main contributor to the Renewable build out. The build-out in Wind thus far has been largely driven by government support but this is about to change in our view. Through a combination of better plant load factors, lower capex and better availability, Wind's levelised cost of Electricity (LCOE) is pushed down and is now reaching "grid parity" in many circumstances. With commercial electricity storage, wind's appeal should increase yet more, as the technology will become dispatchable, i.e. able to compete with gas and coal for baseload.

In 2014, **GE** and **Vestas** each held around a 20% market share of the **onshore market, excluding China**. Vestas has a 26% share of the total installed base. China is dominated by local players and is, to a large degree, closed to international vendors. Goldwind is the largest Chinese player with an installed base of 24GW and 2014 installations of 4.5GW.

FIGURE 87

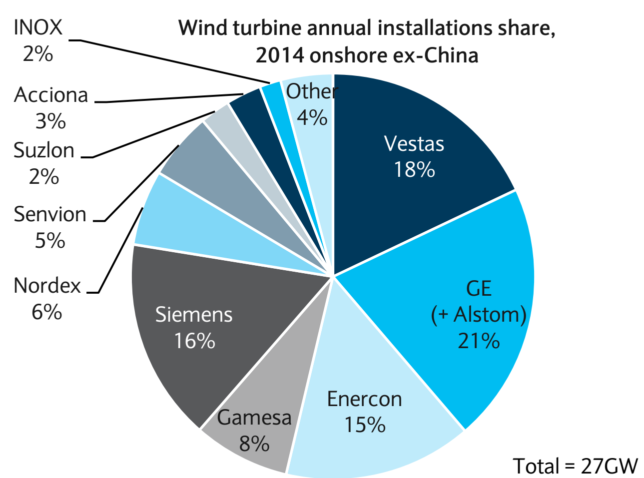
The top-3 have over half of the installed base…



Source: GWEC, Bloomberg, Company Reports and Barclays Research

FIGURE 88

… and a similar share of 2014 installations



Source: GWEC, Bloomberg, Company Reports and Barclays Research

Offshore market still small and dominated by Siemens

The **offshore installed base** currently represents 10 GW out of total wind capacity of 370 GW, according to EWEA. While the capacity factor offshore is higher and planning issues less of a problem, the cost remains too high. The industry aims to bring down cost by developing larger, more efficient turbines and better grid connection technologies. Siemens' target is to cut the cost per kWh to 10 Euro cents by 2020.

Siemens is currently the global market leader on the turbine side with a share of 86% in 2014 (installed base of 4.7 GW, backlog of 5.4 GW) ahead of **MHI/Vestas** (9.5%), **Areva** (3%), **Senvion** (0.8%) and **Samsung** (0.5%) according to EWEA data.

Assessing incremental growth in wind

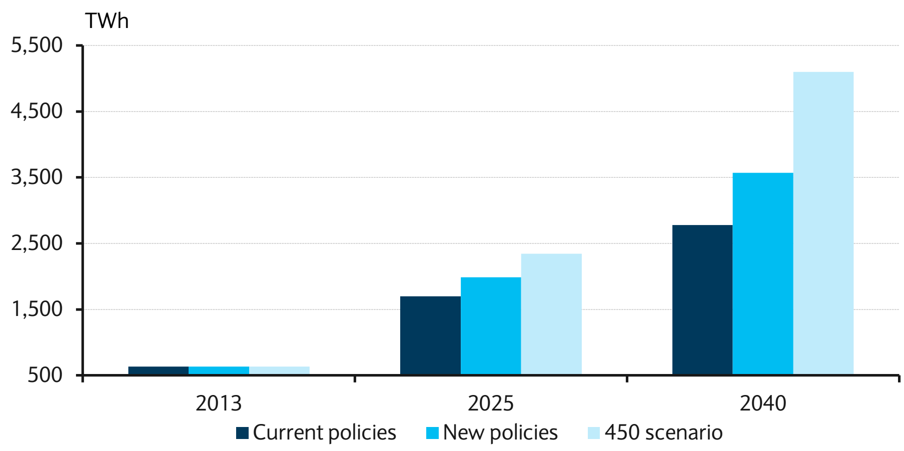
In projecting growth in renewable energy investments, the IEA takes account of three policy scenarios:

- **'Current Policies Scenario'**: only considers policies formally adopted as of mid-2015, assuming no changes to these policies.
- **'New Policies Scenario':** takes into account policies adopted as of mid-2015 plus other relevant intentions that have been announced, even if precise details are not yet available.
- **'450 Scenario':** assumes a set of policies that would allow the international goal, of limiting the goal temperature increase to 2°C, to be achieved (stabilization of greenhouse gas concentration after 2100 at around 450 parts per million).

Based on these three scenarios, global wind energy output could rise from 635 TWh in 2013 to between 1,701 TWh to 2,344 TWh by 2025.

FIGURE 89

IEA projected development of global wind energy output under the three IEA scenarios



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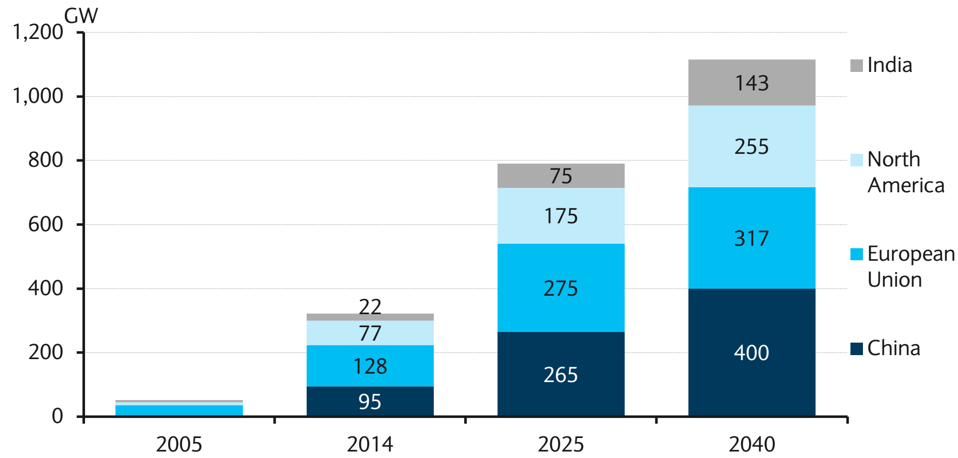
On a regional basis, China, the EU, North America and India are expected to dominate new capacity additions through 2025 and 2040. For the EU, the IEA is projecting an increase in the installed base from 128 GW to 275 GW by 2025 and for North America from 77 GW to 175 GW. These two regions are most relevant for the Western vendors, including Vestas and Siemens.

FIGURE 90

IEA projected growth in global wind installed base by region/country*



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research *under New Policies Scenario

Vestas the key play on the wind market

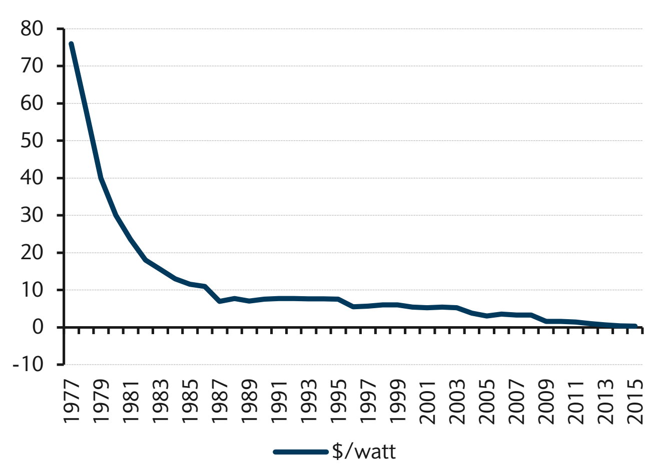
As global market leader and a pure play on wind, we believe **Vestas** is one of the main beneficiaries from a strong policy outcome. We rate the stock OW with a PT of DKK485. **Siemens** is the global market leader in offshore, but we expect Siemens to lose its number 3 position in onshore in 2015. However, Wind only represented 8% of FY2015 group sales.

Solar Energy – close to grid parity in the sunbelt regions

Thanks to a rapid decline in cell prices (courtesy of technology advances and significant Chinese government subsidies), the cost of installed solar power systems has fallen 70% over the past 5 years. In certain sunbelt areas it has now reached grid parity levels. ABB quotes a price as low as 5.84 cents/kWh for a recent project in Dubai. In the US, where gas-fired electricity costs around 6 cents/kWh, solar still requires subsidies. With the current investment tax credit, the price is now around 5 cents kWh.

FIGURE 91

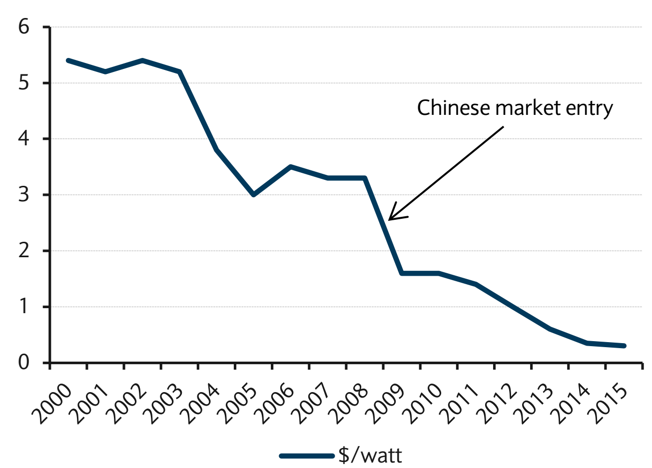
Decline in solar PV price ($/W) since the late 1970s



Source: Bloomberg New Energy Finance and PV.Energytrend.com, Barclays estimates

FIGURE 92

Chinese entry into PV market accelerated price drop post 2008 ($/W)



Source: Bloomberg New Energy Finance and PV.Energytrend.com, Barclays estimates

The global installed base in solar has grown from 15 GW in 2008 to 177 GW in 2014 (source: IEA) with annual investments reaching $150bn last year according to Bloomberg New Energy for 45 GW of capacity. According to SMA Solar, global installation amounted to 34 GW for the first 9 months in 2015. Bloomberg New Energy Finance estimates that annual installations will reach around 60 GW in both 2016 and 2017 under its conservative forecasts. Currently contributing only 1% of annual global electricity generation, we believe that solar could account for over 5% of the world total by 2030. With an installed base of 39 GW, the share of solar has already reached 7% in Germany in 2014 (source: BDEW), which hardly ranks as one of the sunniest countries in the world.

No more major European solar cell vendors left – but ABB now the no. 2 inverter vendor

As a result of stiff competition from China, there are no more major European solar cell manufacturers left anymore (half of the top 10 are Chinese, 2 are Taiwanese, 1 is from the US, 1 from Canada and 1 from Japan). **ABB** became the number two global solar inverter manufacturer – post the acquisition of **Power One** - and maintained this position in 2014 according to IHS rankings. German-based **SMA Solar** (not covered), while having lost share to Asian vendors, remains the global number 1 (IHS PV Inverter Market Tracker Q3, September 2015 as quoted by SMA Solar).

More off-grid systems – in conjunction with power storage

Solar is very effective in combination with storage technologies. ABB is working on off-grid solutions for small towns, especially destined for Africa, which are preconfigured and can be shipped out in a container and easily assembled on site. Globally, 1.3bn people (equivalent to the entire OECD population) do not have access to electricity, with 97% of these located in sub-Saharan Africa and developing Asia (source: IEA). Off-grid solar solutions provide in many cases a cost-effective and clean solution. In India, the government has redirected some of the oil subsidies towards supporting the build-out of solar-powered agricultural irrigation systems which ABB is supplying. These replace traditional diesel powered units.

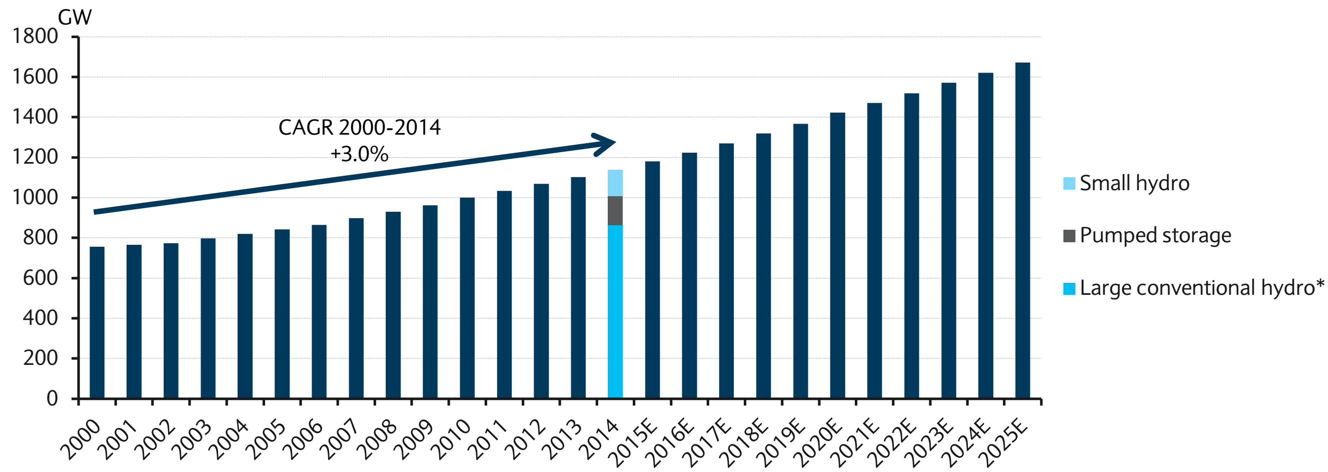
Today, **ABB** offers battery storage solutions from 25 kV to 70 MW which, in conjunction with solar, can offer grid independent solutions for a wide range of applications.

Hydro – Andritz (not covered) remains the only listed play

The global installed base in hydro power reached 1,137 GW in 2014 and is forecast to grow to 1,671 GW by 2025 (source: Andritz/GlobalData).

FIGURE 93

Projected growth of installed base in hydro power: 3.6% annual growth projected with highest level in pumped storage



Source: Andritz, GlobalData * > 30 MW

2014-2025 growth projection (CAGR): 3.6% (2000-2014: 3% CAGR)

- **Small hydro:** 2.7%
- **Large conventional hydro (>30 MW):** 3.1%
- **Pumped storage:** +6.6% - the ability to shift production to peak times and store electricity during off-peak times is driving incremental growth in this segment.

Since 2010, the global hydro market (value of electro-mechanical equipment) has fluctuated between €5.1bn and €8.3bn (average of €6.6bn, according to Andritz) and the company expects demand to remain around €4-5bn over the coming years.

With **Alstom** having sold its Energy business to **GE** and **Siemens** having injected its hydro business into a JV with privately held Voith, the only remaining listed European player on the hydro power market remains **Andritz** (not covered) with 30% of 2014 sales generated in hydro.

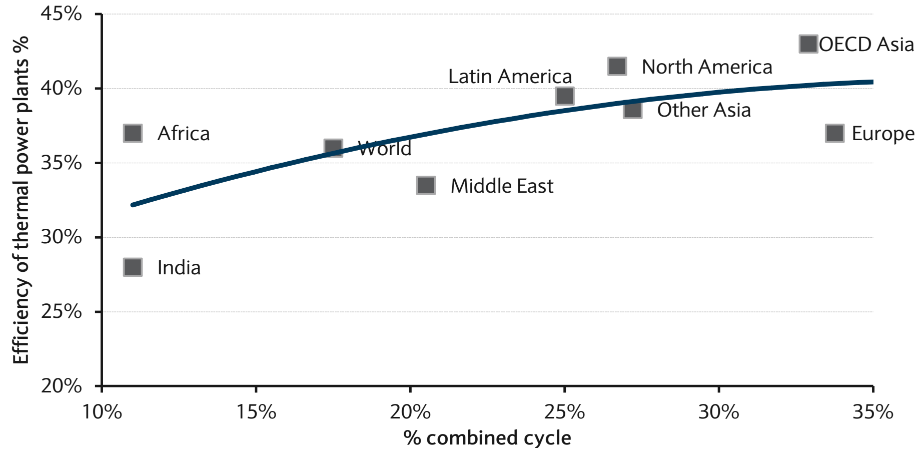
Thermal power - risks to demand, but gas a relative winner: Siemens

We consider thermal power generation to be one of the potential losers under a successful policy outcome. First of all, a greater focus on energy efficiency would impact global electricity demand growth negatively. Secondly, the focus will be on moving away from fossil power sources. However, within fossil power we see gas continuing to gain share from coal. The focus to improve turbine efficiency should continue, but in light of lower overall demand, tough pricing/terms & conditions are here to stay in our view.

Gas replacing coal (with the exception of Europe...)

FIGURE 94

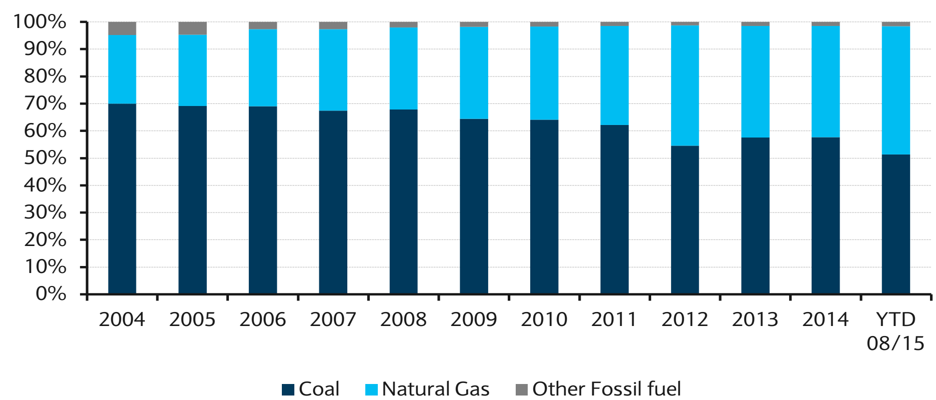
Greater penetration of CCGT technology drives thermal power gen efficiency



Source: ABB, Enerdata, 2013, Barclays estimates

FIGURE 95

Gas continues to gain share vs. coal of US fossil fuel power generation

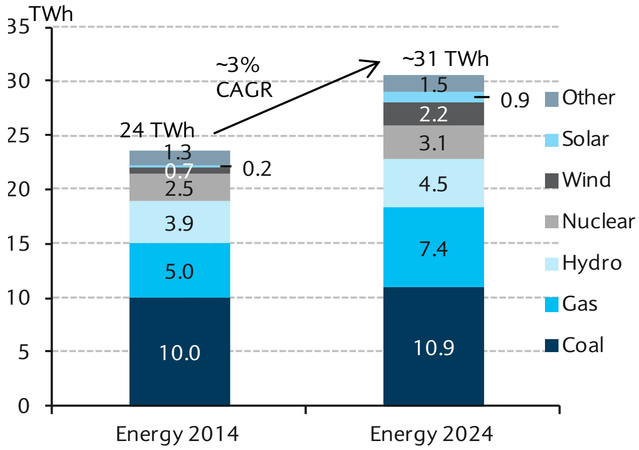


Source: EIA

Coal and gas-fired plants continue to improve in terms of thermal efficiency. On average, a gas-powered plant emits half the level of CO_2 emissions of a coal-powered plant (source: EIA). With gas slowly replacing coal across many countries as the preferred thermal technology (US, UK – which is seeking a full exit by 2025 and according to our utility team may need to add up to 20 GW of gas capacity by the early 2020s- and China over the longer term), there is a big push by three major vendors (**GE/Alstom**, **Siemens** and **Mitsubishi Hitachi Power Systems**) to grow their installed base, especially post the launch of a new generation of H-class turbines. **Ansaldo Energia** (now 40% owned by **Shanghai Electric**) is seeking to establish itself using aggressive pricing as the number four, having acquired the Alstom GT24/26 technology.

FIGURE 96

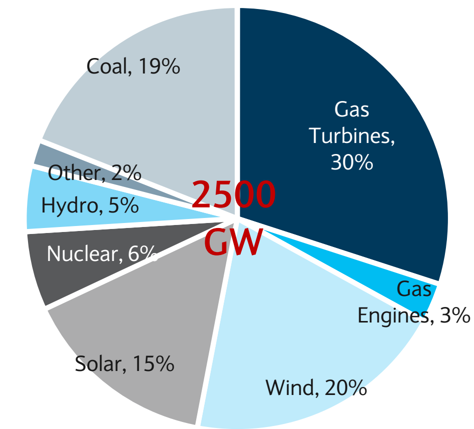
GE forecast growth in electricity demand of 3% p.a. from 2014-2024 (1% p.a. in mature markets)



Source: GE Power Presentation, 20 November 2015

FIGURE 97

GE expects gas to represent 30% of new installations of 2,500 GW* (2014-2024), equating to 75 GW p.a.



Source: GE Power Presentation * net of 570 GW of retirements

Higher carbon prices – big potential driver for gas-fired capacity

Under the IEA's New Policy and 450-Scenarios, the carbon price per tonne could move up to $100 by 2030, further accelerating the shift away from coal to gas. This would be particularly helpful for demand in Europe, where gas capacity is being reduced as a result of lower coal prices and competition from renewables.

FIGURE 98

Assumed CO2 prices for selected countries/regions under IEA scenarios (2014 $/ton)

Scenarios	Region	Sectors	2020	2030	2040
New Policies	EU	Power, industry, aviation	22	37	50
	Chile	Power	6	12	20
	Korea	Power and industry	22	37	50
	China	Power and industry	10	23	35
	South Africa	Power and industry	7	15	24
450-Scenario	US & Canada	Power and industry	20	100	140
	EU	Power, industry, aviation	22	100	140
	Japan	Power and industry	20	100	140
	Korea	Power and industry	22	100	140
	Australia & New Zealand	Power and industry	20	100	140
	China, Russia, Brazil, South Africa	Power and industry	10	75	125

Source: IEA, World Energy Outlook 2015

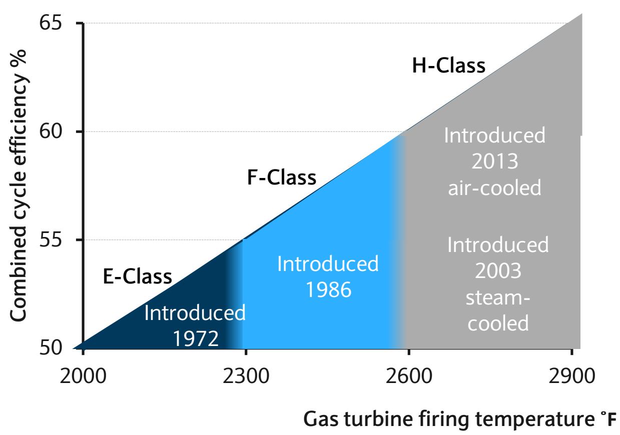
Boosting the efficiency of the new generation turbines

The new generation of H-frame turbines has achieved efficiency levels in excess of 60%. GE is targeting a mid-term efficiency level of 65% for its H-frame by further optimizing materials, combustion and cooling technology. GE calculates that a fleet of 500 H-frames (the target sales level through 2030) can deliver $8bn of annual fuel savings versus the older generation F-frame fleet (55% efficiency). Siemens is currently working on updating its H-frame to boost thermal efficiency from 60.75% to 63%+.

'Every 1 percentage point improvement in the thermal efficiency of a gas turbine represents $5bn in annual fuel savings across the global fleet' - GE

FIGURE 99

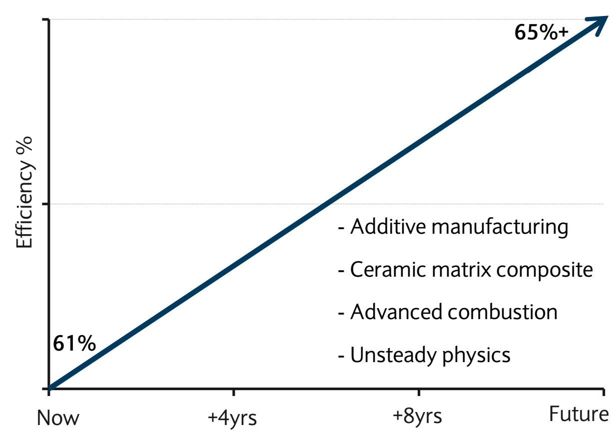
Gas turbine thermal efficiency improvements since 1972



Source: GE

FIGURE 100

Scope to drive H-frame efficiency to 65%+

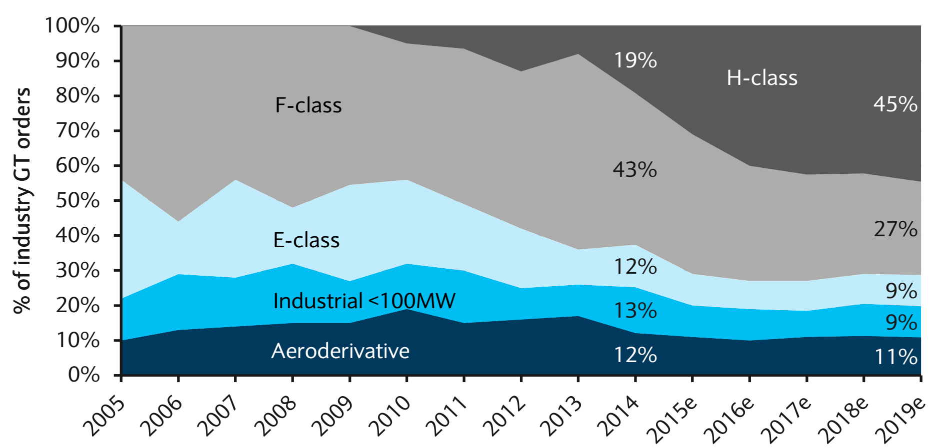


Source: GE

By 2019, GE estimates that H-frame turbines will account for 45% of the market, up from 19% in 2014. As of mid October, Siemens had sold 74 H-frames. As of 20 November, GE has 21 units in the backlog with a total of 70 units selected by customers (including 25 in the US, 10 in Egypt, 7 in Japan and 7 in the UK).

FIGURE 101

H-frames forecast to account for 45% of industry sales by 2019



Source: GE Power presentation, 20 November 2015, Barclays estimates

Combined heat and power (CHP): up to 90% thermal efficiency

Even more efficient are power plants with combined heat and power generation (CHP), which simultaneously generate electricity, heat or process steam and can achieve energy efficiency levels of 60% to >90%. One example is Siemens' Lausward new 595 MW power plant located in the port of Düsseldorf. With the ability to decouple 300 MW of thermal energy from a single gas turbine power plant block in combined cycle mode, the overall efficiency reaches 85%.

Competition from storage technology?

A clear benefit for gas turbines is their flexibility and quick reaction time. This makes the technology ideally suited as back-up for intermittent renewable technology (wind and solar) and for peaking application. With the rapid advances in battery and other technologies, however, there will come a time when storage technology can replace peaking units.

> 'Post 2020, there may never be another peaker built in the US' Jim Robo, CEO of NextEra Energy

NextEra already investing $100m in energy storage projects this year

According to the CEO of **NextEra** (OW, PT $120, covered by Dan Ford)– a leading US clean energy utility – this may occur soon after 2020 if the price deflation witnessed for solar cells is matched in the battery technology segment. Over the next 12 months, NextEra is investing around $100m in energy storage projects in California, Arizona and the Northeast US to back up intermittent renewable sources (wind and solar). Over time, energy storage will not only be used just to provide back up for renewables, but also for reliability purposes and to avoid transmission charges. The CEO aims to position the company as a leader of energy storage in the US.

Rapid growth in battery storage market

According to Lux Research, as published by PV Tech Storage (29 October 2015), 1,788 MW and 3,460 MWh of grid storage has been deployed worldwide on a cumulative basis as of October in 841 projects. Since 2011, the global market for grid storage has grown by a compound average growth rate of 33% (power capacity) and 20% (energy capacity). Li-ion has grown much faster than the global market with CAGRs of 48% and 62% by power and energy, respectively. Japan continues to lead the global market in energy capacity deployed, but the U.S. remains the most promising market with 350 projects and 776MW deployed or under construction. Led by Tesla's claimed reservation (pre-order) figures, the residential market could nearly triple in 2016, assuming that the company ships 29% of its claimed 100,000 reservations.

Technical innovations making batteries lighter and cheaper

As highlighted by the Financial Times (30 October), a breakthrough in electrochemistry at Cambridge University could result in the development of **lithium-air batteries that store 5x more energy** in a given space compared to today's technology. This could significantly extend the range of electric vehicles and at the same time dramatically improve the economics of electricity storage. If this technology can be turned into a commercial product, it would enable a car to drive from London to Edinburgh on a single charge, with batteries that cost and weigh one-fifth of the lithium-ion cells that power today's electric cars.

Recycling old automotive lithium-ion batteries in energy storage applications

This month, **Daimler** announced plans to build what it claims would be the world's largest stationary storage facility made out of re-used electric vehicle batteries. The company's new subsidiary Accumotive will reprocess about 1,000 old lithium-ion batteries, wiring these into groups of 46, with each group providing 600kWh of energy. The system is designed to work in conjunction with intermittent renewable energy and help to support grid stability.

Daimler guarantees its electric vehicle customers a battery life of up to ten years. However, the battery systems are still fully operational after this point, as the low levels of power loss are only of minor importance when used in stationary storage. The company estimates that these batteries can be used for a further 10 years.

Earlier this year, **GM** – working with ABB - showcased a similar idea in a test facility recycling batteries from the Chevrolet Volt. In 2013, there were around 70,000 electric cars on the road in the US (Energy Information Administration). As many of the batteries are retired, there will be significant scope to reuse these for stationary power applications.

For a more on energy storage, please see the Microgrids section on page 79.

Energy efficiency: an $8 trillion+ opportunity?

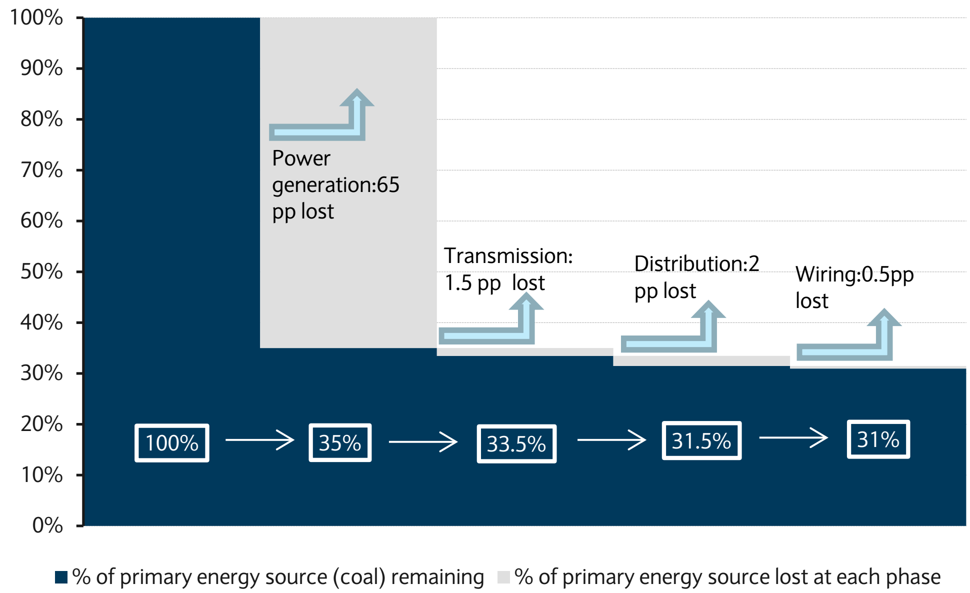
Since 1974, energy efficiency improvements have yielded estimated savings of 1,500 Mtoe (source: IEA) and the untapped potential still remains substantial. From 2005 to 2014, the coverage of energy efficiency regulation in industry, buildings and transport has nearly doubled from 14% to 27% of global energy consumption, according to the IEA. Under the INDC commitments, the IEA forecasts total investments in energy efficiency of $8 trillion through 2030. Looking across the electricity value chain, we see the greatest opportunity in industry, which accounts for over 40% of world electricity demand.

'The only sustainable watt is the negawatt'

As so aptly stated by Schneider, the easiest way to reduce carbon emissions is to reduce consumption. **1 kWh of energy saved at the source of consumption saves 3 kWh in primary energy.**

FIGURE 102

Significant losses across the energy supply chain



Source: Sankey Diagrams

The greatest loss occurs during the power generation process, amounting to around 65% for a traditional coal fired plant. Using a modern combined cycle gas plant, this loss can be cut to under 40%. Across transmission and distribution, there is the potential to cut the combined loss from 10% in this example to around 4%.

Once the electricity has been generated, there is ample scope to reduce consumption. A few examples, discussed in more detail in the Energy Efficiency Section:

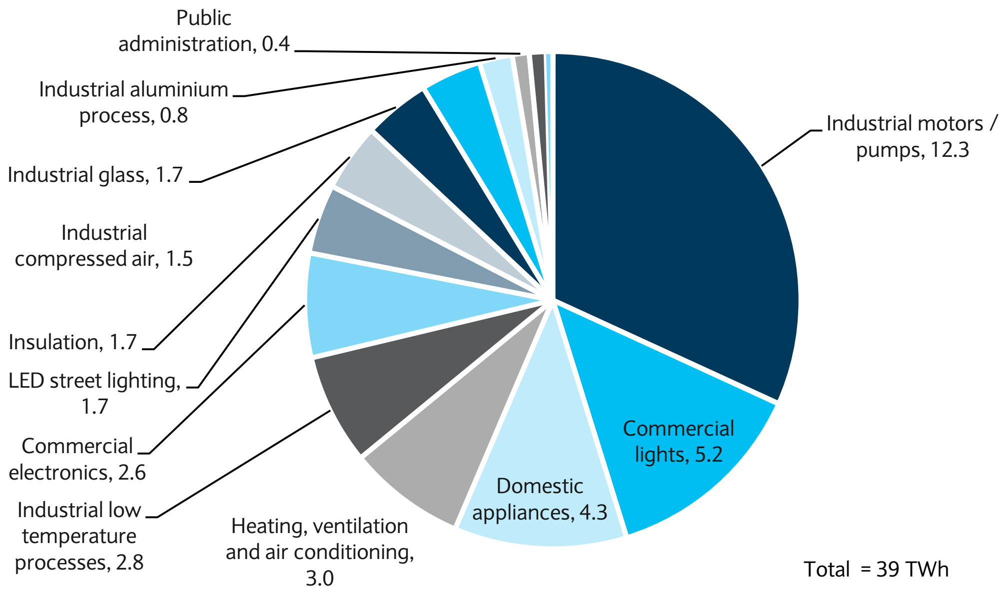
- **Industry (>40% of demand):** 70% of demand accounted for by motors. Scope to reduce consumption by 20-50% using an energy efficient motor and a variable speed drive
- **Buildings (50% of demand):** Scope to cut consumption by up to 30%
- **Lighting (18% of demand):** LEDs offer scope to cut consumption by 85% vs. incandescent technology

The opportunity to save electricity: UK example

From 2008 through 2014, electricity consumption in the UK has declined by 12% driven mainly by energy efficiency measures taken. A study published by the Green Alliance in 2014 highlights the opportunities for the UK to cut 39 TWh of electricity consumption by 2030 - equivalent to 10% of total demand - through energy efficiency measures. The greatest single source lies in the area of **industrial motors and pumps** followed by **lighting**. The average payback is ~2 years in lighting and 3.6 years for industrial processes.

FIGURE 103

How the UK could save 39 TWh by 2030 – reducing the need for peak load equivalent to 8 CCGT power plants



Source: The Green Alliance, 2014

FIGURE 104

Payback on a selective number of Siemens energy efficiency projects in the UK

Projects in the UK (ranked by % of savings)	Annual energy spend (GBP)	Total investment (GBP)	Annual savings identified (GBP)	Savings as % of energy spend	Payback in years	CO2 savings (tonnes)
Modern hospital complex	1,311,913	1,234,735	557,821	43%	2.2	3,181
Food manufacturer	1,259,112	615,381	442,583	35%	0.9	3,810
Large C19th listed office building	723,807	257,000	223,040	31%	1.2	1,108
Pharmaceutical manufacturer	2,525,000	2,149,049	707,000	28%	3.0	7,854
3-year old school	193,560	5,500	54,798	28%	0.1	557
Historic listed castle	352,648	184,189	92,842	26%	2.0	565
Confectionery manufacturer	1,452,380	301,000	305,000	21%	1.0	3,000
1960s office block	114,601	53,501	24,198	21%	2.2	78
International airport	16,842,105	4,800,000	3,200,000	19%	2.1	22,000
Office block on manufacturing site	207,812	47,880	39,666	19%	1.2	252
Modern sports centre	18,398	4,850	2,532	14%	1.9	13
Defence manufacturer	930,731	116,700	93,073	10%	1.2	554
Steel manufacturer	25,714,285	5,400,000	1,800,000	7%	3.0	9,760

Source: Siemens

Top 10 energy efficiency payback ranking

Siemens has compiled a top 10 list for energy efficiency measures

- Targeting and measuring systems offer the quickest payback. In many cases, building owners or industrial companies are not aware of the exact energy consumption by source. In order to save energy, it is vital to understand what is driving overall consumption.
- Energy efficient lighting offers a quick return in buildings.
- For industrial facilities, the easiest way to save energy is to replace motors (70% of industrial electricity demand) with more efficient units and use variable speed drives to control their output.
- Improved automation solutions in both factories and buildings are highly effective, but these investments can take years to pay back.

FIGURE 105

The top 10 energy efficiency payback ranking

Energy efficiency projects	Payback period
Targeting and monitoring systems	1-3 months
Low energy lamps	1-12 months
Variable speed drives	3-12 months
High efficiency motors	3-12 months
Building controls	3 months – 4 years
Intelligent lighting controls	1-4 years
Increased factory of process automation	1-4 years
Power management solutions	1-4 years
Supply voltage optimisation	2-5 years
Combined heat and power	2-7 years

Source: Siemens

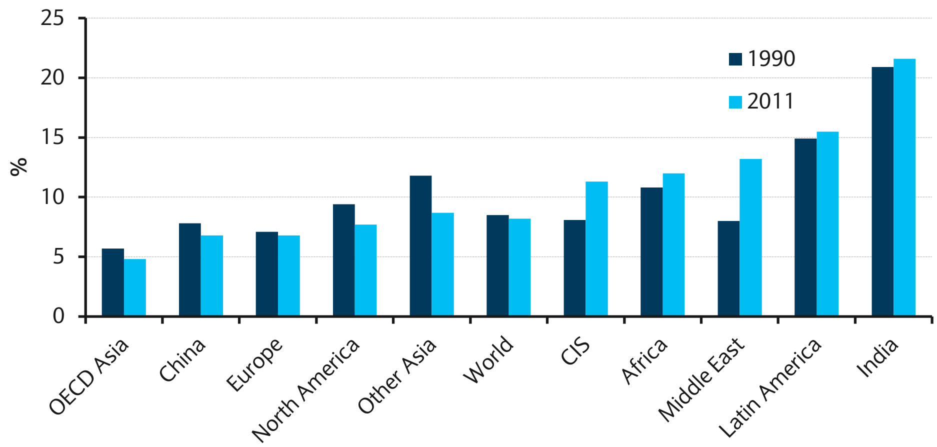
More efficient grid: ABB, Siemens, Prysmian, Nexans

Reducing grid losses – savings potential of 4% of global consumption

Grid losses averaged 9% in 2011 on a global level, ranging from 4% in developed Asia to over 15% and 20% in Latin America and India (where a substantial portion of the losses is non-technical, i.e. linked to non-payment). *If all grids were to perform as well as the OECD Asia average, Enerdata calculates that 4% of global electricity consumption (800 TWh on a 2011 basis) would be saved.* By investing in improved technology, including low-loss conductors and transformers, upgrading of voltages and reactive power control, North America cut its losses from 10% in 1990 to 7% in 2011.

FIGURE 106

Evolution of grid losses by region



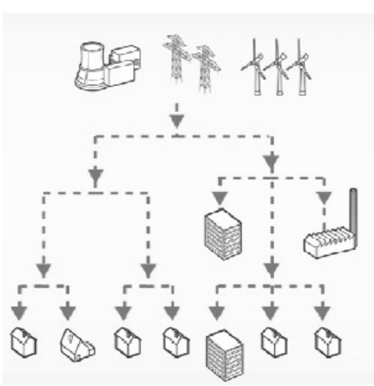
Source: ABB, Enerdata, 2013, Barclays estimates

Smarter grids – dealing with greater volatility and managing demand

The increased penetration of renewables is putting pressure on utilities to upgrade the grid, adding more regional capacity/interconnectors and improving grid automation in order to deal with greater volatility in supply and the growing level of locally generated power.

FIGURE 107

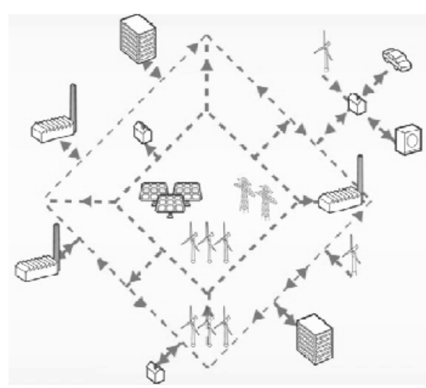
Traditional Grid: strict hierarchy, centralized power generation



Source: ABB

FIGURE 108

Future Grid: greater complexity, greater volatility, multi-directional flows



Source: ABB

Smart grid attributes:

- Combination of electricity and IT infrastructure interconnecting all users in order to efficiently balance demand and supply in an increasingly complex network
- Real time communication
- Demand response – incentivise users to shift demand to off-peak times
- More flexible
- Self-healing characteristics

Interconnections to accommodate more renewables

Simply put, the higher the penetration of intermittent renewable energy, the greater the need for interconnected grids. The EU is mandating that by 2020, 10% of national power generating capacity needs to be interconnected, which is forecast to save consumers €32bn p.a.

National Grid is planning 5 HVDC subsea interconnections with an estimated aggregate investment value of €8bn

FIGURE 109

Significant interconnection projects ahead: ~€8bn future capex opportunity from National Grid alone

National Grid: planned interconnections						Supplier	Value (E)	Supplier	Value (E)	
	Estimated cost (€bn)	Distance (km)	Capacity (GW)	Investment decision	On line date	Cable	Cable	HVDC converter station	HVDC converter stations	Cost per km (€m)
NSN - UK-Norway	1.5	720	1.4	2015	2020	Nex, Prys	890	ABB	410	1.24
NEMO - UK-Belgium	0.5	130	1.0	2015	2019	J-Power	130	Siemens	370	1.00
Viking - UK-Denmark	2.0	600	1.0	2016	2020/21	TBD	720	TBD	1,280	1.20
IFA 2- UK-France	0.9	240	1.0	2016	2020	TBD	240	TBD	610	1.00
IceLink - UK-Iceland	3.5	1,000	1.0	2017+	Post 2022	TBD	1,000	TBD	2,500	1.00
Total	**8.4**	**2,690**	**5.4**			TBD	**2,980**	TBD	**5,170**	
Existing interconnections										
IFA 1 - UK-France		70	2.0		1985					
BritNed - UK-Holland		260	1.0		2011					
Total			8.4							
UK installed base (GW)			72							
Planned inter- connections as % total			12							
Ex IceLink			10							
Statnett-Tennet										**Cost per km (€m)**
NordLink - Norway-Germany	1.5	623	1.4	2015	2020	Nexans (700 km)	500	ABB	670	0.71
						ABB (208 km)	149			

Source: National Grid, Statnett, Barclays Research

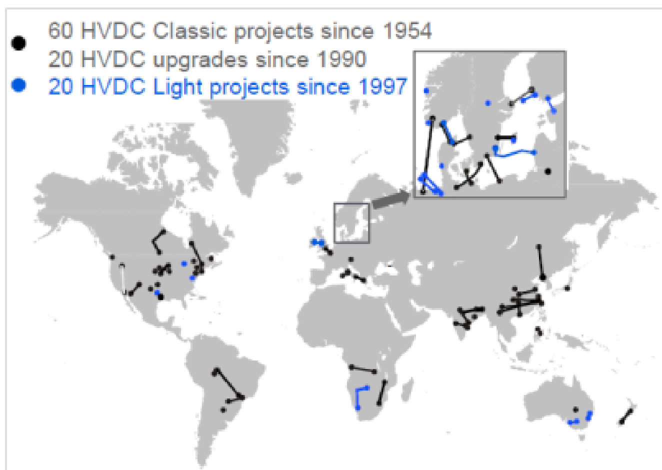
The best example is currently **National Grid's** interconnection projects (UK to Norway, Belgium, Denmark, France and Iceland) which will enable the company to profitably trade renewable energy, while reducing the UK's carbon footprint. This year, Germany and Norway announced Europe's longest HVDC interconnection (1.4 GW), which will trade wind for hydro.

ABB has been the market leader in HVDC interconnections, having pioneered the technology in 1954 with LCC HVDC. In the 1990s, ABB developed voltage sourced converter (VSC) HVDC technology (HVDC Light) which extends the economical range of HVDC transmission to a lower power range and much shorter distances than traditional technology.

ABB has been awarded ~100 HVDC projects representing a total installed capacity of more than 120 GW, accounting for about half of the global installed base. ABB's HVDC Light solution (VSC technology) currently enjoys an even higher market share; the company claims to have delivered 14 of the 15 VSC links that have been commissioned worldwide to date.

FIGURE 110

ABB installed base: >50% of the 190 systems installed worldwide



Source: ABB

The number two in the market is **Siemens**, which has also built a solid position in offshore grid connections. To date, the company has completed 13 connections with an aggregate capacity of 6 GW and is set to deliver another 2 with a total capacity of 1.5 GW. In October, the company launched a new solution (SGA-DRU) for offshore wind farm connections which *promises to be 30% cheaper* than current technology.

Alstom, a distant number 3 in HDVC, has now sold its business to GE.

Subsea cable opportunity

Prysmian remains the global market leader in submarine cables with a 40-50% market share. The company has a backlog of c€3bn, or roughly 3 years worth of sales. Through a combination of a complex product offering, a high level of engineering services and ownership of installation vessels, Prysmian is able to achieve 20%+ EBITDA margins. This makes submarine cables the most attractive profit-pool of the global cable industry.

The growth outlook is not bad either, with both the offshore wind and interconnection space in Europe providing more scope for future growth as set out in Figure 111 below.

ABB provides submarine cables through its Power Systems division, which represents 18% of ABB Group sales in 2014. Out of the $7bn of revenues in this division, ~25% or $2bn is accounted for by Grid Systems which includes power semiconductors, engineering solutions and cables. ABB is the only one of the three major global HVDC manufacturers (which include Siemens and Alstom) that can supply a fully integrated solution including cables. The company also sells cables on a stand-alone basis. ABB's offering includes XLPE (cross-linked polyethylene) insulated cables for AC transmission as well as mass-impregnated paper-insulated cables and polymeric insulated cables for HVDC, HVDC Light (a technology pioneered in the 1990s) and other high-voltage power transmission applications. ABB has delivered more than 7,200 km of XLPE cables for voltage levels above 100 kV around the world. The newest extruded 525 kV HVDC cable, launched in 2014, can transmit up to 2.6 GW of power (enough to supply Paris) over up to 1,500 km.

FIGURE 111

There are another 1,500km of submarine projects in Europe on the drawing board

List of main European projects currently under development					
1	Germany (Borwin IV, Dolwin VI)	NA	7	Denmark-Germany	300
2	France offshore	NA	8	Western Isles Link	150
3	Cobra (NL-DK)	300 km	9	Tunisia-Italy	200
4	France-UK (Eurotunnel)	50	10	Marseille-Languedoc	200
5	Green Connector (CH-IT)	50	11	Belgium-Germany	100
6	Västervik-Gotland	100	Total		1,550

Source: Prysmian and Barclays

Stabilizing existing grids

In order to stabilize existing grids and improve power quality and capacity, static VAR compensation (SVC) solutions are being deployed. SVCs provide fast-acting reactive power on high-voltage electricity transmission networks, regulating voltage, power factor, harmonics and stabilizing the system. A recent example is Poland, which needed to reinforce its grid in light of the excess amount of German wind energy being transported through its infrastructure on its way to southern Germany.

Replacing SF6 gas

Gas-insulated switchgear is used to control power flows where space is at a premium (otherwise air insulated switchgear is often the preferred option) and the most popular insulating material used is **SF6 gas** (sulphur hexafluoride) which has been identified as a greenhouse gas with the greatest global warming potential (*GWP of 22,200 vs. 1 for CO2*). There is pressure on the industry to strictly control leakage and to recover and recycle the gas. The key global suppliers, including ABB, Siemens and Alstom (now GE) are working on solutions using substitutes. Last year, ABB launched a pilot project in Zurich, Switzerland. The company claims that this new solution can lower carbon dioxide equivalent emissions by up to 50% over the lifecycle of the equipment.

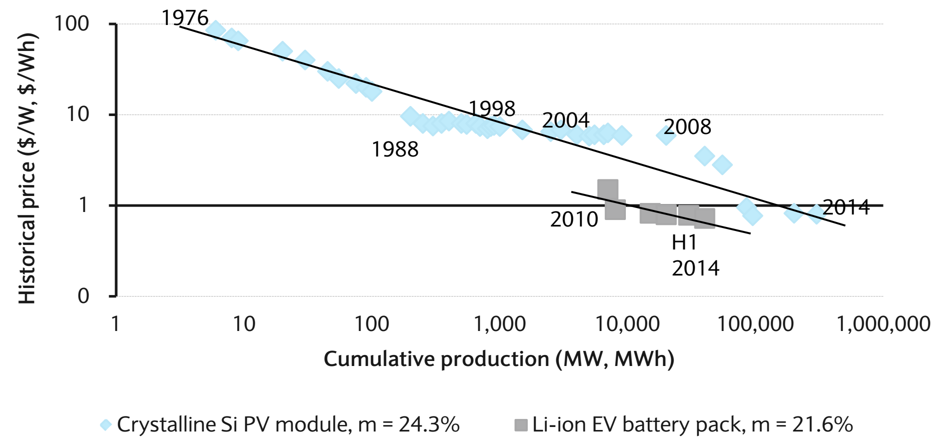
Microgrids: Technology improvement in energy storage driving growth

ABB working with battery partners

Improvement in energy storage technologies is also driving demand for microgrids in both mature and emerging markets. ABB claims a market leadership position, having completed 80 projects worldwide. Last, year, the company delivered a solution for Kodiak Island (Alaska) using battery and a flywheel energy storage solution (1 MW PowerStore grid stabilisation generator). The island with a population of 15,000 and an installed base of 28 MW (hydro and wind) now runs entirely on renewable energy. ABB is actively seeking to expand this business segment working in conjunction with battery partners **Samsung SDI** (utility scale solutions) and **BYD** (smaller solutions).

FIGURE 112

Lithium-ion EV battery experience curve compared with solar PV experience curve



Source: ABB, Bloomberg New Energy Finance Note, Maycock, Battery University, MIIT, Barclays estimates

The advent of new vendors in the energy storage market, such as **Tesla** – working in conjunction with **Panasonic** on the first 'Giga-factory' – may accelerate the price decline of battery technology. This 1 million m2 plant aims to produce as many lithium ion batteries that were produced globally in 2013 by the time it reaches full capacity in 2020 (35 GWh). The aim is to bring down the cost for the battery pack by 30% per kWh. Incidentally, the plant will be powered by renewable energy sources with the aim of achieving net zero energy.

Schneider – energy storage systems for buildings – still in the trialling phase

Schneider has already been trialling a smart grid-ready energy storage and management system for an office building in France (working with Syndicat Departmental des Energies du Morbihan), which integrates electric vehicle charging and maximises the use of solar and wind energy production. The Prosumer Microgrid for home owners is designed to increase energy independence with a battery storage system using a cloud-based platform, smart hardware and an electrical energy storage system. 300 systems are currently being trialled in Martinique, Corsica and Guadeloupe. As a supplier of UPS systems and inverters, Schneider has the ideal portfolio of products and solutions to play in this market. Having exited the high voltage business, the company is not at risk from a reduction in centralised power production.

Siemens - broad solutions for grid, infrastructure, buildings and industry

'SIESTORAGE' is designed to secure a stable and reliable power supply, integrating renewable energy sources and optimizing the usage of fossil generation to a modern eco-friendly grid. Siemens offers power electronics for grid applications and high-performance Li-ion batteries. The design can be adapted to specific demands, and enables a large field of applications for utilities, industries, cities and infrastructure.

90 MW projects by German utility Steag

Steag, a German utility owned by 7 municipal utilities, announced on 11 November that it is spending €100m for 90MW of large-scale battery systems to help stabilise Germany's grid. **LG Chem** will supply batteries, while automation company **Nidec ASI**, formerly known as Ansaldo Sistemi Industriali, will supply and install the complete storage systems, including controls and energy management. 6 lithium-ion battery-based systems, each of 15MW, will be deployed at sites in the northwest and the south of the country to provide primary control reserve (frequency balancing). Steag aims "to take on a pioneering role in the establishment of battery storage and marketing of the energy stored in those batteries".

In our coverage, we view the best plays on grid-related investments as **ABB** (OW, TP CHF23), **Prysmian** (EW, TP €20.50) and **Schneider** (OW, TP €62). While **Siemens** is the global number 2 in the T&D market, Energy Management (ex low voltage) accounts for only 13% of 2015 group sales.

More efficient factories: ABB, Schneider, Siemens, Atlas Copco

Greatest opportunity in motors and drives

According to the IEA, **industry accounted for 42% of all electricity consumed in 2014**. Electricity now accounts for 25% of industrial energy consumption, up from 19% in 1990. Within industry, **motors account for around 70% of electricity consumption**. The use of high efficiency motors coupled with drives can cut consumption by 20-50%. Variable speed drives adjust the speed of the motor to the actual demand level. Currently, only 10% of motors are used in conjunction with drives or other means to adjust speed.

> Industry accounts for >40% of global electricity demand with motors representing ~70% of industrial demand. An energy efficient motor in combination with a drive can cut consumption by 20-50%.

ABB quotes a recent example for a waste water plant where a solution consisting of new motors and drives has yielded 65% energy savings with an 8-month payback for the customer. ABB's installed base of variable speed drives built up over 40 years is estimated by the company to have saved 445 TWh of electricity in 2014, equivalent to the annual consumption of about 110 million European households. Globally ABB has one if not the broadest range of drives; Schneider is stronger on the lower voltage side and Siemens stronger on the higher voltage segment.

Opportunities in Germany

According to ZVEI, total electricity consumption in Germany amounted to 530bn kWh in 2010, of which 200bn kWh (close to 40%), was consumed by motor-powered machines and systems such as pumps, fans, compressors, lifts and conveyor belts. Out of the 35m 3-phase motors currently in use in Germany, only 15% are already equipped with modern electronic speed control, whereas it makes economic sense to have a 50% penetration rate. If the electric motors currently in use were replaced with energy-saving motors of classes IE2 and IE3, and, if applicable, with electronic speed regulation, 38 billion kilowatt hours of electricity could be saved in Germany every year.

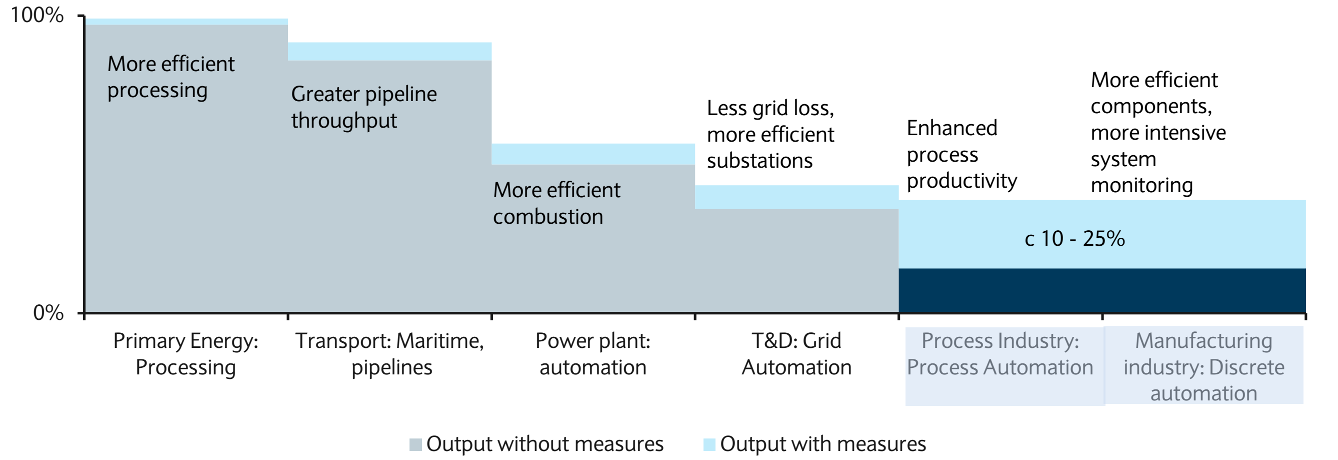
ABB is a global market leader in both motors and drives. **Siemens** is the global number 1 in medium voltage drives and offers a full range of motors from low to high voltage. **Schneider** is strong in low voltage drives.

More efficiency through process automation: ABB, Siemens, Schneider

ZVEI ('More Energy Efficiency through Process Automation') estimates that demand-driven automation technology alone could yield savings of between 10% and 25% in Germany, which already has a high level of automation across its installed base. The savings are particularly pronounced for energy intensive industries, such as cement, steel and chemicals.

FIGURE 113

Opportunity to reduce energy consumption by 20-25% using more process and discrete automation



Source: ABB and ZVEI

Enerdata ('The state of Global Energy Efficiency') estimates the global energy savings potential in the power generation, steel and cement industries at 1,000 Mtoe (worth >$400bn at an oil price of $60/bbl). According to ARC, ABB ranks no 1 in process automation with a 20% market share in 2013. Siemens ranks 3rd and Schneider fourth.

More efficient compressors: Atlas Copco VSD+

Across industry, there remain significant opportunities to improve the energy efficiency of equipment such as compressors. Energy accounts for 70% of the lifecycle costs of a compressor versus 10% for the initial capital outlay, according to Atlas Copco. With its new **VSD+** product range, **Atlas Copco** is able to offer a product with *50% higher energy efficiency versus the average idling compressor*, representing an average 37% reduction in the lifecycle cost of the compressor.

More efficient bearings: SKF

Within the industry business, SKF has developed **low friction and high performance bearings (E2)** which the company claims *can reduce frictional movement by 30%* compared to the already efficient SKF standard bearing and even more versus some competitor products. In addition, as these bearings can run cooler compared to SKF standard bearings at equivalent loads and speeds, they also may reduce lubricant use and potentially extend the life of equipment.

More efficient robots – from product to system optimisation

Industrial robots typically consume between 1-3 kWh according to Kuka. To reduce consumption, **Kuka** has been working on reducing weight (12% over earlier generations), using low friction gears, energy efficient motors, drives and optimised trajectory planning and consumption-optimised run commands. When robots are not in motion, the master PLC can switch the robot controller into energy saving mode. *These measures allow for energy savings of up to 30%*. To further improve efficiency, Kuka advocates a systems approach. If every component is represented in a PLM software solution, it can be modelled in a virtual world based on its total consumption profile. This will enable designers to run various manufacturing scenarios and define manufacturing sequences to optimise consumption using a detailed energy model of the entire system. This should take into consideration the components used for manufacturing, the processes, logistics, and the energy consumed by the building. Concepts to integrate energy as a variable resource could revolutionize manufacturing planning systems. Finally, energy-efficient manufacturing plants that are flexible about peak consumption periods represent the ultimate target in the future.

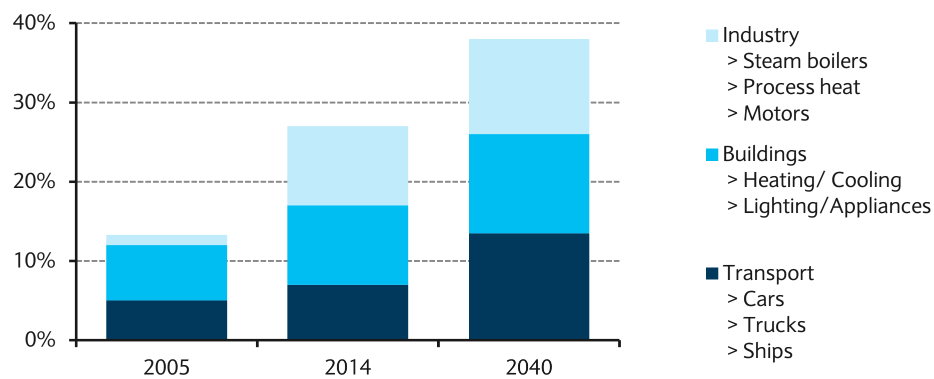
More energy efficiency regulation and incentives needed

Despite often attractive payback times, government incentives are still crucial to drive investments in energy efficiency. The new global energy management standard launched recently (ISO 50001) should support a better global comparability. In 2013, there were close to 5,000 certificates issued, according to ABB, with Germany leading the way (2,477), following by the UK (330), Italy (258), Spain (196) and India (172). With a strong outcome, we would expect the number of energy-efficient standards and incentives to increase further.

As highlighted by the IEA, the percentage of sectors covered by mandatory energy efficiency regulations has risen from 14% to 27% since 2005 and is expected by the IEA to reach close to 40% by 2040.

FIGURE 114

Rising share of global mandatory energy efficiency regulations (as percentage of final energy consumption)



Source: Based on IEA data from the World Energy Outlook © OECD/IEA 2015, IEA Publishing. Licence: www.iea.org/t&c/termsandconditions. As modified by Barclays Research

Funding projects

On 9 November, Schneider launched its first climate bond (10 year €200m with a coupon of 1.84%) to finance R&D programs dedicated to technologies which enable customers to achieve improved CO2 savings. These cover energy efficiency solutions, renewables grid connections, gases with low green-house content and low resource intensity. By the end of 2017, Schneider will offer a comprehensive and transparent estimate of CO2 impacts and gains on all solutions offered by the company.

We have an OW rating on **ABB** (TP CHF23), **Schneider** (TP €62) and **Atlas Copco** (SEK245).

More efficient buildings: Schneider, Legrand, ABB, Siemens, Kone and Schindler

Up to **50% of global Co2 emissions are attributable to residential and commercial buildings**. On average, new construction represents only 2% of the existing building stock. To achieve a fall in energy consumption in buildings by 20% by 2020, Schneider calculates that:

- All new buildings constructed need to consume 50% less energy
- 1 in 10 existing buildings need to reduce consumption by 30% p.a.

Presently over 80% of the economic potential in buildings is untapped, according to Schneider. Through the use of better technology, the energy efficiency of the average existing commercial building can be improved by ~30%, while offering the owners a reasonable return on investment. This includes better lighting controls (presence detectors, daylight harvesting – lighting accounts for ~30% of the typical electricity consumption in a building) and improvements to HVAC systems.

Schneider, Siemens and ABB offer a broad range of products and solutions to improve energy efficiency on a systems level, while Legrand is more focused on components for smaller buildings and holds a strong position in the residential market.

Energy savings opportunities for the home estimated by **Legrand**:

- **Programmable times for HVAC:** up to 12% savings on heating
- **Lighting management:** up to 55% on lighting
- **Dimmers:** Up to 58% on CFL lights dimmed to 25%
- **Shutter management:** up to 10% on heating and 80% on air conditioning
- **Energy consumption monitoring:** up to 15%

California leads the way in the US

California has been leading the way in the US in terms of energy efficiency and even in 2010 (latest data available from the US Census Bureau and EIA) consumed 45% less electricity per capita (6,721 KWh) than the US average (12,146 kWh with a range from 6,721 kWh to 27,457 kWh). From 1990 to 2014, the share of California electricity consumption has fallen from 7.8% to 7.0% of the US total. The launch of new **building energy efficiency standards in 2013** was designed to reduce growth in electricity consumption by 555 GWh and natural gas use by 7m therms for each year of construction (both new builds and retrofits). **Legrand** commented during its Q3 call that the new efficiency standards were driving sales of its energy efficient lighting controls (Wattstopper).

Elevators: Significant energy efficiency progress already made

Elevators and escalators account for **1-10% of a typical building's energy consumption**. **Kone** claims to have cut the energy consumption of its volume products by 70% from 2008 to 2012. In fact, the Kone MonoSpace 500 elevator is *90% more energy efficient than a Kone elevator from the 1990s*. This has been achieved by a more efficient hoisting machine, a highly efficient drive, enhanced standby solutions and LED lighting.

With a global installed base of >12.5m units, of which 45% in EMEA, there is significant scope for vendors such as Kone and Schindler to drive energy savings by modernizing older units.

Datacenters: Significant demand growth driving need for greater efficiency

According to the Natural Resources Defense Council (NRDC), US data centres consumed around 91bn kWh in 2013, twice the consumption of New York City or equivalent to the output of 34 500MW coal-fired plants. With the significant growth in data generated (and the number of connected devices continuing to grow with the Internet of Things), demand growth is set to continue. By 2020, US consumption could reach 140bn kWh. The vast majority of data centre energy is consumed in small, medium, and large corporate data centres (~76% share of electricity consumption) as well as in the multi-tenant data centres (19%) to which a growing number of companies outsource their data needs. These units are far less efficient than the state-of-the-art large-scale cloud computing data centres (4%) and represent the greatest opportunity to improve efficiency. According to the NRDC, electricity consumption in U.S. data centres could be cut by as much as 40%, representing savings of 39bn kWh annually (on a 2014 basis) saving ~$3.8bn a year.

As global market leader, we believe **Schneider** offers the broadest range of products and solutions to improve efficiency in this market. **ABB** (which is pushing for a DC-based solution) and **Siemens** are relatively late entrants into this market, but appear to be gaining share.

More efficient lighting: Osram, Philips

General Lighting (i.e. Buildings and Outdoor) **accounts for 18% of global electricity demand**. LEDs can save up to 85% of a traditional incandescent bulb's energy consumption and some 35% of a modern compact fluorescent bulb. In combination with a reduction in maintenance requirements this can lead to 70-90% lower total costs. Governments around the world started to phase out incandescent from the mid/late 2000s, and halogen will be banned from 2018 in the EU. Whilst these favourable customer economics have driven strong LED volume growth, profitability has remained elusive as barriers to entry have proved virtually nonexistent. With some exceptions, we remain very cautious on General Lighting LED.

According to our estimates, General lighting LED will represent c60% of the future **Philips** (EW, PT €23) Lighting Solutions business in FY17 and c20% for **Osram** (EW, €43), with the latter having no exposure to the most commoditized LED bulbs segment.

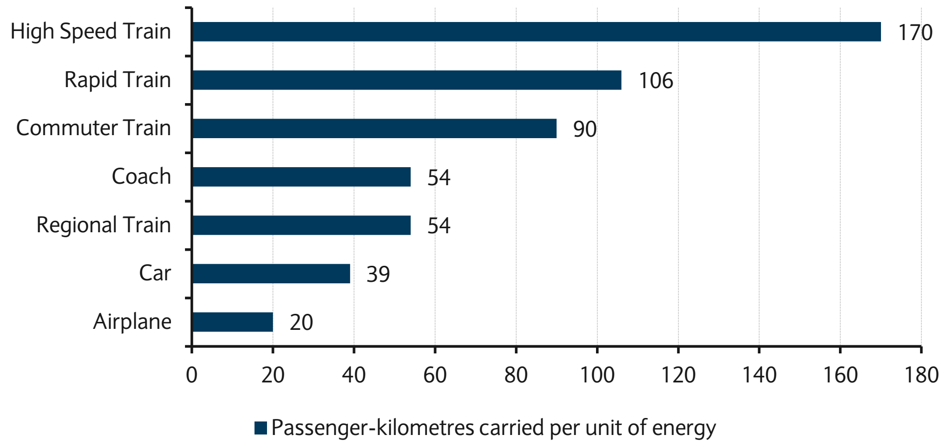
More efficient transportation: Alstom, Siemens, ABB

Rail represents a significantly more energy efficient means of passenger transportation compared to car or air travel. Over the past years, there has been growing governmental support for the build-out of the rail network across many countries, ranging from urban rail projects to high-speed intercity networks. We expect to see an even greater push from governments going forward under a more active greenhouse gas policy scenario.

A high speed train is almost 9x more efficient than an airplane based on passenger-kilometers carried per unit of energy

FIGURE 115

Energy Efficiency: Passenger-kilometers carried per unit of energy



Source: UIC, 2014

The potential of high-speed rail was recognised in the 2011 EU Transport White Paper, which sets ambitious targets for high-speed rail. To meet these targets, the high-speed rail network should triple in size by 2030, with completion of the European high-speed network by 2050, most medium-distance passenger transport should travel by rail by 2050, and all airports on the European core network should be connected to the rail network, preferably high-speed, by 2050.

Alstom represents the European pure play on the rail equipment industry (OW, PT €33). **Siemens** Mobility is a significant vendor in the areas of rolling stock as well as traffic management solutions for both rail and road transport. However, within the context of the group, Mobility only represents 10% of Siemens 2015 sales and 7% of Industry Profit.

Improve efficiency of trains

Within the rail industry, there remains scope to improve efficiency and through the use of more efficient trains as well as better yield management. Alstom highlights that its newest generation of trains consume up to 20% less than prior generations. Improvements to electric traction systems, power electronics still offer considerable potential. ABB claims that its regenerative braking systems can recoup 70% of energy consumed.

The 3 largest rail operators in Europe spend €1.75bn per annum on energy and there are ongoing efforts to reduce this (source: Railenergy).

The opportunity in Marine

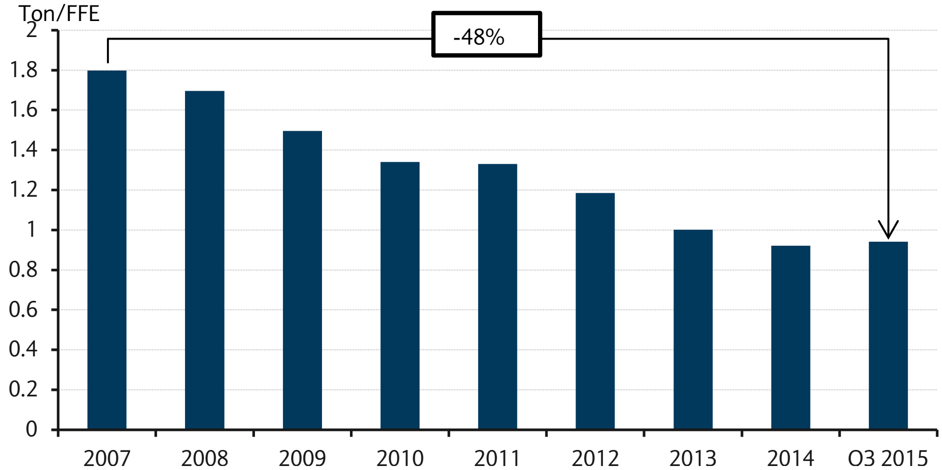
90% of goods are transported by sea and shipping accounts for 3% of global CO_2 emissions. There is significant scope here to reduce fuel consumption and carbon emissions in this area.

Maersk (OW, PT DKK12,100, covered by Mark McVicar) aims to reduce its CO_2 emissions per container by 60% by 2020 from a 2007 baseline. Based on a projected 80% growth in volume by 2020, the company aims to achieve a 200 m ton reduction in CO_2 output from 2007 through 2020. By 2014, the company had achieved a 39% reduction (a significant proportion of which through slow steaming).

The current 2020 target corresponds to 30.8g CO_2 per container (TEU) per kilometre compared to the current Maersk average of 46.7g and the industry average of 58.3g (Clean Cargo Working Group, 2013 data).

FIGURE 116

Maersk: 48% cut to fuel consumption per forty-foot equivalent unit (FFE) moved



Source: Maersk. Does not account for changes in short/long-haul volume mix

The optimisation of the 37,000 voyages the company completes in a year (2014 data) is crucial to supporting the CO2 reduction target. In 2015 **ABB** and Dutch MeteoGroup supplied the company with advisory software for 140 vessels to optimise routes.

Electrification of ships

For ships operating at varying speeds with ever changing loads, an on-board DC grid and electric propulsion technology can save up to 27% in fuel consumption (source: ABB). Annual growth in electric marine propulsion systems is currently running at 12%.

Port electrification solutions

Over 100,000 vessels dock at 4,500 ports around the globe, *releasing as much as much CO2 on an annual basis as 220 coal-fired plants*. A large cruise ship, running its auxiliary engines to power its electrical needs in port will emit as much NOx in 8 hours as 10,000 cars driving from Zurich to London (source: ABB). By using on-shore power instead of on-board power generation, ~98% of pollution and noise are reduced. ABB estimates that connecting one cruise ship to the grid could save $750,000 in annual costs, $3.2m in respiratory and heart treatment costs in the US alone and cut CO2 emissions equivalent to 2,500 cars.

Over 100,000 vessels dock at 4,500 ports around the globe, releasing as much as much CO2 on an annual basis as 220 coal-fired plants

Alfa Laval has been rolling out new products for CO2 emissions in its Marine & Diesel division (37% of group). Here, the company has a wide product portfolio covering a variety of applications including waste heat/fuel recovery (Pure Dry), NOx emissions (PureNox), and SOx emissions (PureSOx). The PureSOx product ("scrubbers") removes sulphur oxides from the ship's exhaust gas by scrubbing it with sea water or fresh water. The company is a market leader together with Wartsila. The company estimates the market opportunity to be 1,000–2,000 vessels to be equipped with scrubbers at a value of €1-2m per ship depending on scope.

COP-21 AND INTEGRATED OILS: BEYOND FOSSIL FUELS – JUST NOT YET

Beyond Fossil Fuels – just not yet

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The easy conclusion to make is that a move towards a lower-carbon economy is a significant negative for the oil and gas industry: implied fossil fuel demand will be lower than it would be without policy changes, and such "decarbonisation" is likely to put pressure on oil and gas valuations. However, although we acknowledge that a co-ordinated policy response would reduce oil and gas demand compared to the current trajectory, we see oil and gas companies as materially undervalued based on any of the scenarios presented to 2040, all of which see energy demand grow. In order to deliver enough production to meet even the lowest of these demand forecasts, significant investment will be required and in order to incentivise this, oil prices need to be higher than currently and we expect a meaningful recovery over the coming three years. From a longer term perspective it is clear to us that the oil & gas industry is set to play a significant role in helping with the transition towards a lower-carbon economy, with technology both improving the availability of resources and reducing the cost of delivery for both conventional and renewable fuels. In our view the easiest and quickest method to meaningfully reduce carbon emissions in the power sector is through the increased use of natural gas within the energy mix, particularly relative to coal. If policy evolves in such a way to support increased use of natural gas, we see this as a long-term positive for those with the largest exposure. Within our coverage universe our analysis shows the key beneficiaries as the newly combined Royal Dutch Shell-BG Group and Statoil. Within the transport sector we expect to see an increased role for third-generation bio-fuels and Finland-based Neste is a leader within this industry.

> "There is no silver bullet solution: a combination of gas, renewables, energy efficiency, CCS, and clean energy for populations who don't have access today – all of this will be needed to combat climate change." Patrick Pouyanne, CEO Total

Delivering energy in a secure, affordable and low-carbon way

No single change or improvement is likely to be sufficient to help reduce CO_2 emissions and none of the options are easy. One key take-away from the IEA's WEO was that under any realistic scenario, energy demand in 2040 is expected to be higher than current levels, with fossil fuels making up anywhere between 60% and 79% of the projected energy mix. The IEA predicts total energy demand to 2040 will grow by 45% under current policies, 32% in its New Policies Scenario and 12% in its 450 Scenario. Given these projections, we see three major challenges that policy makers face namely:

1. Providing energy security in the face of growing demand
2. Delivering energy in an affordable way
3. Delivering lower-carbon energy.

Priorities may well differ across governments and regions, and determine the relative contribution of differing fuels. The focus of the upcoming COP-21 meeting and the plans that have so far been submitted by individual countries suggest that the priority is in lower-carbon areas – but these can be pursued in various ways, with each path having different implications for the oil & gas industry.

Based on both the evolution of demand and the availability and cost of various energy sources, we expect the transition to a low-carbon economy will last for much of this century, with fossil fuels remaining a critical part of the supply mix. While energy efficiency will improve, continued investment will still be needed to offset decline rates. The table below shows options that achieve equal reductions in CO_2 emissions, taken from BP's 2035 Energy Outlook.

FIGURE 117

Options that achieve equal reductions in CO_2 emissions

Abatement option	Change required
Replace coal with gas in power (% of total power)	1%
Add CCS to coal power plants (% of total power)	0.7%
Increase renewables power generation	11%
Increase nuclear power generation	6%
Improve vehicle efficiency	2%
Improve 'other sector' energy efficiency	1%
Improve efficiency of electricity production	1%

* Normalised for a 1% swing in the coal/gas mix in power generation, equivalent to 110Mt CO_2. Estimates are based on energy shares in 2013

Source: BP 2035 Energy Outlook

This transition to a lower-carbon economy and the evolution of both supply and demand is not a new issue for the industry. BP is widely seen as one of the first oil companies to acknowledge a link between energy use and global warming, and in 2000 launched a campaign to position itself as an energy company with a "Beyond Petroleum" campaign. Since then oil demand has risen 20% and natural gas demand 40%, while the returns on renewables investments have been, on our calculations, challenging at best. The reality the world faces is how best to deal with that transition, and where the most effective reductions can be achieved.

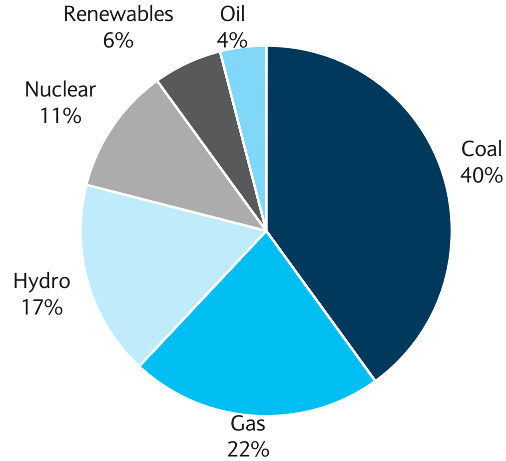
Power sector offers the quickest route to change

Energy demand falls into three broad categories – heat, power and transport. In the vast majority of cases there is an immediate cost to reducing emissions but this is typically lower for power generation than in transportation. As such we see the power sector as offering the greatest scope for reducing emissions, and hence the most likely focus of policy makers.

The power sector has been changing in recent years. A total of 40GW of new solar PV capacity was installed in 2014 – almost as much as the cumulative amount installed by the end of 2010. Yet despite this, coal remains the dominant source of electricity generation, as shown in the chart below, taken from BP's technology outlook to 2050. Given the associated CO_2 emissions, reducing coal consumption in favour of other energy sources is likely to be the main path to curtailing emissions. However, additional economic signals, such as a carbon price, may be needed to drive different consumption and supply patterns. Renewables will continue to increase, but even a relatively modest carbon price could make new-build natural gas more competitive than existing coal.

FIGURE 118

Sources of global electricity supply in 2014



Source: BP, Renewables refers to non-hydro electric renewable sources

Security of supply for power generation is important, particularly for electricity where supply and demand must be matched within very narrow bands. As such one of the key issues that the industry faces with renewables is dealing with the intermittency of solar and wind power generation. This is where continued improvements in technology will be needed with BP recently outlining four primary technology-based options are possible to manage intermittency – increased connectivity and integration of transmission and distribution grids, flexible generation, electricity storage, and demand response/smart grids. Improvements in these technologies could be accelerated by a carbon pricing scheme and this may well be a topic of debate at the upcoming COP-21 summit in Paris, but it will still take some time and during this transition, this irregularity will need to be managed.

> "As oil and gas companies, we can be part of the solution, providing gas as a sustainable fuel for power and industry, pursuing energy efficiency in our operations and products and supporting government efforts to make lower carbon options more competitive." Bob Dudley, CEO, BP

As we highlighted earlier, a 1% switch between coal and gas has the same impact on reducing CO_2 emissions as an 11% increase in renewables production. As such we see natural gas as a key transition fuel, which is likely to support those with higher natural gas exposure longer term. This also fits with the IEA's own analysis which shows that even in its New Policies Scenario (NPS), demand growth for gas could rise by close to 50% over the 2013-2040 period.

FIGURE 119

Projected growth in natural gas consumption

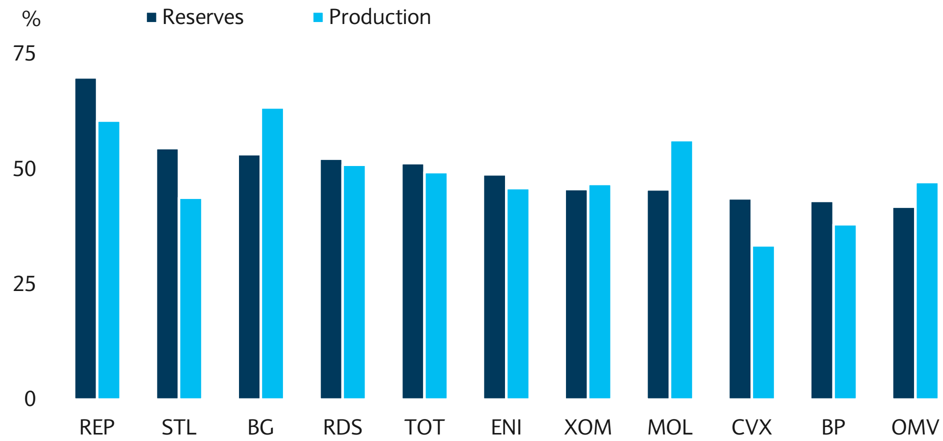
% growth in natural gas	2013-2020	2013-2030	2013-2040
CPS	11%	34%	59%
NPS	10%	27%	46%
450S	7%	15%	15%

Source: IEA WEO 2015, Barclays Research

The chart below shows the proportion of natural gas for both production and reserves as of end-2014. On average for the companies shown below natural gas represents 50% of reserves and 49% of existing production.

FIGURE 120

Natural gas as proportion of production and reserves



Source: Barclays Research

Repsol has higher than average exposure to natural gas, though this has changed slightly post Talisman and this is largely Latin American gas. Statoil and the combined Shell-BG group also have greater than average exposure, though the differences overall are small.

Ultimately we are talking about very long-term trends and over the past 12 months exposure to natural gas and in particular LNG (liquefied natural gas) has been seen as a negative by investors with what appears to be a short-term mismatch between supply and demand. Our own analysis suggests that between 2015 and 2020, some 165mtpa capacity will come on stream compared to just 55mtpa for the prior five years. The combined effect will be to increase overall capacity by 54% from the end of 2014. However, these projects are built typically for 20-30 years and it appears that under almost any scenario additional gas supply will be needed.

"The global energy system is moving towards a progressively cleaner, less carbon-intensive model, characterized by a greater share of natural gas and renewables – and a key role for carbon capture and storage." Ben Van Beurden, CEO Royal Dutch Shell

Improved vehicle efficiency will play a key role

Another key topic and area for future work is the evolution of demand within transport, where continued improvement of the internal combustion engine (ICE) can improve vehicular efficiency and reduce emissions. Electric vehicles and fuel cells still need significant advances in technology to compete on cost with ICE vehicles, and as such out to 2050 energy for transport is likely to be met largely by liquid fuels. Within this, there are alternatives such as sugar cane ethanol but others need significant advances. We expect consumption to grow 1% per year but slow post-2025, with the underlying assumption that efficiency improves at 2-3% per year as a result of increased hybridisation. With advances in battery technology, electric vehicles are likely to be a viable longer-term option, particularly in stop-start urban environments. However, it appears that there is still a long way to go for the ICE to be pushed out and uncompetitive on a cost basis (a 50% reduction in overall vehicle cost) – and this may ultimately prove to be more of an environmental decision.

The Oil & Gas Climate initiative (OGCI)

BG Group, BP, Eni, Pemex, Reliance, Repsol, Royal Dutch Shell, Saudi Aramco, Statoil and Total are all members of the OGCI – a CEO-led organisation that aims to contribute to climate change solutions. The body recently released a report ahead of the COP-21 meeting highlighting the dual challenge of meeting growing energy needs but doing so in a way that is sustainable and affordable. The key conclusion for us was the assertion that *"investment in gas, renewables and lower GHG technologies like CCS today will contribute greatly to reducing the cost and impact of climate change"* Beyond this the report focused on two key issues – the role of the oil and gas sector in reducing greenhouse gas emissions and preparing the companies for a low greenhouse gas future. We briefly look at each of these below.

The role of the O&G sector in reducing GHGs

As the report itself states, energy is at the core of the climate change challenge. While renewables will play an increasing role, they are unlikely to replace fossil fuels as the dominant component of the energy mix for the foreseeable future. There is an acknowledgement that in the power sector the shift may be quicker, given climate policy interventions and the falling costs of wind and solar. Even so the world will still use a combination of gas, oil and coal to provide a significant proportion of energy needs; minimising the associated emissions is likely to be the key area of focus. Within this the OGCI has highlighted four main levers – promoting the growing use of natural gas in the power sector, reducing methane emissions and minimising flaring, improving efficiency in operations and consumption, and ensuring the viability of carbon capture and storage.

Preparing the companies for a low GHG future

There is a recognition that over the long term the push towards the 2 degree ambition will be transformative, requiring the industry to adjust its business models. The OGCI identified three main ways that oil and gas companies are preparing to manage their businesses – integrating climate change into mainstream corporate strategy, pursuing renewable technologies and investing in low greenhouse gas R&D and startups. The table on the following page outlines the key investments and steps of the European-based members of the OGCI.

For further details please see http://www.oilandgasclimateinitiative.com/

Fossil fuel companies are among the largest investors in renewables

Ultimately there is no single solution to climate change. A combination of gas, renewables, energy efficiency, CCS and clean energy for populations who don't have access today will be needed. Within this oil & gas companies are making their own investments in the space – these are significant in terms of the size of the renewables market, though small in the context of their own businesses, reflecting the energy mix as it is today. Highlights are below, but we would also note from an investor standpoint that these have often proven lower return than their core oil & gas projects.

- Total is the world's second largest player in solar PV energy by sales, through its affiliate SunPower.
- Shell is among the largest strategic investors in advanced biofuels.
- Statoil, Repsol and Shell are investors in several of Europe's fast-growing offshore windfarms.
- BP is a top 10 wind business in the US with the single largest wind farm in the country.

FIGURE 121

Key initiatives of European OGCI members

	Key investments	Selected startups
Royal Dutch Shell	Shell is a significant proponent of Carbon Capture & Storage (CCS) technologies. The group recently launched the commercial startup of its Quest CCS project in Alberta in Canada. Quest will capture one-third of the emissions from Shell's Scotford Upgrader, which turns oil sands bitumen into synthetic crude. The CO_2 is then transported through a 65km pipeline and injected more than 2km underground In terms of nearer-term focus, Shell formed a joint venture with Brazilian firm Cosan. The JV, known as Raizen, is a leading producer of ethanol from Brazilian sugar cane, a fuel that can reduce CO_2 emissions by c70% compared to standard petrol	GlassPoint: Designs large-scale solar steam generators to enhance oil recovery
Total	Total typically invests c$500m a year in renewable energy and is one of the leading solar players in PV through its majority stake in US-based SunPower. Total solar investment has amounted to $3bn In a recent interview with Reuters (November 6th), Total CEO Patrick Pouyanne indicated that solar energy could make up 10-15% of the asset base by 2030 from the current 3% Total is also investing cEUR200m to turn its French La Mede refinery into a biofuel plant	LightSail: Has developed an advanced compressed air energy technology using water spray to achieve high thermodynamic efficiency
Statoil	Statoil is focusing on a combination of CCS and offshore windfarms. CCS has been a focus from 1996 and projects operate at the Sleipner West and Snohvit projects in Norway. The company recently announced it is to build the world's first floating windfarm off the coast of Scotland. It is expected to be operational late 2017	
BP	BP was among the earliest of the large oil and gas companies to look at the potential impact of renewables on its strategy, although it appears to us that this has been less of a focus in a post-Macondo world. BP remains one of the top 10 wind businesses in the US with c2600MW of capacity. It also participates in biofuels production in Brazil	Helix Power: Turns waste steam into electricity, boosting energy efficiency in industrial processes
Repsol	Repsol's renewable energy investments focus mainly on offshore wind projects. It has stakes in three early-stage projects – Inch Cape, Moray Offshore, and Beatrice Offshore	Graphenea: Develops graphene materials for use in solar cells, batteries and thermal management
Eni	Focus is primarily on R&D expenditure	Enjoy: An Italian car and scooter sharing service active in key Italian cities

Valuations are bounded by existing reserves

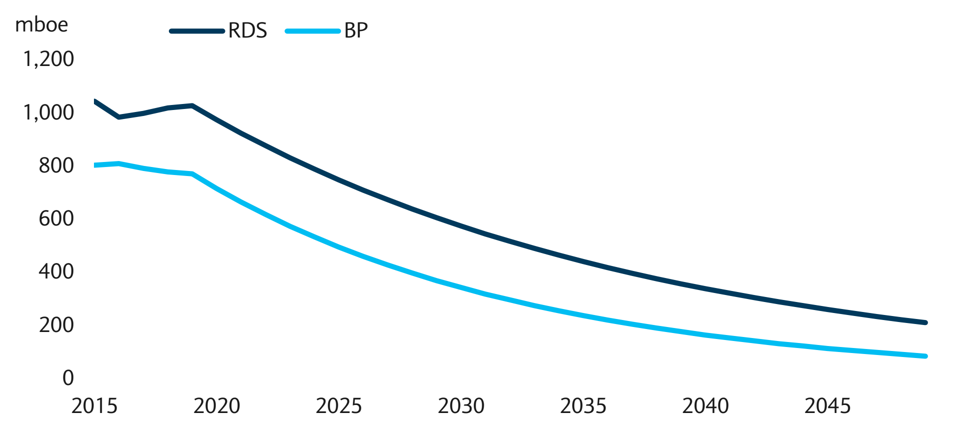
As ever, our investment view on the sector and companies is driven by our assessment of valuation. One concern that the move to a lower-carbon economy has raised for investors is the concept of a "carbon bubble" in valuations of fossil fuel companies. We cannot accept this premise for the oil and gas companies that we cover given that it assumes a scenario that does not reflect the likely reality of the energy market for years to come. To put this into context, the IEA's WEO in its New Policies Scenario requires over 900bn bls of oil and 100tcm of gas to be produced over the period to 2040; the 18% growth in natural gas demand over 2013-2025 is particularly striking. Given these demand figures, we still see a need for investment and the proved reserves of the oil & gas companies.

We have used our sum-of-the-parts NAV methodology for several years to support our company share price targets, and we continue to believe it provides a sound basis for valuation. The advantage in this approach is that we are bounded by existing resource figures.

Upstream valuations typically represent 70-80% of our total asset values. Here we assume capital continues to be invested for the next five years, after which the production profile declines over a 30-year period. The associated cash flows drive our segment DCF valuation. Reserves not developed within five years are valued on a dollars per barrel basis. The chart below shows the production profiles that we use – purely as a modelling assumption for BP and Royal Dutch Shell.

FIGURE 122

Natural gas as proportion of production and reserves



Source: Barclays Research

2P reserves which are not on-stream within five years are valued at 50% of the post-capex NPV of the producing reserves, and 3P (technical) resources are valued at 10% of this amount. These probabilities reflect the P50 and P10 statistical probabilities typically associated with probabilistic modelling of field reserves and resources. The formal reserve disclosures for oil companies give the estimated proven reserves, which are a conservative (90% confidence level) view of the quantities likely to be produced eventually. Put another way, on average only 20% of our valuations relate to assets not developed by 2020.

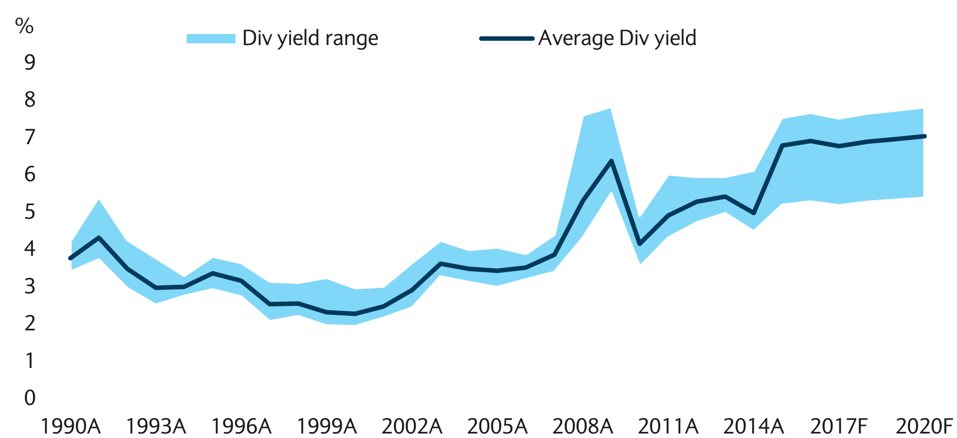
This approach is conservative and production is likely to be held stable or increased beyond our modelling approach. As the IEA itself highlights, the demand for oil and gas resources is more than the current proved reserves base and as such further significant investment in the sector will be required – something that can only happen if prices are high enough to support this.

Decline rates are destiny and valuations ignore it

Decline rates differentiate the oil market from other commodity markets with the base level of production declining by a minimum of 3-4% per year. This decline rate, combined with the delays in developments over the past 12 months, makes some form of recovery in the oil price inevitable, in our view. Essentially, under any reasonable demand scenario, prices need to move higher than what the oil futures market is currently pricing in, or there will not be enough supply – a view shared by our commodities team. In *Upward bound*, they state that prices are likely to move higher starting in the latter part of 2016, to provide producers with incentives to mitigate the decline from existing supply. They forecast prices to reach $85/bl by 2020 in the base case and $75 and $100/bl in low- and high-demand cases, respectively

Given this expectation of an oil price recovery we continue to see the risk reward profile as favourable with the benefits of a rising oil price more than offsetting the impact of new policies on demand growth on our forecast period out to 2020. Yet our view that there is significant value in the European Oil & Gas industry is not predicated only on a recovering oil price. The sustained low oil price during the last year has been far from an easy experience for the sector but it has also been the catalyst for a much-needed change in mindset. Management teams are now addressing the operational inefficiencies, bloated budgets and poor capital allocation that eroded returns and investor confidence in recent years. We believe the results of these changes should begin to emerge in 2016 and with them a wider acceptance of the underlying value and ability to pay dividends. Our Top Pick in the sector is Royal Dutch Shell (OW, PT 2850p), while our other key Overweights are BG Group (1350p), Total (€56.50), BP (600p) and GALP (€15.00).

FIGURE 123
Dividend yields



Source: Barclays Research

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Galp Energia (GALP.LS, 20-Nov-2015, EUR 9.55), Overweight/Positive, D/J/L

Legrand SA (LEGD.PA, 20-Nov-2015, EUR 53.60), Equal Weight/Neutral, J

Metso OYJ (MEO1V.HE, 20-Nov-2015, EUR 23.30), Underweight/Neutral, J/K/M/N

Neste (NESTE.HE, 20-Nov-2015, EUR 25.07), Overweight/Neutral, A/D/J/K/L/M/N

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Total (TOTF.PA, 20-Nov-2015, EUR 46.26), Overweight/Positive, A/C/D/E/F/J/K/L/M/N

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Saras (SRS.MI)		
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Enel SpA (ENEI.MI)	Gas Natural SDG SA (GAS.MC)	Iberdrola SA (IBE.MC)
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