

A large-scale solar farm with rows of solar panels stretching into the distance under a clear sky.

# Lost in Transition:

A field of oil pumpjacks (jackals) in a dry, open landscape under a clear sky.

How the energy sector is missing  
potential demand destruction

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# Executive Summary

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## **Demand destruction = climate security**

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The majority of the world's fossil fuel suppliers appear to be betting on demand for their product continuing to grow as per business as usual (BAU). The direction of travel we see from the worlds of policy and technology is for destruction of fossil fuel demand. This paper is designed to explore the downside for fossil fuel producers and understand why the reality of our future may differ from the scenarios published by the energy industry. This in turn provides optimism that the world can deliver a low emissions trajectory. It is clear that the world will need to deviate from BAU if we are to prevent dangerous levels of climate change.

## **Will the future repeat the past?**

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Scenarios are used to help people understand different futures and identify blind spots in their current assumptions about what might transpire. Many financial and industry energy projections suffer from 'straight-line' syndrome, where historical trends or energy mixes are extrapolated into the future over long periods. This can lead to a built-in assumption that the future will repeat the past – something that does not match-up with either preventing climate change or adapting to it.

## **Scenarios struggle to consider non-linear change**

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The risk of 'straight-line syndrome' hints at the biggest remaining energy modelling challenge, which is to understand system transformations, i.e. dramatic changes in policy or technology which cause non-linear change in trends.

This is much more challenging to model or predict, but it is these kind of events which will have the biggest impact on a sector.

## **These scenarios often justify investment in additional fossil fuel supply**

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Investments in future fossil fuel supply are predicated on an assumption of future demand that is often presented in or informed by corporate energy scenarios. However, while many energy companies have established scenario teams, the full range of outcomes they consider is not necessarily presented publicly or to the investor community. This could change amid increasing focus on fossil fuel company scenarios as investors engage more around carbon asset risk and future capital investment plans (See also our partners [Ceres](#), [IIGCC](#), [LAPFF](#), [CIG](#), [ShareAction](#) and [Client Earth](#) on Carbon Asset Risk and 'Aiming for A'). The scenarios produced

by the IEA and US EIA need to be placed under similar scrutiny given the amount they are referenced by the fossil fuel industry, which often results in the cherry-picking of scenarios and the views of these organisations echoing and reinforcing each other.

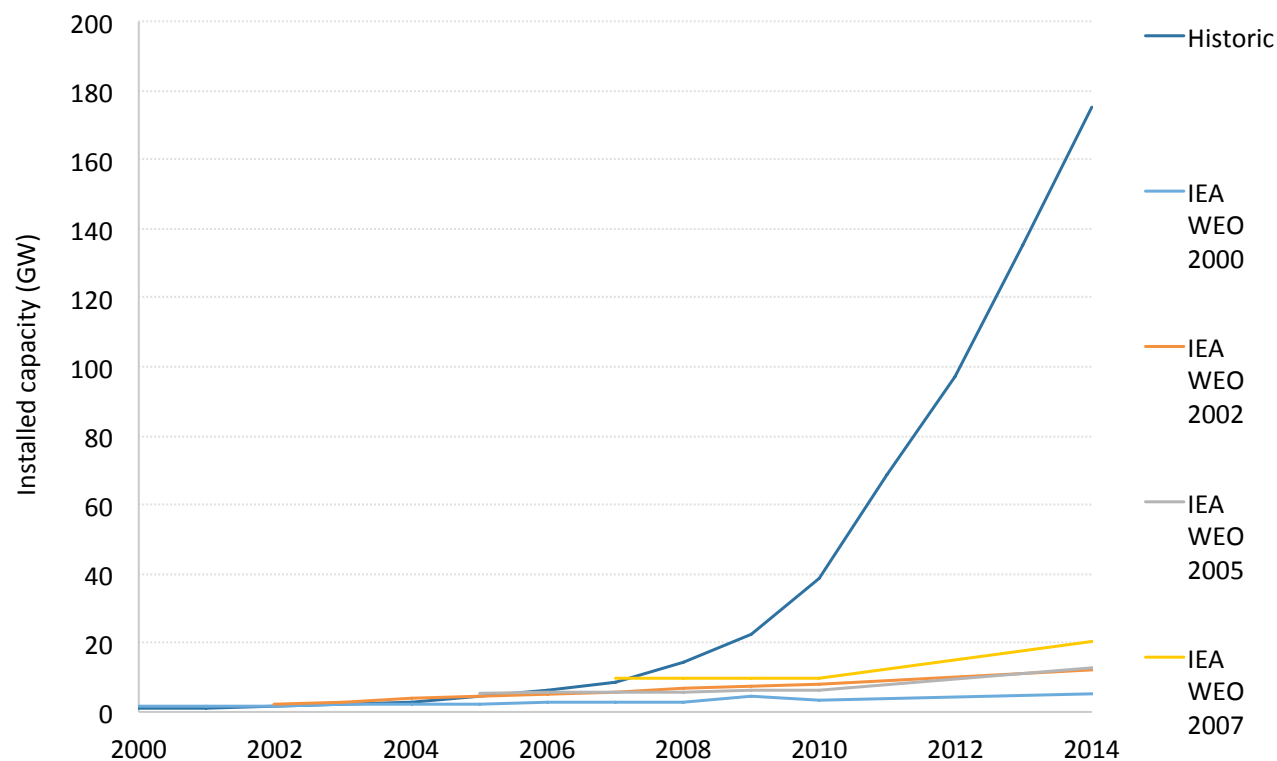
## Track record isn't great

Another reason for reviewing the scenarios and assumptions underpinning energy industry plans is that their track record of getting it right is not that strong. This is not to say that energy sector projections are easy - however with hindsight it is evident that organisations such as the IEA are consistently behind the curve in their projections of renewables costs and deployment, for example. Figure A shows how IEA forecasts since 2000 have been far off the mark in predicting today's levels of solar generation, let alone looking further into the future.



“The International Energy Agency (IEA) estimates in its World Energy Outlook 2014, Current Policies Scenario, that worldwide primary energy demand will grow 50% between 2012 and 2040. Demand for coal during this time period is projected to rise 51%, and the growth in global electricity generation from coal is expected to be greater than the growth in oil, natural gas, nuclear and solar combined.”- Peabody Energy Annual Report 2014<sup>1</sup>

Figure A: IEA solar PV capacity forecasts against actual



1. <https://mscusppegrs01.blob.core.windows.net/mmfiles/files/investors/2014%20peabody%20annual%20report.pdf>



## Risk assessment

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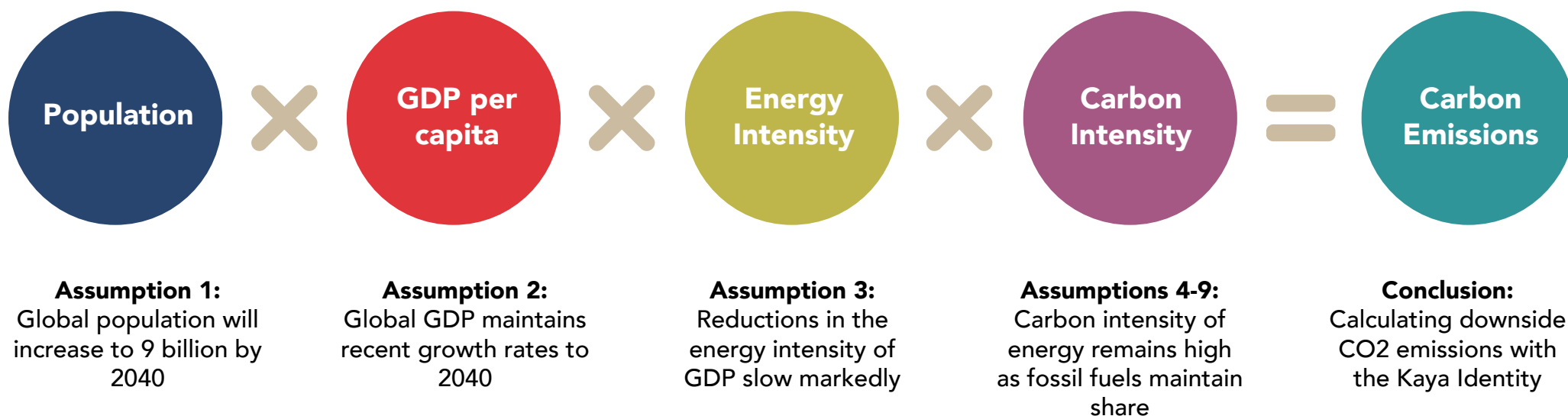
This report only focuses on the downside demand potential for fossil fuels because it is our contention that current base case energy scenarios are at the bullish end of the range of potential fossil fuel demand outcomes. In terms of understanding risks, it is therefore necessary to focus on the extent to which these scenarios are potentially underestimating the pace and scale of the transformation of the energy sector. We would note we are only using the opposite ends of the ranges of projections from industry, analyst or government sources to test the potential for change. There are a range of even more aggressive scenarios from environmental organisations which would push the boundaries even further.



## Changing system dynamics

At the highest level there have traditionally been three fundamental factors in energy demand: population, economic activity and the efficiency of technologies employed to meet the energy demands of the economy. We present alternative futures for these three demand factors and what this could mean for fossil fuel demand. We follow this with a downside examination of the potential carbon intensity of energy supplied to meet this demand, i.e. the mix of fossil fuels and low-carbon technologies. From these components we calculate the extent to which global CO<sub>2</sub> emissions could be lower if these alternative downside futures transpire rather than an average industry expectation. We do this using the Kaya Identity:

Figure B: This report is structured around the Kaya Identity



The Kaya identity is an economic model that tries to bring the factors together in a simplistic way. While it may not be able to capture the full complexity or inter-connectedness, it provides a useful means of understanding the key energy drivers of CO<sub>2</sub> emissions. As Figure B shows, the structure of this report works through elements that contribute to determining the Kaya Identity equation and stress-tests the impact on fossil fuel demand if each ratio disappoints on the downside. This ranges across the complete gambit of factors from urbanisation to economic growth to efficiency to technological change.

# BAU Assumption 1: Global population will increase to 9 billion by 2040

1

BP, ExxonMobil, Statoil and energy commentators such as the US EIA and IEA all assume population growth rates that are consistent with the UN's 2015 median-growth variant. That sees global population rising to 9.7 billion by 2050 – refer Figure C.<sup>2</sup>

Figure C: The UN expect global population to grow significantly

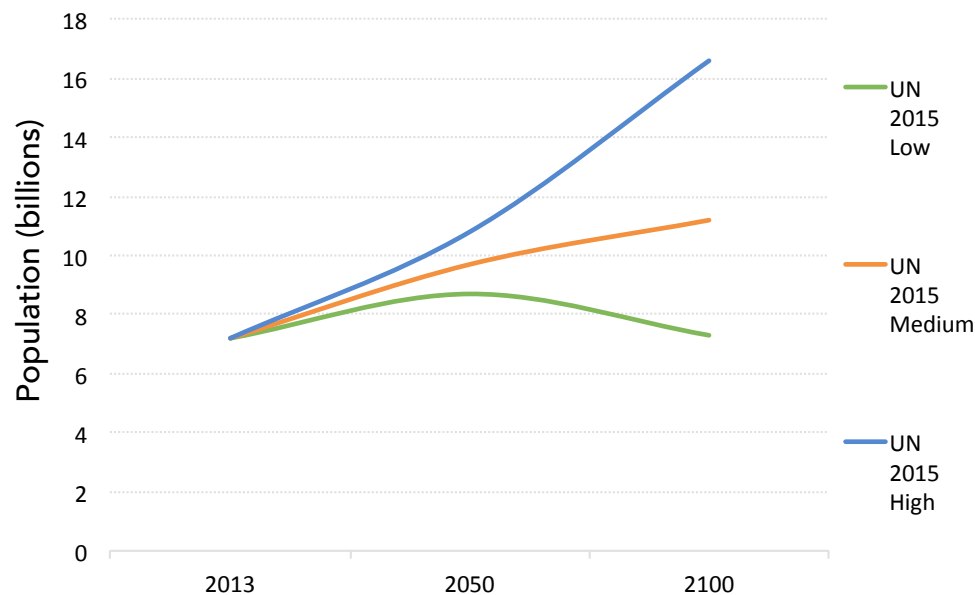
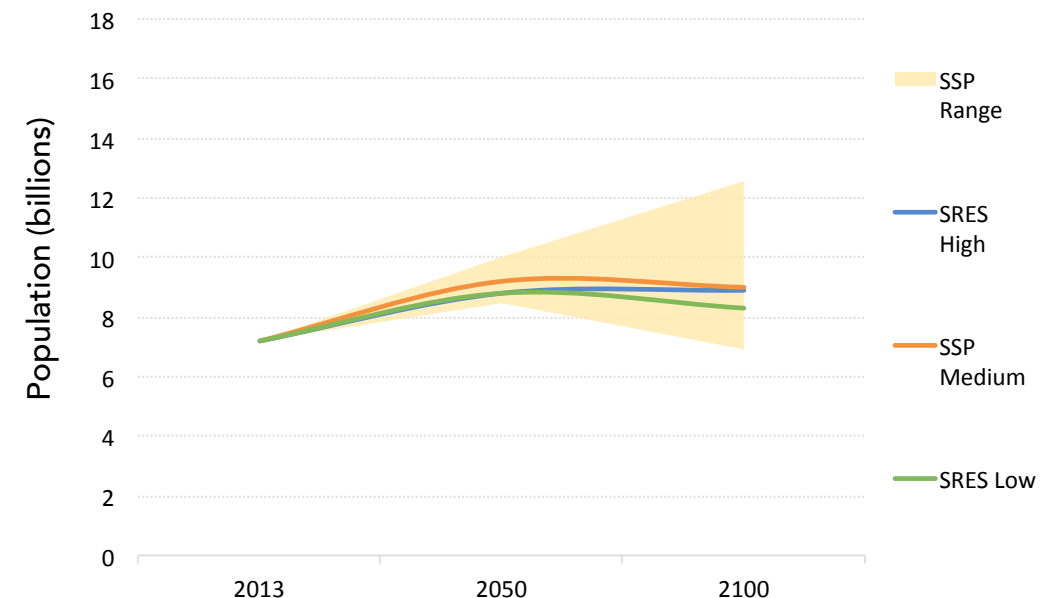


Figure D: Climate and socioeconomic scenarios show that population growth is not certain<sup>3</sup>



UN modelling “may still be off by two billion” by 2100 – John Wilmoth, Head of UN Population Division<sup>4</sup>

2. [http://esa.un.org/unpd/wpp/Publications/Files/Key\\_Findings\\_WPP\\_2015.pdf](http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf)

3. SRES scenarios - [http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Global\\_Energy\\_Assessment\\_FullReport.pdf](http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/Global_Energy_Assessment_FullReport.pdf); SSP scenarios - <http://www.sciencedirect.com/science/article/pii/S0959378014001095>

4. <http://news.nationalgeographic.com/news/2014/09/140918-population-global-united-nations-2100-boom-africa/>

## Linking population to climate modelling

Figure D shows two modelling projects presented by the International Institute for Applied Systems Analysis (IIASA), one based on the Special Report on Emissions Scenarios (SRES) that underlie the IPCC's emission scenarios, the other based on five socioeconomic pathways (SSPs). Both the 'high' and 'low' SRES scenarios see global population being 0.9bn lower in 2050 than the UN's 2015 medium-variant scenario. The median SSP projection is also below this median UN projection. Evidently, future population growth is not certain. **Using the DECC Global Calculator, we find that if population growth takes a lower growth trajectory (8.3 billion by 2050), fossil fuel demand will be 17% lower than the UN's assumption applied by all fossil fuel companies.** Coal demand is 25.5% lower in the low population growth scenario to 2050 compared to the central assumption, whereas oil and gas are 12% and 8.5% lower respectively.



“Eliminate energy poverty by ensuring that half of all new generation is coal-fueled.” - The Peabody Plan<sup>5</sup>

5. <http://businessroundtable.org/sites/default/files/Peabody-Energy.pdf>

6. <http://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2015/bp-statistical-review-of-world-energy-2015-coal-section.pdf>

7. <http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/>

8 [http://esa.un.org/unpd/wpp/Publications/Files/Key\\_Findings\\_WPP\\_2015.pdf](http://esa.un.org/unpd/wpp/Publications/Files/Key_Findings_WPP_2015.pdf)

## The poor will not save coal demand

Despite claims that coal can solve energy poverty, the geography of energy access, coal reserves and projected population growth do not match up. Figure E lists the 8 countries the UN forecast to exhibit the fastest rate of population growth and shows many have large numbers of people without power little to no coal reserves. Therefore, coal is not the most appropriate solution for these countries to try and connect the rural poor with power because expensive new grid and importing infrastructure would be needed. The Asian countries which have coal reserves – India, Indonesia and Pakistan have had decades of coal power already to solve energy access problems, but have not seen the problem solved.

Figure E: Population growth regions do not match up with coal reserves geographically

	COAL RESERVES (2014, BT) <sup>6</sup>	POPULATION WITHOUT ELECTRICITY (2012, MN) <sup>7</sup>	POPULATION CHANGE (2015-2050, MN) <sup>8</sup>
INDIA	60.6	304	+394
NIGERIA	0	93	+216
TANZANIA	0	36	+84
CONGO	0	3	+118
INDONESIA	28	60	+65
UGANDA	0	31	+63
PAKISTAN	2.1	56	+121
ETHIOPIA	0	70	+39
GLOBAL	891.5	1285	+2376





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## Conclusion:

Population growth trends are by no means locked in, meaning expected demand for fossil fuels may not transpire, especially as the profile and geography of the world's population changes.

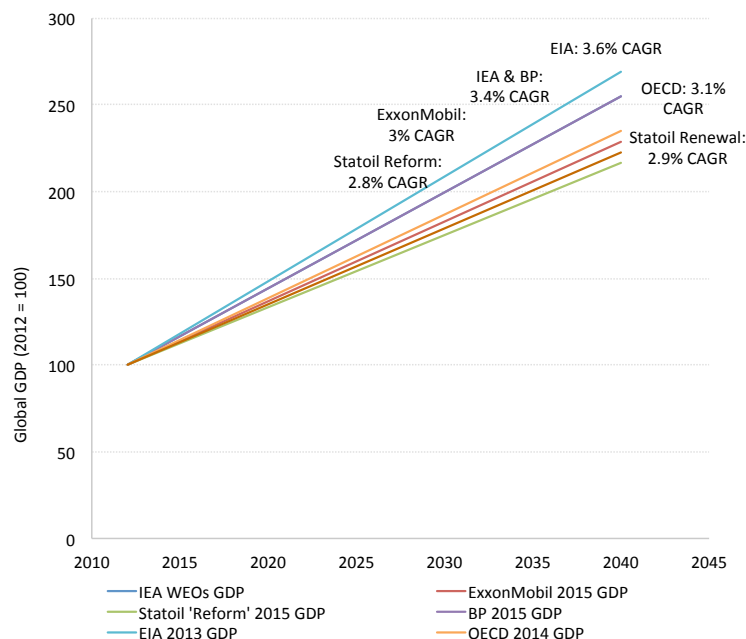
# BAU Assumption 2: Global GDP maintains recent growth rates to 2040

2



“GDP is expected to more than double...and increases in income per person is a key driver behind growing demand for energy.” BP<sup>9</sup>

Figure F: Expectations of future GDP growth vary<sup>10</sup>



9. <http://www.bp.com/en/global/corporate/energy-economics/energy-outlook-2035.html>

10. When comparing long term GDP forecasts there are a number of consistency factors that need to be watched for: 1) country inclusion differences; 2) basis for calculation, e.g. the IEA uses GDP in US\$ in 2013 Purchasing Power Parity (PPP) while the OECD use either US\$2005 PPP or US\$2010.

The OECD GDP forecasts in Figure 2.1 and our Kaya Identity calculations are in US\$2010 PPP so differences to the IEA could be due to slightly different methodologies.

11. IEA WEO 2014

12. <https://data.oecd.org/gdp/gdp-long-term-forecast.htm#indicator-chart>

13. Statoil Energy Perspectives, 2015, [http://www.statoil.com/en/NewsAndMedia/News/2015/Pages/04Jun\\_Energy\\_perspectives.aspx](http://www.statoil.com/en/NewsAndMedia/News/2015/Pages/04Jun_Energy_perspectives.aspx)

The assumed rate of future GDP growth has significant implications for energy demand expectations - as the IEA note, economic activity is “the principal driver of demand for each type of energy service”.<sup>10</sup> In turn, this has big implications for fossil fuel demand.

## Global GDP growth could disappoint, meaning lower energy demand

GDP is complex to forecast and relies on accurate assumptions of population growth (Assumption 1) and the level of productivity of this additional labour supply (GDP per capita). As such, energy industry expectations of GDP growth to 2040 range from 2.8% per annum to 3.6% - refer Figure F. The majority of this economic growth is expected from non-OECD countries.

For many the IEA act as a benchmark – they assume across all three of their scenarios that global GDP will remain at 3.4% on average to 2040. Evidently this is at the high end of the range of GDP forecasts from the energy industry. Median forecasts are around the 3.1% mark to 2040 which the OECD’s 2015 Outlook expects.<sup>11</sup> This is 0.3% lower than the IEA’s scenarios, which, by our calculations, is equivalent to approximately half global energy demand in 2012. Statoil’s Reform scenario is at the low-end of the presented range at 2.8%, a further 0.3% down on the OECD 2015 Outlook.<sup>12</sup> This would have further energy demand impacts.

## China cooling down

China is one region expected to see strong economic growth, however recent history reveals a tendency for China's GDP to be overestimated. For example, in 2010 the IMF estimated China's economy will grow 9.5%, 9.0% and 9.5% in 2011, 2012 and 2015 respectively.<sup>14</sup> Realised GDP growth rates were in fact 9.3%, 7.8% and 7% (estimate<sup>15</sup>). This lower-than-expected GDP growth has significant knock-on effects for expectations of fossil fuel demand. Figure G shows the expectation that GDP growth in China will be lower still, but to varying degrees. To get an idea what this could mean for fossil fuel demand, we look at BP's 'Low-GDP scenario' in which they apply a 4% per annum GDP growth rate to China and India – this results in global energy demand being 8.5% lower than their base case by 2035.

## Tackling climate change is positive for the global economy long term

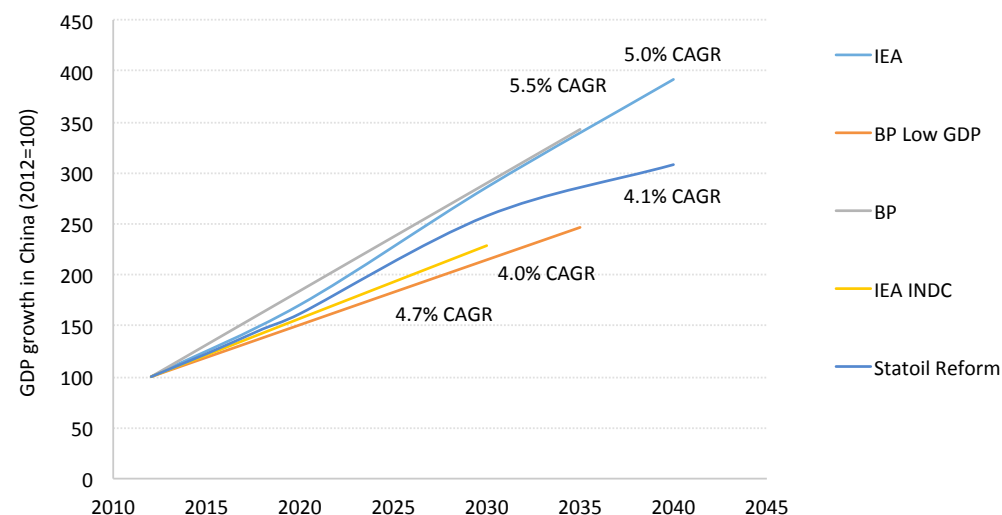
Statoil's Energy Perspectives 2015 gives an indication that a scenario which prevents dangerous levels of global warming and sees strong growth of renewables, (the Renewal scenario), sees higher economic growth than a gradual energy transition or a world with increasing rivalry and dysfunction. In particular this comes through in the 2030s, and the analysis states that

14. <https://www.imf.org/external/pubs/ft/weo/2011/02/pdf/text.pdf>

15. <http://www.theguardian.com/business/2015/jul/15/china-surprises-economists-with-gdp-rise-of-7>

16. Citi, (2015), *Energy Darwinism II*

Figure G: Projections of future Chinese GDP growth



the gap in GDP would only grow further if it was extended beyond 2040.

Tackling climate change is often portrayed as a cost to society, albeit one that is likely to reduce costs later on. Economic analyses such as those by Lord Stern have illuminated how it will be cheaper to address climate change sooner rather than later. Citi's Energy Darwinism research also concludes that there is very little difference in total energy expenditure to 2060 required in 'Action' and 'Inaction' scenarios – in fact costs are 1% lower with 'Action' to tackle climate change compared to BAU.<sup>16</sup>

The background of the slide is a close-up, slightly angled view of several US dollar bills. The focus is on a \$100 bill, showing the portrait of Benjamin Franklin on the right side. The serial number 'AB 39048518 L' is clearly visible in the center-left. The Federal Reserve seal is also present. The bills are layered, with some parts of other bills visible underneath.

2

## Conclusion:

GDP growth could be lower than expected in major markets reducing fossil fuel demand growth.



# BAU Assumption 3: Reductions in the energy intensity of GDP slow markedly

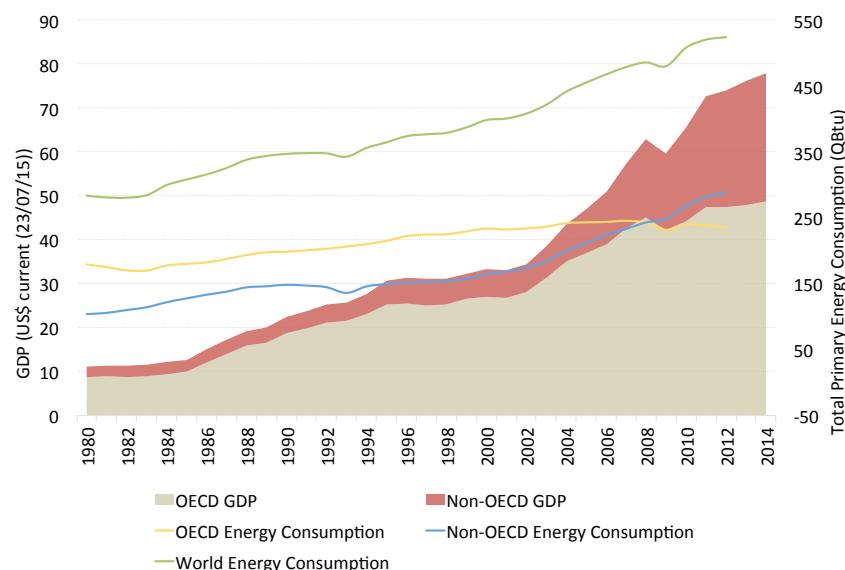
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Energy intensity is a measure of the amount of energy used per unit of GDP. Global energy intensity has been falling, but this varies across geographies. Energy intensity will continue to fall in the future. The rate of this decline, however, is up for debate.

## The significance of GDP growth as a driver of energy demand is diminishing

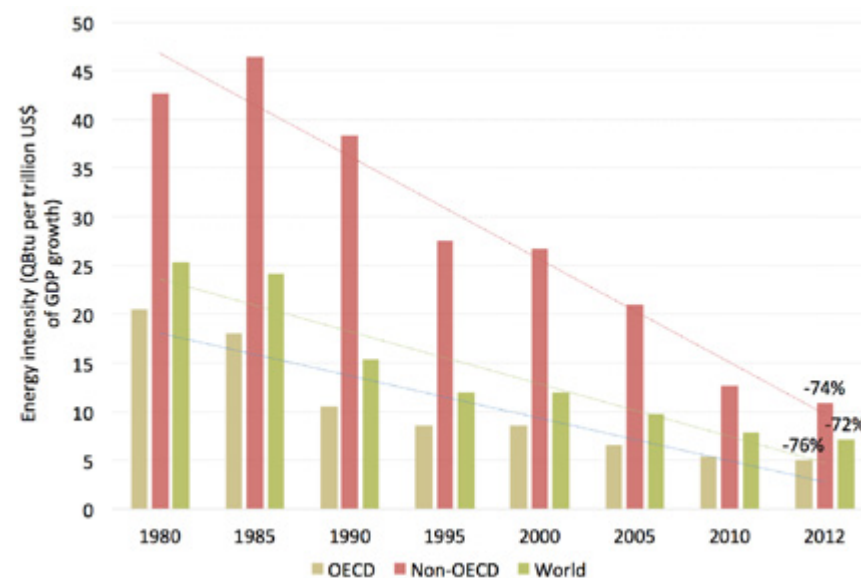
The world is increasingly decoupling energy demand from GDP growth – refer Figure H. This is a result of the world's largest energy consuming nations transitioning towards service-based economies and energy efficiency gains worldwide.

Figure H: Global GDP growth is decoupling from energy demand



Source: US EIA, World Bank

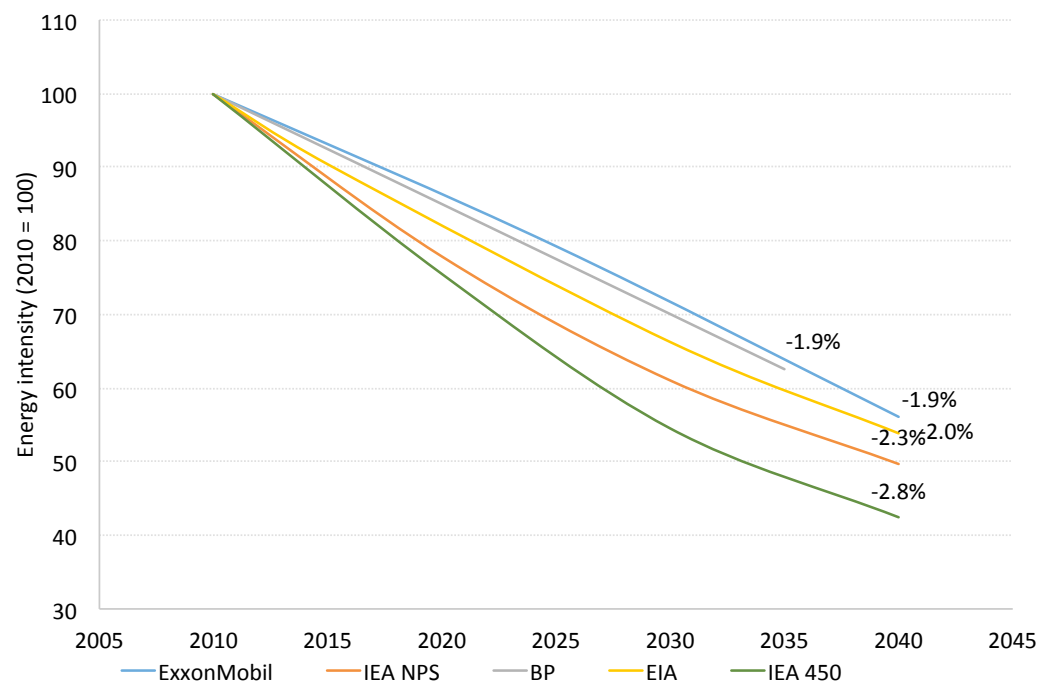
Figure I: Energy intensity ratios, 1980 to 2012



NB: 2012 % change is against 1980 start year Source: World Bank, 2015

Figure I shows energy intensity has fallen in OECD nations by 76% between 1980 and 2012, as GDP grew on average by 5.4% annually, while total energy consumption only grew 0.9% each year. Similar falls have occurred in non-OECD nations, but energy intensity remains almost over twice as high in OECD regions. There is scope for advancement in these regions.

Figure J: Comparison of energy intensity of GDP in industry scenarios



## Energy intensity falls could go deeper than expected

'Decoupling' of energy demand from GDP is a result of efficiency gains globally and structural economic changes towards service-based economies in developing countries. This downward trend in energy intensity is expected to continue by all in the energy industry – assumed annual energy intensity rates vary from -1.9% and -2.8% across scenarios – refer Figure J.

Again, global energy intensity will largely be determined by non-OECD nations, where many are decoupling their energy systems faster than expected. For example, falling energy demand is reducing energy intensity rapidly in China. Unofficial statistics suggest energy demand growth in China amounted to 4.3% in 2012, 3.7% in 2013 and 2.6% in 2014. Energy demand in China has grown by 8.5% per annum on average since 2000. For many, this is a sign that China is undergoing an economic transition towards a service-based economy that is structurally changing the relationship of energy and GDP. The rate of this transition in the future may continue to surprise.



# 3

## Conclusion:

Energy efficiency and economic transitioning increases the ability of economies to decouple economic growth and the energy demand. Falling energy intensity of GDP could be deeper and faster than most expect.



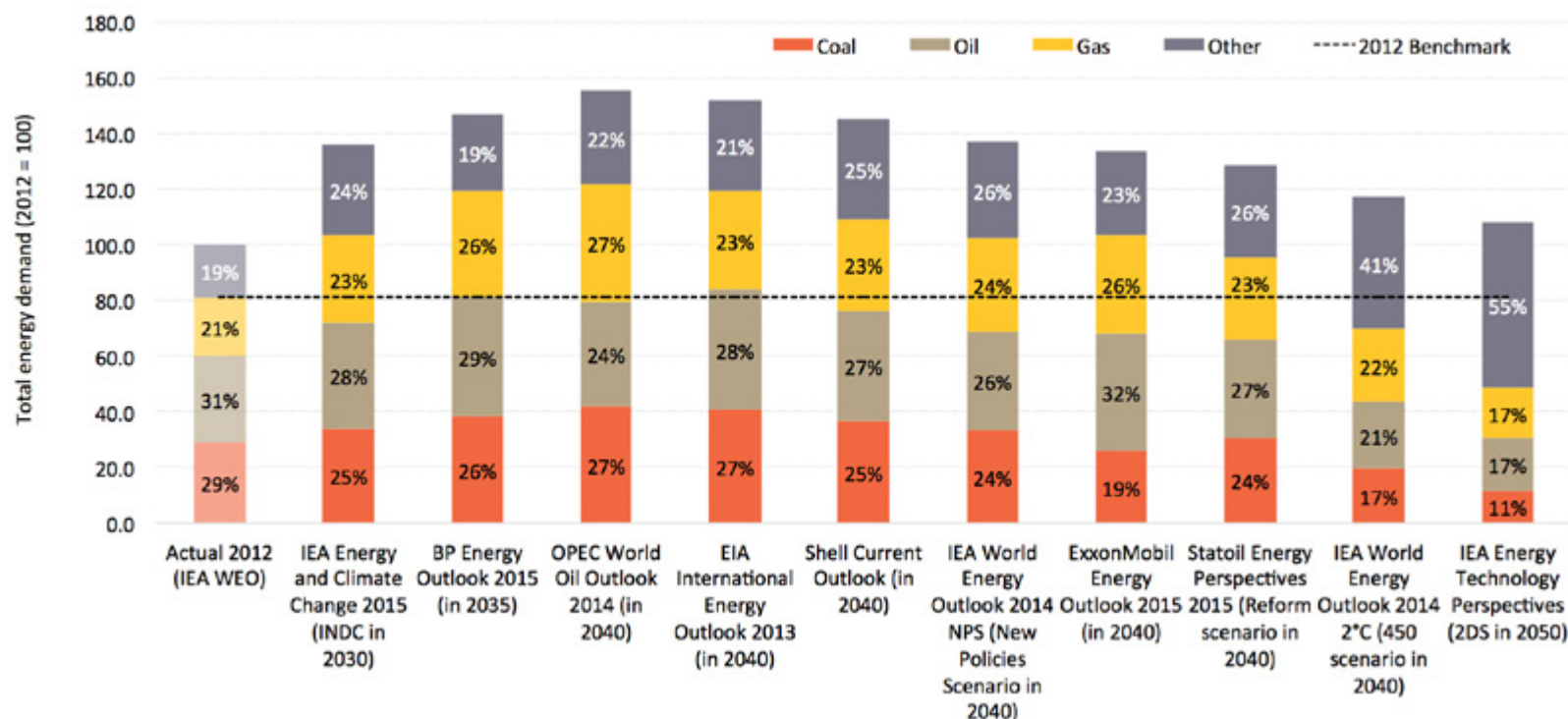


## BAU Assumption 4: Carbon intensity of energy remains high as fossil fuels maintain share

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The final component of the Kaya Identity to determine CO<sub>2</sub> emissions in addition to global population, GDP per capita and energy intensity is carbon intensity of energy demand, i.e. the energy supply mix. As of 2012, fossil fuels made up 81% of global energy demand. Scenarios and forecasts show the energy industry do not see this changing greatly over the next few decades – most see fossil fuels making up three-quarters of energy in 2040. Furthermore, Figure K shows most companies see overall energy demand increasing too, resulting in an overall increase in fossil fuel demand. Only specific low carbon scenarios have absolute levels of fossil fuel consumption declining.

Figure K: Expectations for the future fuel supply mix<sup>17</sup>



<sup>17</sup> 2012 baseline is taken from the IEA World Energy Outlook. For forecasts beginning in 2010, the CAGR over the entire forecast period was applied to the 2012 start year.



## Conservative carbon intensity falls

Scenarios that foresee fossil fuels making up three-quarters of total energy demand in 2040 equate to conservative carbon intensity falls of approximately 0.4% per annum. As Figure K suggests, this is much larger in 2°C scenarios, where carbon intensity rates are between -1.8% (Statoil Renewal) and -2.3% (IEA 450). As one would expect, this deeper decline in carbon intensity impacts fossil fuel demand substantially.

## Industry not planning for NPS or INDCs as a base case

Energy industry scenarios exceed the initial commitments made by countries in their INDCs by up to 100GtCO<sub>2</sub> – refer Figure L. These are more consistent with a trajectory for 4-6°C of warming in light of the extent they exceed the IEA NPS. Given that the INDCs are the latest policy commitments - which can be ratcheted down further - this would appear a sensible reference point to build into planning.



“The Paris agreement should certainly be geared around an end-goal of net-zero emissions but the realistic, albeit still aggressive, time span for this is 80+ years, not 35 years.”

David Hone, Shell Climate Change Advisor<sup>18</sup>

18. <http://blogs.shell.com/climatechange/2015/02/by2050/>

Figure L: CO<sub>2</sub> overhang of scenario compared to IEA INDCs

SCENARIO	TOTAL CO <sub>2</sub> EMISSIONS, 2013-2030 (GtCO <sub>2</sub> )	CUMULATIVE DIFFERENCE TO THE IEA INDC SCENARIO (GtCO <sub>2</sub> )
IEA INDC	575.9	0
IEA NPS	587.1	11.2
EXXONMOBIL	596.0	20.1
STATOIL	596.7	20.8
BP	613.7	37.8
EIA	614.8	38.9
SHELL MOUNTAINS	631.1	55.2
SHELL OCEANS	676.7	100.8

## Deep decarbonisation scenarios not being taken seriously by industry

The IEA 2DS which runs to 2050 has 45% of primary energy demand being met by fossil fuels, which is in the range of the G7 announcement to reduce fossil fuel use by 40-70% by 2050. There are further initiatives such as Track0 being developed by governments and business to achieve net-zero emissions by 2050. There may be some residual fossil fuel use by 2050 where CCS and offsets are employed to allow for continued use within emissions constraints. However CCS is not currently on track to deliver significant proportions of captured emissions streams, even by 2050.



# 4

## Conclusion:

The industry base case projections consist of absolute growth in fossil fuel demand hiding behind slight reductions in the overall proportion of energy generation. These scenarios exceed existing INDC policy commitments and do not factor in technological advances.

# BAU Assumption 5: Renewable energy technologies do not penetrate at speed or scale

5

When forecasting renewable energy growth, one must make assumptions of renewable cost-down rates, load factors and lifetimes. Due to the limited track record of the sector, and the constantly evolving technology, initial assumptions are often overly conservative. Figure M shows, with the benefit of hindsight, that the IEA has been significantly underestimating solar plus wind generation growth. The IEA continues to increase its estimates but is still catching up. Figure N compares forecasts across the energy industry. It confirms the IEA take a conservative standpoint; Statoil's Renewal scenario, Bloomberg New Energy Finance (BNEF) and Shell's Current Outlook are the most optimistic, applying a compound annual growth rate (CAGR) twice the rate of the most conservative BAU scenarios. Shell's 2013 Oceans scenario is the most bullish. However, this must be considered in the context of much higher energy demand growth than other scenarios. In essence, therefore, all energy sources increase strongly in the Oceans scenario.

Figure M: IEA scenarios of solar + wind generation have evolved over time

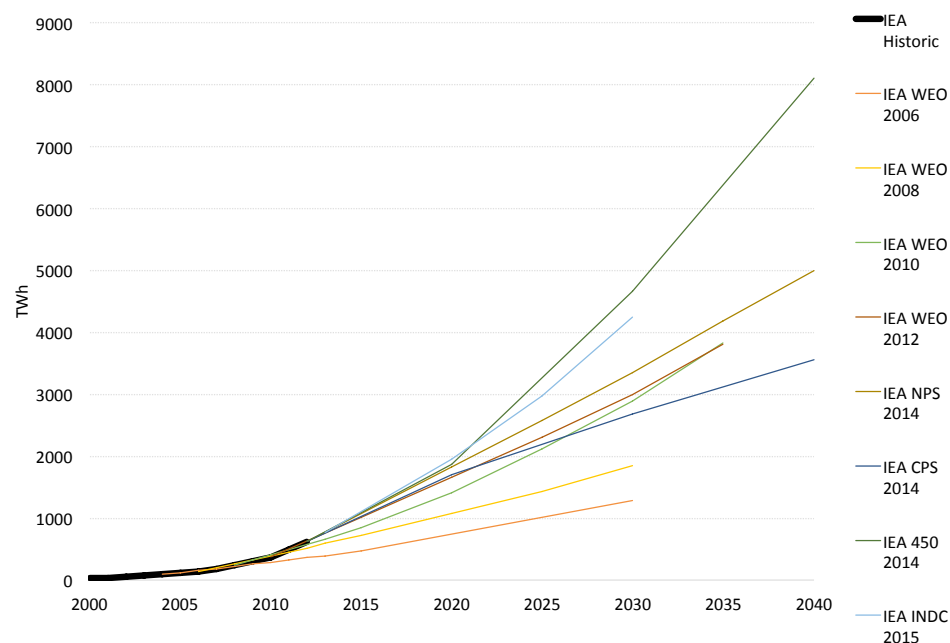
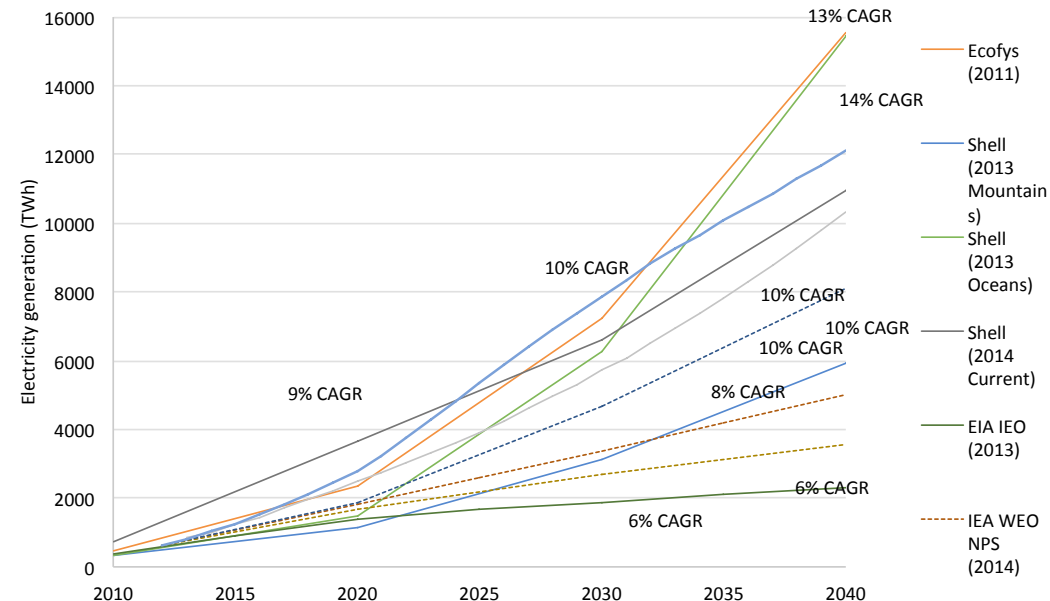


Figure N: Comparing growth rates for wind + solar electricity generation



## Rapid cost reductions are beating most expectations

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Cost reductions in solar PV and wind are continuing strongly. With every doubling of cumulative production, wind turbine costs have fallen 14% since 1984; for crystalline silicon PV modules this rate is 25%, according to BNEF. This has meant the price of electricity generated from solar PV has fallen from US\$76.67/watt in 1977 to just US\$0.74/watt in 2013. There is variation between scenarios in the assumed percentage of time solar and wind technologies will be operating at full capacity, i.e. the load factor. This assumption affects perceived costs. For example, some scenarios assume only a 10% load factor for solar PV generation. If scenarios double the assumed load factor this will half the levelised cost of energy (LCOE) and increase assumed electricity generation. Similarly, if a lower load factor is assumed for coal and gas generation, perhaps if they no longer form baseload, the economic viability of these power sources will suffer.

## Data doesn't capture the whole picture

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It is possible renewable energy generation is larger than some models think because small scale solar is not recorded. Generally, monitoring the level of renewable energy generation is not as established as for incumbent large scale fossil fuel power plants. Our research suggests some organisations do not capture generation from solar facilities below 1MW.

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19. Bernstein (2015) *Asia strategy: Shouldn't we all be dead by now?*

Including this generation could double the amount of generation, which would also advance where analysts believe solar is in bringing down costs.



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‘Solar is a technology. Costs fall over time and will continue falling. Fossil fuels are, by definition, extractive. Costs tend to rise over time.’ Bernstein<sup>19</sup>

## Renewables are already competing in China

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Analyses of current and future LCOE for wind and solar in China are consistent with the narrative of renewables becoming increasingly competitive with fossil fuel power generation. China is setting aggressive targets for improving air quality, and reducing GHG emissions, and the government is known for delivering on its objectives. China and the US have developed bilateral agreements around tackling climate change. If the world's major economies are putting substantial effort into bringing more renewables into their energy mix, this can only result in rapid development at scale, which will bring the costs down for the rest of the world.



## Energy markets and finance changing too

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The other barriers to renewables penetration relate to the greater variability of generation, and the need for different financial structures to facilitate investment. The German 'Energiewende' example shows that given the right framework, renewables can already make a major contribution - a quarter of German electricity in 2014. And if utilities fail to adapt it will challenge their business model. New retail offerings such as SolarCity in the US have increased residential take-up, whilst YieldCos are packaging renewables for institutional investors in a way which can match their risk and return appetites. Reducing the risk profile is critical to bringing down the discount rates for renewables finance, and not all models are up to date on the lower costs being seen.

### 5

#### Conclusion:

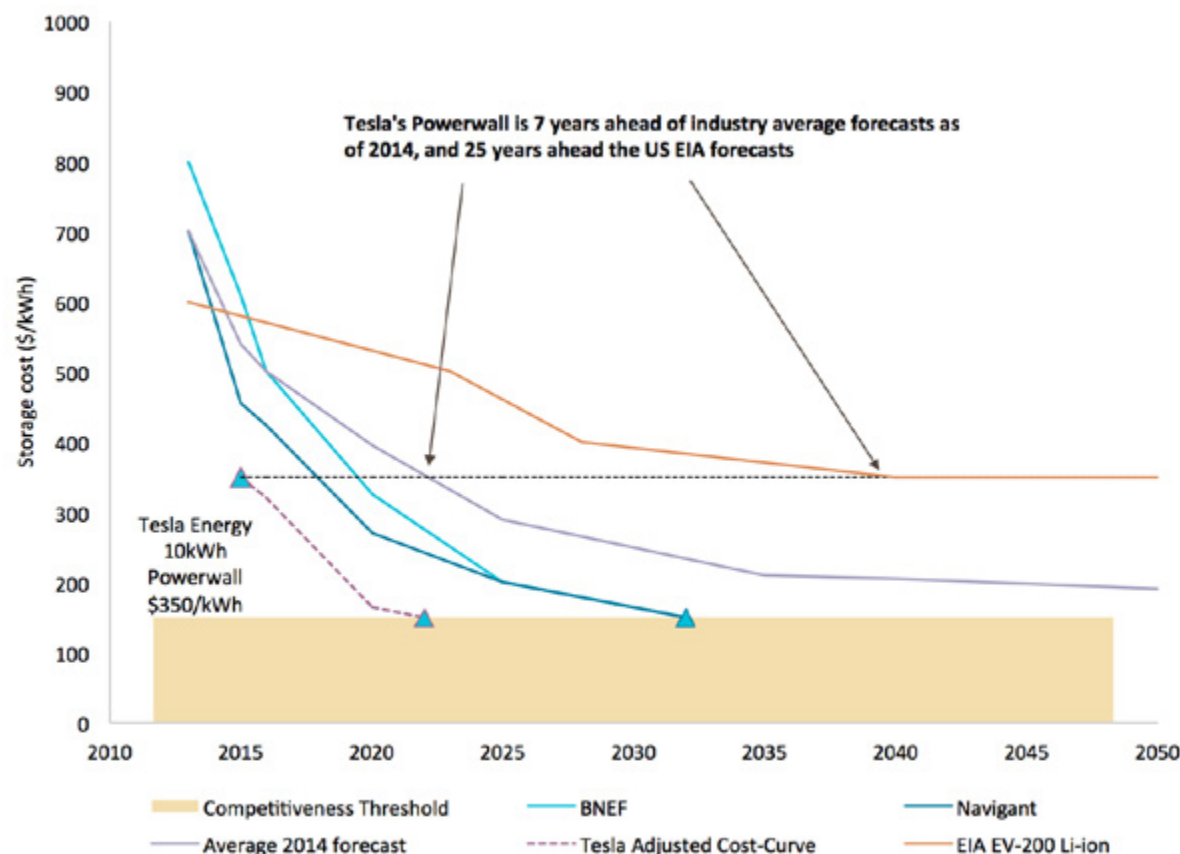
Renewable energy technologies are already with us, and get cheaper all the time. Energy markets and finance are adapting to the new opportunities around renewables. The potential for renewables to continue to beat expectations is huge.

## BAU Assumption 6: The energy system will see only incremental change, not transformational shifts

6

'Transformational' or 'disruption' factors are potential 'gamechangers' that could initiate a paradigm shift in the demand dynamics of an energy system. Whilst transformational factors may be hard to predict, and deemed less probable, the magnitude of their impact is far larger than incremental shifts. Ignoring them makes it very difficult to adapt if they transpire. Energy storage is one such factor.

Figure O: Battery costs are coming down faster than expected



### Cost trajectories being brought forward by decades

It is typically considered that energy storage costs need to be \$150/kWh or below to be financially attractive. The current industry reference scenarios don't see this threshold being met by mid-century – see Figure O. On April 30th, Tesla proved this forecast is likely to be hugely conservative. The Rocky Mountain Institute estimate Tesla's Powerwall costs \$350/kWh. Figure O shows this cost level is 7 years earlier than the industry average forecast as of 2014 and fully 25 years ahead of the US EIA. We have drawn an illustrative cost curve on Figure O in line with this new price point – this adjusted curve hits \$150/kWh just after 2020. As a result of the Tesla announcement, Deutsche Bank also updated their forecast to suggest \$150/kWh will be hit by 2020.

## Technologies combining to transform power markets

The continuing evolution of energy storage is vital to the deployment of renewable energy technologies. Storage helps remove the barrier of intermittency and so could catalyse the penetration of renewable energy sources. Forecasts of 'battery parity' – the point where renewable energy, typically solar, and battery costs match grid supply costs – show renewables and energy storage could be cost competitive in the near-term. Deutsche Bank sees battery parity being reached in Germany in 2016, while Bernstein see solar PV plus storage outcompeting retail power prices in Australia, Japan, Spain and Brazil by 2018 – refer Figure P. It is therefore the synergies between these technologies that could be the transformative factor, rather than just their development in isolation.



“Energy storage, when combined with solar power, could disrupt utilities in the US and Europe to the extent customers move to an off-grid approach” – Morgan Stanley, 2014<sup>20</sup>

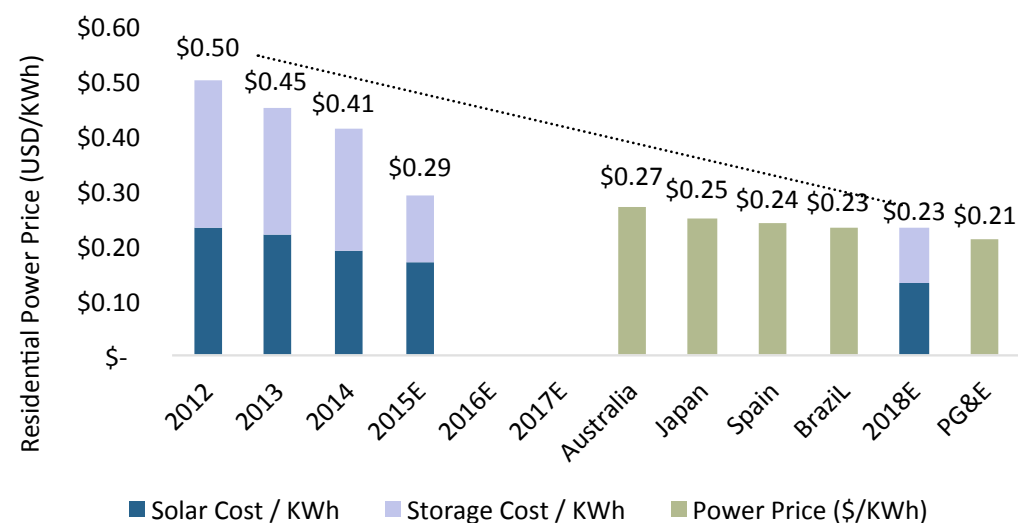
20. Morgan Stanley (2014) Solar power & energy storage: Policy factors vs improving economics

21. Bernstein (2015) Asia strategy: Shouldn't we all be dead by now?

## Energy is no longer an engineering sector, but a 'new technology'

The world's leading technological innovators see the transformation that is occurring and understand that big money can be made by early-movers. That is why Google has committed \$1.8bn to renewable energy projects and why Apple has invested \$3bn in solar facilities. Technologies typically penetrate markets in an S-curve. Given the rate of cost reduction, we could be at the cusp of the rapid uptake of renewable energy technologies with the coevolution of energy storage.

Figure P: Forecasts of battery parity in power markets<sup>21</sup>







# 6

## Conclusions

Energy models need to start considering the impact of transformational technology combinations which see energy storage, decentralised renewable generation and communications technology revolutionising the way consumers relate to power.



# BAU Assumption 7: Demand for coal continues to increase

7

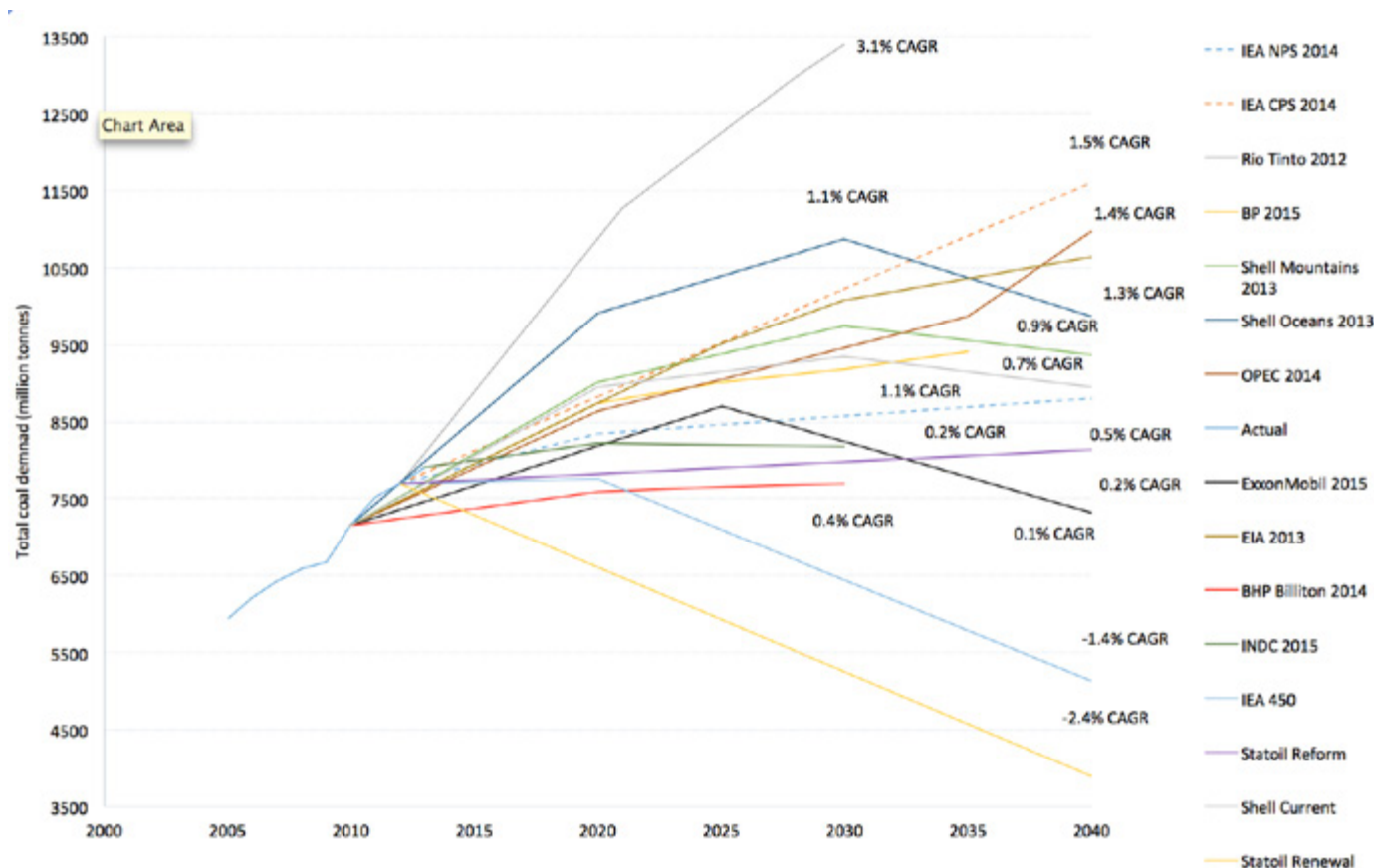
Over the past 12 months, a number of market analysts and investment banks have publically warned the future of coal demand is uncertain. Figure Q below shows all fossil fuel companies see coal demand growing to some extent to 2040. To demonstrate how the industry thinking has recently moved, we have included a rate from Rio Tinto in 2012 that is 2-3 times larger than most commentators are now forecasting.

## Coal demand dominoes keep falling

### Coal demand is being eroded in China

Coal demand in China fell by 2.9% in 2014 and 5.0% in the first half of 2015. We believe a structural economic change has occurred. Coal companies tend to quote the IEA CPS, however, which sees Chinese demand growing 1.3% each year on average to 2040. This is down from the heady days of WoodMac's 2013 'Illusion of peak coal' forecast indicating 3.7% CAGR to 2030, but still conflicts with market views. For example, Bernstein foresee a -3.7% CAGR decline in Chinese thermal coal demand to 2030.

Figure Q: Forecasts of total coal demand



## ***The rise of solar and wind in India continues***

In the absence of demand in China, producers are turning to India to provide an end-market. However, in October 2015, Prime Minister Modi announced the target of 175GW of renewable energy capacity by 2022. Around 160GW of this is expected to be solar and wind capacity, which we calculate could displace 158mt of coal demand by 2022. To give an indication of scale, this is approximately the amount of India's total coal imports in 2012. This renewable energy target serves as a huge risk, therefore, to foreign coal exporters.

## ***Increasing competition between coal producers***

Seaborne exporters are also at risk from domestic producers in India. Coal India sees domestic production rising such that coal imports are virtually flat on 2012 levels. Adani, Glencore Xstrata and the Australian Bureau of Resources and Energy Economics (BREE) see Indian coal imports roughly trebling. Exporters will be left disappointed if India scales up its domestic production.

## ***New coal exports need higher prices***

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We see a structural decline occurring in the global thermal coal sector meaning that prices will not recover. Market analysts have acknowledged this in their price forecasts - In 2015, Citi lowered their long-term price forecast to US\$80/tonne, Morningstar to US\$67/tonne and Goldman Sachs to US\$65/tonne as they called the 'retirement age' for the thermal coal industry. However, the IEA's scenarios, which are heavily relied

upon by the coal industry, have not made this integration. The IEA's NPS thermal coal price forecasts have not shifted to any significant degree since 2009 and see coal prices increasing to US\$112/tonne by 2040. Even the IEA 450 scenario thermal coal price estimate is higher in 2040 than current prices despite global demand being forecast to be 33% lower than 2012 levels. New export coal mines, and associated infrastructure, require a recovery in coal prices to make economic sense, yet the terminal decline observed by most market analysts has not filtered through to the mining companies, who continue to cite out-of-date IEA scenarios.

## ***Impact on revenues***

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As an indication of the impact of lower demand on revenues, BHP Billiton recently published its analysis of the impact a two degree scenario could have on its EBITDA. The diversified mining company has already reduced its thermal coal interests by spinning off South 32, leaving coal as 6% of its group revenue today. This is projected to fall to 4% under business as usual conditions, with a maximum downside of a drop to 2% in the event of sudden action to tackle climate change. As a diversified company, this is not terminal for BHP Billiton, but an equivalent 50% drop in earnings for pure coal mining companies would be very significant, especially as many in the US are already filing for bankruptcy protection.

An aerial photograph of a vast coal train yard. Numerous parallel tracks stretch across the landscape, each filled with long trains of coal cars. The cars are dark and rectangular, creating a rhythmic pattern of lines that recede into the distance. The yard is situated in an industrial area, with some buildings and infrastructure visible in the background under a clear sky.

# 7

## Conclusions

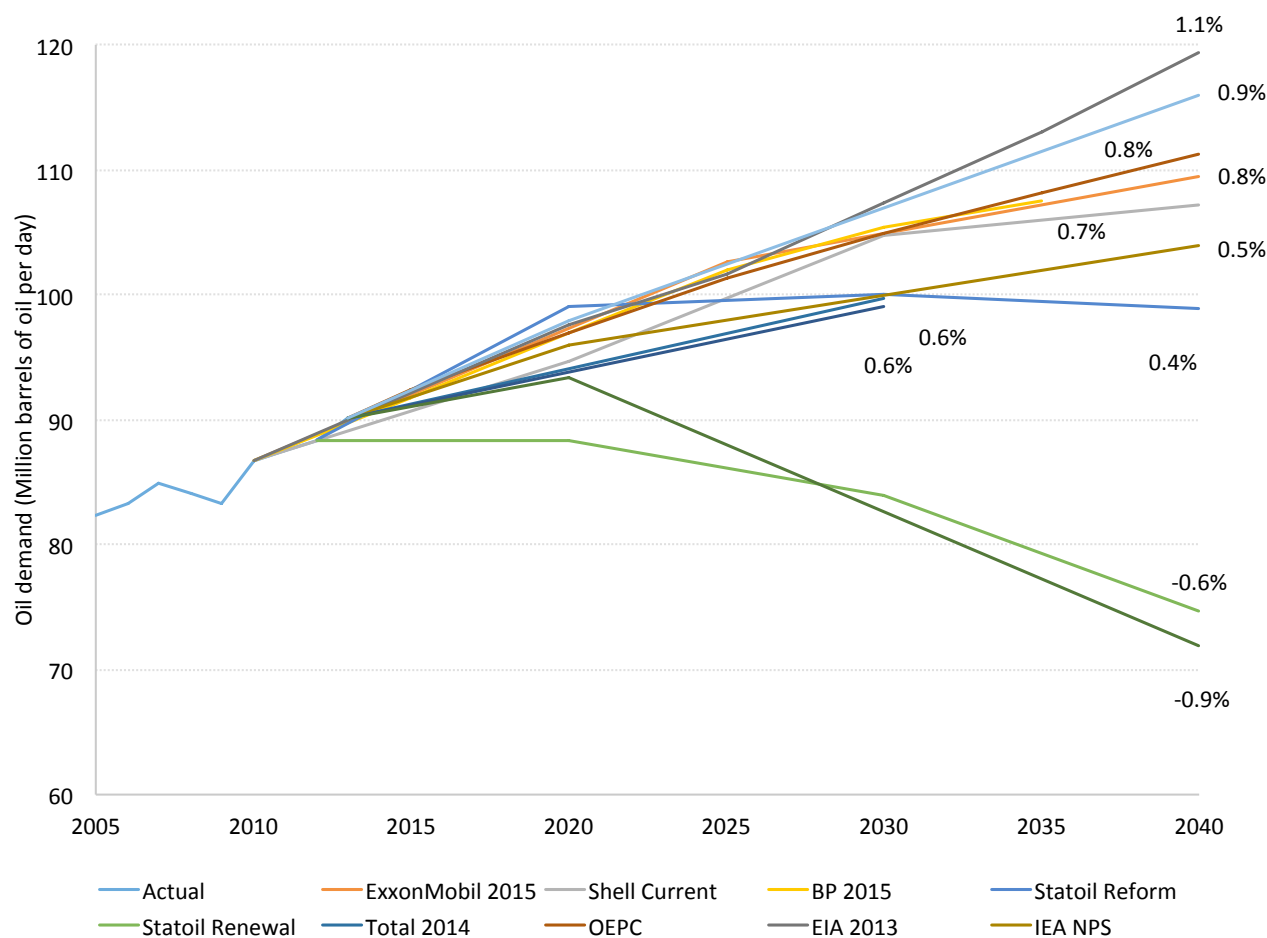
Coal demand is already declining in OECD markets and is being eroded in China and India below previous expectations. Companies expecting exports to see an upswing are increasingly detached from the market view of a terminal decline.

## BAU Assumption 8: Demand for oil continues to increase

8

As scrutiny over the risk profile of carbon-intensive assets has increased over recent years, oil has been posited as a 'safer bet' than other fossil fuels because it is not easily substitutable and entrenched in modern life. This may be about to change.

Figure R: The energy industry foresees oil demand growth (% CAGR)



All energy industry forecasts, apart from 2°C trajectories, see moderate oil demand growth between 0.4% and 1.1% per annum – see Figure R. Each scenario, therefore, sees cumulative demand to 2030 exceeding the level expected to result from national INDCs.

Road transport is the single largest oil demand sub-sector. We see efficiency gains and the emergence of electric vehicles (EVs) as potential drivers of lower-than-expected future oil demand.

### Efficiency of passenger cars (LDVs) to improve

Oil demand from LDVs in OECD countries is plateauing and declining as 'peak car' is achieved. In non-OECD countries, China is the most significant market having accounted for 58% of all new sales in



2013. They have introduced strict fuel efficiency targets to 2020 that would surpass projected gains for OECD nations like the US. Therefore, while companies like ExxonMobil see China's LDV fleet growing by 400m to 2040, efficiency gains could significantly offset any oil demand growth. India also has strict efficiency targets in place.

## EVs to be cost-competitive by 2025

An academic study that summarises EV cost curve forecasts concludes EVs could be cost competitive by 2030.<sup>22</sup> However, the costs of Tesla's recent Model-S were at least five years ahead of this industry average. As such, assuming learning rates are maintained, EVs could be cost competitive with internal combustion engine (ICE) cars by 2025. This is also the conclusion reached by Bernstein. By 2025, the IEA 450 scenario sees 80m EVs on the road. After cost-parity is reached, this number will surely increase further.

Other energy industry forecasts are less optimistic. ExxonMobil see 85m EVs on the roads but by 2040 - the IEA NPS puts this figure at 57m by 2040. These forecasts include up to 15 years in which EVs achieve and exceed cost-parity with ICEs. One could expect that once cost parity is reached, demand for EVs will increase exponentially, but this doesn't appear to be factored into increased sales. This demand shift would also impact supply – BMW, for example, have already said they expect all their models to be electric by 2025. In this context, the forecasts of ExxonMobil and IEA NPS look overly bearish.

22. Nykvist & Nilsson (2015), *Rapidly falling costs of battery packs for electric vehicles*, *Nature Climate Change*, 5:329-332

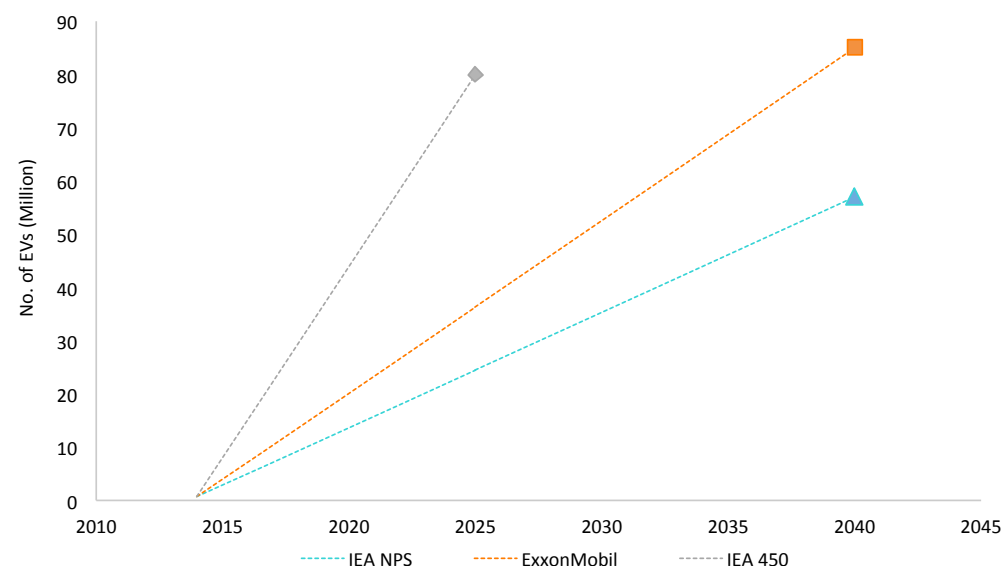
23. Bernstein (2015) *Asia strategy: Shouldn't we all be dead by now?*

24. Technologies tend to grow exponentially. In the absence of given data points however, we have drawn dotted lines solely to help read the graph



“If electric vehicles ever reach 3% of global fleet additions; the next stop after 3% is 97%” - Bernstein<sup>23</sup>

Figure S: Forecasts of EV fleets<sup>24</sup>



## Oil companies see strong growth in HDV oil demand

In their 2015 Outlook, ExxonMobil hail 'the rise of heavy-duty vehicles' (HDVs) as a source of oil demand growth. The IEA NPS sees an additional 6mbd being needed by HDVs in 2040. However, one must consider if this demand growth will transpire amid: i) fuel efficiency regulations increasingly being extended to HDVs; ii) medium-term substitution risk from the increasing role of electrification; and iii) the potential for slower GDP growth – after all, the need for commercial transport is entirely reliant on economic growth.

## Oil price volatility makes it harder to match supply and demand

The recent downturn in the oil price following three years of stable high prices is challenging models that rely on the last three years performance being a good indicator of the future. The new OPEC strategy to try and secure market share, alongside more flexible, increased US shale production has changed the dynamic in the market. Lower average prices will impact revenues, whilst spikes in prices will serve as warnings to dampen demand.

## 8

### Conclusions

The scenarios being used by the oil industry typically have very low rates of electric vehicle penetration. Faster uptake of EVs and efficiency gains in road transportation would alter the balance of supply and demand.

# BAU Assumption 9: Demand for gas grows strongly

9

The gas market is hard to predict. Few commentators saw the US shale gas boom coming and LNG has grown to become an increasingly global trade. However, the much-heralded European coal to gas switch has failed to materialise and gas demand in carbon constrained scenarios could be lower than that of the 'transition fuel' many expected. Figure T demonstrates that universally future gas demand is expected to grow strongly. Most projections and scenarios tend to congregate between the IEA's CPS (45% growth, 2015-2035) and NPS (38% growth, 2015-2035) scenarios.

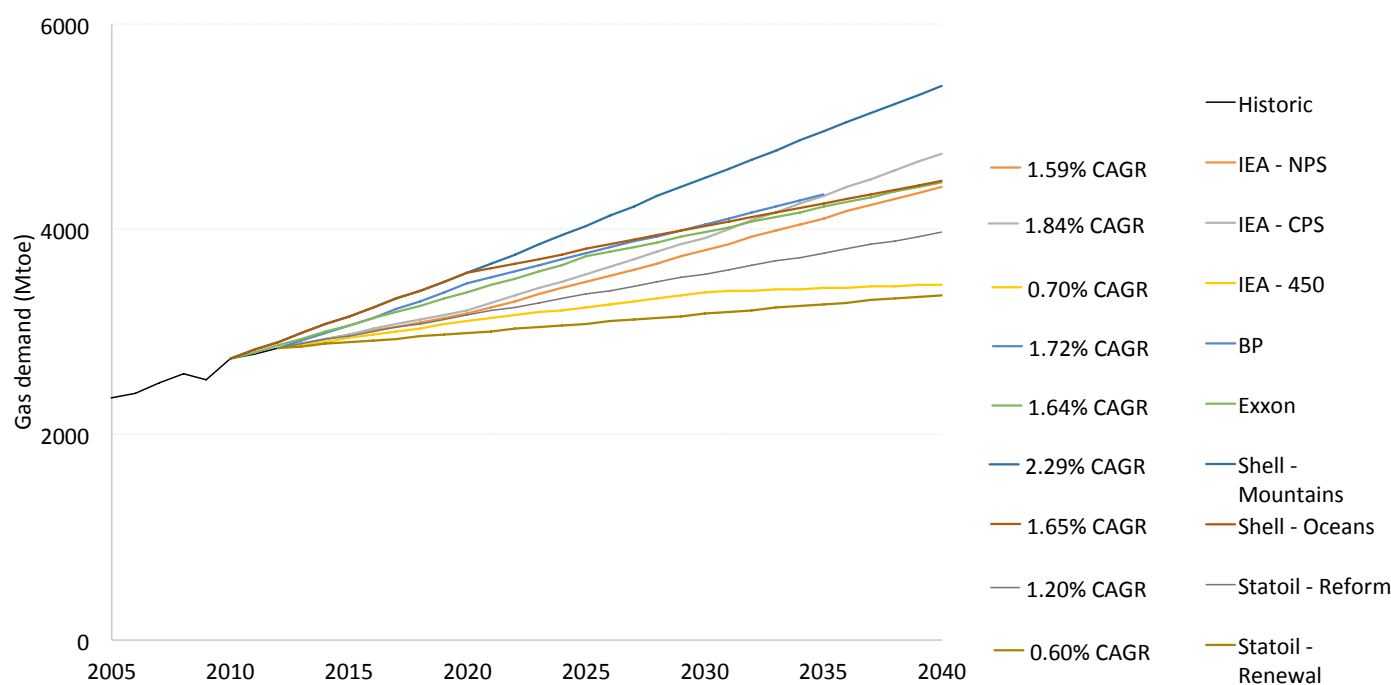
## Gas demand is not untouched by carbon constraints

2°C scenarios have room for gas demand growth, but far less than business as usual. For example, by 2040, the level of gas demand is 22% lower in the 450 scenario and 24% lower in Statoil's Renewal scenario, compared to the IEA's NPS scenario.

## Power sector uncertainty is under-weighted

The power sector remains the biggest single sector for future gas demand. The scenarios highlighted in Figure T may be underweighting the uncertainties of power supply, in particular fuel

Figure T: Comparing change in global gas demand across scenarios to 2035





substitution risk. For example, the US produced more electricity from gas than coal in 2015 for the first time. Few saw this turnaround coming, never mind at the rate it did - it demonstrates the substitutability of power sources.

## Changing role alters gas plant economics

A changing power landscape threatens to dislodge gas as a 'base-load' fuel leaving it as a back-up option. Germany's Agora Energiewende contend that, as renewable technologies with lower marginal costs gain market share, capacity factors for fossil fuelled power generation are lowered, making new plants less viable without market restructuring.

# 9

## Conclusions

Gas can still see limited growth in low carbon scenarios. Gas is caught between coal and renewables, and its role is changing in some markets to a back-up option, making the economics challenging.

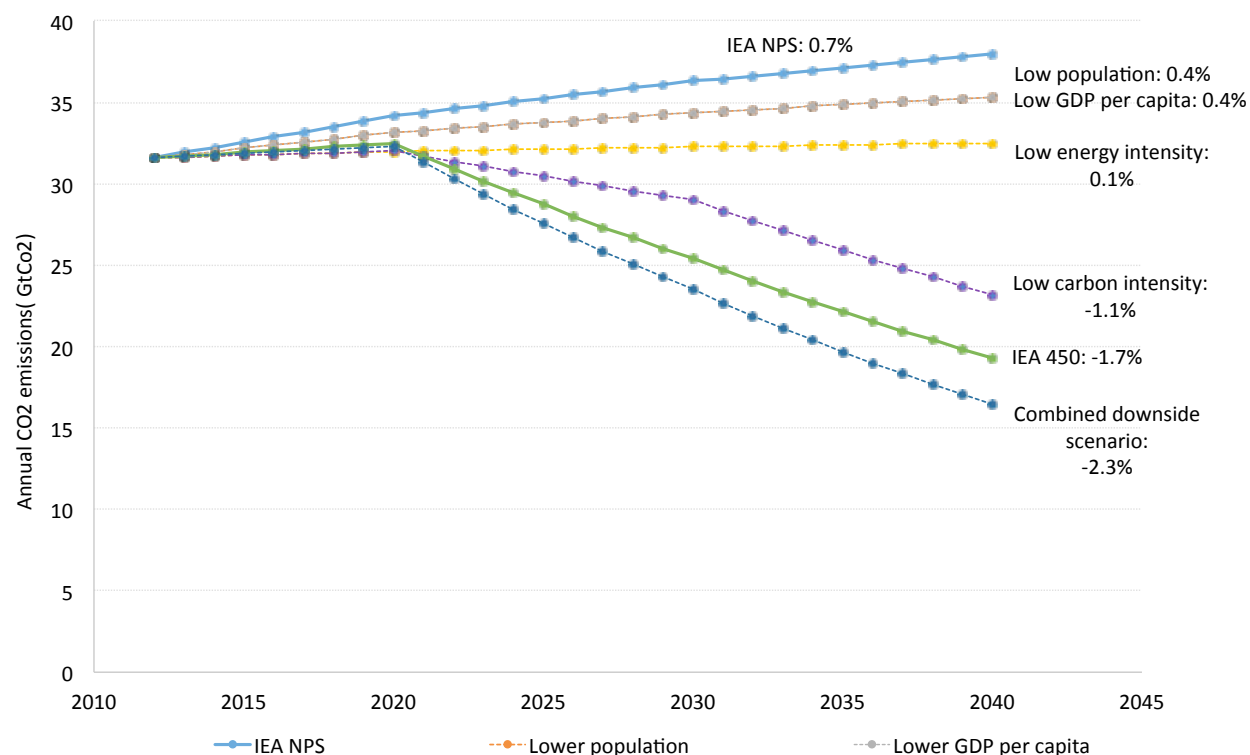


# Conclusions:

## How downside contributions could add up to reduce carbon emissions



Figure U: Comparing the CO2 impact of different rates of Kaya variables



Assumptions 1-9 presented a range of assumptions of the four components of the Kaya Identity. Figure U and the accompanying table (Figure V) show the impact on CO2 emissions if the downside demand possibilities of these four components are applied to the Kaya Identity. To recall, these are:

- i) population growing more slowly to 8.3bn by 2040 in line with SSP and SRES trajectories;
- ii) GDP growth of 3.1% in line with the OECD forecasts, affecting GDP per capita growth;
- iii) energy intensity falls accelerate to -2.8% in line with the IEA 450; and
- iv) carbon intensity falls accelerate to -2.3% in line with the IEA 450.

Figure V: Summary of impact on carbon emissions of varying Kaya identity factors (annual growth rates)

		POPULATION GROWTH	GDP PER CAPITA GROWTH	ENERGY INTENSITY	CARBON INTENSITY	CO2 CAGR	TOTAL CO2 (2012-2040)	% GAP FROM NPS TO 450 COVERED
NPS DOWNSIDE	IEA NPS	0.9%	2.5%	-2.2%	-0.5%	0.7%	1022	
	Lower population	0.6%	2.5%	-2.2%	-0.5%	0.4%	979	19%
	Lower GDP per capita	0.9%	2.2%	-2.2%	-0.5%	0.4%	979	19%
	Low energy intensity	0.9%	2.5%	-2.8%	-0.5%	0.1%	932	39%
	Low carbon intensity	0.9%	2.5%	-2.2%	-2.3%	-1.1%	847	76%
2°C VARIATIONS	IEA 450	0.9%	2.5%	-2.8%	-2.3%	-1.7%	792	100%
	2°C Low population, GDP & energy intensity	0.6%	2.2%	-2.8%	-1.7%	-1.7%	792	100%
BEYOND 2°C	Combined downside scenario	0.6%	2.2%	-2.8%	-2.3%	-2.3%	755	

Figure U shows that we isolated each component of the Kaya Identity and compared its impact on CO2 emissions against a base case, for which we used the IEA NPS. (In the table, cells coloured orange highlight the assumption that has been downgraded; those coloured green identify a variable that has been made higher). The results show:

- **Reducing assumed population growth** to levels in SSP and SRES trajectories reduces annual CO2 emissions growth from 0.7% in the NPS to 0.4%. This equates to lower CO2 emissions that get you 19% of the way from NPS to the 2°C 450 trajectory;
- **Reducing GDP per capita growth** in line with OECD forecasts has the same impact as reducing population because CO2 emissions growth is again 0.4% per annum;
- **Accelerating the energy intensity rate of change** to -2.8% per annum in line with the 450 scenario as opposed to -2.2% per annum gets you 39% of the way from the IEA NPS to 450 scenario.
- **Accelerating the carbon intensity rate of change** to -2.3% per annum in line with the 450 scenario as opposed to -0.5% per annum gets you 76% of the way from the IEA NPS to 450 scenario.

Clearly, each variable can make a meaningful contribution in getting from a likely base case trajectory to 2°C. This exercise shows that, depending on one's views of what economic, demographic and energy futures might transpire, getting to a 2°C pathway could be more achievable than previously perceived.

Adding up the percentage growth rates of the four components of the Kaya Identity acts as an accurate proxy for the subsequent growth rate in CO2 emissions. As such, one can attribute deeper cuts in ratios where desired and understand how this feeds through the Kaya Identity to less dramatic changes in other parts of the energy system. To demonstrate we run a trajectory that achieves the same -1.7% CAGR of CO2 emissions as the 450 scenario, but via a different combination of assumptions:

- **If lower population growth and economic growth as well as accelerated energy intensity falls** are achieved simultaneously, **the carbon intensity of energy only has to fall by -1.7%** each year as opposed to the original -2.3% in the 450 scenario.

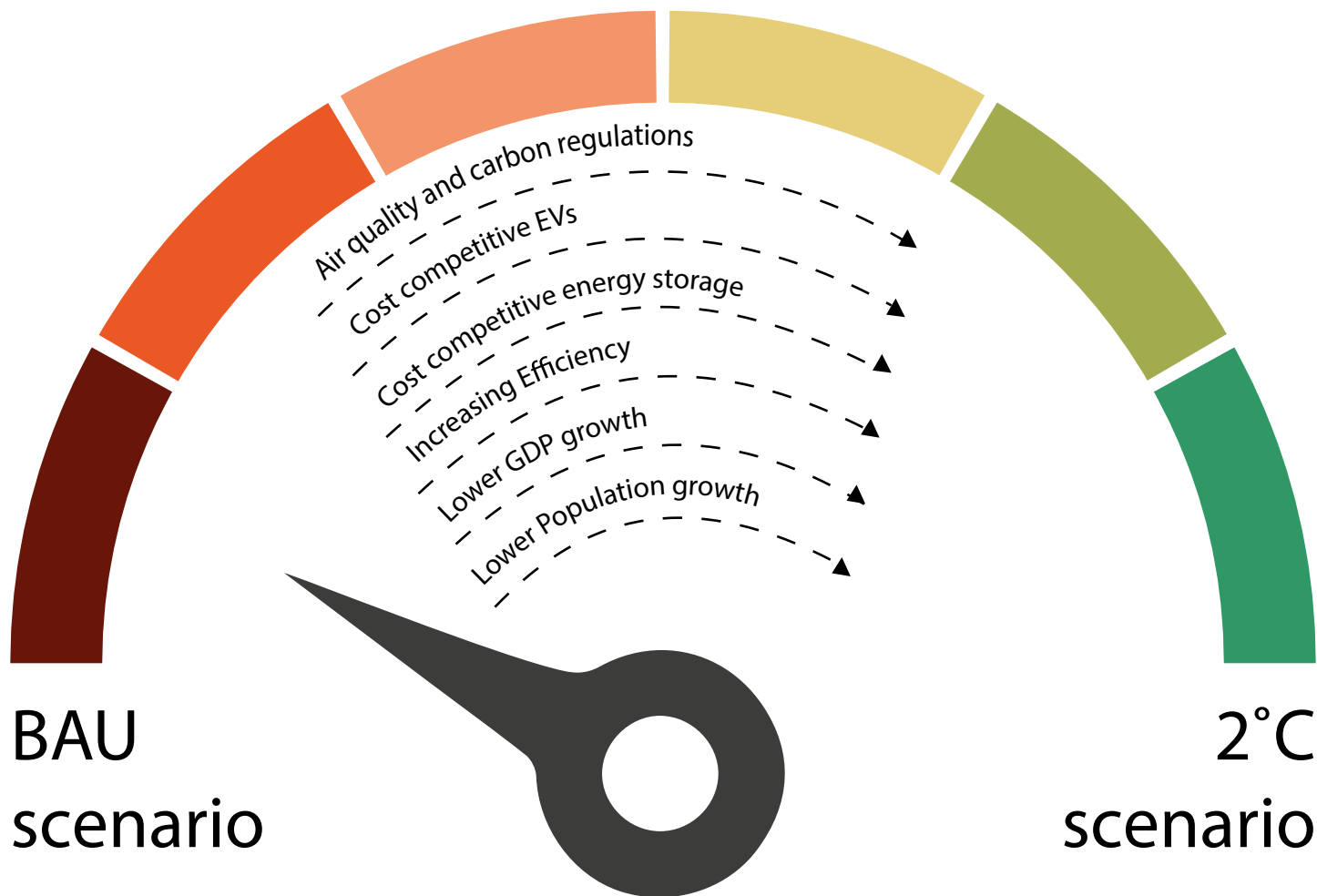
We also explored what would happen to CO2 emissions if downside scenarios transpired for all four components of the Kaya Identity. **In this 'combined' scenario, CO2 emissions are 5% below the IEA 450 scenario.** This analysis is encouraging that there is still the potential for limiting global warming to 2°C, even if some dramatic changes to the energy system are required.

## Recommendations:

R

**Investors** need to understand where company scenarios are on the spectrum of demand assumptions.

**Companies** need to explain how their business model would change in a lower demand scenario.





## About Carbon Tracker

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The Carbon Tracker Initiative is a team of financial specialists making climate risk real in today's financial markets. Our research to date on unburnable carbon and stranded assets has started a new debate on how to align the financial system with the energy transition to a low carbon future.

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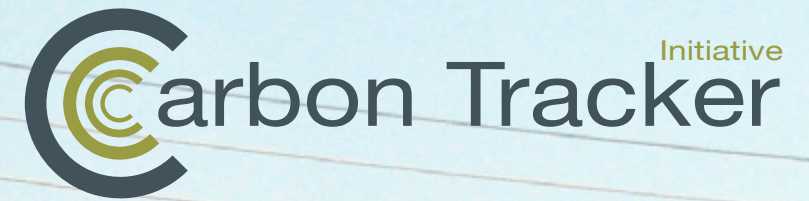
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