

THE FUTURE OF CHINA'S POWER SECTOR

From centralised and coal powered to distributed
and renewable?

Executive Summary

27 August 2013



SECTION 1. EXECUTIVE SUMMARY

Following its rapid economic expansion in the past decades, China has now become the world's largest power market, the world's largest carbon dioxide emitter and it consumes half the world's coal. By 2030 its power market will have more than doubled in size and coal's dominance will be challenged by competitive renewables, increased awareness of environmental pollution, the prospects of shale gas and a potential price on carbon emissions.

In this report, Bloomberg New Energy Finance examined the following questions:

- What are realistic scenarios for China's power sector development until 2030 given fast declining renewable costs, the potential for shale gas and increased energy efficiency?
- Besides the much needed top-level political will to realise its 'Beautiful China' dream, how are economic and technological drivers pushing China's transition towards a cleaner future?
- How should businesses position themselves in anticipation of the next wave of power market reform and benefit from China's evolving power sector over the next 20 years?

The new Chinese leadership is responding to calls for more equitable and sustainable economic growth, a faster pace of reform, and to concerns over environmental degradation. Expected structural reforms will gradually reduce the government's interference in the economy, allow more private capital to enter state-dominated sectors such as energy, and impose further environmental controls. It is against this background that we have modelled the outlook for China's power sector according to four scenarios until 2030 – Traditional Territory, New Normal (our base case), Barrier Busting, and Barrier Busting scenario including a carbon price. All modelling was done with the China module of our proprietary Global Energy & Emissions Model (GE₂M), which leverages data and knowledge from our China-based team of experts.

Main findings and conclusions

- *We project that China's total power generation capacity will more than double by 2030 with an additional 1,583GW to reach 2,707GW (Figure 1). This is under our New Normal scenario, which we believe is most likely given the current policy, technology and economic situation. This growth is required to meet China's projected electricity consumption growth of 5% per year and is equivalent to 88GW/yr, which is equivalent to adding the total installed capacity of the UK every year.*
- *Renewables will contribute to more than half of new capacity growth and by 2030 installed renewable capacity will be equal to that of coal. Coal-fired power generation capacity will decrease from 67% in 2012 to 44% in 2030 though in absolute terms will continue to grow by 25GW/yr – still almost one-third of new construction and equal to two large coal plants every month. Renewables including hydro will increase from 27% to 44% in 2030 at 47GW/yr.*
- *The key reasons underlying the rapid growth of renewable energy are similar to those observed in other countries. These include i) the continuously improving economics of wind and solar PV due to falling technology costs, ii) increasing costs for coal-fired plants as a result of environmental controls, and iii) the expected uptake of distributed solar PV in China's commercial sector.*
- *As a result of renewables having a lower capacity factor relative to fossil fuels the share of coal-fired power generation will remain dominant at 58% in 2030; this is down from the 72% seen in 2012. Despite accounting for more than half of added capacity, renewables including hydro will only increase its share of generation from 21% in 2012 to 29% in 2030.*

Figure 1: Power generation capacity mix under different scenarios, 2012 vs. 2030e (% , GW)

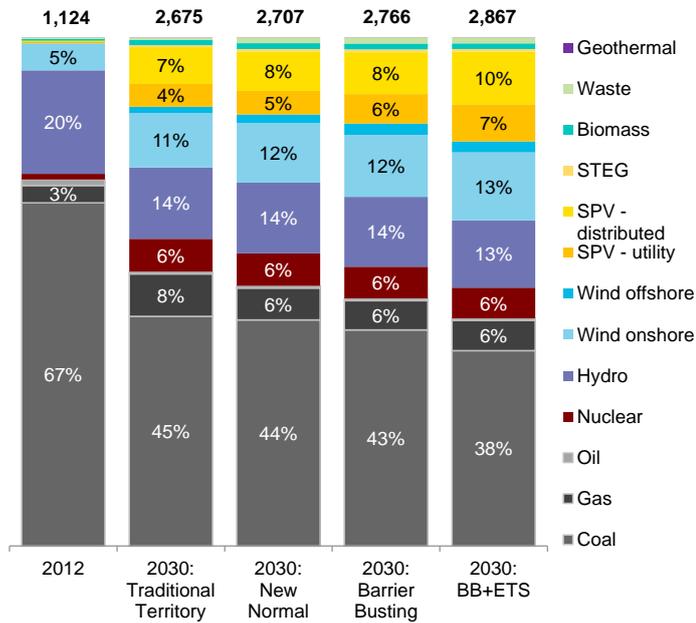
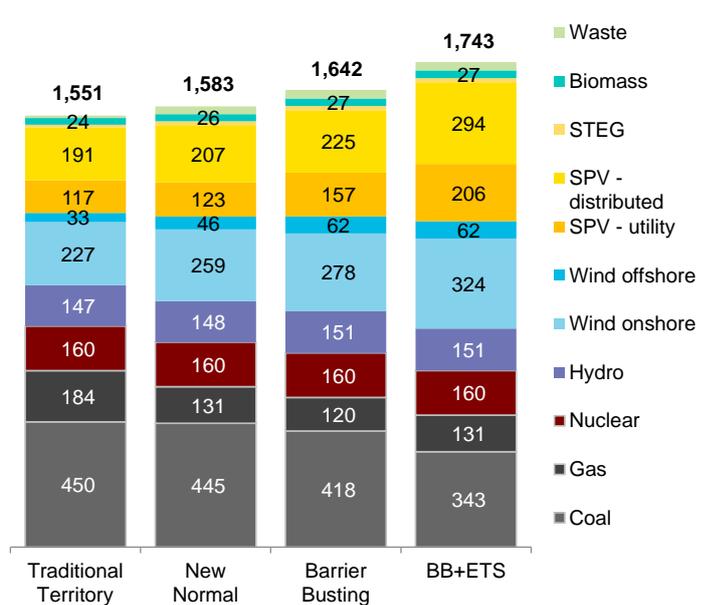


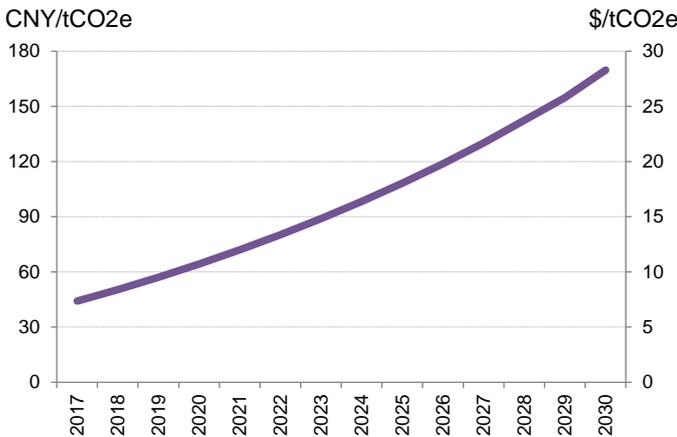
Figure 2: Power generation capacity additions under different scenarios, 2013-30e (GW)



Source: Bloomberg New Energy Finance. Note: Pumped hydro excluded.

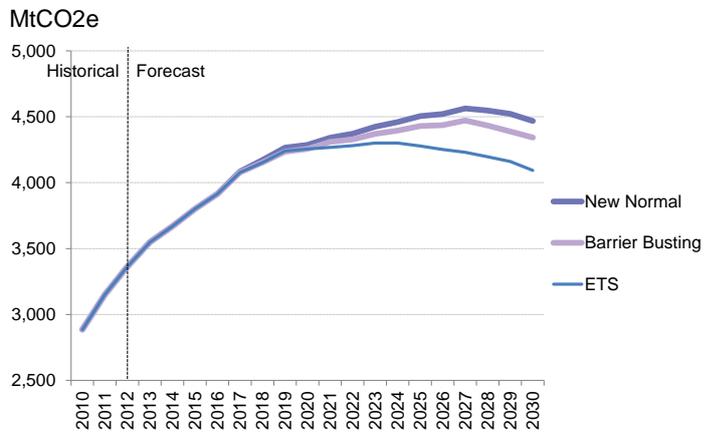
- The overall outcomes under the Traditional Territory and Barrier Busting scenarios are not wildly different. For the scenarios we used varying assumptions regarding environmental costs for coal-fired plants, natural gas prices, renewable policies, and the penetration of distributed PV. Events that could induce major change to these scenarios are i) a shale gas boom at the end of this decade resulting in gas prices less than \$5/MMBtu, ii) a nuclear disaster leading to a halt in new nuclear build, or iii) a halving of costs in the offshore wind sector.
- If a carbon price is placed on China's power sector, emissions will peak as soon as 2023 at an average carbon price of only CNY 99/tCO₂e (\$16/tCO₂e) during 2017-30 (Figure 3 & Figure 4). Combining our Barrier Busting scenario with an emissions trading scheme (ETS) starting in 2017 will result in only 77% of new coal plants being built compared to our base case. This will be replaced by more renewables and natural gas and will therefore reduce emissions.

Figure 3: Carbon pricing forecast of China's power sector ETS, 2017-30e



Source: Bloomberg New Energy Finance.

Figure 4: China power sector emissions under different scenarios, 2010-30e



Source: Bloomberg New Energy Finance. Note: ETS is implemented within the Barrier Busting scenario.

- Building out China's power fleet on such a large scale will require investments of \$159bn/yr or 2% of China's total GDP in 2012 of which half will go to renewables (Figure 5). Around \$77bn/yr will be invested in renewables including hydro, approximately equal to investments of the past few years. This signals a stable financing requirement for the renewable sector over the next two decades though there will be a noticeable shift towards distributed projects.
- To accommodate the projected additions of power generation capacity, especially more intermittent renewables, China will have to invest \$57bn/yr in supporting infrastructure (Figure 6). We estimate an additional \$1,024bn is required for long distance transmission lines, smart grid, storage projects and demand response systems under our New Normal scenario. This is around one-third of total investments going into generation capacity itself.

Figure 5: Total capital investment requirements for power generation capacity additions under different scenarios, 2013-30e (\$bn)

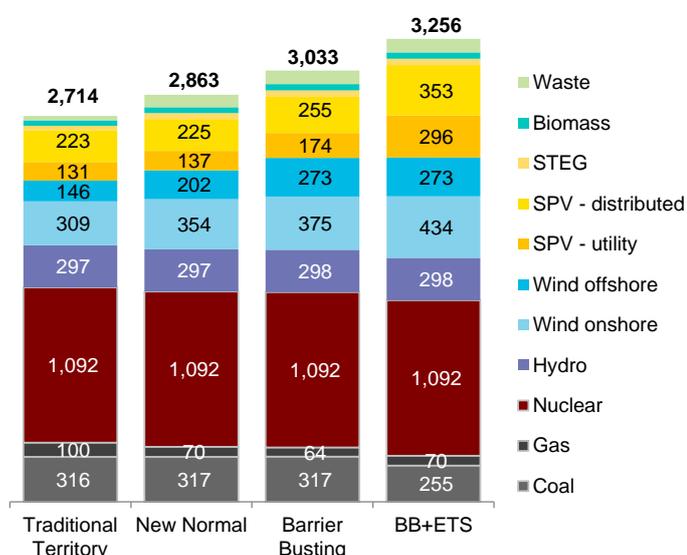
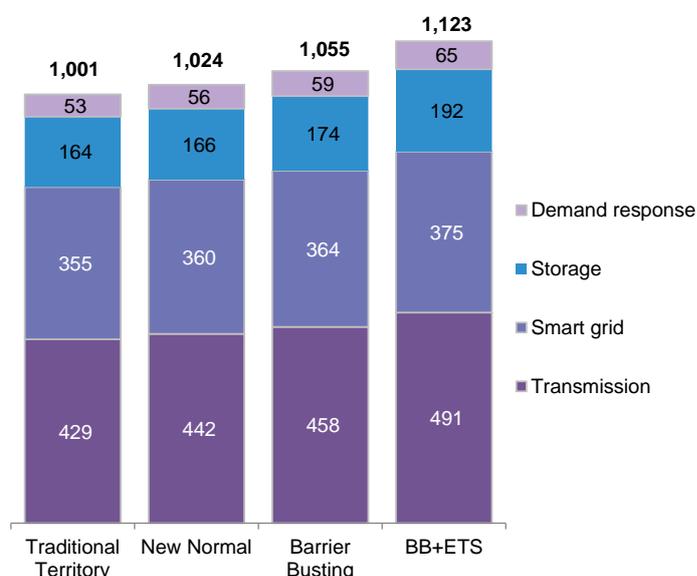


Figure 6: Additional investment requirements for supporting infrastructure under different scenarios, 2013-30e (\$bn)



Source: Bloomberg New Energy Finance Note: Pumped hydro excluded.

Source: Bloomberg New Energy Finance Note: Pumped hydro excluded.

Implications and recommendations

Looking at the four scenarios for China's power sector it is hard to underestimate the significance of this 'revolution' and the challenges and opportunities it creates for various stakeholders in China. The impact will also be felt far beyond China. These trends will have major implications for anything from coal and LNG prices to gas turbine, wind turbine and solar module demand. From a business perspective, the key question is how to develop strategies that allow companies to capitalise on the changing landscape of China's power sector.

• **Policymakers**

- Coal will remain dominant in 2030, accounting for over 50% of the total power generation under all the four scenarios. Hence, implementing stricter environmental standards on coal plants will alleviate local air pollution conditions, but may not significantly alter investment patterns in the industry – absolute growth in coal generation capacity continues under all four scenarios.
- To stimulate a cleaner supply mix, stronger support for renewable energy, natural gas, energy efficiency and clean coal technologies needs to be provided. Shale gas has major potential, but its development is heavily dependent on the right regulatory conditions and addressing water availability issues. A well structured carbon pricing mechanism, such as a tax or an emissions trading scheme, will give the right incentives to ensure power sector emissions peak early in the next decade.

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- Distributed solar PV can play a major role in the future energy mix given that it is increasingly cost competitive, but will require an enabling policy environment so that business owners can easily invest in their own solar capacity.
- **Grid companies**
 - With non-hydro renewable power generation reaching 18% in our New Normal scenario by 2030, grid companies will need to create an actionable plan to manage these distributed and intermittent energy sources. Partnerships with other grid operators worldwide who have experiences managing high level of renewables could bring valuable lessons. In addition, the regulator is likely to respond with new rules on the back of this development.
 - The rapid growth of distributed PV means that there will have to be increasing focus on the distribution and end-user side, rather than transmission as has been the focus thus far. This means more and faster investment in distribution automation, distributed storage and demand response.
- **Power companies**
 - Power generators whose portfolio is heavily dominated by coal should acknowledge the potential financial risks that a carbon liability or increased renewables in the system could create. Gaining capabilities in renewable generation and diversification into other power generation technologies could be an important way to manage these risks.
 - With both distributed gas and PV growing in the long term, it could be strategically important for power companies to expand into those areas. This could protect revenue attrition as a result of distributed generation, which has been observed in other markets.
 - Grid integration technologies such as energy storage and demand response could provide alternative revenue streams and growth areas. This can build on successful experimentation and rollout in other countries.
 - In the long term, a national carbon pricing mechanism is likely and possibly essential for China to meet its policy targets. As such, power companies need to take into account the impact of such a mechanism when making long term strategy and investment decisions. Other environmental concerns such as water constraints should also be considered as 85% of China's power capacity is located in water-scarce regions and 15% of this relies on water-intensive once-through cooling technologies.
- **Equipment suppliers**
 - Nuclear, power transmission, solar PV, smart grid, onshore wind, as well as energy efficiency across all parts of the economy are likely to be the biggest areas of investment in China over the next 20 years. For Chinese equipment suppliers these rapidly expanding markets will create significant opportunities.
 - International companies should look at bringing in technologies that are lacking in China's domestic market and explore effective pathways for future sales, including strategic relationships. For example, this could include expertise on the integration of renewables, energy efficient technologies, advanced energy storage equipment, software and hardware for grid upgrades and energy and data management, high efficiency turbines for coal and natural gas, and services and technology for shale gas development.
- **Electricity users**
 - Given the increasing investment requirements of the sector and the relatively low current power prices, prices are likely to have to rise. Heavy power users could better utilise energy management companies to help improve their energy efficiency and manage these rising power prices.
 - The increasing importance of distributed power generation in China and ongoing market restructuring could open up opportunities for end users to have their own generation

assets for self-consumption and/or sale. The ongoing evaluation of the economics of distributed generation technologies is important to realise these commercial opportunities.

Next steps

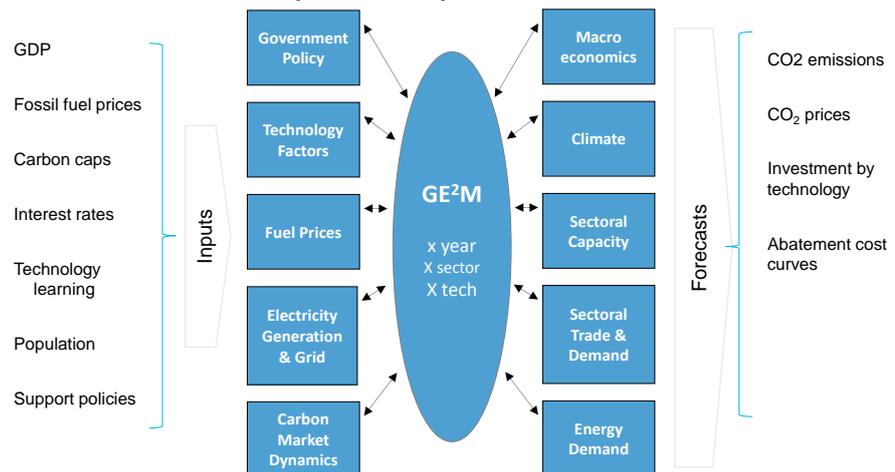
Modelling scenarios can be a valuable exercise. By attempting to quantify possible alternative futures we can better understand how markets and market participants might be affected by various factors. The future will not exactly follow any of our four scenarios; instead, it will most likely lie somewhere in between these scenarios, especially given some of the significant uncertainties that we can see in China. These include the volumes and cost levels at which China will be able to extract its shale gas reserves, the impact of water and environmental constraints for coal mining and combustion, potentially lower LNG prices on the back of a global supply expansion, a nuclear disaster in China, social unrests and movements in response to air pollution, or even drastic weather events as a result of climate change leading to a significant shift in the government's climate policy. Some of these uncertainties have already been modelled in this report, whereas many of the others will be covered in future reports.

APPENDIX: METHODOLOGY

This report presents the latest forecasts from Bloomberg New Energy Finance on the future of China's power sector out to 2030. The analysis uses Bloomberg New Energy Finance's proprietary model of the energy system and clean energy technologies – the Global Energy and Emissions Model (GE²M) – together with expert interpretation of current and proposed policies and targets.

The model incorporates short-, medium- and long-term projections of energy demand based on economic, demographic and technological drivers as well as detailed sector and technology analyses covering all sectors of the economy and types of fuel. The analysis draws on the contribution of experts within Bloomberg New Energy Finance across renewable energy, energy smart technology, carbon market, gas and power sectors. The short-term market projections are based on our detailed understanding of the construction pipeline in each sector and government targets, while longer-term forecasts use a combination of modelling energy policies and the costs and resource availability of each technology. The analysis covers asset finance in all the main forms of electricity generation technologies including small distributed capacity.

Figure 7: Schematic of GE²M inputs and outputs



Source: Bloomberg New Energy Finance

Assumptions

All results in this report are underpinned by the above-described modelling as well as Bloomberg New Energy Finance expert views on the markets and important assumptions regarding technology trends, commodity prices, impact of policy, marginal abatement cost curves, etc. These views and assumptions have been researched in-depth by our dedicated global analyst teams and are continuously updated according to market developments. Table 1 highlights the key assumptions and which of our services can provide more detail on these topics.

Table 1: Bloomberg New Energy Finance GE²M assumptions

Topics	Bloomberg New Energy Finance Insight Service
Natural gas prices and market analysis	Gas Insight
Renewable energy costs and deployment	Renewable Energy Insight
Carbon pricing fundamentals and Marginal Abatement Cost Curves (MACCs)	Carbon Insight
Smart grid, demand response, energy storage, electric vehicles and energy efficiency	Energy Smart Technologies Insight

Source: Bloomberg New Energy Finance

Additional research

Due to the flexibility of the model, its coverage of the whole Chinese economy and our expertise across China's energy sector there are many other questions that we can answer:

- At what natural gas price will gas generation start to reduce coal generation? Would this price level be achievable for the country's future shale gas production?
- What emissions reduction target can China's economy reach at a carbon price below \$20/t? How would this fit with other country's targets?
- What would these scenarios look if China does not impose any environmental costs?
- How will China's power market reform change the dynamics of investments across the sector?
- What technology improvements are required for offshore wind to grab a larger market share?
- What kind of business models can be deployed in China to achieve the levels of penetration modelled for small-scale solar PV?
- Which companies are best positioned to profit from the transition of China's power sector?
- What cost levels need to be achieved by companies producing onshore wind turbines or solar PV modules to ensure they remain competitive and market demand develops?

APPENDIX: BLOOMBERG NEW ENERGY FINANCE

Bloomberg New Energy Finance (BNEF) is the definitive source of insight, data and news on the transformation of the energy sector. BNEF has staff of more than 200, based in London, New York, Beijing, Cape Town, Hong Kong, Munich, New Delhi, San Francisco, São Paulo, Singapore, Sydney, Tokyo, Washington D.C., and Zurich.

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Regular research

Supporting each of these service areas are a range of proprietary models and data. Models range from short term market tools to complex long term fundamental forecasting models. Through our regular research we provide detailed data and analysis of all of the above markets. This output includes regular publications in the form of Research Notes, Analyst Reactions, Quarterly Outlooks and Annual Reports.

Each month we produce around 50 pieces of research across the world's evolving energy markets. These cover all key geographies and markets. Examples are provided below for power market analysis and China specific projects.

China market research

We also conducted regular research on the evolving energy sector in China. To date much of this has focussed on the clean energy sector. Examples of our research include:

- **China and India rework domestic gas pricing programmes.** This Note examines the gas pricing reforms in China and India and analyses the implications.
- **China Deep Dive: seven pilots prepare for take-off.** This Note analyses the fundamentals of China's seven pilot schemes and potential national trading scheme.
- **Coal methane: a quicker fix for China than shale gas.** This Note analyses the Chinese unconventional gas market and examines the current policies and barriers of coal methane.
- **China's shale gas strategy.** This Note examines the 12th Five-Year Plan's targets, analyses the policy incentives, and highlights the challenges and investment opportunities.
- **China announces its favoured energy technologies.** This Note analyses which renewable technologies are likely to benefit from China's 12th Five-Year Plan for Energy Technology.
- **Thirsty coal dries up China's water supplies.** This Note investigates how China's water scarcity may shape its energy mix.

- **Shining fresh light on China Development Bank's credit lines.** This Note turns its spotlight on the actual loans that China Development Bank has extended to clean energy companies thus far.
- **China hesitates on nuclear as it studies Fukushima.** This Note investigates whether the Fukushima accident could have important implications for China's energy programme.
- **Cleaning up Chinese industry.** This Note analyses the impact of the closure of 2,087 factories to hit China's carbon and energy intensity targets by 2020.
- **How China Development Bank built clean energy muscle.** This Note looks at the implications of China Development Bank's multibillion-dollar for the clean energy sector.

Power market analysis

Our regular analysis of the power markets has mostly been in the developed markets of Europe, North America and Australia. Published research in these markets includes:

- **Global Renewable Energy Market Outlook.** This Note presents our latest forecasts on the future size of the world renewable energy markets.
- **Costs of UK shale gas.** This Note assesses the potential costs of developing the UK's shale gas and the implications for the European energy market.
- **Scenarios for the European power industry.** The European power industry faces a period of significant change. This Research Note charts potential scenarios for the future of the industry over the next 20 years.
- **European power generation quarterly.** Shifting environmental policies, volatile commodities and changes in demand are just a few of the factors facing generators. This Long-term Generation Outlook explores the trends affecting European power and reveals how capacity, generation and the technology mix could evolve to 2030.
- **European power - understanding capacity mechanisms.** Capacity mechanisms help ensure the 'lights stay on' by placing a price on capacity. This Technical Note introduces both the theory behind these mechanisms and how they are implemented in practice.
- **PJM Capacity markets.** This Note assesses the implications of the cost of complying with new capacity payments in the US's largest east coast power market.
- **Changes to US coal plants.** This note examines the impacts of new emissions rules for the ageing US coal fleet. The analysis quantifies the costs of meeting the new regulations and projects likely coal retirements over the medium term.

Consulting assignments

In addition to our regular reports we also undertake regular consulting assignments for a wide range of public and private sector clients. These are categorised under (i) Energy policy and economics, (ii) Low carbon corporate strategies and (iii) China specific projects.

China specific projects

- **Private client (confidential), 'Analysis of China's ability to meet carbon and energy targets'.** Detailed modelling of Chinese economy to 2020 including structural, demographic, technology and market related factors. Derived implicit carbon price through MACC curves.
- **US private equity firm, China market entry strategy.** This project for a US based client assessed the opportunities for investing in the clean energy sector in China. The work involved assessing the attractiveness of the market and potential market entry strategies including acquisition, JVs or direct project investment.
- **Research Institute, 'Opportunities and Challenges for Foreign Investment Banks within the Chinese Renewable Energy Market'.** This project examined the role of financial institutions in the growing renewable energy market in China.

- **Oil Major, 'China's Renewable Energy Surcharge: Provincial Supply and Demand'**. This project looked at the Provincial level on the demand and supply for renewable energy technologies. From this analysis the client was able to identify new investment opportunities.
- **Major Chinese Wind Turbine Manufacturer. 'Target Market Report: USA, Brazil, India and Turkey'**. This project assisted a Chinese wind turbine manufacturer in focussing its export business into the most productive markets.

Energy policy and economics

- **UK Government, Development of long term abatement cost model for Europe**. This work built on our well established carbon abatement cost modelling to create a highly sophisticated tool with which to assess the cost implications for the EU moving to a 30% target by 2020.
- **EBRD, Abatement cost analyses for Turkey, Ukraine, and Kazakstan**. Conducted in conjunction with the consultancy NERA and a team of local consultants in each country, this project will develop the most complete picture of the abatement potential in these three countries. This will be used to inform the Bank's policies and investment activities.
- **Danish Energy Agency, Design of EUA auction system**. In this project we advised the Agency on the advantages and disadvantages of different approaches to auctioning EUAs and the various platform structures.
- **European Commission. Analysis of emissions performance standards**. This study for the Commission examined the implications of adopting fixed emission limits on new build power stations that would effectively ban new coal fired plants. The study analysed the costs of different plant types and how investment economics changed under different carbon prices
- **UK Government, Development of detailed industrial abatement cost curves for EU ETS industrial sectors**. Building on our existing database of industrial abatement activities in our EU carbon model, this project involved extensive additional secondary research to update and validate the data and assumptions. The results fed into the UK's own carbon price model.

Low carbon corporate strategies

- **Oil Major (confidential), European carbon strategy**. For this project, we assessed the company's existing installation-level analysis of its exposure to the EU ETS and developed internally consistent carbon market scenarios to 2020 with associated emissions and pricing views. We also helped the company develop its internal emissions trading strategy.
- **German utility (confidential), Study on the long-term development of the carbon market**. This major project provided multiple scenarios for long term carbon price forecasts (up to 2040) taking into account political, legal and energy sector conditions.
- **Major Asian steel company, Strategic implications of the impacts of carbon markets on business operations**. This project provided a detailed analysis of the effects of the EU emissions trading scheme on European steel companies and how they have responded. The output of the work enabled the client to develop its internal strategy for cap and trade schemes that could be implemented in other parts of the world where it has operations.
- **Australian investment bank, Development of an Australian ETS model**. We developed the first-ever Australian pricing model for greenhouse gas emissions. This was done in conjunction with several energy companies in Australia as well as the bank's internal staff and our own in-house modelling team.

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