中英（广东）CCUS 中心
UK–China (Guangdong) CCUS Center

2009年，中国国务院提出2020年温室气体排放行动目标，并在2010年把广东省列为低碳试点省份。英国能源与气候变化部与广东省发展及改革委员会在广东省省长朱小丹的见证下于2013年9月在伦敦签订了推动低碳合作的联合声明，以深化双方合作，其中强调了开展碳捕集与封存（CCS）合作的重要性。2013年12月18日中英（广东）碳捕集，利用与封存产业促进与学术交流中心，即中英（广东）CCUS中心正式成立。中心致力于推动大型CCUS项目的示范，应对人类面临的温室气体排放的挑战，为中国面对的雾霾、水污染的问题提供国际合作平台，催化清洁化石能源技术产业化，以及培养相关专业人才。

In 2009, China's State Council proposed its 2020 goal for greenhouse gas emissions, and then in 2010 made Guangdong a low carbon pilot province. Guangdong has made remarkable achievements in greenhouse gas emission control to which the UK-China low carbon cooperation has contributed significantly. In September 2013 the UK Department of Energy and Climate Change (DECC) signed a joint statement in London with the Guangdong Development and Reform Commission, witnessed by governor Zhu Xiaodan of Guangdong Province, to strengthen low carbon cooperation. The joint statement highlights the importance of collaborating in Carbon Capture and Storage (CCS). Supported by the Guangdong and UK governments, the UK-China (Guangdong) Carbon Capture, Utilisation and Storage Industry Promotion and Academic Collaboration Centre (the "Centre") was officially founded on December 18th, 2013. The Centre is committed to promoting the demonstration of large-scale CCUS projects to tackle greenhouse gas emissions. At the same time, the Centre will also provide an international collaboration platform for solutions to other local pollution problems (such as haze, water pollution) caused by coal utilization, and to accelerate the industrialization for clean fossil energy technologies and to train qualified professionals.

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近零排放

Cover Story | 封面故事

2030
欧盟能源与气候变化目标
European 2030 Energy and Climate Targets

“规定欧盟成员国在2030年之前将温室气体排放量削减到比1990年水平减少40%，同时保证可再生能源在欧盟能源结构中所占的比例不低于27%”

中英（广东）CCUS 中心
UK–China (Guangdong) CCUS Center

实现近零排放须有愚公移山的精神

Achieving Near Zero Emission Requires Persistent Efforts

李 佳，邓广义
Jia Li, Guangyi Deng

欧盟在1月初公布了2030年气候与能源政策白皮书，尽管中国国内大部分媒体认为该目标有利于低碳和清洁能源发展，但深入分析，欧盟委员会在本轮政策制定过程中充分考虑了清洁能源价格对工业的影响，从而降低了可再生能源在成员国中的比例。在白皮书公布后，欧盟主要能源公司纷纷叫停新能源项目，如苏格兰南部电力公司，叫停了大部分海上风电和生物质发电项目，仅保留一个海上风电项目的开发。欧盟的能源政策也强化了碳市场作为主要碳减排机制的地位。

七个碳市场试点的推出，为中国低碳经济发展、形成环境污染防治体系，打下坚实基础。然而，要让碳市场刺痛排放大户，进行长期的低碳投资，仍需要国内外政策环境条件和政策之间的协调。一方面，一个强的清洁能源政策目标会导致弱的碳市场，从而给投资者一个错误的信号。另一方面，进行低碳技术的示范和储备需要未雨绸缪。第二届中英（广东）CCUS专家会议刚刚召开，经过过去九个月的准备工作，华润海丰电厂完成了国内首份CCS预留设计方案。广东CCUS示范一体化项目，作为一项前瞻性的国际合作项目，即将进入为期一年的项目预可研阶段。

中国政府开始对近零排放技术和示范非常重视，特别是对看得见的污染物——大气污染物的治理，地方政府陆续出台措施尝试改善空气污染，实现大型排放源传统污染物的近零排放。中国全国人大常委会通过了新修订的环保法，对环保责任更加明确。面对更严格的法律和监管要求，要迅速实现传统污染物的近零排放和满足新增能源需求，中国需要应用大量先进技术，如湿法电除尘，煤制气等。回顾过去英国治理‘伦敦雾’的过程，国内要实现空气治理还需要长时间的努力和坚持，也需要机构改革和观念转变。

The EU published the “2030 framework for Climate and Energy Policies” at the beginning of January, and most media outlets in China reported that the targets set out therein would facilitate further development of low carbon and clean energy. In fact, the European Commission reconsidered the impact of the cost of clean energy on industry in the policy making process. Following the publication of the draft proposal, key energy companies in Europe successively suspended new energy projects, an example being Scotland Southern Electric (SSE), one of the largest utility companies in Britain, which suspended the development of most offshore wind and two biomass power projects, leaving only one offshore power project still in the development process. The EU’s energy policy also revitalized the role of the carbon market in carbon emission mitigation.

The emergence of 7 pilot carbon markets in China has provided a strong boost for China’s low carbon economic development and environmental pollution system. However, encouraging large emission sources to make long term low carbon investments in the carbon market still requires comprehensive coordination between domestic and international environmental policies. A strong clean energy policy could lead to a weak carbon market, thereby passing the wrong signal to an investor. On the other hand, demonstrating low carbon technology requires significant preparation work. Such work is underway in China: The 2nd UK-China (Guangdong) CCUS Expert Workshop has been successfully held on 15 May 2014, after several months’ preparation, the first CCS Ready design in China has been completed for China Resources Power (Haifeng) Project. In addition, the Guangdong integrated CCUS demonstration project, as a prospective international cooperative project, is entering into a one-year pre-feasibility study stage.

The Chinese Government has started paying great attention to near-zero emission technology and demonstration projects, particularly in order to tackle visible atmospheric pollutants. Local governments are gradually introducing measures to try to reduce air pollution and to achieve zero emission targets for conventional pollutants from large emission sources.

Stricter laws and regulations requiring the rapid achievement of near zero emission targets for conventional pollutants – at the same time as having to satisfy increasing energy demand – is forcing China massively to apply advanced technologies, such as wet electric dust removal, and coal-to-gas technologies. Looking at how the UK tackled the “London pea-soupers” (very bad fog brought on by atmospheric particulates in the 1950s), China will need a long and consistent effort, to reform agencies and change concepts in order to manage climate change.

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近零排放：重要新闻回顾（2014年1月至4月）

NZE: Important News Digest (January to April, 2014)

中国国务院总理部署大气污染治理工作：国务院总理李克强2014年1月12日主持召开国务院常务会议，研究部署进一步加强雾霾等大气污染治理工作，首要措施提到合理控制煤炭消费总量，推广使用洁净煤。业内专家称，这将利好国内IGCC（整体煤气联合循环）、煤制气等洁净煤技术项目建设。（来源：内蒙古煤炭交易中心）

Keqiang Li, the Premier of China's State Council deploys atmospheric pollution control measures: On January 12th, 2014, Keqiang Li hosted an executive meeting to discuss the further deployment of atmospheric pollution (e.g. haze) control measures. The meeting concluded that the primary measures needed are to control the total consumption of coal and promote the use of clean coal. Industry experts said that this will benefit the development of domestic clean coal technologies such as IGCC (integrated gas combined cycle), coal to gas etc. (Inner Mongolia Coal Trading Center)

图片来源：网易新闻
Source: NetEase News

欧盟议会通过支持碳捕集与封存报告：欧盟议会全体会议于2014年1月14日在斯特拉斯堡表决通过了《2013年欧洲推广应用碳捕集与封存技术执行报告》，其中赞成票524张，反对票141张，弃权票25张。该报告由自由主义团体欧洲自由民主联盟中的欧盟议会议员Chris Davies发起，不具备法律效力。（来源：领先财纳公司）

The European Parliament agrees a CCS report: On January 14th, 2014, the European Parliament's plenary session in Strasbourg passed the 'implementation report 2013: developing and applying carbon capture and storage technology in Europe' with a vote of 524 to 141 with 25 abstentions. The report was initiated by Chris Davies, a Member of the European Parliament (MEP) from the liberal group ALDE, and it is non-binding. (Linkschina)

图片来源：sunwindenergy.com
Source: sunwindenergy.com

欧盟委员会推出2030年能源与气候变化目标草案：2014年1月22日，经过非常激烈的辩论，欧盟委员会推出2030年能源与气候变化目标草案。该草案在推动碳减排和发展低碳经济的同时，强调能源价格竞争力。草案确认了碳市场作为主要减排机制的地位，同时建议降低其它低碳政策对碳市场的影响。（来源：欧盟委员会）

The European Commission publishes a draft plan for 2030 energy and climate change goals: The draft EU framework on climate and energy for 2030 was presented on January 22nd, 2014 by the European

Commission after heated debate. The framework aims to drive continued progress towards a low-carbon economy and a competitive and secure energy system, and it highlights the competitiveness of energy pricing. The draft framework recognises the carbon market as the major means of carbon reduction and proposes to reduce the influence of other low-carbon polices on the carbon market. (European Commission)

图片来源：cnqcr.com
Source: cnqcr.com

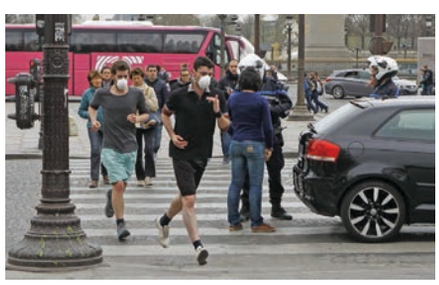
中国环保部推“大气十条”配套政策：2014年2月11日，国新办召开新闻发布会，环保部副部长翟青透露，备受瞩目的“大气十条”将很快有包括推广气代煤、扩大清洁煤在内的22项具体政策与之配套。这22条近期将提交国务院审议。（来源：中国能源报）

China’s Ministry of Environmental Protection pushes for supporting policies for “10 atmosphere rules”: The Information Office of the State Council held a press conference on February 11th, 2014. At the conference Qing Zhai, the deputy director of the Ministry of Environmental Protection, revealed that the highly anticipated “10 atmosphere rules” will soon be supplemented with 22 specific policies such as the replacement of coal with gas and the promotion of clean coal. These policies will be submitted to the State Council for review in the near future. (China Energy News)

图片来源：theguardian.com
Source: theguardian.com

中美就合作应对气候变化达成进一步共识：2014年2月15日，中美两国在美国国务卿克里访华结束时发表联合声明称，双方将通过强化政策对话，包括交流各自2020年后控制温室气体排放计划的有关信息，开展合作。（来源：路透社）

U.S. and China agree to work on climate change: On February 15th 2014, China and the United States, the world's top emitters of greenhouse gases, pledged to work together to attenuate the effects of global climate change. A U.S.-China joint statement issued at the end of U.S. Secretary of State John Kerry's whirlwind Beijing visit said that “China and the United States will work together to collaborate through enhanced policy dialogue, including the sharing of information regarding their respective post-2020 plans to limit greenhouse gas emissions". (Reuters)



图片来源：theguardian.com
Source: theguardian.com

巴黎措施应对雾霾：2014年3月14日，法国首都受罕见持续雾霾袭击，政府采取三天免费公共交通措施应对，以及限制车速。巴黎PM10最高值曾经达到180，是欧盟标准的两倍多。值得注意的是，法国核电在能源系统中占主导地位。（来源：BBC）

Paris offers free public transport to reduce severe smog: The French capital region and 30 other departments have been on maximum pollution alert for several days. On March 14th, 2014, authorities in Paris took the rare step of making public transport free for three days to reduce severe smog caused by unusually warm weather. The level

of PM10 recorded in Paris once reached a maximum of 180, which is more than twice the European standard. It should be noted that nuclear power takes the lead in France's energy system. (BBC)

图片来源：nfdaily.cn
Source: nfdaily.cn

中国环保部收紧垃圾焚烧排放标准：2014年4月9日，环保部常务会议决定修改《生活垃圾焚烧污染控制标准》，涉及的二恶英等排放指标将与欧盟看齐，达到“史上最严”。新标准或将采用连续监测，达标项目包括小时均值和日均值，数据将比现行标准更严格，与欧盟标准接近。二恶英类的新标准或比现行标准有大幅提高，修订后的标准与欧盟一致。（国能网）

The Chinese Ministry of Environmental Protection tightens the standards for waste incineration: On April 9, 2014, an executive meeting of the Ministry of Environmental Protection decided to modify the Pollution Control Standards for Household Garbage Burning, and stated that henceforth dioxin emission indexes will keep pace with the European Union's standards and be 'the severest in history'. The new standards are more severe than the current ones and closer to those of the EU, and require continuous monitoring the mean of hourly and daily levels. The new standard for dioxin-like chemicals will be sharply higher than the current one, in line with the EU standard. (CMEN.CC)

图片来源：sunwindenergy.com
Source: sunwindenergy.com

欧盟收紧可再生能源补贴以及允许补贴高耗能企业能源成本：2014 年 4 月 9 日，欧盟委员会发布新规，要求限制对太阳能、风能、生物能等可再生能源的国家补贴，以及引入竞争防止市场扭曲。同时，成员国将允许补贴68个高耗能行业，降低他们受使用可再生能源技术带来额外成本的影响。（欧盟委员会）

The EU has tightened renewable energy subsidies and allowed the energy costs of high energy-consuming enterprises to be subsidized: The European Commission released new regulations to limit the public subsidies for renewable energy, such as solar, wind and bioenergy etc. and on April 9, 2014 introduced competition to prevent market distortion. Member States are now permitted to subsidize 68 high energy-consuming industries to reduce the influence of their additional costs brought about by using more expensive renewable energy technologies. (European Commission)

图片来源：changqingyoutian.cn
Source: changqingyoutian.cn

中国石化联合会、中国石油和神华集团联合成立CCUS领导小组：2014年4月22日，中国石油和化学工业联合会、中石油集团、神华集团日前联合发出通知，决定成立陕甘宁蒙地区二氧化碳捕集、驱油和封存工作领导小组，以加强对这一地区碳捕集、驱油和封存工作的组织领导和协调。领导小组主要职责为研究决定相关重大事项和工作部署；协调解决各参与单位工作中的重大问题；对陕甘宁蒙地区二氧化碳捕集驱油和封存工作进行督促检查。领导小组下设3个承担相应具体工作的工作组，分别为综合与政策研究工作组（领导小组办公室），碳捕集工作组，运输、驱油和封存工作组。

China Petroleum and Chemical Industry Federation, PetroChina Group and Shenhua Group set up a joint CCUS leading group: On April 22, 2014, China Petroleum and Chemical Industry Federation, PetroChina Group and Shenhua Group jointly issued a notice saying they had decided to establish a leading group to strengthen the organization, leadership and coordination of work on CO2 capture, oil displacement and storage in the regions of Shaanxi, Gansu, Ningxia and Inner Mongolia. The main responsibility of the leading group is to review, study, decide related major issues, deploy work, and to coordinate and solve the significant problems in the work of each unit involved. Within the leading group, the 3 sub-working groups set up to undertake specific tasks are (i) the Comprehensive and Policy Research Sub-working Group (Leading Group Office), (ii) the Carbon Capture Sub-working Group and (iii) the Transportation, Oil Displacement and Storage Sub-Working Group.

图片来源：apdnews.com
Source: apdnews.com

中国第十二届全国人大常委会第八次会议通过新修订的环保法：2014年4月28日，环境保护部副部长潘岳昨日表示，新《环保法》加重了行政监管部门的责任，一方面授予对各级政府、环保部门许多新的监管权力，另一方面也规定了对环保部门自身的严厉行政问责措施。新环保法有利于绿色国民经济核算，健全预警机制和问责机制，明确公民知情权和参与权，提高媒体监督的能力。（人民网）

In China the 8th meeting of the 12th session of the Standing Committee of the National People's Congress passed a new revision of the Environment Protection Law: In April 28, 2014, Pan Yue, the deputy minister of the Ministry of Environmental Protection, said the new Environment Protection Law increases the responsibility of the administrative supervision departments. On the one hand, governments and environmental protection administrations at all levels are given many new supervisory powers; on the other, the environmental protection administrations will be subjected to severe administrative accountability. The new Environment Protection Law helps green national economic accounting, improves early warning and accountability mechanisms, clarifies citizen's rights to knowledge and participation, and improves media supervision. (people.com.cn)

图片来源：gaoloumi.com
Source: gaoloumi.com

广东省气象局资料显示珠三角去年灰霾65天创20年最低：2014年4月21日，全国政协人口资源环境委员会调研组来粤，就“重点区域大气污染综合防治”问题进行调研。在省政协召开的座谈会上，省气象局有关负责人表示，多年连续监测数据表明，2007年以前，珠三角灰霾年平均天数逐年增加，到2007年，珠三角的灰霾天气天数达到历史最高的149天，2008年以后，灰霾天数则呈逐年下降趋势，2013年下降到只有65天，为近20年最少的年份，灰霾天气得到明显改善，但要达到西方国家的水平仍需持续努力。（南方日报）

According to the data from the Weather Bureau of Guangdong province, there were 65 days of dust-haze in Pearl River Delta last year, a 20 year low: on April 21, 2014, the investigating group from the

Population Resources and Environment Committee of the National People's Political Consultative Conference arrived to Guangdong Province to research issues on 'comprehensive prevention and control of atmospheric pollution in key areas'. At the symposium held by People's Political Consultative Conference of Guangdong Province, the provincial Weather Bureau officials said that the data from many years' continuous monitoring shows that the annual average number of dust-haze days increased year by year in Pearl River Delta until 2007, when it hits an all-time high of 149 days. After 2008 onward, the number of dust-haze days have declined annually until it reached 65 days, a 20-year low, in 2013. Although the appearance of dust-haze days is clearly improving, the continuous effort is still needed to meet the western countries' levels.

欧盟2030年气候与能源政策框架辩论：如何发展CCS?

What Now for CCS as Europe Debates The 2030 Policy Framework?

Indira Mann
苏格兰碳捕集与封存中心沟通与知识交流主管
Communications and Knowledge Exchange Executive, SCCS

世界媒体满怀期待地在一月份聚集在布鲁塞尔，等待着欧盟委员会发布2030年气候与能源政策框架。直到最后一刻，议员们都还在就怎样最好地解决世界经济面临的最重要的问题进行激烈的辩论。

在接下来的几天里，该框架提议的目标因缺乏让欧洲主导2015年在巴黎举行的联合国气候谈判所需的雄心而遭到炮轰。对于碳捕集与封存技术的支持者来说，最失望的莫过于缺少通过具体且可衡量的里程碑来对气候技术做出的明确承诺。

欧盟委员会提出了一个统一战线和许多温和的举 措，其中包括到2030年将温室气体减排40%的目标，这被认为是对成员国来说最具成本效益的目标，以及将可再生能源在电力市场中所占份额提高至27%的目标。该委员会还曾提议进行排放权交易体制的改制，但到目前为止，也没有从真正意义上履行鼓励脱碳的最初承诺。“雄心勃勃”和“负担得起”曾是其中的流行词。该框架本身曾被树立为提振投资者信心、解决对进口油气的依赖问题以及在欧洲支撑其工业的同时实现气候目标的情况下确保其能源供应的一种方式。据主持新闻发布会的欧盟委员会主席Jose Manuel Barroso称，最后这两个目标并不是互不相容的。

那么，这将使欧洲的碳捕集与封存技术置于何地？欧盟也曾支持过这一技术，欧盟议会起初还呼吁到2015年实现12个示范项目的运行。但到

In January, an expectant gathering of world media in Brussels awaited the unveiling of the Europea Commission’s framework for climate and energy policies from 2030. Feverish debate amongst the commissioners had taken place, up to the last minute, on how best to tackle what are arguably the most critical issues facing the world’s economies.

In the days that followed, the framework’s proposed targets came under fire for lacking the ambition needed if Europe is to lead the way at the United Nations climate talks in Paris in 2015. For the advocates of carbon capture and storage (CCS), the biggest disappointment was a lack of any clear commitment to the climate technology through specific and measurable milestones.

The Commission had presented a united front and a number of modest measures, including a greenhouse gas emission reduction target of 40% by 2030 – considered the most cost-effective for Member States – and a target of 27% of the electricity market for renewable energy. It also proposed a shake-up of the Emission Trading Scheme, which has so far failed to deliver on its original promise of incentivising decarbonisation in any real sense. The buzzwords were “ambitious” and “affordable”. The framework itself was promoted as a means of boosting investor confidence, tackling a dependency on oil and gas imports and ensuring energy supply for a Europe that must support its industries while meeting its climate targets. According to Jose Manuel Barroso, the Commission’s President, who led the press conference, these last two goals were not mutually exclusive.

So where does this leave CCS in Europe? The technology was once championed by the EU, and the European Council originally called for 12 demonstration projects to be operating by 2015. To date, not one has been delivered. And despite some encouraging developments – such as progress on securing funding for the design of two full-scale

目前为止，一个项目都没有交付。虽然出现了一些鼓舞人心的进展——比如英国的两个全规模示范项目的设计在获得资助方面的进展，但是，目前欧洲在碳捕集与封存技术的发展上落后于北美。

二月，在布鲁塞尔举行的普拉茨第八届欧洲碳捕集与封存年度会议的首日会议上，全球碳捕集与封存研究院在众多与会代表面前发布了其一年一度的碳捕集与封存进展现状报告。其中的数据显示，2011年以来，全世界在建或已实现运行的碳捕集与封存项目的数量增长了50%。然而，在美国、加拿大和中东都计划在这一技术领域开辟道路的同时，统计数据显示欧洲在此方面出现了明显放缓趋势， 4个大型项目被取消或搁置。

全球碳捕集与封存研究院的首席执行官Brad Page呼吁“各国对碳捕集与封存技术的资金分配应给予更紧迫的政策支持，尤其是在不确定的经济环境下需要更灵活的融资和政策安排的欧洲”。

这一观点与我们苏格兰碳捕集与封存中心自己的现状分析相似，而且，在普拉茨会议召开的同一周，我们发表了直接针对欧洲委员会决策者的关于欧盟2030年框架的政策简报。该报告遵循了我们在2013年十一月发布的《为欧洲探索北海二氧化碳封存潜力：未来五年的实际行动》报告的思路，指出政策机制和实际行动可以重建欧洲碳捕集与封存技术的发展势头。我们在该报告中勾勒的五年计划（见图1）强调了碳捕集与封存商业化规模发展道路上的关键要素，主要将北海海

demonstration projects in the UK – Europe has now fallen behind North America and China in making progress on CCS.

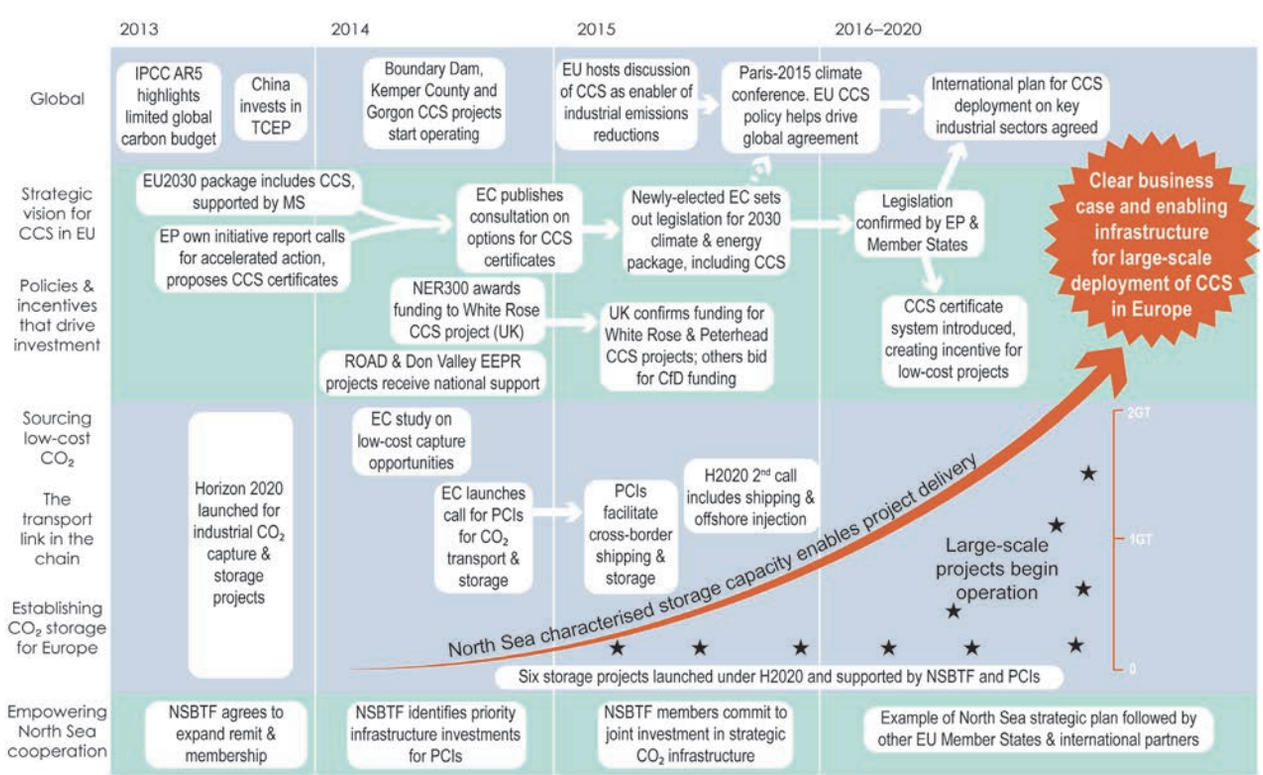
As delegates gathered in Brussels in February for the first day of the Platts 8th annual European Carbon Capture and Storage conference, the Global CCS Institute (GCCSI) published its annual status report on CCS progress. The figures showed a 50% increase since 2011 in CCS projects under construction or already operating worldwide. However, it is initiatives in the USA, Canada and the Middle East that are blazing a trail, while the statistics show a marked slowdown in Europe, where four large-scale projects have been cancelled or put on hold.

Brad Page, GCCSI’s CEO, called for “urgent policy support for funding allocations for CCS technologies, particularly in Europe, where more flexible funding and policy arrangements are needed in an uncertain economic climate”.

This view echoes our own analysis of the situation at Scottish Carbon Capture & Storage (SCCS) and, in the same week as the Platts conference, we published a policy briefing on the EU2030 framework, aimed squarely at decision-makers within the European Council. The paper follows the thread from our November 2013 report, Unlocking North Sea CO2 Storage for Europe: Practical actions for the next five

图1：五年计划图

Figure 1: Caption For Five-year Framework Graphic



底的地质封存点作为封存欧洲碳排放的主要地点。我们在二月提出的建议中继续呼吁用战略性眼光看待碳捕集与封存技术，将该技术整合到2030年框架中就是一个明显的步骤，同时还要制定政策和鼓励措施鼓励对这一技术的投资。

在2014年期间，欧盟委员会将着手对关于二氧化碳地质封存的《欧盟碳捕集与封存指令》进行审查，该指令2009年就已生效。作为该流程的一部分，欧洲委员会可能且应该再列入三个更深一层的要素。关于2030年欧盟国家需要达到的可再生能源目标的提案中可以补充包含实际、可量化的碳捕集与封存里程碑的内容，这将让欧盟能推动其在碳捕集、运输和封存上向前取得进展。在提议的新的管理结构中，成员国将根据国家计划自由决定是否实施推广碳捕集与封存技术。

第二个要素将是确定融资工具，以支持工业及发电行业的碳捕集与封存项目，并支持成员国的政策。最后，存在甚至可在2030年之前“快速制胜”的方法，这包括利用二氧化碳提高石油采收率的潜力，此方法还有助于评估封存点并发展基础设施。欧盟范围内也有可提供必要支持的机制，比如共同利益项目和地平线2020融资计划。

欧盟自2008年采用其最早的气候与能源政策一揽子计划以来，取得了一些进步。例如，欧盟认为其在完成2020年温室气体减排和可再生能源目标方面已步入正轨。能效提升方面也取得重大进展。但在2014年初，欧盟议会议员在一次会议上通过了Chris Davies议员提出的一项报告，其中总结道，“欧盟正失去其在碳捕集与封存领域的技术领导地位，目前也没有能推动碳捕集与封存旗舰项目发展的有效政策。”

在二月召开的普拉茨会议中，Davies向代表们说道，尽管该报告不具备法律约束性，他认为议员们对他的报告所投的多数赞成票是“支持碳捕集与封存技术的宣言”，这也让该报告具有“一定的政治意义”。但是，他警告说：“现实反映出全球的能源需求正逐年增长，到2035年，全世界四分之三以上的能源仍将来源于化石燃料，且煤炭很有可能将维持目前的重要地位。”

国际能源署在2012年指出，若要将全球平均气温增幅维持在两摄氏度以内，2050年之前要消耗将近三分之一的化石燃料探明储量，除非大范围地推广碳捕集与封存技术。Davies告诉代表们：“如果真正承诺在2050年之前将欧洲的碳排放量减少80%以上，碳捕集与封存技术必须成为其解决方案的重要组成部分。”随着2015年巴黎联合国气候变化框架公约谈判的不断临近，显然需要更多的辩论以及最终的政策制定来确保上述情景的实现。

years, which identified policy mechanisms and practical actions that could rebuild momentum for CCS in the EU. Our five-year framework (see **Figure 1**) from that report highlights key elements on a pathway to commercial-scale CCS, focusing on geological storage sites beneath the North Sea as the prime location for Europe's CO2 emissions. The recommendations we set out in February continue to call for a strategic vision for CCS – integrating the technology into the 2030 framework being an obvious move – alongside policies and incentives to encourage investment in CCS.

During 2014, the Commission will also undertake a review of the EU CCS Directive on the geological storage on CO2, which came into force in 2009. As part of that process, the European Council could – and should – include three further elements. The proposal for an EU-wide renewables target for 2030 could be complemented by the inclusion of practical and quantifiable milestones for CCS, which will allow the EU to drive forward progress made in capturing, transporting and storing CO2. As part of a proposed new governance structure, Member States would be free to decide whether to deploy CCS under national plans.

A second element would be the identification of funding instruments to support CCS projects on industry and electricity generation, in support of Member State policies. Finally, there are “quick wins” out there, even before 2030, including the potential for enhanced oil recovery with CO2 to help evaluate storage sites and develop infrastructure. Mechanisms exist within the EU, such as Projects of Common Interest and the Horizon 2020 funding programme, which could provide the necessary support.

The EU has made some progress since it adopted its first package of climate and energy measures in 2008. For example, it believes it is well on track to meet 2020 targets for greenhouse gas emissions reduction and renewable energy. Significant strides have also been made in energy efficiency. But in early 2014, a gathering of MEPs agreed a report by fellow MEP, Chris Davies, which concluded that “the EU is losing its technological lead in CCS and … now has no effective policy to promote development of CCS flagship projects”.

Davies addressed delegates at the Platts conference in February, where he acknowledged that the MEPs' majority vote in favour of his report was a “declaration of support for CCS” that lent it “a certain legitimacy”. But he warned: “Reality recognises that global energy

欧洲及世界在2020年之前实现商业化规模碳捕集与封存的关键要素，苏格兰碳捕集与封存中心2013年十一月的报告《为欧洲探索北海二氧化碳封存潜力》中有所阐述。

下载地址 **www.sccs.org.uk/unlocking-north-sea**

苏格兰碳捕集与封存中心是英国地质调查所、赫瑞瓦特大学、亚伯丁大学以及爱丁堡大学的研究合作伙伴，也是英国最大的碳捕集与封存研究组织。

demand increases year by year, that by 2035 more than three quarters of all the world's energy is still going to be coming from fossil fuels, and that coal is likely still to be playing a part as big as today."
The International Energy Agency pointed out in 2012 that, to contain a global average temperature increase to 2C°, less than one third of proven reserves of fossil fuels can be burned prior to 2050 unless CCS is widely deployed. Davies told his audience: "If a genuine commitment exists to reduce Europe's CO2 emissions by more than 80% by 2050 … CCS must play a part in providing the solution." As the world counts down to the UNFCCC talks in Paris in 2015, it is clear that much more debate and, ultimately, decision-making is required to ensure that it does.

Key elements on a pathway to commercial-scale CCS in Europe and worldwide by 2020, identified in the SCCS report, Unlocking North Sea CO2 Storage for Europe, November 2013.

Download at **www.sccs.org.uk/unlocking-north-sea**

SCCS is a research partnership of British Geological Survey (BGS), Heriot-Watt University, University of Aberdeen and the University of Edinburgh. It is the largest carbon capture and storage research group in the UK.

中国碳市场能否激励长期的碳减排投资

Will China's carbon market signal long term emission reduction investment?

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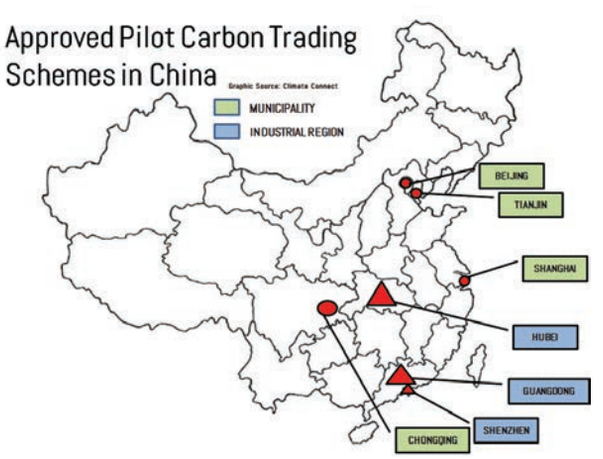
作为世界头号能源消费大国，中国在2012年的碳排放量占全球总量的28%（超过90亿吨）。全世界80%以上的碳排放增长来自中国。为削减温室气体排放和降低全球气候变化的风险，中国实现碳减排至关重要。

2011年3月，中国政府在其发布的最重要国家文件——“十二五计划”中正式提出碳排放交易机制。同年10月，国家发展和改革委员会授权7个城市开始进行试点相关交易。中国强有力的政策和财政支持确保了国内的一个中试项目从理论到实践的快速过渡：去年，中国排放交易所成功地在深圳、上海和广州等城市成立了分支机构。预计“十三五计划”中将建立一个全国性排放交易体制，这将成为全世界最大的碳交易市场，未来的碳减排需求量将超过60亿吨。



As the world's leading energy consumer, in 2012 China accounted for 28% - over 9 billion tons - of total global carbon dioxide emissions. More than 80% of the world's increase in carbon emissions was from China. To help mitigate Greenhouse Gases and curb global warming, China has revealed its ambitions in carbon emission reduction.

In March 2011, China officially put an Emission Trading Scheme (ETS) in the Twelfth Five-Year Plan, which is the most important national document released by the Chinese Central Government. In October of the same year seven pilot cities were authorised to commence trading by the National Development Reform Commission (NDRC). Strong policy and financial support ensures the rapid transition of a pilot project in China from theory to practice: last year China Emission Exchanges in Shenzhen, Shanghai, and Guangzhou etc. were launched successively. It is expected that a national emission exchange will be formed in the Thirteenth Five-Year Plan, which could be the largest carbon trading market in the world with a demand for more than 6 billion tons emission reductions in the future.

ETS is a crucial financial incentive scheme to encourage emission reductions, mitigate global warming, and tackle climate change. Within the ETS, enterprises may trade-off investing in technical transformation with purchasing emission permits from the carbon trading market, according to their own carbon abatement costs. When the carbon emission allowances allocated by government are insufficient, enterprises will seek to adopt advanced abatement technologies to mitigate emissions or buy extra permits from the carbon trading market. Compared to the reduction of emissions through previous governmental administrative and financial measures, optimal emission reduction patterns can be guided by the carbon price signal, and the efficiency of investment by private capital invested in low carbon projects can be improved. Therefore ETS significantly enhances the initiative of enterprises to reduce emissions through their direct

排放交易体制是鼓励碳减排、缓解全球变暖趋势以及解决气候变化问题的一项关键性激励机制。企业在排放交易体制下可以根据它们自身的碳减排成本通过从碳交易市场上购买排放配额来权衡对技术改造的投资。当政府分配的碳排放配额不够时，企业将设法采用先进的减排技术以削减排放或从碳交易市场购买额外的排放配额。与通过前期的政府行政及金融措施来实现减排相比，最佳的减排模式可由碳价信号来引导，这样低碳项目中的私人资本投资效率也会得到提高。因此，排放交易体制通过直接影响生产成本以及从出售额外的排放配额中获得额外收益大大地增强了企业减排的主动性。

另外，在碳排放交易机制下，那些排放量高于行业平均值的企业会将他们的收益转移到排放量较少的企业。这样一来将会优化同一行业竞争性企业的结构。即使在不同的行业之间，也可通过调整利益来实现结构优化。再者，碳市场不仅是刺激能源密集型行业实现大规模节能减排以及鼓励企业选择成本效益好的减排机制的有效途径，还是促进碳捕集与封存等碳减排技术的实施以及建立节能环保工业发展模型的良好机会。

不过，碳排放配额价格是碳市场中推动碳减排活动的关键指标。欧盟排放交易体制下的碳价暴跌，从将近30欧元迅速地下降到3欧元，削弱了依靠碳市场达到减排目标的信心。这甚至被看作是“告诉世界其他各国碳排放交易和基于市场的解决方案都不是应对气候变化的方法的信号”。然而，碳排放配额的过量发放是导致欧盟排放交易机制危机的主要原因之一。怎样分配合适的排放配额并避免出现导致欧盟排放交易机制下碳价暴跌的情景，将是中国碳市场在发展初期面临的最重要的问题。

碳排放交易机制通常采用“限额与交易”的原则，也就是说，排放配额由政府控制并会随着时间逐渐减少，这样总排放量就会下降。但是，在中国的部分碳市场，排放配额与国内生产总值（GDP）挂钩，而GDP又与产量等因素高度相关。这可能会导致未来碳市场供给和需求的不确定性，因为中国排放交易机制的限制在交易的过程中会得到调整。这些不确定性反过来又会影响碳价和企业作出低碳投资的积极性。

另一重大挑战将是不同的碳减排激励机制的结合。排放交易机制、碳税、可再生能源义务以及排放绩效标准等多种节能减排激励机制可能会有冲突并在不同的情况下产生不同的边际减排成本和收益。中国政府过去推出了大量促进节能减排的政策和机制（如可再生能源目标，节能目标，电价改革，燃油税，控制煤炭总量等措施）。这些政策与机制的变化往往能够实现更多的碳减排，但与此同时会对碳排放权价格造成压力，从而误

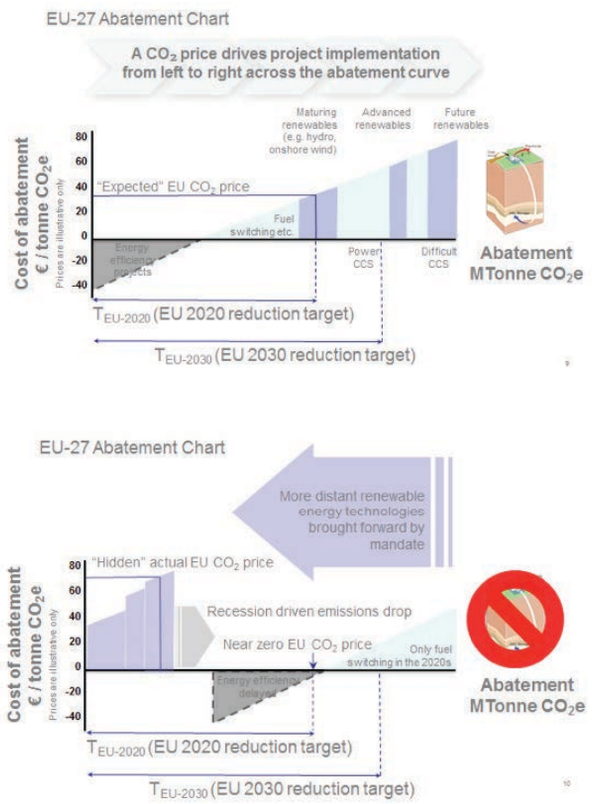
impact on the production cost, and additional profits that can be generated from selling extra permits.

In addition, through carbon emission trading, enterprises with emissions higher than the mean in their industry will transfer their profits to those with lower emissions. This will have the effect of optimizing the structure of competitive enterprises in the same industry. Even between different industries, structural optimization could be realized through adjusting benefits. What's more, the carbon market is not only an efficient pathway to motivate huge energy savings and emission reductions in energy intensive industries, and to encourage enterprises to select cost-effective abatement mechanisms, but also an opportunity for promoting the implementation of carbon abatement technologies, such as Carbon Capture and Storage (CCS), and simulating the development of energy conservation and environmental protection industries.

Nevertheless, the carbon price is the critical indicator in the carbon market to drive carbon abatement activities. Carbon prices collapsed in the EU ETS, dramatically dropping from approximately 30 to 3 Euros, weakening the confidence in carbon markets to achieve emission reductions. This has even been considered as “a signal to the rest of the world that emission trading and market-based solutions are not the solution to climate change”. However, excess allocation of carbon emission permits was one of the main causes of the EU ETS crisis. How to allocate appropriate emission permits and avoid the situation which caused the carbon price collapse in the EU ETS will be the most important issues that the Chinese carbon market will have to confront in the initial stage.

ETS normally applies a 'cap and trade' principle, which means that emission allowances are controlled by government and will be decreased over time so that total emissions will be reduced. However, in the Chinese carbon market, emission allowances are linked to Gross Domestic Product (GDP), and GDP is highly correlated with production. This could cause supply and demand uncertainties in the future carbon market, due to the 'cap' of the ETS in China being adjusted during the trading process. In turn these uncertainties could affect the carbon price and the enthusiasm of enterprises to make low carbon investment.

The other significant challenge will be the coordination of the different incentive schemes for carbon abatement. Multiple energy saving and emission reduction incentives, such as ETS, carbon taxation, renewable energy obligations, emission performance standards



图一：其他低碳激励机制（如可再生能源目标，碳税）和经济萧条促使边际减排曲线右移，碳减排额价格大幅度下降（来源：壳牌集团，2013）

Figure 1: Other Parallel Low-carbon Incentive Mechanisms (such as renewable targets, carbon tax) and economic recession causes the marginal abatement cost to shift to the right, and a significant reduction of the carbon allowance price (Source: Shell, 2013)

导企业在低碳或高碳领域投资的决定。（如图1描述）。

此外，一个稳定并给出强烈减排信号的碳市场的运行需要全面、一致及改进的监管规定和政策环境。一个不明确或不成熟的监测、报告和验证（MRV）系统会影响投资者信心，这样碳市场就会失去其对投资者的吸引力，并由此降低其在大幅削减排放水平方面的效率。

虽然中国的排放交易机制仍处于发展的初期阶段，其将对节能减排起到能力建设作用。尽管欧盟的排放交易机制出现碳价格暴跌，其在第一阶段之后碳市场对碳减排的影响显著，同时经济活动和能源价格都保持增长。不可否认，排放交易机制在激励中国达到其在2020年之前将每单位GDP的碳排放同比2005年减少40%-45%的目标上符合好的成本效益。然而，国家应提供一个明确的碳市场与其它能源政策管理和协调体系，完善对MRV体系的监管，稳定长期的碳价信号，以刺激有效的和长期的碳减排投资。

etc., may be conflicting, and generate different marginal abatement costs and benefits under different situations. The Chinese government has developed many policies and schemes (such as renewable energy targets, energy-saving targets, electricity price reform, fuel tax, control of total quantity of the coal) to promote energy conservation and emission reduction in the past. The change in these policies and schemes always leads to greater carbon emission reduction, but at the same time will also put pressure on the price of carbon emission credits, which will eventually mislead enterprises' investment decision on low carbon or high carbon field (described in **figure 1**).

Furthermore, a stable carbon market with a strong signal for emission reduction could not operate without comprehensive, consistent and improved regulations. An unclear or immature monitoring, reporting and verification (MRV) system would influence investor confidence, such that the carbon market would lose its attraction for investors thereby being less effective in achieving drastic cuts in emission levels.

In conclusion, though the Chinese ETS is still in the initial phase it is expected to be effective in capacity building of energy conservation and emission reduction. Despite the carbon price slump, the EU ETS had a significant effect on carbon emission reductions after Phase I, while economic activity and energy prices kept increasing. It's undeniable that ETS is a cost-effective incentive mechanism for China to achieve its target of reducing CO2 emissions per unit of GDP by 40 to 45 percent by 2020 from the 2005 levels. However, a clear and long term carbon market and other management and coordination system of energy policies should be provided with better MRV system regulation and stable and long term carbon price signal to strongly incentive efficient and long term emission reduction investment.

透视欧盟最新公布的2030气候与能源政策目标

Insight into the European 2030 Climate and Energy Policy Framework

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欧盟委员会在2014年1月22日公布了2030年气候与能源政策目标白皮书草案（后简称‘白皮书’），该草案可能会对中美未来应对气候变化和能源政策产生重要影响。该草案规定欧盟成员国在2030年之前将温室气体排放量削减到比1990年水平减少40%，设立可再生能源在欧盟能源结构中所占比例不低于27%的目标，以及改革欧盟碳排放权交易市场。该白皮书的总体思路是‘在维持欧盟低碳技术应用的领导地位，充分考虑产业的竞争力和推动市场化改革’。尽管该白皮书建议了可再生能源的总体目标，但不再要求成员国制定可再生能源目标，提出在推动气候变化工作时考虑工业和消费者的承受能力和竞争力因素，也体现出了以市场为主体来实现能源和气候目标的精神。

另一方面，在白皮书退出前1周，欧盟议会全体会议于2014年1月14日在斯特拉斯堡表决通过了《2013年欧洲推广应用碳捕集与封存技术执行报告》[1]。该报告向欧盟委员会及成员国传达了明确的信息：欧盟议会的议员希望看到碳捕集与封

[1] 其中赞成票524张，反对票141张，弃权票25张

On 22 Jan 2014, the European Commission announced the draft of the 2030 Climate and Energy Policy Framework White Paper (called ‘White Paper’), which might have a substantial impact on US and Chinese climate and energy policy. The draft White Paper suggests an EU level target of 40% greenhouse gas reduction from 1990 to 2030, a EU level renewable energy goal of 27%, and reform of the EU ETS scheme. The overall theme of the White Paper is to ‘fully consider industry competitiveness and promote market base reform, while maintaining the leadership of European low-carbon technology application’. Although the White Paper suggested an overall renewable energy target, it doesn’t require member states to set individual renewable targets (or obligations), and highlights the importance of industry competiveness and consumer affordability in promoting climate change mitigation activities, as well as the market based philosophy to achieve energy and climate change goals.

1 week before this announcement, the European Parliament’s plenary session in Strasbourg passed the ‘implementation report 2013: developing and applying carbon capture and storage technology in Europe’ with a vote of 524 to 141 with 25 abstentions. The report delivered a clear message to member states: European Parliament members are willing to see the development of CCS technologies in Europe and provide overall guidance and suggestions for developing CCS.

The European Commission announced the 2020 to 2030 Energy and Climate Change Policy Framework White Paper on 22 Jan 2014. The White Paper highlights the importance of maintaining ‘economic development’ and ‘international competitiveness of energy prices’ in promoting energy and climate policy. At the same time, the paper recommends market based mechanisms (such as the carbon market) to promote low carbon technologies, including renew-

存技术（CCS）在欧洲发展起来，给出发展CCS的总体指导方针和具体建议。

欧盟委员会在2014年1月22日公布了2020至2030年能源与气候变化的政策框架的白皮书。白皮书强调了在推动能源和气候政策要兼顾‘经济发展’和‘能源价格的国际竞争力’，同时倾向于采用市场化的手段（如碳市场）去推动包括可再生能源在内的低碳技术。该白皮书将会在2014年3月的欧盟峰会上讨论，并在2014年夏季在欧盟新一届的立法会上进行讨论。白皮书究竟为欧盟气候政策与能源系统带来什么影响？中国应该如何应对?

尽管白皮书还需要欧盟立法会通过，然后由成员国立法，但预计白皮书的主要内容已经经过成员国代表充分讨论不会有大的改变。白皮书包括七点内容，其相关影响如下所述。

able technologies. The draft paper was debated heatedly in the March 2014 European Council Meeting, and will be discussed in the new parliament in summer 2014. How does the White Paper affect the European Climate and Energy System, and how may China respond?

Although the White Paper still needs to pass the legislative process in the European Parliament, as well as in each member state, as most of the contents of the draft paper have been fully discussed by representatives of the member states, the parliamentary debate may not lead to significant change. The Draft White Paper sets out the following seven proposals, and their impacts are described below.

The White Paper sets a 40% absolute emission reduction target at the European level. The absolute greenhouse gas emissions in 2030 should be 40% lower than the level in 1990. The target is a compromise after

图表1：欧盟能源与气候变化2030年政策目标组合影响分析结果
Table 1: Impact Assessment Results of European Energy and Climate 2030 Policy Portfolios

	基准情境 Baseline Scenario	温室气体减排37% 37% Greenhouse Gas Reduction	温室气体减排40% 40% Greenhouse Gas Reduction	温室气体减排40%/节能目标 40% Greenhouse Gas Reduction / Energy Conservation Goal	温室气体减排40%/可再生能源30%目标 40% Greenhouse Gas Reduction / 30% Renewable Energy Goal	温室气体减排45%/节能目标/可再生能源30%目标 40% Greenhouse Gas Reduction / Energy Conservation Goal / 30% Renewable Energy Goal
温室气体比1990年水平减排 Carbon Reduction	-32.4%	-37%	-40.6%	-40.3%	-40.7%	-45.1%
可再生能源比例 Renewable Energy %	24.4%	24.7%	26.5%	26.4%	30.3%	35.4%
节能量 Energy Conservation %	-21%	-22.9%	-25.1%	-29.3%	-30.1%	-33.7%
减排污染物和健康影响的成本（亿欧元每年） Pollution Reduction and Relevant Health Impact Cost (billion Euro per year)		42-88	72-135	174-348	167-332	219-415
总额外成本占GDP的比例 Total extra cost as a % of GDP	0%	0.13%	0.15%	0.54%	0.54%	0.84%
平均电价（欧元/兆瓦时） Average Electricity Price (Euro/MWh)	176	176	179	174	178	196
碳排放权价格（欧元/每吨二氧化碳） Expected Carbon Allowance Price (Euro/tCO2)	35	35	40	22	11	14

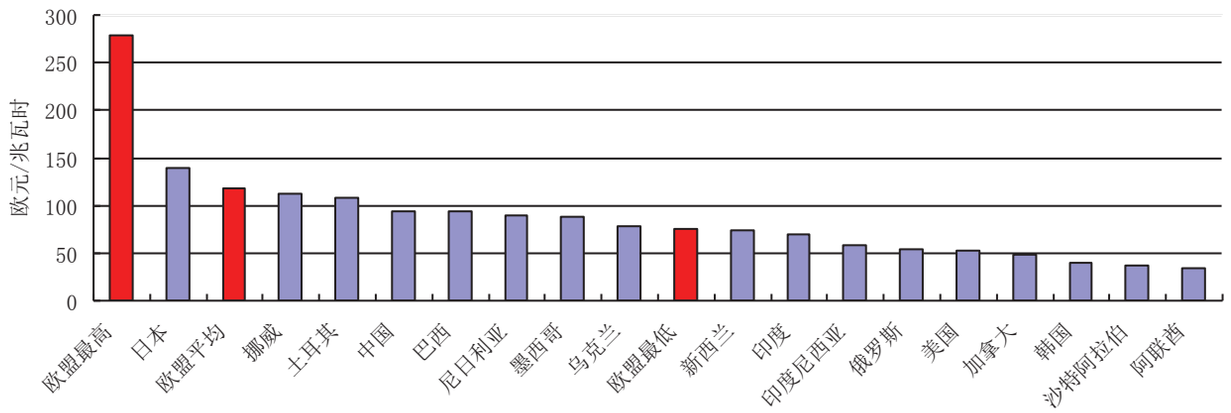

图1：2012年工业用户零售电价比较

白皮书设立了欧盟范围内40%减排的总目标。2030年温室气体排放绝对量比1990年的水平降低40%，此目标是欧盟各成员国经过激烈辩论后的妥协方案。欧盟委员会同时表示，在国际气候谈判达成协议之前，无意提出较高的，有条件的减排目标。该目标发布后，大量的环保非牟利组织（如绿色和平，地球之友）批评该方案不足以减缓危险的气候变化。

尽管目前欧盟成员国需要执行2020年20%的强制性可再生能源目标，新的白皮书建议不设立国家水平的强制可再生能源目标。该白皮书设定2030可再生能源目标在27%水平，低于此前30%的预期，同时欧盟委员会建议取消要求成员国立法制定可再生能源目标，而是采取市场化手段（如图1欧盟碳交易机制在没有可再生能源立法目标的情况下，会实现较高的碳价格）来促进可再生能源发展。取消成员国强制目标将降低可再生能源总体的开发成本，但不会促进成员国加速推进可再生能源，总体上对欧盟推广可再生能源不利。

白皮书没有提及‘节能目标’。有别于欧盟委员会在2007年设立的2020年‘三位一体’的目标（简称‘202020’，包括到2020年实现比1990年20%的碳减排，可再生能源份额达到20%，能源利用效率提高20%），欧盟委员会没有设立2030年能源利用效率能源目标，相信是寄望市场机制能够促进减排。

改革碳排放权交易制度与建立欧盟国内一体化的市场环境成为条件碳减排政策的重点。欧盟委员会建议在欧盟碳排放权第四阶段（2021年后）引入配额预留机制，根据预先设定的机制，自动调节配额的拍卖量，从而稳定市场价格。预计欧盟的碳交易机制在2021年可能会重新回到30欧元每吨的水平。欧盟委员会建议碳市场作为成熟低碳技术的主要激励方式。该白皮书还建议欧盟成员国在2020年取消国家补贴（称为‘State

very heated debate by member states. The European Commission also indicated that, prior to reaching an international climate agreement, it is unlikely to suggest a higher, conditional emission reduction target. The target, after the announcement, received substantial criticism from not for profit institutes (such as Greenpeace, Friend of the Earth) indicating that the target is insufficient to mitigate the effects of dangerous climate change.

Although the current EU Member States are required to implement a mandatory 20% renewable energy goal by 2020, the White Paper doesn't suggest establishing mandatory goals at the member state level. The White paper sets the 2030 EU renewable level at 27%, lower than the 30% expected earlier. At the same time, the European Commission suggested eliminating the need for member states to formulate legally binding renewable energy goals and instead to adopt market based measures to promote renewable energy development (e.g. the Table 1 above shows a high carbon allowance price is likely to occur in the absence of mandatory renewable targets at the member state level). Eliminating mandatory targets could potentially reduce the overall development cost of renewable energy in Europe, but it would not accelerate the promotion of renewable technologies, and overall it is disadvantageous to renewables development in EU.

Unlike the European Commission '202020' target set in 2007 (i.e. 20% carbon reduction from 1990 to 2020, 20% renewable energy by 2020, 20% higher energy efficiency), the European Commission doesn't set a 2030 energy efficiency target, hoping that a market based mechanism will achieve emission reductions.

The reform of the Emission Trading Scheme (EU ETS) and establishing a European level market based

Aid’），一方面建议取消所有对成熟能源技术的补贴（包括可再生能源技术），另一方面减少能源税收的干预。

能源价格的竞争力成为讨论的焦点。欧盟委员会意识到最近一段时间，欧盟与主要经济体的能源价格差距正在迅速扩大。特别在美国大规模应用页岩气后，欧盟工业用电平均价格比美国高两倍以上（如图1所示）。尽管与中国和韩国的价格差异没有明显扩大，但能源价格较高的劣势仍然非常明显。尽管公众与利益攸关者对开采页岩气安全和环保影响监管政策的争论非常激烈，白皮书内没有为页岩气开采增加监管的障碍，有利于页岩气的开发。

该草案放弃了燃料质量指令。欧盟委员会放弃了2020年后对进口和国内运输燃料温室气体需要减排6%的目标，这相当于结束了‘燃料质量指令’。废除这项指令对高碳排放燃料来源有利，如从油沙生产的高碳排放燃料。

欧盟作为中国主要贸易和投资伙伴，低碳技术和产业发展的火车头，欧盟能源与气候变化政策，与中国制造业息息相关，中国在欧盟的可再生能源投资项目数量已经超过40个，而欧盟是中国太阳能光伏出口的重要市场。中国企业应该如何部署欧盟的政策方案？本文提出五点粗浅的建议。

一是加强与欧盟气候总署与能源总署沟通，及时掌握未来欧盟对可再生能源，核电和CCS等低碳技术的激励措施，把握能源和碳市场改革的方向。可以通过国内高校和研究机构，通过中欧合作（如最近推出的‘水平线2020项目’），建立紧密联系。

二是善用中国制造业优势，积极与欧盟内企业进行投资和经贸合作，迅速推动低碳技术的成本下降，在中国国内限制新上可再生能源有关落后的制造项目及淘汰现有可再生能源落后产能。白皮书的推出已经打击欧盟的可再生能源产业，部分大能源公司已经在重新评估正在开发的项目。目前正在开发的可再生能源项目重新分布，海上风电等较昂贵的技术可能不会被优先发展。

三是积极推动和维护市场化手段从而实现中国能源与气候目标，审慎推出非市场化减排手段，保持和提高国内低碳产业的竞争力。吸取欧盟能源与气候变化政策协调得经验，慎重考虑制定强制性的能源发展目标，慎重推出碳税与节能交易等措施。

四是重视新技术创新，研究及开发新一代技术（包括可再生能源的技术），和鼓励企业进行以掌握技术为动机的收购及投资活动，促进企业

environment is an important part of the climate policy framework. The European Commission suggests introducing an allowance reserve mechanism (from 2021), similar to an earlier mechanism, automatically adjusting the volume of allowances auctioned, to stabilize the market price. The EU ETS price is expected to return to 30 euro/tCO2 level before 2021. The European Commission suggests that the EU ETS will be the primary incentive scheme for mature low-carbon technologies. The White Paper also recommends European member states cancel both ‘state aid’ in 2020, and all subsidies for mature energy technologies (incl. mature renewable energy technologies), as well as less interference with energy taxes.

Energy price competitiveness is central to the debate. The European Commission realized recently that energy price differences between European member states and other major economies are increasing. In particular, since the US started large-scale extraction of shale gas, the European industry electricity price has become about twice that of the US. Although when compared to China and Korea the gap has not increased, the energy price disadvantage is still quite significant. Although the public and key stakeholders have heated debates on the safety of mining shale gas and environment impact regulations, the White Paper doesn’t specify additional regulatory barriers for developing shale gas resources in Europe.

The draft White Paper abandons the Fuel Directive. The European Commission gives the 6% greenhouse gas abatement target for imported and domestic transport fuel after 2020. Abandoning the target will benefit high carbon footprint fuel, such as hydrocarbons produced from tar sands.

The European Union is a primary trade and investment partner of China, and a locomotive of low-carbon technology and industrial development. European energy and climate policy has quite a high impact on the Chinese manufacturing industry, and China has made more than 40 investments in renewable projects, while Europe is the largest export market for Chinese Solar PV equipment. How should Chinese industries respond to the European Energy and Climate Policy Framework? The following are five preliminary suggestions.

First of all, it is important to communicate with the European Climate DG and Energy DG, to understand the latest incentive policy measures for renewable, nuclear and CCS technologies, and to understand the direction of the energy and carbon market reform. Close links should be established through academic

在成本，技术安全型和可靠性具备国际竞争力。按照目前欧盟委员会的思路，未来低碳技术的发展中成本将作为主要因素。成本较低的可再生能源技术会优先得到应用。

五是把握发展脱碳技术的先机和治理国内大气污染物的实质需求，联合国内外先进技术供应商，示范近零排放技术降低成本。欧盟议会大比数对碳捕集与封存技术发展表示支持，但该法案不具备法律效力。鉴于化石燃料企业对政府的影响力仍然很大，最近欧盟成员国陆续有新建的煤电厂，在碳市场恢复运作后，会刺激脱碳技术的推广。

and research institute collaborations, or through Sino-Europe collaboration (such as participating in the Horizon 2020 project).

Second, Chinese industry should focus on collaborating with European industries to achieve rapid cost reduction. The White Paper will adversely affect the renewable industry in Europe, and many large energy utilities have re-assessed the viability of emerging renewable projects (such as offshore wind). A redistribution of renewable projects would prioritise low-cost mature renewable technologies, and disadvantage emerging and high cost renewable technologies, such as offshore wind projects.

Third, national and local governments in China may consider promoting and maintaining the role of the market to achieve Chinese clean energy and climate goals, and should be cautious in promoting non-market based carbon reduction mechanisms, to maintain and promote domestic low-carbon industrial competiveness. China may learn lessons from Europe, being cautious in formulating mandatory renewable development targets, carbon taxes, or other energy efficiency trading measures.

Fourth, China should highlight the importance of innovation, applying innovative technologies to achieve cost reduction. Cost will be a primary issue in future low-carbon technology development, and lower cost renewable or other low carbon technologies will be applied in priority.

Fifth, China should build on domestic demand in reducing air pollution, developing low-carbon and decarbonisation technologies, and demonstrating and lowering the cost of near zero emission technologies. A majority of Members of the European parliament (MEPs) in January 2014 voted for developing CCS technologies. The measures to improve the carbon market, if implemented, may trigger the deployment of CCS technologies.

CCUS给产业发展带来的机会（下）：示范二氧化碳海底封存带动海洋经济发展

Industrial Opportunities for Developing CCUS Technologies (Part Two): Demonstrating CO2 Offshore Storage to Promote Marine Economic Development in China

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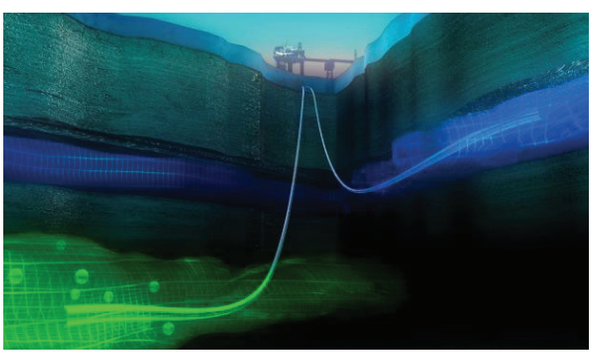

英国能源技术研究院的研究表明，如果英国能源系统不采用CCS 技术，英国实现2050年的低碳目标将需要每年增加300 至400 亿英镑的成本（相等于英国GDP的1%）。2014 年2 月24 日，英国能源与气候变化部与壳牌公司签订协议，由政府出资支持壳牌牵头的CCS 示范项目团队，对位于苏格兰的南苏格兰电力公司彼得黑德燃气电厂进行二氧化碳捕集与封存项目的前端工程设计。而在两个月前，英国政府与阿尔斯通公司牵头的CCS项目团队达成另一个协议，由政府出资支持其位于英格兰北部约克郡的富氧燃烧百万吨捕集CCS 项目往前推进。值得注意的是，英国政府支持推进的这两个百万吨示范项目都计划使用管道运输二氧化碳到北海，注入到海底枯竭气田或咸水层进行封存。

尽管CO2海底地质封存相对陆上地质封存不仅昂贵而且技术难度更高，英国的大型CCS 示范项目仍然采用海底封存，这有三个重要原因：一是英国缺乏合适的陆上封存地点，通过CCS实现

Research from the UK Energy Technology Institute (ETI) indicates that, in the absence of CCS technologies, the cost of decarbonising the energy system in the UK will increase by 300 to 400 billion pound (equivalent to 1% of GDP in the UK). On 24 Feb 2014, the UK Department of Energy and Climate Change and the Shell Group signed an agreement to start the FEED (front end engineering design) study for a CCS demonstration project team led by Shell based on the Peterhead Gas Power Plant, owned by the Scottish Southern Electricity (SSE). Two months ago, the UK government and Alstom signed another agreement to start the FEED study for the million tonne White Rose Oxyfuel CCS project. Noticeably, both projects use offshore pipelines to transport CO2to the North Sea, and inject it into depleted gas fields or saline aquifers for geological storage.

Although CO2 offshore geological storage is more expensive than onshore, and the technology is more challenging, both large-scale CCS demonstration projects adopt offshore geological storage, for the following three key reasons: (1) the UK lacks suitable onshore storage sites, and CCS with offshore storage is therefore essential for decarbonising fossil fuel; (2) offshore storage of CO2 has a lower environmental safety risk, and is therefore more easily accepted by the public; (3) demonstrating offshore storage of CO2 helps consolidate the UK energy industry. According to the recent estimate by the CCS association and the TUC company, promoting CCS would create 15000 to 30000 job opportunities each year, thereby achieving 2 billion to 4 billion sterling economic benefit. Developing CO2 storage technology capacity and training experts could lead to the UK developing a CO2 storage hub in the North Sea, to provide CO2 storage and sequestration for large-scale emission sources in North West Europe.

The development of offshore CO2 storage is taking place internationally. Currently, most of large-scale

大幅度二氧化碳减排必然需要海底地质封存。二是海底封存二氧化碳环境风险较小，公众较容易接受；而欧洲在过去十年推动CCS 技术示范和应用的主要障碍是公众反对陆上封存项目。三是进行海上封存技术的示范有利于巩固英国强大的能源产业；根据CCS协会和TUC公司最近的预计，推动CCS会为英国创造每年15000 至30000 个就业职位，以及每年20 至40 亿英镑的经济效益。发展二氧化碳封存技术能力和培养人才，促使英国未来有能力通过北海作为CO2 封存枢纽（图1）为西北欧的大型排放源提供运输和封存服务。

图1：英国北海中北部地区二氧化碳封存2050 年规划

英国的情况在国际上有一定代表性。目前欧盟内新规划的大型CCUS 示范项目大部分采用海底地质封存，挪威和澳大利亚都开展了大型二氧化碳海底地质封存示范项目（见表1）。在亚洲，韩国有两个大型海底地质封存示范项目项目处于评估和初步确认阶段，而韩国和日本企业对海底二氧化碳运输与封存技术进行了积极的部署，日本CCS 公司计划在2016 年在北海道Tomakomai 地区进行二氧化碳封存注入项目。

根据目前二氧化碳运输与封存的供应链模式（表2），二氧化碳海底地质封存会为项目开发企业（包括石油与天然气公司、专门的封存公司、电

CCUS demonstration projects in the EU plan to store CO2 in offshore geological formations, and Norway and Australia have also started developing large-scale CO2 storage offshore. In Asia, Korea has two large-scale offshore geological storage projects at the evaluation and identification stage, and Korean and Japanese companies are also actively planning for offshore CO2 storage related technology development. A Japanese CCS company is planning to start a pilot offshore CO2 injection project in the Tomakomai area in 2016.

According to the current supply chain model, CO2 offshore geological storage would provide commercial opportunities for project development companies (e.g. oil and gas companies, professional CO2 storage operators, utilities and transportation companies), EPC institutes, consulting companies, and relevant product and technology service companies. Apart from direct participation, the second tier of the supply chain would include major EPC and consulting companies providing reservoir and oil fields services, and relevant equipment and subsea and offshore engineering. The third tier suppliers would provide wider product and technology services. In addition, offshore CO2 geological storage would provide new opportunities for the current engineering and financial service industries, such as qualification services (e.g. DNV GL has developed a recommended practice for CO2 storage), insurance services (e.g. Zurich Insurance has developed a CO2 geological storage insurance product).

From the Chinese perspective, China's oil and gas, services and equipment manufacturing firms should change their focus, and consider CO2 storage as a service business and a future opportunity instead of a pure environment investment. Developing and demonstrating CO2 offshore storage has the following six strategic implications:

1. It helps to achieve a deep cut in greenhouse gas emissions. China tops the world in total greenhouse gas emissions, while at least a quarter of China's emissions are located in East and Southeast coastal provinces. Similar to the Northwest of Europe, it is very hard to identify suitable onshore storage sites in this part of China, and developing CO2 offshore storage technologies is an essential way to achieve a deep cut in greenhouse gas emissions.

2. Offshore CO2 storage could contribute to marine economic development in China, and contribute towards achieving the marine silk road. Developing the marine economy is a priority task on the Chinese government's agenda. Within the 12th Five Year Plan,

项目生命周期	项目名称	所在地区/国家	年封存量（百万吨）	开始运作的时间	排放源	捕集方式	运输距离（公里）
运行	Sleipner CO_2 Injection	挪威北海	0.9	1996	天然气加工	燃烧前捕集	0.11
运行	Snøhvit CO_2 Injection	挪威巴伦海	0.6-0.8	2008	天然气加工	燃烧前捕集	152
建设	Gorgon Carbon Dioxide Injection Project	澳大利亚西北部	3.4-4.1	2015	天然气加工	燃烧前捕集	7
定义阶段	Don Valley Power Project	英国南约克郡	4.0-5.0	2019	发电	燃烧前捕集	175
定义阶段	White Rose CCS Project	英国北约克郡	2.0	2020	发电	富氧燃烧	不确定
定义阶段	Peterhead Gas CCS Project	英国阿伯丁郡	0.8-1.0	2018	发电	燃烧后捕集	102
定义阶段	Rotterdam Opslag en Afvang Demonstratiep roject (ROAD)	荷兰	1.0-1.2	2017	发电	燃烧后捕集	25

表1：全球正在运营，建设或定义阶段中的海洋封存CCSU项目

力公司、运输公司）、承包机构和顾问公司，以及相关产品及技术服务公司带来新的商业机会。除了直接参与的企业，供应链的第二级包括主要承包商和顾问公司，涵盖盆地服务、油井服务、相关设备以及海底和海洋工程。第三级供应商包括更广泛的产品和技术服务。此外，二氧化碳海底封存还会为许多现有的服务行业带来新的机会，包括认证服务（如挪威船级社积极投入CCS标准制定）、保险服务等。如苏黎士保险、瑞士再保险等保险公司与英国CCS协会合作，在2012 年为二氧化碳封存所带来的产业机会进行过深入的评估。

对于中国而言，中国的海洋石油和天然气生产、服务和装备制造公司需要改变观念，把二氧化碳封存作为一项新兴的基础设施服务的产业，看作一个机会，而不是考虑为一项单纯的环保投资。在中国开发和示范海洋封存技术有以下六点战略意义：

一是有利于大幅度降低温室气体排放。中国的碳排放总量已经达到世界第一，而中国东部和东南沿海地区的大型排放源约全国四分之一。类似于欧洲西北部地区，在中国东部和东南部很难在陆上找到合适的封存场地，发展海洋封存技术

the Chinese government launched the ‘National Marine Economy Development 12th Five Year Plan’, suggesting marine GDP should account for 10% of national GDP, and that the leadership capability of the Pearl River Delta, the Yangtze River Delta and the Bohai Economic Area should be fully utilized. In 2010, the State Council listed Guangdong as the marine economy pilot province in China, and on 8 Jan 2014, the national marine economy leadership group hosted their first working meeting, launching China’s first national marine economic survey.

3. Offshore CO2 storage could contribute to offshore engineering related equipment manufacturing, services and advanced technology R&D, and reduce the cost of applying offshore technologies. It is an emerging offshore engineering project; developing relevant technology and equipment would benefit the current offshore engineering industry and human resources capacity, and further promote the offshore engineering and services industry in China.

4. Developing an offshore CO2 demonstration project would consolidate a potential offshore engineering and

第一级 运输与封存 开发公司	石油及天然气公司	专门的 CO_2 封存公司	电力公司	专门的 CO_2 运输公司	
供应链环节	**盆地**	**井**	**设备**	**海洋和海底工程，及管道**	**其他支持和服务**
第二级 主要承包商和顾问公司	封存地模型与管理盆地工程	油田服务钻井合同	建设，运作和拆除工程设备 工程咨询	海洋及海底工程服务 重型设备服务	认证服务 责任保险
	取得三维地震数据	井有关工程顾问	结构设计	铺管服务	设备管理
				浮式生产装置	海空运输服务
				船舶运输服务	仓储服务
					通信服务
					安全服务
第三级 产品服务，供应商					医疗服务
	监测技术	油井可靠性分析	设备再利用	海底管汇设计与制造	金融服务
	盆地模型技术	材料开发与测试	设备设计及制造	海洋及海底设备	能源咨询服务
	风险管理顾问	水泥供应合同	工程支持	管道供应	
	地质科学咨询	钻井设备设计和制造	专业工程服务	海底监测服务	
	数据分析顾问	钻井管道	钢材和管道专业服务		
	三维地震设备	实验室服务			
	数据存储				
	计算机软硬件				

表2：二氧化碳海底封存带动的相关产业（来源：Senior CCS, 2010）

将是中国东部和东南部地区通过CCS实现大幅度碳减排的必需选择。

二是有利于中国海洋经济的发展，有利于实现海上丝绸之路。发展海洋经济是中国政府高度重视的一项工作，中国政府在第十二个五年计划期间对出台了《全国海洋经济发展"十二五"规划》，提出2015年海洋生产总值要占国内生产总值10%，充分发挥珠三角，长三角，和渤海湾经济区的引领作用。2014 年1 月8 日，全国海洋经济调查领导小组召开第一次会议，启动了中国第一次全国范围的海洋经济调查。而国务院在2010 年把广东列为海洋经济试点省份。

三是有利于海洋工程相关装备制造，服务和先进技术的研发，降低应用相关技术的成本。二氧化碳进行海底封存是一项新兴的海洋工程；开发相关技术和装备，有利于巩固现有的海洋工程服务产业和人才队伍，进一步发展海洋工程和技术服务产业。

四是有利于发展和巩固海洋工程和服务产业枢纽基地，增加海工产品出口能力和竞争力。广东省已经具有海洋工程装备基地（如珠海的高栏港）和海洋工程服务基地（如深圳的赤湾港），

services industry hub, and increase the export capacity and competitiveness of offshore engineering products. Guangdong province already has an offshore engineering equipment manufacturing hub (the Gaolan Terminal in Zhuhai) and an offshore engineering service hub (the Shenzhen Chiwan Terminal). Demonstrating and developing geological storage technologies would benefit offshore engineering and the competitiveness of the relevant services bases, and help companies within these hubs to enjoy the benefits of entering the industry chain of an offshore CO2 storage project.

5. Offshore CO2 storage helps large-scale infrastructure development and implementation. The public perception of environment issues becomes a critical barrier for developing a large-scale infrastructure project. Developing an offshore CO2 storage project could reduce potential public resistance to a CCS infrastructure project.

6. Chinese oil and gas companies will benefit from developing offshore oil fields. Most oil companies increase their overseas investments gradually. An early access to CO2 storage technologies (e.g. utilizing depleted oil and gas fields for CO2 storage, reusing

发展和示范海底地质封存技术，有利于巩固海工和相关服务基地的国际竞争力，并有助基地内的企业及早进入海底地质封存项目的产业链。

五是有利于大型基建项目的实施和开发。公众的环保意识对开发大型基建项目的影响在日益增加。从沿海大型排放源捕集二氧化碳并在海底封存，能够实现大型基建项目的近零排放，从而提高公众对新项目的认可程度。

六是有利于中国企业在海外开发油田。中国各大石油公司在国外的投资在逐年增加。优先掌握二氧化碳封存相关技术（如利用废弃油气田为排放源进行二氧化碳封存服务、再利用油田平台和钻井进行二氧化碳封存、利用二氧化碳充注提高海洋石油采收率等技术），有利于提升中国的石油公司的竞争力和最大化海外投资的收益。

中国人口总量为英国的 20 倍，为挪威的250倍。作为一个强调海洋战略的大国，尽快建设百万吨级的二氧化碳海底封存示范项目，掌握其中的主要技术环节，具备重大意义。以下对中国企业和政府在推动二氧化碳海底地质封存技术的开发和示范提出八点初步建议：

一是由政府主导，以企业为实现主体，制定中长期规划，逐步推进。发展二氧化碳海上运输和海底地质封存产业需要协调大量能源企业和专业机构（如表2 所示），不可能一蹴而就，需要政府具备前瞻性的战略部署和进行积极的引导，稳步推进。建议政府把二氧化碳海底封存纳入海洋新兴产业，制定激励政策，鼓励企业投资和参与，并走出去在海外市场为海底封存项目服务。

二是积极利用区域经济优势，协同相关海洋经济区的建设。2011年7 月国务院批复同意《广东海洋经济综合试验区发展规划》，根据该规划广东省海洋经济将要2015 年达到全省生产总值的1/4。示范海洋封存技术，可依托广东现有海洋经济试验区和海工产业服务区域的优势，鼓励企业参与二氧化碳封存有关的研究和示范，产生协同效应。

三是通过国际合作，共同开发先进技术和海外市场。英国正在积极示范海底二氧化碳地质封存，可通过今年成立的“中英（广东）CCUS 中心”或其他形式加强二氧化碳海底封存、提高石油采收率和监测方面的技术开发和产业合作，共同开发大型示范项目。国际合作不仅有利于外国企业在中国进行示范，也有利于中国企业进入二氧化碳封存项目的国际产业链。

四是积极引进海洋封存有关技术和服务的人才。目前全球二氧化碳海洋封存示范还处于早期阶段，近期依托广东示范项目或研究项目引入人

offshore platforms; and using CO2 for EOR) would help promote Chinese oil companies' competitiveness and maximize the benefits of overseas investment.

China's population is 20 times that of the UK, and 250 times that of Norway. As a country which highlights the importance of marine strategy, China should start to develop a million tonne scale offshore CO2 storage project, in order to master the technology.

The total population in China is approximately 20 times of the United Kingdom, 250 time of Norway. As a nation highlighting the importance of marine strategy, China should consider develop at least one million tonne offshore CO2 storage demonstration project, to establish the technical capacity. The preliminary recommendations for Chinese industry and government in regard to offshore CO2 storage are listed as below:

1. The offshore CO2 storage programme should be led by the government. The industry will be the core implementer, formulating medium to long term development plan to move forwards. Develop offshore CO2 transport and storage industry capacity require a coordination of a large number of energy companies and professional institutes (as shown in Figure 2). It is impossible to establish the industry overnight, and definitely requires a future proof plan formulated by the government. The Chinese government should consider incentives for offshore CO2 storage related industry, and encourage related companies to provide services for demonstration projects overseas.

2. Guangdong should actively take advantage of the geographical advantages, developing offshore CO2 storage projects along with the marine economy zone development plan. In Jul 2011, the State Council approves a plan to give Guangdong the status of a marine economy pilot zone. According to the plan, the marine economy in Guangdong should contribute to 1/4 of total GDP in the province by 2015. Demonstrating offshore storage technology, might receive policy benefit from the pilot zone plan, and also provided side benefits in developing the pilot marine economy zone.

3. Guangdong industry should work closely with foreign companies to co-develop technologies and overseas market. The international collaboration could be achieved through the 'UK-China (Guangdong) CCUS Centre', or through other mechanisms to strengthen industry collaboration in offshore CO2 storage, enhanced oil recovery, monitoring, and jointly developing demonstration projects. International collaboration could generate mutual benefits for both

才和技术，机会成本会比在未来市场扩张时行动要低。

五是委托科研机构与海洋石油公司合作，开展二氧化碳海底封存选址和源汇匹配研究。我国海域广阔，有许多大型沉积盆地和良好的封存条件。优先进行二氧化碳潜在封存的选址和排队工作，将有利于企业为区内大型排放源开展封存业务，有利于推动CCS 及近零排放预留工作，也有利于明确海洋权益。

六是推动跨行业的示范项目工作组，尽快促成首个大型示范项目。例如，通过政府引导华润电力海丰公司与中海油合作，建成亚洲首个百万吨燃煤电厂捕集海底地质构造封存项目。

七是进行海洋封存方面的立法和制定示范项目的监管措施。根据欧盟的经验，监管海洋地质封存活动需要制定相关监管措施，如环境影响评估和义务管理办法、二氧化碳泄露的监测和管理办法、注入时及注入后监控措施和管理办法、以及纳入碳排放权交易制度的管理办法等。

八是积极引入国外财政支持。海底咸水层封存是不带有提高石油开采经济效益的大型海洋工程活动，成本会比陆上封存高很多，中国作为首个发展中国家开展此类型的项目，需要积极从发达国家或多边组织引入财政支持。

值得注意的是，在30 多年前，由于中国缺乏海洋石油资源的技术、知识和装备，国务院于1982 年1 月30 日发布了《中华人民共和国对外合作开采海洋石油资源条例》。借助于多年来的对外合作，现在中国已经具备了海洋石油和天然气开采的技术力量。然而，在降低二氧化碳排放已成为世界共识的今天，如果中国的企业仍不能掌握二氧化碳封存有关的技术，在碳排放约束进一步加强的时候，中国企业就可能再次需要依赖国外的技术。因此，及早进行CCS的战略性部署和示范，有利于中国企业融入国际二氧化碳海底地质封存的产业链。

Chinese and foreign companies in market and technology access.

4. Attract overseas technology and engineering services experts to work in Guangdong. Currently, global CO2 offshore storage is still at an early development stage, the Guangdong CCUS demonstration project and related R&D programmes should attract foreign experts and technology, as the opportunity cost to introduce experts would be much higher when the market enters the expansion stage.

5. Appoint R&D institutes to work with China National Offshore Oil Corporation (CNOOC), to start Site Identification and Source Sink Match related research activities. China has significant offshore ocean area, and a large number of sediment basins offshore could have good storage capacity. The site identification and selection activities could benefit industry in making large CCUS project decisions, and also help to promote CCS and near zer emission ready activities.

6. Establish a joint working group in demonstration project, and promote the first large-scale CCUS demonstration with offshore storage project in China as soon as possible. For example, Guangdong provincial government could help coordinate collaboration between China Resources Power (Haifeng) project and CNOOC, to establish the first million tonne CO2 capture with offshore storage integrated CCUS project.

7. Start to formulate the legislation and regulation for demonstration programmes. According to the EU experiences, regulating offshore storage activities require specific measures, such as environment impact assessment, and management methods for liability, CO2 leakage monitoring programme, management methods for injection, decommissioning and post-injection periods, and rules to include CCS in the emission trading scheme.

8. Actively introduce foreign financial supports. Offshore saline aquifer storage is a pure CO2 emission reduction activity without other energy income. The offshore storage cost is much higher than onshore stage especially at the demonstration phase. China, as the first developing country proceed offshore CO2 storage activity should attract financial support from developed country and multilateral institutes.

Because of a lack of technical capacity, in 1982, China adopted an international joint-venture model to explore offshore oil and gas assets. Today, CO2 reduction has become a global consensus, if Chinese indus-

try is not starting to accumulate CO2 offshore storage technical capacity, Chinese industry might have to rely on foreign technical support again in CO2 storage later at a more significant carbon constrained era. Therefore, demonstrate and deploy CCS early would ultimately benefit Chinese industry, being integrated into the international industry chain related to offshore CO2 storage.

‘伦敦雾’治理的过程以及对中国治理雾霾的启示

李　佳　爱丁堡大学工程学院
李科浚　中国交通企业管理协会
杨　晖　中国能建广东省电力设计院

严重的大气污染，曾让伦敦‘雾都’闻名。国内媒体和学者常常联系中国主要城市的雾霾现象与‘伦敦雾’。究竟英国在过去半个世纪治理城市大气污染的有什么经验和教训值得中国治理雾霾借鉴，治理雾霾有没有特效药?

下决心处理城市大气污染

在1952年12月5日至9日，由于气候上出现了逆温层以及燃煤带来的污染物排放，一场浓厚和持续的污染烟雾事件导致了大约四千人和大量牲畜非正常死亡，法医和死亡登记注册处的工作人员首先意识到了这场灾难的严重性。自从18世纪的工业革命，燃煤导致的频繁污染雾已经早已成为伦敦生活的一部分。但这一场严重的污染雾促使民众通过议会，迫使英国政府下决心制定措施来治理大气污染。这场烟雾事件烟尘浓度（图1）达到北京雾霾极值的三倍水平。

英国在治理城市大气污染的采取了哪些措施?

伦敦市随即在1954年出台了伦敦市法律，制定了无烟区和搬迁煤电和部分重工企业到郊区。值得关注的是，英国政府在1952年毒雾事件后还没有马上下决心，哈罗德 麦美伦，房屋和地方政府部长（后成为首相），认为没有马上针对大气污染物立法的需求而要求地方政府采取已有的权力来治理污染雾。迫于民选民选议员们和一份大气污染物评估报告的压力，英国政府最后妥协。英国议会在1956年通过了大气净化法，作为给了政府更大的权力来控制黑烟，颗粒物，粉尘，和金属尘，并且给予英国政府权力制定烟尘控制区（禁止燃烧烟气排放）和制定认可燃料。该法在1968年进行了修订，要求增加烟囱高度来扩散排放。尽管大气净化法在1956年通过，在1952年后的十年，雾霾仍然频繁发生。在1962年后健全统计体系后，数据显粉尘和硫化物逐步下降（图2）。很多学者认为1956年英国大气净化法是治理污染物的第一步法律，事实上英国议会在19世纪中期就开始制定烟尘控制有关法律，而早在1661年，约翰 伊芙林爵士一位著名的作家，就向查尔斯二

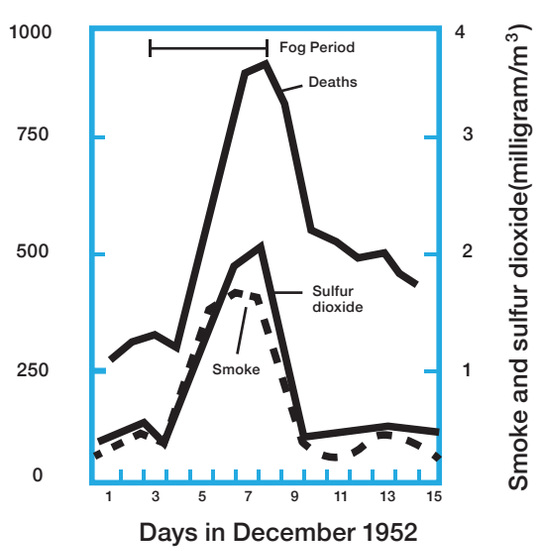

图1：1952年12月上半月伦敦市每天死亡人数，大气中烟尘及氧化硫浓度（来源：圣安德鲁大学）

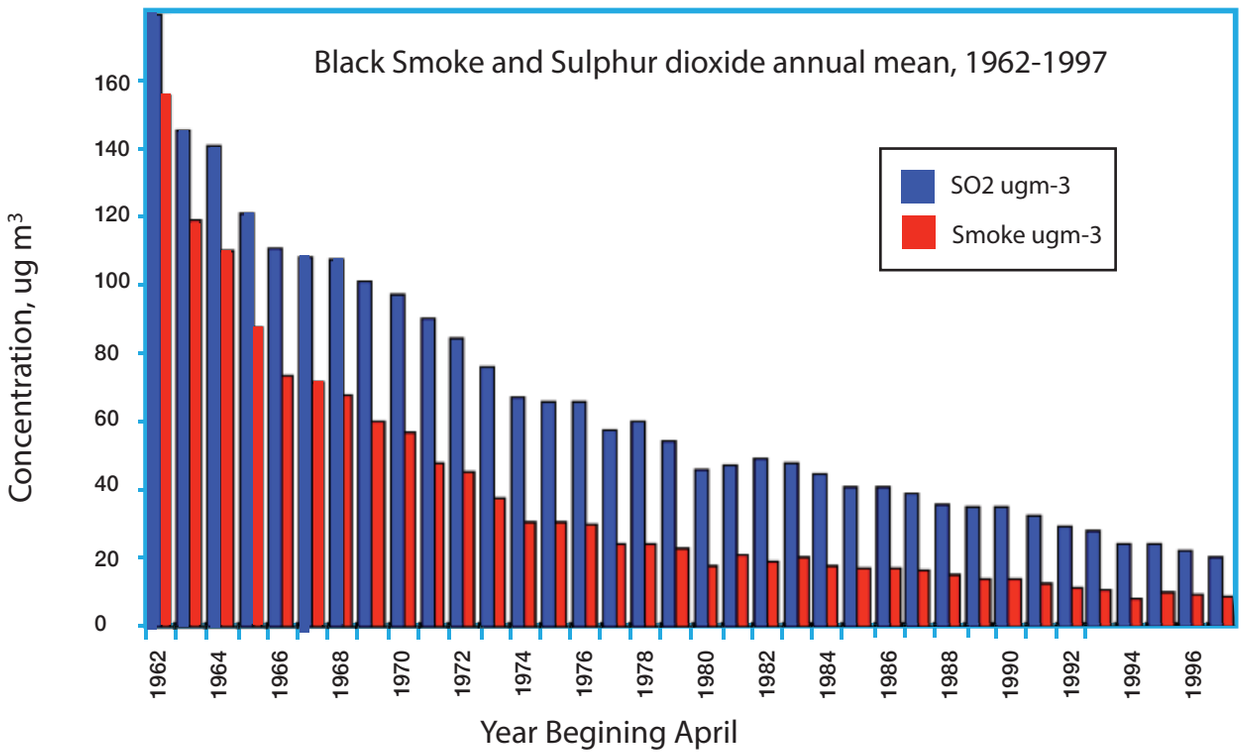

图2：伦敦烟尘和氧化硫的平均浓度

世国王提出伦敦的浓烟对民众身体会有影响，发表了第一部关于伦敦空气污染的论文《论空气的不适和笼罩伦敦的浓烟》。

在毒雾时间随后的二十年，技术方面的变化协助实现大气污染治理，最显著的措施是燃料转换，在第二次世界大战之前，西方国家居民的取暖和煮食燃料主要来源于煤炭。转换居民燃料为天然气，电力和无烟煤为降低城市大气污染带来巨大的变化。与此同时，很多工业企业也采用电力来替代燃煤。伦敦市政府在2002的报告显示1965年后天然气的使用是污染物大幅度降低的最主要因素。其次，减少发电过程的排放技术得到应用和推广，通过燃烧前（洗煤），燃烧过程中（如改变燃烧室设计，混烧石灰石）和燃烧后（脱硫和除尘）的治理技术，以及使用低硫煤，大幅度改善了发电带来的的污染。大气净化法律也促使了新技术的开发。在交通方面，除了更高效率地燃烧，和尾气催化净化过程，使用传统燃料很难有

在成本影响较低范围内巨大的污染物控制突破。目前，伦敦市的大气污染主要由汽车排放造成。

英国治理‘伦敦雾’经验对中国治理雾霾有何启示?

英国从开始治理污染雾，到实现污染雾的控制，颁 布大气污染法律，用了大约二十年的时间（控制粉尘在50微克每立方米水平）。事实上，政策，技术和时间是三个不可或缺的因素。大部分英国过去采用的治理措施，已经在中国得到应用，如严格的大气污染物排放标准，燃烧管制区（如广东的禁燃区），燃煤电厂和重工业向郊区转移。

从污染源方面，英国伦敦在1952年12月严重污染雾发生后的一个月发表了污染雾来源的重要报告。这份报告为英国下议院推动政府立法起到重要作用。而中国经历了多次严重雾霾事件（如导致飞机停飞），尚未有对雾霾成因达成一致共识。

大部分英国采用的污染物控制技术（如去除粉尘和脱硫）已经在中国大型排放源得到广泛应用。燃料转换是最重要的方式，但‘煤改气’在中国受制与气源紧张（中国40%天然气依赖进口）和气价较高的因素。另一方面，政府采取了区域煤炭消费总量限制，以及限制新建煤制气项目，也限制了非天然气气源。

英国的经验显示，降低雾霾也许没有特效药，需要持之以恒的努力，特别当中国的能源需求仍然快速增长而城镇化过程仍在进行。细致城市污染物减排技术路线图，科学地分析排放源和气候情况。片面的压减排指标和空气污染物，只会扭曲治理雾霾工作，降低政府和企业减排工作的透明度。

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苏格兰政府能源与气候变化司副司长兼石油与天然气处处长
Head of Oil and Gas Division & Deputy Director, Energy and Climate Change Directorate, Scottish Government

第二届广东国际碳捕集利用与封存（CCUS）研讨会会议记录

2nd Guangdong International Carbon Capture, Utilisation, and Storage Workshop Minute

会议纪要

2014 年 5 月 15 日，在广东省发改委和英国驻穗总领馆的大力支持下，第二届广东国际碳捕集利用与封存（CCUS）研讨会在中国能源建设集团广东省电力设计研究院（简称广东院）隆重举行，会议由中英（广东）CCUS产业促进与学术交流中心（简称中英（广东）CCUS中心）主办，广东院、英国爱丁堡大学和深圳领先财纳公司共同承办。广东省常务副省长徐少华、省发改委副主任吴道闻、广东省科技厅副厅长龚国平、英国能源与气候变化部副部长 Gregory Barker、英国驻穗总领馆 Andrew Massey 等来自国内外的专家和代表 100 余人参加了会议。会议中，各方与会者就广东省转变经济发展模式，低碳能源领域的国际合作，碳捕集与封存技术的发展及产业化等方面进行了讨论。会议纪要包括以下几个方面：

1. 参与会议的领导强调，广东需要找到一条经济合理增长同时碳排放量持续下降的绿色低碳发展之路实现真正意义上的经济转型。其中相关工作包括完善碳排放方面的法律法规，建立排放交易体制，加大低碳清洁能源方面的研究力度，学习国外的先进技术和经验，加强各方合作 推动产业转型。

2. 英国政府已经明确承诺要发展 CCS 项目并投入 10 亿英镑作为项目资金，同时，英国政府愿意与各国分享技术和经验。英国研究理事会希望能和中国自然科学基金会共同运作一个价值 2000 万英镑的低碳创新项目促进双方的合作。作为中外合作的典型案例，中英（广东）CCUS 中心自去年 12 月成立以来，在短短几个月已经实现良好开局，正着手开展碳捕集、利用与封存（CCUS）相关研究及示范项目工作，示范项目华润海丰电

Summary

The 2nd Guangdong International Carbon Capture, Utilization and Storage (CCUS) Workshop was held in Guangdong Electric Power Design Institute (GEDI) on 15 May 2014. The conference was held by UK-China (Guangdong) CCUS Industry Promotion and Academic Collaboration Centre (UK-China (Guangdong) CCUS Centre), co-organized by GEDI, University of Edinburgh and Linkschina Investment Advisory. The Deputy Governor of Guangdong Provincial Government Mr XU Shaohua, Deputy Director General of Guangdong Development and Reform Commission Mr WU Daowen, Deputy Director General of Guangdong Science and Technology Department Mr GONG Guoping, UK State Minister of Energy and Climate Change Mr Gregory BARKER, and UK to Guangzhou Consulate General Mr Andrew Massey, and more than 100 delegates from China, UK, Australia, Norway and Netherlands. In the conference, the participants had talks on economic transition in Guangdong, international collaboration on low-carbon technology, CCS deployment and commercialization, and so on. The conclusions are as follows:

1. Guangdong needs to identify a green pathway to achieve significant economic growth and at the same time reduce carbon emissions. The main points include completing legislation, establishing emission trade system, facilitating low-carbon technology development, learning from the lessons and experience of other countries and enhancing collaboration with different companies and countries.

2. The UK government has clearly committed to invest 1 billion pounds to CCS projects. Meanwhile, they would like to share their technology and experience with other countries. UK Research Council would like to cooperate with Natural Science Foundation of China to launch a 20 million pounds low- carbon innovation project. As a good example of UK-China cooperation, from the establishment of last

厂完善了国内首份 CCS 预留设计方案，百万吨 CCUS 项目预可研阶段启动。英方希望中英（广东）CCUS 中心可以继续努力，为推动低碳发展和中英共同应对气候变化做出积极贡献。

3. 来自华润电力、中海油、壳牌集团、中集集团和华南理工大学等的各位专家代表分别围绕“广东 CCUS 示范项目介绍”、“国外开发示范项目的经验”、“高附加值装备制造产业的发展经验”和“示范项目的知识共享和知识产权保护”等话题发表演讲，向与会者展示了在低碳减排方面已经做的努力成果以及国外项目的经验等。

4. 二氧化碳的捕集是全链中至关重要的一环。如何降低捕集成本也成为了 CCS 技术产业化推广的重中之重。借鉴英国和脱硫技术发展的经验，捕集预留集群和建设大规模脱碳装置都有可能实现成本的降低。此外，技术创新和资金支持对碳捕集技术的发展也有至关重要的作用。

5. 在二氧化碳运输和储存方面，挪威船级社制定的 DNV-RP J202 和 DNV-RP J203 标准提供了参考流程和操作规范。管道运输中的泄露，埋藏地的选址问题仍然是各方专家关注的重点。同时，设施是否能够被应用，与油气勘探公司的沟通协调合作，埋藏地什么时候可以开始使用也是需要考虑的问题。经过研究讨论，专家组得出结论：广东省更适合海底封存。海陆封存相比内陆封存安全性更高，存储条件更适宜，但是成本相对也更高。

6. 公众对技术的认可度的提高是取决于 CCS 是否能大规模发展的关键性问题。要提高公众的认可度，可以分别通过政治家、企业家、媒体、金融界等大规模资本，联合社区和科普教育，以及针对个别的项目去影响，在当地进行交流。针对中国情况，第三方机构和媒体在 CCS 宣传方面应该发挥更大，更积极的作用。关于 CCS 立法与政策法规，欧盟、英国和美国都已经出台了相关的法规来支持 CCS 技术的开展，而我国在立法这方面仍旧是空白。所以，建立完备标准的管理体系、针对性的融资机构和保护机制是需要解决的问题。

December, the members of UK-China (Guangdong) CCUS Centre have completed the first CCS readiness design plan for China Resources Power (Haifeng) project, kick-offed the pre-feasibility study of million tonne CCUS project. The UK government wish UK-China (Guangdong) CCUS Centre would make their all efforts to deploy low-carbon technology to realize common green future for the whole world.

3. Experts and delegates from China Resources Power, China National Offshore Oil Corporation, Shell Group, CIMC Group and South China University of Technology, etc. gave introduction to topics on ‘CCUS demonstration project in Guangdong’, ‘International experiences in developing demonstration projects’, ‘High value added manufacturing industry development experiences’, and ‘Intellectual property right protection and transfer’, etc.. They demonstrated their results on low-carbon technology development and experiences of overseas projects.

4. Carbon capture is a very important part of full chain CCS. One main problem concerns how to reduce the cost. Learning from the experience in recent development of Flue Gas Desulfurization technology (FGD) and the experience of UK, capture-ready clusters and large scale CO2 capture devices are viable options to reduce cost. Besides, technology innovation and financial support also play crucial parts in carbon capture.

5. For carbon transport and storage, DNV published DNV-RP J202 and DNV-RP J203 guidelines for work flow design and standards. The leakage of pipeline transport, the screening and selection of geological storage site are still major concerns. Apart from this, other problems like the re-use of exploring facilities, negotiation and collaboration with oil companies, the availability of storage sites should be taken into account during siting phase. The conclusion for Guangdong storage siting is: off- shore storage is more suitable for GD. Comparing to on-shore storage, off-shore storage is more secure and manageable, but more expensive.

6. Public perception is a major barrier for CCS large scale deployment. A proper way to settle the problem is to influence public views via communication with key stakeholders, such as politicians, entrepreneurs, media and financial sectors, or by community and education, or use experiences of real project to persuade the public. Based on the specific environment of China, independent institutes and mass media should play important part to make it more convincing. In terms of CCS legislation, EU, the UK and the US have already launched CCS related regulations and Acts, while China has no CCS legislation by far. Therefore, comprehensive CCS related legislation system, and mechanism to protect public and investors need to be established.

双边会谈纪要

正式会议开始前，广东省副省长徐少华先生与英国能源与气候变化副部长Gregory Barker先生在广东院举行了双边会谈。会谈中，徐少华回顾了去年朱小丹省长访英期间与英方在能源合作、低碳发展等方面所签署的联合声明。徐少华说，“很高兴看到联合声明签署后，双方在所涉及的各个领域的合作都在务实推进”。“广东需要找到一条经济合理增长同时碳排放量持续下降的绿色低碳发展之路。”徐少华表示，在转变经济发展模式的过程中，广东应完善碳排放相关的法律法规，通过市场机制完善碳排放交易。

徐少华希望广东院这样的企业积极发展和引进先进的低碳技术，在碳捕集利用与封存和清洁能源方面加大研究力度。同时徐少华表示，广东非常希望借鉴并学习英国在碳排放交易机制建设、清洁能源发展等方面的先进经验。更希望今后广东与英国的企业加强合作与交流，推动 广东企业的低碳转型。

巴克对广东省在低碳发展领域充满信心，非常高兴看到广州碳排放交易中心和欧洲已经完成同步运作，“我对广州碳交易市场的未来非常看好。”CCS 技术在显著减少排放、促进能源安全和为全球减碳方面有着实质性的潜力。巴克透露，国际能源机构预计到2050 年，全球 CCS 市场价值将达一千亿英镑。他希望更多的国家尽快发展 CCS 项目，从而实现这个潜能。

会谈结束后，徐少华和巴克共同出席了第二届广东国际碳捕集利用与封存（CCUS）研讨会开幕式并致辞。

Bilateral Meeting Briefing

Before the conference, Mr XU Shaohua, the Deputy Governor of the Guangdong Government had a bilateral discussion with Mr Gregory Barker, Minister of Climate Change at the UK Department for Energy and Climate Change. In the meeting, Deputy Governor of Guangdong Mr XU Shaohua reviewed the achievements and MoUs signed between UK and Chinese institutes during the visit by the governor ZHU Xiaodan. Mr XU suggested Guangdong to identify a green pathway to achieve significant economic growth and at the same time reduce carbon emissions. Mr XU indicated Guangdong should improve emission trading related laws and regulations, and improve carbon emission trading through market mechanisms.

Mr XU hoped institutes such as GEDI, could enhance research strength in CCUS and clean energy. Mr XU also suggested that, Guangdong is very keen to learn from the advanced experiences of UK in ETS development, clean energy development, etc.. Hopefully, Guangdong and UK could enhance collaboration and promote Guangdong industry to achieve a low-carbon transition.

Mr Barker felt confident about low-carbon development in Guangdong, and was pleased to see the ETS in Guangdong in operation in parallel as EU does. Mr Barker is optimistic about Guangdong carbon market. CCS technologies should extract significant potential in greenhouse gas reduction, enhance energy security. Mr Barker revealed that IEA predicted the global market value of CCS should reach 100 billion pounds. He hoped more countries should kick-off CCS projects to realize the potential.

After the meeting, Mr XU Shaohua and Mr Gregory Barker attended the 2nd Guangdong International CCUS conference and made an open speech.

中英政府官员致辞，项目启动与中心活动回顾

时间 9:30-10:20,2014/05/15
会场 1：发布大厅

演讲人：
徐少华 广东省常务副省长
Gregory Barker 英国能源与气候变化部副部长
罗必雄 中国能建广东省电力设计研究院院长
陈澜 中英（广东）CCUS 中心主任，中国能建广东省电力设计研究院总工程师
梁希 中英（广东）CCUS 中心秘书长，爱丁堡大学副教授

Opening speech. Project kick-off and activities review

Time 9:30-10:20,15th, May, 2014
Location: Room 1

Speakers:
XU Shaohua Deputy Governor of the Guangdong Government
Gregory Barker Minister of Climate Change at the UK Department for Energy and Climate Change
LUO Bixiong President of Guangdong Electric Design Institute (GEDI)
CHEN Lan Director of UK-China (Guangdong) CCUS Centre, Chief Engineer of GEDI
LIANG Xi Secretary of UK-China (Guangdong) CCUS Centre, Senior Lecturer of the University of Edinburgh

日程安排：
9:30-9:35 徐少华副省长致辞
9:35-9:40 Gregory Barker 副部长致辞
9:40-9:45 罗必雄院长致辞
9:45-9:50 陈澜主任进行中英（广东）CCUS中心发展介绍
9:50-9:55 梁希秘书长进行中英（广东）CCUS中心工作简报
9:55-10:00 发布华润电力（海丰）示范项目CCS预留设计报告，华润大型CCUS示范项目计划启动

Agenda:
9:30-9:35 Speech by Mr XU Shaohua, Deputy Governor of the Guangdong Government
9:35-9:40 Speech by Mr Gregory Barker, Minister of Climate Change at the UK Department for Energy and Climate Change
9:40-9:45 Speech by Mr LUO Bixiong, President of GEDI
9:45–9:50 UK-China (Guangdong) CCUS Centre Development Introduction by CHEN Lan
9:50-9:55 UK-China (Guangdong) CCUS Centre Work Review by LIANG Xi
9:55-10:00 Releasing the China Resource (Haifeng) CCS Ready report, launch of the large-scale CCUS demonstration project. (Chaired by CHEN Lan)

会议进程

会议由中心秘书长梁希主持

徐少华常务副省长致辞

徐少华常务副省长在致辞中介绍了广东省作为国家低碳减排试点省在过去的工作中做出的努力和成果，并提出了广东省在低碳经济发展中的使命和挑战。CCUS技术作为能够大幅度降低二氧化碳排放重要的技术，对已实现近零排放的目标有着重要的意义。中英（广东）CCUS中心的建立对于中外合作交流和CCUS技术在广东的推广是非常好的范例。徐少华希望中英（广东）CCUS中心不断健全机制，提升服务水平，紧紧围绕技术产业化、示范CCUS、融资和商业化等三个重点领域，为广东省及国内外绿色低碳发展提供智力支持。希望英国方面继续为广东实现近零排放提供更多借鉴。

Gregory Barker 副部长致辞

Barker副部长在发言中说，CCS在实现近零排放方面被公认为有极大的潜力。英国政府已经明确承诺要发展CCS项目并投入10亿英镑作为项目资金，同时，英国政府愿意与各国分享技术和经验。英国研究理事会希望能和中国自然科学基金会共同运作一个价值2000万英镑的低碳创新项目促进双方的合作。作为中外合作的典型案例，中英（广东）CCUS中心自去年12月成立以来，在短短几个月已经实现良好开局，正着手开展碳捕集、利用与封存（CCUS）相关研究及示范项目工作，示范项目华润海丰电厂完善了国内首份CCS预留设计方案，百万吨CCUS

Proceeding

Conference was chaired by Mr LIANG Xi, Secretary of Centre

Speech by Mr XU Shaohua

XU Shaohua, the Deputy Governor introduced the efforts and results of Guangdong on low-carbon industry as a demonstration province. He also expressed the challenges and threats ahead. As a major technology to realize CO2 emission reduction, CCUS technology is of great significance to realize near zero emission target. The establishment of UK-China (Guangdong) CCUS Centre is a very good example to enhance closer collaboration of China and overseas, and the deployment of CCUS technology in Guangdong. Mr XU Shaohua hoped UK-China (Guangdong) CCUS center could strengthen operational mechanism and improve service quality, highlight technology industrialization, CCUS demonstration, financing and commercialization three key areas, to provide intellectual support for Guangdong and international green and low-carbon development. He also hoped UK partners should continue to provide support to achieve near zero emission in Guangdong.

Speech by Mr Gregory Barker

Mr Barker stated that CCS has huge opportunities in realizing near-zero emission. The UK government has clearly committed to invest 1 billion pounds to CCS projects. Meanwhile, they would like to share their technology and experience with other countries. UK Research Council would like to cooperate with Natural Science Foundation of China to launch a 20 million pounds low- carbon innovation project. As a good example of UK-China cooperation, from the establishment of last December, the members of UK-China (Guangdong) CCUS Centre have completed the first CCS readiness design plan for China Resources Power (Haifeng) project, kick-offed the pre-feasibility study of million tonne CCUS project. The UK government wishes UK-China (Guangdong) CCUS

项目预可研阶段启动。英方希望中英（广东）CCUS 中心可以继续努力，为推动低碳发展和中英共同应对气候变化做出积极贡献。

罗必雄院长致辞

罗必雄院长在致辞中表示，广东省是中国的能源大省，节能减排任务艰巨。广东省电力设计研究院在发展先进技术实现节能减排方面做出了诸多努力，在核能，风能发电发面已经有了可喜的成绩。在 CCS 技术发展方面，从 2009 年开始 CCS 技术研究直到 2013 年中英 CCUS 中心成立，广东院都积极投入参与。CCUS中心英中合作的一大成果，罗院长希望中心能肩负起为广东省提供低碳环保提供技术支持的使命。

陈澜主任介绍中英（广东）CCUS中心介绍

中英（广东）CCUS 中心是一个中英技术经验交流的平台，同时为企业提供技术支持的职能机构。本次会议作为中心的重要活动，主要目的是为了展示国际最新 CCUS 技术研究成果，推动技术产业化。本次会议将针对CCUS技术在广州的示范项目，技术发展，融资以及战略路线图进行深入交流。

中心秘书长梁希做 CCUS 中心工作汇报

中英(广东)CCUS 中心已经取得了包括广东省电力设计院，清洁能源发展机构，英国 CCS 中心，苏格兰 CCS 中心的一致认同和参与。中心构成包括三个工作组和一个国际专家委员会。中心已经完成了中国第一个大型煤炭燃煤项目碳捕集预留方案，第一份中国 CCUS 法制和监管环境报告，CCUS 项目建设报告，广东海洋封存报告和提高石油产收率技术报告。中心同时着手设计大型CCUS创新工作平台，与大型装备制造企业合作，为降低碳捕集成本做出努力。中心已经出版两份《近零排放》杂志试刊，同时通过网站、杂志、研讨会等渠道为 CCUS 技术在广东省的宣传提供媒介。中英（广东）CCUS中心作为一个纽带促进中英各方面更加深层次的合作提供准备。

Centre would make their all efforts to deploy low-carbon technology to realize common green future for the whole world.

Speech by Mr LUO Bixiong

In the address, Mr Luo stated that since Guangdong is among the largest emission province in China. The task of reducing emission is arduous. Guangdong Electric Design Institute (GEDI) has done a great work in emission reduction, especially in nuclear and wind power development. GEDI began to involve in CCS in 2009 , and helped to establish the centre in 2013. During the period, GEDI made great efforts in CCS development. CCUS centre is an important result of UK-China collaboration. Mr Luo hoped the centre could shoulder the task of providing technology support for Guangdong low carbon transition.

Introduction of UK-China (Guangdong) CCUS Centre by Mr CHEN Lan, Director of CCUS Centre

UK-China (CCUS) Centre is an important communication platform, and it also aims to providing technology support to companies and institutes. The major target of the 2nd Guangdong international CCUS conference is to display the most advanced CCUS technology and to realize the industrialization. In this conference, experts and delegates will have an in-depth discussion about the demonstration projects, CCUS technology, financing support and the roadmap based on Guangdong situation.

Centre Secretary General Xi Liang made a work report

UK-China (Guangdong) CCUS Centre has got 4 important participants: GEDI, Clean Energy Development Institute, UK Carbon Capture and Storage Research Centre and Scottish Carbon Capture and Storage Centre, with three working groups and one international advisory panel. By far, CCUS Centre has completed China's first large scale coal-fired plant capture ready scheme, first CCUS legislation and monitoring environment report, CCUS project construction report, Guangdong off- shore geological storage report and CO2-EOR report. Meanwhile, centre has begun designing large- scale CCUS innovation working platform, and tried to collaborate with some large equipment manufacturers to reduce the cost of carbon capture. Centre has published two pilot issues of Near Zero Emissions Magazine, and together with other media such as website and seminars, to propagate the CCUS technology deployment. UK-China (Guangdong) CCUS centre could act as a link to build closer collaboration between UK and China in comprehensive respects.

大型 CCUS 示范项目启动

陈澜主任宣布广东大型百万吨一体化CCUS示范项目正式启动。副省长徐少华先生为广东院能源规划研究院揭牌，英国能源部副部长Barker 访问中英（广东）CCUS 中心及各接受媒体采访。

The kick-off of CCUS demonstration project

Mr CHEN Lan, the director, announced the kick-off of the pre-feasibility study of Guangdong large- scale 1 million tonnes full chain CCUS project-China Resources Power (Haifeng) CCUS demonstration project. Mr XU Shaohua, Deputy Governor of Guangdong, helped GEDI open the Energy Planning Institute. Mr Barker, the Minister visited UK-China (Guangdong) CCUS centre and was interviewed by media.

全体会议：如何推动示范项目和技术产业化

时间 10:40-11:00
会场 1：发布大厅

发言人：
朱和平 华润(海丰)示范项目负责人
杨勇 中国海洋石油公司规划计划部处长
曹孙辉 中海油惠州炼化公司副总经理
王岩 华南理工大学知识产权学院教授
Tim Bertels 壳牌集团 CCS 经理
胡爱和 中集安瑞科技术总监

日程安排：
10:40-11:00 广东 CCUS 示范项目介绍
11:00-11:10 示范项目的知识共享和知识产权保护
11:10-11:25 国外开发示范项目的经验
11:25-11:40 高附加值制造产业的发展经验
11:40-12:00 展览参观活动

Discussion on Strategies for Developing Demonstration Projects and Technology Industrialization

Time 10:40-11:00
Location: Room 1

Speakers:
Mr ZHU Heping demonstration working group lead of China Resources (Haifeng) CCUS project
Mr YANG Yong Section Chief of China National Offshore Oil Corporation (CNOOC)
Mr CAO Sunhui CNOOC Huizhou Refiner Deputy General Manager
Pro WANG Yan Professor of School of Intellectual Property at South China University of Technology
Mr Tim Bertels Head of CCS of Sell Global Solution International B.V.
Mr HU Aihe technical Director of CIMC Enric Holding Co., LTD

Agenda:
10:40-11:00 Introduction to the CCUS Demonstration project in Guangdong
11:00-11:10 Knowledge sharing and IPR Protection for CCUS demonstration projects
11:10-11:25 International lessons in Developing CCUS Demonstration Projects
11:25-11:40 High value added equipment manufacturing development experiences
11:40-12:00 Exhibition visit

会议进程

会议由陈澜，Bill Senior 主持

Proceeding

In this section, conference was chaired by Mr CHEN Lan and Mr Bill Senior.

华润（海丰）电厂CCUS项目基本情况介绍

（演讲人：朱和平，华润海丰项目）

华润（海丰）电厂位于广东省汕尾市，是华润集团投资的首个百万千瓦级别电力项目，机组扩建工作的申请已经报送到广东省发改

Introduction to China Resources Power (Haifeng) CCUS Project

(Mr ZHU Heping, China Resources Power (Haifeng) Project)

China Resources (Haifeng) power station locates in Shanwei City, Guangdong. It is the first largest million KW level power station invested by China Resources. The extension applica-

委，其中扩建工程中包括 CCUS 示范计划。目前，华润电力和广东省电力设计院在爱丁堡大学的支持下，正在进行 CCUS 项目用地的方案设计。同时希望能与中海油合作，在广东省近海进行碳封存。CCUS技术被认为是唯一一项能够降低石化行业碳排放的技术，同时发展 CCUS 技术能够提高国际影响力，获得国际支持。

tion has been sent to Guangdong Development and Reform Commission, which includes CCUS demonstration project. At present, under the support of GEDI and the University of Edinburgh, the land use planning is under study. At the same time, China Resources would like to cooperate with CNOOC to do carbon storage in the near sea. CCUS is believed to be the only technology that could dramatically reduce the carbon emission of power station. China Resources also want to use this opportunity to expand their international influence.

做好顶层研究，加强专题工作，谨慎和稳步推进海上碳封存工作

（演讲人：杨勇，中海油集团）

• 中海油开展CCUS项目介绍

从 2003 年起，为了解决南海气田多二氧化碳的问题，中海油已经开始了一些列的项目研究二氧化碳的捕集利用和封存。在十二五规划中，海上工厂的二氧化碳排放检测已经有了一些进展，但是相对来讲封存方面还是空白，但是通过调研和资料收集，对于南海的地质构造情况已经有了一定的了解。广东省陆上盆地非常稀少，要发展碳封存技术的主要目标应该是海上。

Make high-level research and planning. Strategies to deploy off-shore carbon storage

(Mr YANG Yong, CNOOC)

• Introduction of CCUS in CNOOC

CNOOC started to study carbon storage technology since 2003 . In the twelfth five-year plan, the carbon monitoring has already got some improvements, but carbon storage is still in stagnant. However, via several years' research, CNOOC already has some understandings of geological setting of South Sea. There are few basins on-shore in Guangdong. The storage target should be off-shore.

• 广东省周边油气田介绍，及海上探测技术难点

广东省周边海域已经开发了 23 个油田，20个固定式海上平台，30个海底管线，最近的惠州油田和西江油田离海岸线有一百多海里。海上碳封存的主要问题存在于：

a. 国内没有先例作为指导
b. 海上封存技术有其特殊性
c. 各项成本高
d. 海上封存安全性，可注入性的研究欠缺
e. 二氧化碳在注入后的状态研究
f. 数值模拟和技术检测手段

• Introduction to oil fields of near sea, and difficulties in carbon storage

We have already developed 23 oil fields, 20 exploring platform, and 30 pipelines. The nearest is
Huizhou oil field and Xijiang oil field. The major difficulties include:

a. There is no off-shore storage examples in China before
b. Technology difficulties of off-shore storage
c. High cost
d. The security problem and injectivity problem
e. The long term fate of stored CO2
f. Establishing numerical models and monitoring measurements

• 关于开展海上碳封存的几点建议

明确目标，借鉴成功案例，与中英（广东）CCUS中心合作开展研究课题。在条件成熟后稳步开展项目。

• Several suggestions for off-shore storage

making sure the target, learning from examples, cooperating with UK-China (Guangdong) CCUS Centre and kicking-off project cautiously

对于二氧化碳捕集和封存的几点建议

（中海油惠州炼化分公司副总经理曹孙辉代表中海油总经理助理董孝利中英（广东）CCUS 中心顾问委员会主席发言）

中海油惠州炼化公司是中海油投资新建的

Several suggestions for carbon dioxide capture and storage

(CNOOC Mr CAO Sunhui, representing Mr DONG Xiaoli, the Chair of UK-China (Guangdong) CCUS Centre Advisory Panel)

Huizhou Refining and Chemical Company is a large-scale

一家大型石化企业，在其二期项目建成投产后二氧化碳的排放总量将高达 1000 万吨。中国海洋石油总公司的领导和相关企业都感受到了发展 CCUS 项目的必要性和紧迫性，也愿意加入示范项目的建设中。惠州炼化公司愿意作为一个平台，对省内其他项目起到示范作用。以下有几点建议：

a. 捕集，封存和应用实现区域化
b. 建立碳排放市场交易，不再收碳税
c. 政府给予重要支持

petrochemical company invested by CNOOC. The CO2 emission after the second construction project could reach 10 million tonnes. The officials and related companies deeply feel the necessity and urgency of developing CCUS demonstration project. Huizhou Refining and Chemical Company would like to be an example to other companies in the province. Here are several suggestions:

a. Regionalize carbon capture, utilization and storage
b. Build up ETS, no carbon tax
c. Government support is important

示范项目的知识共享和知识产权保护

（演讲人：王岩，华南理工大学）

• CCUS技术在未来将由市场主导

王教授认为 CCUS 技术室一项高度前瞻性的技术，随着环境的日益恶化，人类最终会为过度排放二氧化碳付费，能源成本随之提高，最终形成市场需求。这项事业的前期工作需要政府、企业的参与。王教授预计，在未来，二氧化碳减排成为市场需求，CCUS会逐步依靠市场推进而不是政府主导推进。

• 知识产权激励CCUS技术研发

知识产权机制的建立，可以杜绝其他企业在技术研发方面产生消极的“搭便车”心态，建立企业进行自主研发的良性环境。

• 中国CCUS知识产权申请现状分析

相对于国外的企业和机构，国内关于CCUS技术的专利申请还很少。关于国内CCUS知识产权申请，王教授提出了以下几点需要研究的问题：

a. 政府资助项目知识产权的归属
b. 公司在实施项目过程中积累的知识产权共享
c. CCUS 技术标准中的专利权限制
d. 涉及到重大公共利益，CCUS 专利技术的强制许可
e. 当法律保护专利的行为不利于 CCUS 工作的推进时应该怎么做

随后，Bill Senior先生登台介绍了中英CCUS 技术合作现状。英国的 CCUS 项目建设从2005年第一个示范项目开始到现在经历了很多年。中国可以吸取英国和其他国家发展CCUS项目的经验，更好更快的开展项目。现阶段在广东省发展 CCUS 技术要求我们需要有耐心，勤奋，协同合作的精神（例如与油气公司的合作）。由于近海已经开展了油气田开发项目，已有的知识和设施可以应用，广东省适合发展海上碳封存技术。海上封存

Intellectual property sharing and protection

(Prof WANG Yan, South China University of Technology)

• CCUS Technology Tends to be Market Oriented

Pro Wang stated that CCUS is a highly prospective technology. As the deterioration of environment and climate, people will eventually have to pay for CO2 emission. The cost of energy will increase, and carbon reduction will be in demand. The initial work should be helped by government and companies. Pro Wang anticipated, in the future, CCUS deployment will be competitive in market.

• Intellectual Property Protection Stimulates CCUS Technology Deployment

Intellectual property protection stimulates CCUS technology deployment, and helps to build a more healthy market.

• Analysis of China's CCUS Intellectual Property Application Status

After analyzing Chinese CCUS intellectual property situation, it is clear to see that there are much fewer intellectual properties applied than other countries. Some problems should be paid attention to:

a. The ownership of intellectual property by government support project
b. The sharing of intellectual property by companies
c. The intellectual properties in standards
d. The mandatory permission of intellectual property right when it concerns with significant public interest
e. What should we do when the law is against CCUS deployment

Thereafter, Mr Senior introduced the present situation of UK-China cooperation. It has been many years since UK began CCUS project study from 2005. China could learn from UK and other countries' experience to make the deployment quicker and better. To develop CCUS in Guangdong, we need patience, hard work and cooperation (e.g. with oil companies). Since Guangdong already has many oil fields exploration projects, the understanding of the geological setting and infrastructures are available, it is more suitable for off-shore storage, which is far from the population and has

由于远离人群，相对内陆封存泄露风险更低。英国和中国有良好的合作关系，CCUS中心的建立是个很好的平台连接中国和世界。

low leakage influence. UK and China has good cooperation history, the establishment of CCUS Centre is a good platform to link China and the world.

CCUS 项目建设中的历史经验和教训
（演讲人：Tim Bertels，壳牌集团）

• CCUS 技术在未来将会有广大的需求。目前，全球有21个大型项目正在运行或建造，但是需要更多的项目。

• 壳牌公司有 5 个CCS示范项目正在运行，建造或在 FEED 阶段。Peterhead 项目是世界首个CCUS全流程项目。他将从Peterhead电厂捕集二氧化碳注入气田。这个项目还在 FEED 阶段，计划在 10 年的时间里将运行投产。

• 根据以往的经验得到，CCUS项目必须具备以下几个条件：
a. 价格竞争力
b. 政策支持
c. 良好的运输和封存设施
d. 创新推动力
e. 民众接受度

Lessons and experiences in developing CCUS projects
(Tim Beterls, Shell Group)

• CCUS will be in great needed in the future. At present, there are 21 large-scale projects in operation or under construction in the whole world, but many more will be needed in the future.

• Shell company has 5 CCS demonstration projects in operation, construction or in FEED. Peterhead CCUS project is the world first full-scale project. It will capture CO2 from Peterhead Power Station and inject CO2 into gas reservoir. This project is still in the FEED phase, and is planned to be operational at the end of the decade.

• According to the lessons and experiences in the history, CCUS project needs to have:
a. Cost competitiveness
b. Regulatory support
c. Good transport and storage infrastructure plan
d. Innovation drive
e. Public acceptance

高附加值装备制造产业的发展介绍
（演讲人：胡爱和，中集安瑞科）

来自中集安瑞科的胡爱和先生在演讲中介绍了中集集团作为能源、制造、化工类企业在低碳环保领域所做的努力。中集安瑞科在全球有十几家制造基地，全球主要客户包括了能源领域的壳牌集团，化工领域 BP 集团以及食品领域的百威和青岛等。中集集团肩负着为全球提供装备，为全球的技术进步和产业发展，为公司利益相关者的利益最大化，全人类生活更加美好做出贡献。

High value added manufacturing industry development
(Mr HU Aihe, CIMC Enric)

Mr Hu Aihe from CIMC Enric introduces CIMC Group effort in energy, manufacturing, chemical areas. CIMC Enric has more than 10 manufacturing bases in the world, the major clients include Shell Group, BP, Budweiser etc. CIMC Group carries the responsibility to provide equipment for advancing technology and industry development in the world and to maximize interests of key stakeholders, contributing to a better environment for human being.

分组讨论
近零排放杂志特别举办：
燃煤近零排放及超清洁技术论坛

时间：13:30-14:15
会场 2：D112

Group Discussions: Near Zero Emission Magazine: Near Zero Emission and Ultra-clean Technology Forum

Time:13:30-14:15
Location: D112

发言人：
邹竞成 工程师，广东省电力设计研究院
李凡总监 阿尔斯通集团
李佳 爱丁堡读大学，《近零排放》杂志主编

日程安排：
13:30-13:45 燃煤电厂近零排放技术介绍
13:45 – 14:00 阿尔斯通集团在传统污染物处理经验
14:00-14:10 讨论
14:10-14:15 《近零排放》杂志介绍

会议进程

由李佳和邓广义主持

燃煤电厂近零排放
（演讲人：邹竞成，广东省电力设计研究院）

国家出台了新的清洁能源的排放标准，新标准规定的粉尘、二氧化硫、氮氧化物的排放标准也是全世界最严格的，并将会在中国的发达地区实行。周工程师分别介绍了 GEDI 主要的近零排放技术，包括高效脱硝，除尘，脱硫，脱汞，脱碳，废水排放和固体污染物综合利用。

随后李佳博士总结道，大多数电厂的碳捕集技术主要是燃烧后捕集，这项技术对于电厂的其他污染物排放要求很高。所以在这样的前提下碳捕集才能更好的进行。

阿尔斯通集团在传统污染物处理经验
（演讲人：李凡，阿尔斯通）

阿尔斯通集团在环保方面被业界认为是公认的领导者，全球有1500多人在从事环保方面，包括 CCUS 方面的业务。就脱硝方面，阿尔斯通主要运用 SCR 技术，脱硫方面有传统的石灰石石膏法、海水脱硫、干法脱硫。干法脱硫通常和布袋除尘结合运用。脱汞技术主要有主要除尘技术包括布袋除尘。主要除尘技术包括布袋除尘，干式和湿式除尘。阿尔斯通以上的这些污染物处理都能达到非常好的处理效果，通过这些努力，阿尔斯通想向政府证明一个观点：燃煤也可以达到近零排放。

Speakers:
Ms ZOU Jingcheng Engineer, Guangdong Energy Design Institute
Mr LI Fan Director, Alstom Group
Dr LI Jia Lecturer of the University of Edinburgh, chief editor of *Near Zero Emission* Magazine

Agenda:
13:30-13:45 Near-zero emission in coal-fired plants
13:45-14:00 Alstom experiences in traditional pollutants control
14:00-14:10 Discussion
14:10-14:15 Introduction to *Near Zero Emission* Magazine

Proceeding

The group meeting was chaired by Dr LI Jia and Ms DENG Guangyi

Near-zero emission in coal-fired plants
(Ms ZOU Jincheng, GEDI)

The Chinese government has recently announced the new pollutants standard for clean energy. This standard is the strictest in terms of NOx, SOx and particulate, and it will be implemented in most developed regions in China. Ms ZOU introduced the near-zero emission technology used in GEDI, including NOx removal, SOx removal, Hg removal, carbon capture, waste water treatment and solid waste usage.

Thereafter, Dr Li concluded the reason for why the meeting spend time to introduce the treatment of other pollutants, is because for most CCS project, post-combustion capture is the first choice. Post-combustion capture is based on the condition that other pollutants should be removed from the flue gas. Only under this circumstance, carbon capture could be proceeded smoothly.

Alstom experiences in traditional pollutants control
(Mr LI Fan, Alstom Group)

Alstom Group has a good reputation in the field of environmental protection. There are around 1500 people in Alstom work for environmental protection, as well as the deom project of CCUS. In terms of denitration, we mostly use SCR. For desulfurization, we have three technologies: limestone, saline water and dry method. Dry method desulfurization is always combined with filter bag. For dust removal, we usually use filter bag, dry dust collector and wet dust collector. All these technologies could achieve very good performance. These high efficiency technologies demonstrate to the government that coal-fired plants could also achieve near-zero emission.

随后，与会者对于阿尔斯通零废水排放的技术进行了热烈的讨论。讨论内容包括流程设计，活性炭的用量，活性炭活化处理和成本等细节问题。

Thereafter, the participants had a heated discussion on the near-zero waste water discharge. The topic included the work flow design, the amount and activation of activated carbon, and the cost.

近零排放杂志介绍

（演讲人：李佳，爱丁堡大学）

《近零排放》杂志是李佳博士和邓广义女士合作主编，在会上，李佳博士希望各位与会的专家能给与宝贵的建议。徐少华副省长看过杂志后表示，希望看到《近零排放》杂志一直办下去。李博士呼吁各公司和技术供应商可以把杂志作为平台来宣传先进的近零排放技术和产品。

Introduction to *Near Zero Emission* Magazine

(Dr LI Jia, the University of Edinburgh)

The Magazine *Near Zero Emission* is co-edited by Dr Li Jia and Ms DENG Guangyi from GEDI. Dr Li hope the experts in the meeting could give them precious suggestions in the future to make it better. The Deputy Governor XU Shaohua spoke highly of the magazine, and wished it could be continued and better and better in the future. The companies and technology providers could perceive the magazine as a platform to propagate their advanced technologies and products.

封存与运输最佳实践工作组公开会议

时间：13:30-14:15
会场 3：D114

演讲人：
Per Christer Lund 挪威船级社
Stuart Haszeldine 爱丁堡大学地球科学学院，苏格兰碳捕集与封存中心
周蒂 中科院南海研究所
彭勃 中国石油大学

日程安排：
13:30-13:45 二氧化碳封存与运输指导标准介绍
13:45-13:55 碳封存的不确定性
13:55-14:10 广东省二氧化碳地质封存可行性研究结果报告
14:10-14:20 国内大型 CCS 项目介绍以及标准体系的建立

CO2 Storage and Transportation Best Practice Working Group Open Meeting

Time: 13:30-14:15
Location: D114

Speakers:
Per Christer Lund DNV GL
Stuart Haszeldine School of Geosciences, University of Edinburgh, Scottish Carbon Capture and Storage Centre
Di Zhou South China Sea Institution of Oceanology, China Academy of Science
Bo Peng China Petroleum University

Agenda:
13:30-13:45 Guidelines for carbon storage and transport.
13:45-13:55 Uncertainties in carbon storage.
13:55-14:10 Results of feasibility research of Guangdong geological carbon storage.
14:10-14:20 Large scale CCS projects in China and standard system construction.

会议进程

最佳实践工作组会议于 15 日下午 13:30 由主持人李科浚宣布开始
主持人：李科浚，Per Christer Lund

Proceeding

Meeting called to order at 13:30 by Kejun Li, chaired by Kejun Li and Per Christer Lund

CO2 地质封存地的鉴定，检验和验证及项目展示

（演讲人：Per Christer Lund,，挪威船级社）

Validation, verification and certification of CO2 geological storage sites and projects

(Per Christer Lund, DNV)

- 挪威船级社历史及公司贡献介绍
- DNV-RPJ202运输管道标准和DNV-RPJ203CO2封存标准介绍
- 良好的行业间沟通对CO2封存很重要

- Introduction of the history and contribution of DNV company
- DNV-RP-J202 and DNV-RP-J203 are guidelines for CO2 pipelines and CO2 storage, respectively.
- Good communication is important for CO2 storage.

二氧化碳封存与运输最佳实践

（演讲人：Stuart Haszeldine，中英（广东）CCUS 中心 副主任）

- 在CO2封存中有六项不确定因素：寻找存储地，运输途径，充注过程中的安全性，与附近油气开采项目的协调，以及公众接受度。
- 在封存地选择过程中需要考虑的因素包括：地质条件的适合度，所需数据是否能获得，以及长时间的项目验证审核。
- 在确定封存地时因考虑到多种可能性。

Storage and transport best practice

(Stuart Haszeldine, UK-China (Guangdong) CCUS Centre Deputy Director)

- Six uncertainties about carbon storage includes: finding storage sites, how to transport, monitory of the operations, maintaining harmony with other offshore activities (oil and gas discovery) and public acceptance.
- Many factors should be taken into account during carbon storage site selection, such as the geological suitability, data acquisition and the long term to prove (it takes 5 years to find the location)
- More storage options should be taken into account.

广东省 CO2 封存地在哪？

（演讲人：周蒂，中科院南海海洋研究所）

- CCUS 项目在广东省实施的可行性研究结果回答了一下几方面的疑问：

a. 广东省是否需要发展CCS技术？
b. 广东是否适合发展CCS？
c. 如何在广东开展 CCS 项目
d. 为广东CCS技术发展提出路线图

- 其结果显示包括以下几个方面：

a. 广东省进行海底封存的可能性较大（仅珠江口盆地可封存广东数百年排放的CO2）
b. 对惠州21-1油田和陆丰2-1油田进行充注模拟显示充注容量可观，盖层安全性良好。
c. 需要解决的问题包括：统筹油气开采，以及海陆封存的高成本。

- 总结：广东省近海有充足的 CO2 封存地资源；封存地筛选排序工作需要尽快开展；全过程 CCS 项目的实施是迫切需要。

Where are the sites for storing CO2 from Guangdong?

(Pro. Di Zhou, South China Sea Institute of Oceanology, Chinese Academy of Sciences)

- Guangdong CCS feasibility research (from 01/04/2010-31/03/2013) answers the following questions:

a. Whether GD needs CCS
b. Is GD suitable for deploying CCS
c. How to deploy CCS in GD
d. Suggesting GD CCS roadmap

- The research results include:

a. The ideal storage sites for GD are offshore (Pearl River Mouth basin alone could store hundreds of years' CO2 emission of GD)
b. Taking Huizhou 21-1 and Lufeng 2-1 oil fields as models to illustrate the reservoir capacity, CO2 migration and leakage possibility. It comes to the conclusion that these two reservoirs have good capacity and not likely to leak.
c. The problems need to be settled includes how to cooperate with oil and gas producing activities, and the high cost of offshore storage.

- Overall conclusion: there are sufficient CO2 storage sites for CO2 emission from GD; potential sites ranking and selecting should be undertaking as soon as possible; full chain CCS project is needed.

CCS 量化与检验标准体系的建立
（演讲人：彭勃，中国石油大学）

• 国内大型碳封存项目介绍：
a. 中石油吉林油田项目
b. 中石化胜利油田项目
c. 神华集团鄂尔多斯盆地项目
d. 延长石油 CCUS-EOR 项目

• 正在策划或即将投产的CCUS项目：
a. 华能集团天津 IGCC-EOR 示范工程
b. 神华集团和中石油联合进行的鄂尔多斯示范项目。这是我国首个CCS全流程旗舰项目。

• 与 CCUS 相关标准制定的重要性。

Develop Standard System and CCS quantification and verification
(Pro. Bo Peng, China Petroleum University)

• Introduction of CCS projects in operation in China:
a. Jilin oil field project operated by CNPC
b. Sheng Li oil field project operated by Sinopec
c. Ordos basin project operated by Shenhua
d. CCUS-EOR project operated by Shaanxi Yanchang Petroleum Company

• Projects in design:
a. Jilin oil field project operated by CNPCTianjin IGCC and EOR project
b. Ordos basin project based on the collaboration of Shen Hua and CNPC, will be a full chain, flagship project.

• The importance to establish relevant standard for CCS.

专家小组座谈 1
如何降低碳捕集技术成本

时间：14:30-16:00
会场：D112

演讲人：
Richard Smith Howden Group
王健 豪顿华
梅报春 阿尔斯通集团
张国华 壳牌康索夫
刘练波 华能清能院
安炯雄 爱丁堡大学

日程安排：
14:30-14:40 如何降低碳捕集成本
14:40-14:50 英国 CCS 白玫瑰工程介绍
14:50-15:00 火电厂清洁技术的应用
15:00-15:10 二氧化碳成本降低可能方向
15:20-15:20 制氢厂实现二氧化碳捕集
15:20-16:00 讨论

Panel Meeting 1
Cost reduction for Carbon Capture

Time:14:30-16:00
Location: D112

Speakers:
Richard Smith Howden Group
Jian Wang Howden Hua
Mei Baochun Alstom Group
John Zhang Shell Cansolv
Lianbo Liu Huaneng Clean Energy Research Institute
Hyungyong Ahn University of Edinburgh

Agenda:
14:30-14:40 Cost reduction for Carbon Capture
14:40-14:50 White Rose CCS Project
14:50-15:00 An application for cleaning up coal-fired power
15:00-15:10 Cost reduction potential for CO2 capture
15:20-15:20 CO2 capture from hydrogen production plant
15:20-16:00 Discussion

会议进程

如何降低碳捕集成本
（演讲人：Richard Smith 和王健，豪顿集团）

碳捕集成本的降低在于碳捕集项目全生命周期的优化。豪顿集团减少成本的主要理念是为顾客提供给终身，高价值的服务。豪顿集团参与了全世界不同国家的 CCUS 项目。美国 Kemper County 的 IGCC 是全世界最大的，豪顿为其提供了风机压缩机等产品

Proceeding

Cost reduction for Carbon Capture
(Richard Smith and WANG Jian, Howden)

Howden Group has done a lot in cost reduction. The major cost reduction drive is to provide life-time, long-term value for customers. In terms of CCUS, Howden has already been involved on varies projects. The IGCC in Kemper County in America is the world largest. Howden provided them with large equipments including air blowers and compressors,

总计能耗 63MW。另一个豪顿正在研究的第二代二氧化碳捕捉技术。另外，现在正在适用于近零排放的机械式在压缩技术也可以用于碳捕集中。总的来讲，豪顿对于成本减少的理念是，除了减少初期成本，后期运行成本的降低也是关键。

whose energy consumption is 63MW in total. Another technology concerning is the Next Generation Carbon Capture technology. Besides, Mechanical Vapour Recompression could also be used in carbon capture. In summary, Howden's concept on cost reduction is not only on cutting initial cost, but also on reduction on operational cost.

英国 CCS 白玫瑰工程介绍

（演讲人：梅报春，阿尔斯通公司）

阿尔斯通集团参与的英国白玫瑰 CCS 项目，是英国政府批准的两个大型 CCUS 项目之一，是目前来讲最大的富氧燃烧，并且有潜力进行商业化运作的项目。白玫瑰项目拟发电 426 万千瓦，每年捕集 200 万吨二氧化碳。电厂应用生物能源，捕集二氧化碳90%，实现负排放。项目现在正出于前段工程设计阶段(FEED)。英国政府对于项目会制定标杆电价支持。项目同时也入选欧盟 NER300 清洁发电项目。项目的实行能够证明富氧燃烧是一种灵活可靠、价格低廉的碳捕集方式。预计 FEED 于 2015 年完成，项目将于 2019 年正式启动。

White Rose CCS project

(MEI Baochun, Alstom)

White Roase CCS project is one of the two large-scale CCUS projects supported by British Government, and it would be the largest Oxy-fuel carbon capture plant, which has great potential to realize commercialization in the future. It generates 4.26GW and capture 2 million tonnes O2. It is a negative emission power plant using biofuel and 90% carbon capture. At present, the project has started FEED. The government will support it via benchmark price policy. White Rose has also been selected as European NER300 Clean Energy project. The objective of this project is to demonstrate that oxy-fuel could be a reliable, flexible and cheaper choice for carbon capture. It is participated that FEED will be finished by the end of 2015, and the project will began operation in 2019.

火电厂清洁技术的应用

（演讲人：张国华，壳牌康索夫）

张国华认为，壳牌康索夫公司在有机氨脱硫技术经验在今后很有可能运用到脱碳技术中。他的主要介绍了壳牌康索夫公司在脱硫方面的经验。通过多年的运营，康索夫的脱硫脱碳技术已经达到很稳定，吸收剂的选择性高毒性很小，装置适用范围很广，满足国家排放要求，运行时间长。根据SO2脱除和CO2捕集装置截面积对比可知，扩大二氧化碳捕集量的潜力还很大。

An application for cleaning up coal-fired power

(ZHANG Guohua, Shell Cansolv)

Zhang Guohua believed the experience in desulfurization could be used in carbon capture in the future. In the meeting, he majorly introduced the experience of Shell Cansolv on desulfurization. After several years' operation, the technology has matured: the sorbent has high selective and low poisons, the equipment could be used in various processes, the pollutant emission could meet the government's standard, and has long operating life. According to the comparisons of the cross area of SO2 adsorption tower and CO2 adsorption tower, there should be great potential for the CO2 capture capacity.

二氧化碳捕集成本降低可能方向

（演讲人：刘练波，华能清能院）

华能集团作为世界上最大的燃煤发电集团，对于二氧化碳减排的任务艰巨。华能集团清洁技术研究院在二氧化碳减排方面的研究包括基础理论研究，应用基础研究和应用技术集成。现在一共有四个项目在运行。二氧化碳捕集建设成本的降低随着大型规模化是可以实现的，但是运行成本高主要原因在于再生塔的蒸汽的浪费，运行成本的降低现在是

Cost Reduction Potential for CO2 Capture

(LIU Lianbo, Huaneng Clean Energy Resarch Institute)

Huaneng Group as the largest power group in the world, has great responsibility in carbon emission reduction. Huaneng Clean Energy Research Institute is now studying on this from three scopes: theoretical study, fundamental application study and technology application study. At present, there are four projects under operation. Mr Liu believed the reduction of initial cost is achievable with large-scale application of the technology, the problem concentrated on the operational

个难题。研究院目前拟通过物理膜分离的方式来实现二氧化碳分离来降低成本，目前实验式正在研究之中，希望能进行小规模测设。

cost resulting from the waste of vapour from regeneration tower. The research institute is now studying to use membrane separation to realize cost reduction. He hoped this technology could be tested in the real project in the future.

制氢厂实现二氧化碳捕集
（演讲人：安炯雄，爱丁堡大学）

安炯雄介绍，目前，氢气被越来越多的工业生产所需要。由于碳捕集成本的高昂，制氢厂碳捕集的设计研究成为需要。相比传统发电厂碳捕集的设备拥有的制氢和发电的设备，在本研究中 用 IGCC 技术叠加 H2 PSA 技术，实现高纯度氢气的分离（99.99%以上）和循环利用和二氧化碳的捕集。

CO2 Capture from Hydrogen Production Plant
(Hyungwoong AHN, University of Edinburgh)

There is increasing demand for hydrogen by various industrial processes. It is needed to study the carbon capture processes for H2 plants. Comparing to the carbon capture processes in traditional coal-fired power station, which has H2 production and power generation modules, in this study, IGCC is added with H2 PSA technology to realize the high concentration H2 separation (above 99.99%) and recycling, and carbon capture.

专家小组会议 3
政策，融资与传播战略

时间：14:30-16:00
会场：D112

演讲人：
Peta Ashworth 澳大利亚联邦科学与工业研究组织
林亚茗 广东省科技记者协会代表
黄莹 中科院广东能源研究所

日程安排：
14:30-14:40 比较国际公众对 CCUS 项目的认识
14:40-14:50 公众关系对能源项目开发的影响
14:50-15:00 CCS 法制和监管环境

会议进程

主持人：Peta Ashworth，梁希

公众对 CCUS 技术认识的国际比较
（Peta Ashwroth，澳大利亚联邦科学与工业研究机构）

来自澳大利亚CSIRO的Peta Ashworth教授比较国际公众对 CCUS 项目的认识，并具体描述了其中几项具有代表性的调查结果。Peta女士认为，应从以下几个方面去影响公众

Panel meeting 3 Policy, Financing and Communication Strategy

Time:14:30-16:00
Location: D112

Speakers:
Peta Ashworth CSIRO (Australia)
LIN Yaming Representative of Science Journalist Association in Guangdong
HUANG Ying Chinese Academy of Sciences Guangdong Institute of Energy Conversion

Agenda:
14:30-14:40 Public perceptions on CCUS projects: An international comparison
14:40-14:50 The role of public relation in energy project development
14:50-15:00 CCS legal and regulatory framework

Proceeding

Chair: Peta Ashworth and Xi Liang

International Comparisons on Public Perceptions on CCUS
(Peta Ashworth, CSIRO)

Prof Peta Ashworth from CSIRO presented an international comparison of public perception on carbon capture and storage. Peta suggested influencing public views on energy technology development through three aspects: first,

对能源技术的看法。首先从政治家、企业家、媒体、金融界、非营利机构、这些利益相关者入手，他们可以利用大规模资本和群体去影响。其次是社区和教育，可以通过圆桌会议，统计数据，能源知识宣传册去影响。最后是针对个别的项目去影响，在当地进行科普、交流。

communicate with key stakeholders, such as politicians, entrepreneurs, media and financial sectors. They could influence capital and public. Secondly, communicate with public and society through roundtable, statistic data and energy knowledge. Thirdly, communicate based on a specific local project.

公众认识与大型能源项目

（林亚茗，广东广东省科技记者协会）

广东省科技记者协会林亚茗女士介绍中国公众理解与大型项目的运营的关系。林女士主要比较了中国近年来政府和民众对于大规模能源项目的态度。在中国，大型能源项目在实施前一般不会与普通民众沟通，也不需要得到民众的批准，而是只需要得到政府的批准。但情况在近 3 年发生了变化。厦门 PX 项目和广东 PX 项目因为民众的强烈不满而取消，使得政府的权威受到了挑战，大型国企发现他们的发展方案不再受到欢迎，而政府头疼的是民众对大型项目日益剧增的敏感。政府的过多解释反而增进了民众的怀疑。“不了解”是恐慌的根源，民众普遍对于英文缩写存在恐惧。曾有网民将 PX 词条中的少毒改为剧毒，造成了民众恐慌。最后是清华大 学的化学系学生对该网友进行了科普，才使得该网友最终承认了自己的错误。对于 CCUS 技术，人们最为关心的是二氧化碳对于人类的影响，一旦泄露会对人类带来什么。由于政府的解释威信已经不大，或许对于这种情况，请可信的独立第三方机构进行调查澄清，可信性提高很多。另外，利用媒体，包括电子媒体和纸质媒体一起对民众进行相关科普，宣传也是一个好办法。

Public Perception and Large Infrastructure Project

(Yamin LIN, Guangdong Association of Scientific Journalists)

Ms Yamin LIN from Guangdong Association of Scientific Journalists introduces the relationship of Chinese public views and large infrastructure project. In China, owners of large energy infrastructure projects was not used to communicate with the public, and don’t need to receive approval from the public, but the situation has changed in the last 3 years. The PX project in Xiamen and Guangdong causes public riots and has to be cancelled at the end. This change is now challenging government authorities. Large state owned enterprise found their project development plan is no longer welcome by the public, and the government is painful on the public’s growing concerns in developing large infrastructure projects. Government’s explanation now doesn’t improve public perception instead causes more questions and concerns. Lack of understanding is the driver of public fear, and public fears acronyms, such as ‘PX’. Some internet user changes ‘PX’ from ‘minor poisonous’ to ‘extreme poisonous’ and cause public fear. Finally, a Tsinghua chemistry student conducts a scientific education, and causes the internet user to accept the mistake. In regards to CCUS technology, the public most likely concern how CO2 leakage may affect the society. Independent third party verification is the best way to address public concern. Also electronic and paper media communication is a good mechanism.

CCS 法律和监管框架

（黄莹，中科院广东能源所）

黄莹女士介绍了 CCS 立法与政策法规。在全球现有六十多个 CCS 项目,其中 21 个正在建设或运营，二氧化碳目前的封存量在4000万吨每年。美国和欧洲的项目占据六十多个项目中的超过一半。欧盟在 09 年 4 月发布了第一个CCS的详细立法:Derective 2009/31/EC。CCS 项 目也自 2009 年被列入欧盟碳交易市场 EU ETS。英国在 2008 年 11月的气候变化法案中提到CCS是电力市场的关键技术选择。在2013年的电力市场改革

CCS Legal and Regulatory Framework

(HUANG Ying, Guangdong Institute of Energy Conversion, Chinese Academy of Sciences)

Ms HUANG Ying introduces CCS legislation and policy framework. There are more than 60 CCS projects in the world, of which 21 projects are in construction or operation, and the total CO2 sequestration is approximately 40 million tonne per year. The US and Europe dominate the project database. European Union in April 2009 made the first CCS legislation. The UK in Nov 2008 launched the Climate Act and mentioned CCS is an important technical option in electricity market. US also passed CO2 storage related Acts in 2008. In China, there is not yet a completed legislation in CCS, but

中，英国出台了一系列支持政策，包括差价合约，碳底价等。美国也在2008年出台了相关的 CCS 封存法案。但在中国，目前还没有完全的 CCS 立法，但已经有多部法规来支持CCS。黄莹女士对于广东 CCUS 法规方面的发展提出了以下建议：首先要明确 CCUS 主管部门，并建立完备的许可证申请，审批和发放秩序，其次是构建严格的二氧化碳封存许可管理体系，并建立CCUS技术检测标准。另外要为全链 CCUS 设计完全的报告系统，明确CCS各阶段不同的利益方的责任。最后，要建立公众健康保护制度，针对性的投融资机构和保护机制。

there are many existing legislation or regulation could potentially support the development of CCS projects. Huang Ying believed CCUS regulation should first clarify management department, and establish completed permit application system, approval process, and clearance procedure. Secondly, constructing a strict CO2 storage permit system; thirdly, the full chain CCUS project reporting system, liability of different parties should be established; finally, mechanisms to protect public, investors should be established.

专家小组会议 2
如何在广东推进碳运输，封存与利用工作

时间：14:30-16:00
会场：D114

演讲人：
Bill Senior Senior CCS 有限公司
魏宁 中国科学院武汉岩土所
范先锋 爱丁堡大学工程学院
Per Christer Lund 挪威船级社

日程安排：
14:30-14:50 通过历史经验教训对广东省CCUS工作开展的建议
14:50-15:10 煤质二氧化碳封存
15:10-15:30 孔隙学角度研究盖层安全性
15:30-15:40 二氧化碳地质存储地点的鉴定、检验和验证及项目展示
15:40-16:00 讨论和总结

会议进程

主持人李科浚宣布会议开始

通过历史经验教训对广东省 CCUS 工作开展的建议

（演讲人：Bill Senior，Senior CCS咨询公司）

• 经验1：很多项目中途夭折
原因有很多，比如缺少政策和公司方的支持，经费问题，封存地址问题等等
建议：建立一系列可行项目的组合

Panel meeting 2 How to promote CO2 transportation, storage and utilization works in Guangdong

Time:14:30-16:00
Location: D114

Speakers:
Bill Senior Senior CCS Limited
Ning Wei Institute of Rock and Soil Mechanics, Chinese Academy of Sciences
Xianfeng Fan School of Enginnering, University of Edinburgh
Per Christer Lund DNV GL

Agenda:
14:30-14:50 Lessons learnt and recommendations for Guangdong
14:50-15:10 Coal oil reservoirs for carbon storage
15:10-15:30 Pore scale study for caprock's security
15:30-15:40 Validation, verification and certification for carbon transport and storage
15:40-16:00 Discussion and summary

Proceeding

Meeting called to order by Kejun Li

Lessons learnt from past projects & recommendations for GD

(Bill Senior, Senior CCS)

• Lesson 1: many demonstrations projects fall away during project development
There are many reasons for the projects failure, such as lack of policy and company's support, funding problems, issues with storage sites, et al.
Recommendation: A portfolio of projects.

• 经验2：地质学选址和特征性描述阶段有决定性作用
需要考虑到的因素包括地址的可用性，已有设施的可利用性，能否得到所需油田数据等。
建议：可靠的选址计划，开发评价井

• 经验3：石油公司的参与度
石油公司因其有丰富的经验、技术、数据库、专业人员，使其参与变得非常重要
建议：与石油公司合作共同开发

• 经验4：CO2利用和EOR技术对碳封存技术的挑战
CO2 的利用和 EOR 因其具有经济效益相对于碳封存具有优越性
建议：碳封存与 EOR 技术可以同时进行。

• 经验5：碳封存项目对比传统的油气开发项目具有其特殊性
建议：在项目策划和实施过程中充分考虑到碳封存的特殊性

• 经验6：关于CCS的法律框架的建立还需要更多努力
建议：在现有的法律框架下进行完善，并且借鉴别国的经验。

• Lesson 2: storage site selection and characterization are rate determining activity
The availability of storage sites, re-used infrastructures and data will be constrained by the decline of oil fields.
Recommendation: developing robust plans for site selection and funding appraisal wells.

• Lesson 3: Engagement of oil companies are crucial
Oil companies possess experience, technology, data, and more expertise to manage the project. Recommendation: cooperate with oil companies.

• Lesson 4: CO2 utilisation and EOR are challenging CO2 storage.
CO2-EOR and CO2 utilisation are always priorities because of economy benefits.
Recommendation: progress CO2-EOR in parallel with other storage options.

• Lesson 5: Standard oil and gas production activities and additional CO2 activities are needed
Recommendation: incorporating CO2 activities into GD projects

• Lesson 6: Extensive work need to be done to set up legal frameworks
Recommendation: Legal framework could be built on existing framework or international experience.

关注煤化工厂，解析中国CCS技术初期发展机会
（演讲人：魏宁，中科院岩土所）

• 二氧化碳封存的源汇组合介绍
• 碳封存成本模型建立分析
• 沿海地区煤化工工业的CCS发展前景解析
随后，魏宁博士介绍了国华富氧燃烧电厂示范项目二氧化碳在鄂尔多斯盆地封存预可研成果。以刘家沟组砂岩层储-盖组合和马家沟• 组灰岩层储-盖组合作为例介绍了：
• 神木CCS项目碳埋藏地选择
• EOR地址选择
• CCUS的经济性模型评估

Early opportunities of CCS development in China, focusing on coal chemical plants
(Dr Ning Wei, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences)

• Source-sink matching of carbon storage
• Cost potential estimation of CCS project
• Costal potential of CCS preojct for coal chemical plants
Thereafter, Dr WEI gave a brief introduction of the results of pre-feasibility study of CO2 geological storage demonstration project for Guohua oxy-fuel combustion plant in the Ordos Basin. Liujia Gou sandstone formation and Majiagou carbonate formation are taken as examples to illustrate:
• The site selection framework of Shenmu CCS project
• The site selection for EOR
• Technical-economic model for CCUS evaluation.

从孔隙学角度分析了二氧化碳封存和EOR 技术
（演讲人：范先锋，爱丁堡大学）

• 二氧化碳在地层孔隙中运移

Pore scale study for CO2 storage and enhanced oil recovery
(Dr Xianfeng Fan, University of Edinburgh)

• Introduction of CO2 displacement and migration in pores

• 空气、CO2、天然气在相同孔径中有不同的运移阻力。实验证明，能够安全封存天然气的盖层不一定能安全封存 CO2。
• 接触角的实验结果及影响因素分析得出，接触角与空隙大小，流质成分等有关。
• 孔隙润湿过程视频，当压力大于 60 bar 时CO2由气相转变为液相。

• Study of pore resistance of air, CO2 and natural gas. The result shows if a reservoir can hold natural gas does necessary mean it can hold the same column height of CO2.
• Contact angle between wetting and non-wetting phase is influenced by the pore size, fluids chemistry, et al.
• Video of pore wetting process in difference pressure. CO2 turns from gas phase to liquid phase at about 60 bar.

二氧化碳地质存储地点的鉴定、检验和验证及项目展示

（演讲人：Per Christer Lund，挪威船级社）

• 挪威船级社（DNV）全球人才、分布、组织框架介绍
• DNV对于CCUS的理想
• CCUS项目在 DNV RP-J203 标准规范下的验证过程
• 地质封存地筛选要求
• 项目的鉴定和检验
• 以CarbonNet项目为例说明DNV-GL认证框架对于碳储存地的鉴定、检验、验证过程。

Validation, verification and certification of CO2 geological storage sites and projects

(Per Christer Lund, DNV GL)

• The exceptional people, geographic distribution and organization arrangement of DNV in a global network.
• The ambition of DNV for CCUS.
• Certification process of geological carbon storage in accordance with DNV RP-J203.
• Requirements for storage sites in screening phase.
• Validation and verification of CO2 storage projects.
• Taking CarbonNet project as an example to illustrate the validation, verification and certification of a project.

讨论和总结

（总结发言人：Bill Senior，Stuart Haszeldine）

• 海陆封存相比内陆封存安全性更高，存储条件更适宜，但是成本相对也更高，并且没有先例可供借鉴。
• 二氧化碳的从地层的泄露可能性非常小。一些天然二氧化碳泄露实例不能作为碳封存项目的安全性类比。
• 运输管道是最主要的泄露途径。
• 与石油公司合作得到可靠的数据非常重要。中国地质图集即将发表。

Discussion and summary

(Bill Senior and Stuart Haszeldine)

• Offshore storage is much better because it is more secure, manageable and had better capacity. But it is more expensive and there is no experience for offshore CO2-EOR.
• The possibility of CO2 leakage is rather small. Some natural leakages could not be good analogues.
• Pipeline transport is most risky to cause leakage.
• Data acquisition is still a big problem. Collaborating with oil companies is important. ATLAS of China is about to publish.

会议照片
Meeting photos

图 1：徐少华常务副省长（左二）与 Gregory Barker 大臣（右一）在会议第一节结束后亲切交流

Figure 1: Mr XU Shaohua (left 2) and Mr Gregory BARKER (right 1) has a discussion after the first session

图 2：罗必雄院长（左一）与徐少华常务副省长（左二），吴道文副主任（右二），龚国平副主任（右一）介绍广东院情况

Figure 2: GEDI President LUO Bixiong (Left 1) introduces GEDI to Deputy Governor XU Shaohua (Left 2), and Deputy Director General of GDDRC WU Daowen (Right 2) and Deputy Director General of Guangdong Science and Technology Department Mr GONG Guoping (Right 2)

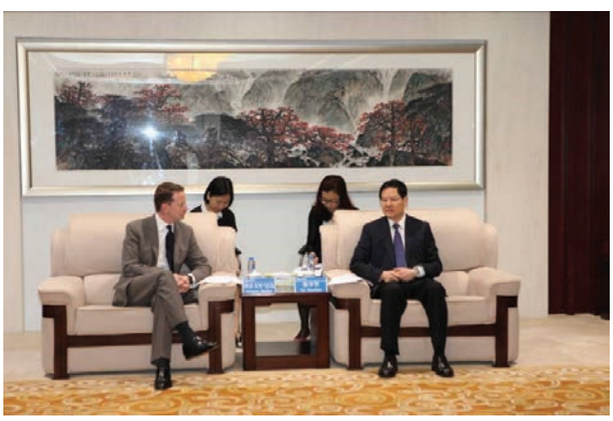

图 3：Gregory Barker 与徐少华常务副省长在广东院进行会谈

Figure 3: Gregory Barker Minister and Deputy Governor XU Shaohua discusses in GEDI

图 4：Gregory Barker 部长与部分参会嘉宾在中英（广东）CCUS中心合影

Figure 4: Group Photo at UK-China (Guangdong) CCUS Centre

图 5：英国能源与气候变化部副部长 Gregory Barker 先生在第二届广 东国际碳捕集利用与封存会议上发言

Figure 5: Mr Gregory Barker Speaks at the 2nd Guangdong International CCUS Conference

图 6： 英国能源与气候变化部副部长 Gregory Barker 先生和英国代表团就坐

Figure 6: Mr Gregory Barker and UK Delegates take seat

图 7：中国能建广东省电力设计院罗必雄院长致词

Figure 7: President of GEDI, Mr LUO Bixiong gives a speech

图 8：中英（广东）CCUS 中心主任陈澜在第二届广东国际碳捕集利用与封存会议上致辞

Figure 8: UK-China (Guangdong) CCUS Centre Director CHEN Lan speaks at the 2nd Guangdong International CCUS Conference

图 9： 中海油杨勇处长为 CCUS 示范项目与顶层规划给予建议

Figure 9: Director YANG Yong from CNOOC advices on CCUS demonstration project and planning

图 10： 王岩教授致辞讲述知识产权保护和转让

Figure 10: Speech by Prof WANG Yan from South China University of Technology on IPR Protection & Transfer

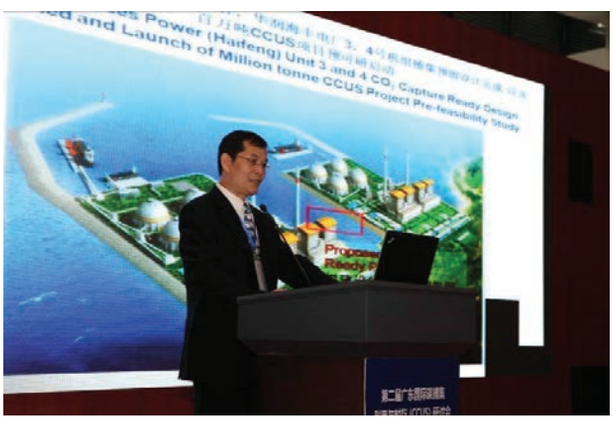

图 11： 华润电力朱和平先生介绍华润海丰 CCUS 示范项目

Figure 11: Mr ZHU Heping from China Resources Power (CRP) introduces the CRP CCUS demonstration programme.

图 12： 英国政府 CCS 示范项目顾问 Bill Senior 先生主持示范项目环节

Figure 12: UK Government CCS demonstration project advisor Mr Bill Senior chairs the session

图 13： 壳牌集团 CCS 总经理 Tim Bertels 先生介绍壳牌 CCS 项目

Figure 13: Shell Group CCS General Manager Tim Bertels introduces Shell CCS Projects

图 14：中心秘书长做中心工作简报

Figure 14: Mr LIANG Xi, Secretary General of the Centre, released the work report

图 15：英方专家参观中英（广东）CCUS 中心办公室。从左至右：Stuart Haszeldine 教授，李佳博士，Gregory Barker 先生，Jon Gibbons 教授，梁希秘书长，杨晖先生

Figure 15: UK experts visited the office of UK-China CCUS Centre. From left to right: Pro Stuart Haszeldine, Dr LI Jia, Mr Gregory Barker, Pro Jon Gibbins, Dr LIANG Xi, Mr YANG Hui

图 16：中英（广东）CCUS 中心顾问委员会副主席主持最佳实践工作组会议

Figure 16: Mr LI Kejun, deputy chairman of UK-China (Guandgong) CCUS Centre Advisory Panel co-chairs the best practice working group meeting

图 17：挪威船级社专家 Per Christer Lund 主持最佳实践工作组会议

Figure 17: Per Christer Lund from DNV GL co-chairs the best practice working

图 18 ： 豪顿集团 Richard Smith 先生在成本下降分组讨论中发言

Figure 18: Richard Smith from Howden Group speaks in the cost reduction

图 19：英国 CCS 中心主任 Jon Gibbins 教授进行总结发言

Figure 19: Director of UKCCSRC Prof Jon Gibbins concludes for the workshop

图 20：中海油惠州炼化代表曹孙辉对于碳封存的建议

Figure 20: Representative of CNOOC Huizhou Refining and Chemical makes suggestions for carbon storage

图 21 ： Stuart Haszeldine 教授介绍二氧化碳封存最佳实践

Figure 21: Pro Stuart Haszeldine introduces the best practices for carbon storage

图 22：广东院工程师邹竞成女士介绍燃煤电厂近零排放

Figure 22: Ms Zou from GEDI introduces near zero emission in GEDI

图 23：中科院南海所周蒂教授介绍广东碳封存地

Figure 23: Pro ZHOU from South Sea Institution of Oceanology introduces carbon storage sites in Guangdong

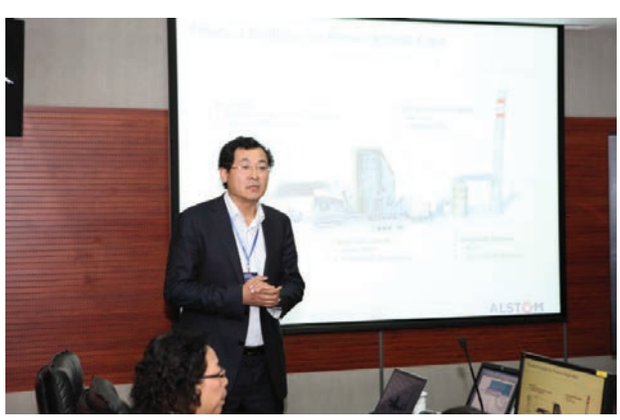

图 24：阿尔斯通李凡先生介绍传统污染物处理经验

Figure 24: Mr LI Fan from Alstom introduces traditional pollutants treatments

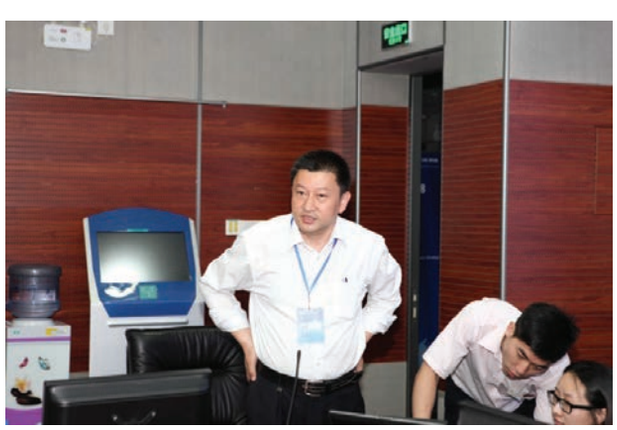

图 25：中国石油大学彭勃教授介绍 CCS 量化与检验标准体系的建立

Figure 25: Pro PENG Bo from China Petroleum University introduces Standard System Construction of CCS quantification and verification

图 26：来自阿尔斯通的梅报春先生介绍英国 CCS 白玫瑰项目

Figure 26: Mr MEI Baochun from Alstom introduces UK CCS White Rose Project

图 27：广东省科技记者协会代表林亚茗女士介绍公众关系对能源项目开发的影响

Figure 27: Ms Lin Yaming from Science Journalist Association introduces the role of public relation in energy project development

图 28：中科院武汉岩土所的魏宁教授介绍二氧化碳内陆封存

Figure 28: Prof WEI Ning from Institute of Rock and Soil Mechanics, Chinese Academy of Science, introduces on-shore carbon storage

图 29：华能集团清能院刘练波先生介绍华能碳捕集中试项目

Figure 30: Mr LIU Lianbo from Huaneng Clean Energy Institute introduces the Huaneng Carbon Capture Pilot Project

图 30：来自爱丁堡大学的安炯雄先生介绍制氢厂实现二氧化碳捕集

Figure 30: Mr Hyungwoong AHN from the University of Edinburgh introduces carbon storage in H2 plants

图 31：壳牌康索夫张国华先生介绍火电厂清洁技术

Figure 31: Mr ZHANG Guohua from Shell Cansolv introduces clean power technology in coal-fired plants

图 32：政策、融资与传播小组会议讨论现场

Figure 32: Policy, finance and communication strategies panel meeting

图 33：陈澜主任总结 CCUS 示范项目讨论结果

Figure 33: Mr CHEN Lan, the director of the centre makes conclusion for CCUS demonstration projects

图 34：爱丁堡大学李佳博士总结近零排放和成本下降有关讨论结果

Figure 34: Ms LI Jia introduces conclusions for near zero emission and cost reduction for carbon capture

图 35：李科浚先生总结运输、封存、利用讨论组结果

Figure 35: Mr LI Kejun makes conclusion for transport, storage and utilization group panel

图 36：中海油杨勇先生总结碳封存

Figure 36: Mr YANG Yong from CNOOC concludes for carbon storage

图 37：Peta Ashworth 教授总结政策、融资与传播战略专场

Figure 37: Prof Peta Ashworth concludes for Policy, finance and communication group meeting panel

胡爱和
Aihe Hu

胡爱和，男，现就职于中集安瑞科控股有限公司，任技术总监。毕业于江西工业大学化工设备与机械专业，获同济大学环境工程专业硕士学位。曾在国内某大型企业历任技术科长、研究所长、副总经理、副总工程师、总经理。研究成果液化气体汽车罐车获省级新产品二等奖、大型热交换器获国家经贸委优秀新产品奖、球形储罐获省部级名牌产品称号等以及多篇论文、论著在权威科技期刊发表，曾任国家锅容标委/低温工作组组长，获压力容器设计审批员资格证书等。

Aihe Hu is technical director of CIMC Enric Holding Co., LTD. He received his Bachelor's degree in chemical equipment and machinery from Jiangxi University of Technology, and then received a Master's degree in environmental engineering from Tongji University. He has worked for a large domestic enterprise successively as the technology section chief, research director, deputy general manager, deputy chief engineer and general manager. A liquefied gas tanker designed by him was awarded the second prize for provincial new products. He also developed a large heat exchanger which was awarded Excellent New Product by the State Economic and Trade Commission and a spherical tank that was awarded the provincial famous brand. He has published several papers and treatises in authoritative technical journals. He has been an ADC examiner for pressurized vessel design and worked for the Boiler Pressure Vessel Standardization Technical Committee as the leader of the low temperature working group.

Bill Senior

Bill Senior是一位专门从事碳捕集与封存（CCS）的独立低碳能源顾问。他一直为欧洲委员会、英国政府、英国石油公司、其他大型能源企业和较大型咨询公司工作。他的主要专业领域涉及CCS和上游油气项目开发、地质封存、CCS政策法规以及上游油气。在CCS方面的经验包括在英国、阿尔及利亚以及中国的各类项目。他曾是政府间气候变化专门委员会（IPCC）《碳捕集与封存特别报告》的主要作者之一，负责地质封存和经济部分。先前他曾参与实施欧洲CCS指令的指引文件准备工作，而且还为DECC审查英国地质封存的工业潜力和封存义务。参与了当前英国的CCS竞赛。他一直为许多项目担任顾问——目前参与广东-英国CCS项目，而且是CO2QUEST项目的顾问委员会成员。
Bill以前曾在英国石油公司的商业和技术部门履职32年，工作涉及可替代能源、天然气的勘

Bill Senior is an independent low carbon energy consultant who specialises in Carbon Capture and Storage (CCS). He has worked for the European Commission, UK Government, BP, other major energy companies, and larger consultancies. His main expertise is in CCS and upstream Oil/Gas project development, geological storage, CCS policy/regulation and upstream oil and gas. His experience with CCS projects includes various projects in UK, Algeria and China. He was a Lead Author on the Intergovernmental Panel on Climate Change (IPCC) Special Report on Carbon Capture and Storage contributing to the chapters on Geological Storage and Economics. He was previously involved in preparation of Guidance Documents for implementation of the European CCS Directive as well as reviews of industry potential for geological storage in the UK and storage liabilities for DECC. He is involved in the current UK CCS Competition. He has acted as an adviser on a range of projects - he is currently involved with the Guangdong-UK CCS project and is on the Advisory Board for the CO2QUEST project.

Previously Bill spent 32 years with BP in business and technology roles covering alternative energy, exploration and production and gas. He was BP's first technology manager for carbon capture and storage technology and subsequently a Senior Advisor in BP Alternative Energy.

探和开采等方面。他曾是英国石油公司碳捕集与封存技术首位技术经理和其后的英国石油公司可替代能源公司的高级顾问。他在石油地质学和上游石油业务的早期职业经历为其在地质封存方面的专业知识打下了基础。在八国峰会和2004-2006年英国欧盟轮值主席国期间，Bill还曾被借调到英国政府的国际气候变化小组。他曾在欧洲、美国、东南亚、中国和俄罗斯工作过。他获得了牛津大学地质学学位，而且是地质学会会员。

His earlier career experience in petroleum geology and upstream oil business underpins expertise in geological storage. He was seconded to the UK government's International Climate Change team during the G8 and EU presidencies between 2004-2006. He has worked in Europe, USA, SE Asia, China and Russia. He is a Fellow of the Geological Society and has a degree in geology from Oxford University.

周蒂
Di Zhou

1994年6月加入九三学社。现任中国科学院南海海洋研究所研究员、博士研究生导师、中国科学院边缘海地质重点实验室学术委员会副主任，广东省石油学会常务理事、地质专委会委员副主任。曾任中国科学院南海海洋研究所副所长，国际数学地质学会理事，国际地层学会定量地层委员会秘书，中国地质学会数学地质专委会副主任，德国波罗的海海洋研究所客座教授、台湾大学客座教授。1965年中南矿冶学院毕业，1984年美国堪萨斯大学获博士学位。

Di Zhou received her PhD degree from the geology department of the University of Kansas, USA in 1984 and majored in mathematical geology. After that she worked in the South China Sea Institute of Oceanology (SCSIO) of the Chinese Academy of Sciences, studying the geological structure, evolution, and hydrocarbon resources of the South China Sea. She has led over 30 research projects and published over 150 professional papers. She served as the vice director of the SCSIO, council member of the International Association for Mathematical Geologists, and secretary of the International Committee of Quantitative Stratigraphy. She also served as a member of the standing committee and vice chairman of the Committee for Population, Resources, and Environment in the Guangdong Provincial Political Consultant Committee. From 2003-2005 she worked as one of the lead authors of Chapter 5 (underground geological storage) of the IPCC Special Report Carbon Dioxide Capture and Storage. From Apr 2010 – Mar 2013 she led and completed the project CCS Readiness in Guangdong Province (GDCCSR), which is the first comprehensive and regional CCS-readiness study in China. Prof Zhou is also contributing to the ICCUS project.

张国华
Guohua Zhang

在电力和环保行业工作了19年，其中有10年的时间在巴布科克•威尔科克斯公司担任设计工程师、项目工程师和项目经理职务；有7年的时间在美国玛苏莱环保技术公司担任中国区首席代表。1995年毕业于哈尔滨理工大学热能工程专业，2005年毕业于中国人民大学经济学院获得经济学硕士学位。2012年加入壳牌，并在其旗下全资子公司康索夫科技北京公司担

John Zhang has 18 years of experience in the electric power and environmental industries of which 10 years has been with the Babcock & Wilcox Company as design engineer, project engineer and project manager. Additionally, he worked for seven years for Marsulex Environmental Technologies Inc. as Chief Representative in China. John graduated from Harbin University of Science and Technology in 1995 with a Bachelor in Engineering and also received a Masters in Economics from Renmin University of China in 2005. He joined Shell Cansolv in 2012 as Deputy General Manager of Shell Cansolv China, a subsidiary of Shell and responsible for the commercial and business

任副总经理，并负责康索夫公司在中国的商务和业务开发。

development of Cansolv in the China market.

朱和平
Heping Zhu

朱和平1980年3月参加工作，在列车电站从事锅炉运行工作，担任司炉。后调入锦州发电厂（总容量1200MW）从事热能动力设备的检修技术管理工作，先后任班组技术员、生技处锅炉专责工程师、副处长、处长、检修副总工程师，2008年7月起任华润电力(海丰)有限公司技术副总监。朱总监长期从事火力发电厂的技术管理工作，熟练掌握火力发电厂的生产工艺流程，具有较高的技术水平并积累了丰富的管理经验，曾到过美国和日本相关企业进行考察学习，对IGCC和CCUS有充分的了解。朱和平先生也是中英（广东）CCUS中心示范项目工作组组长。

Mr Heping ZHU started his career in March 1980 as a chief stoker. Then he moved to work in the maintenance department at Jinzhou Power Plant (1200MW total installed capacity), starting as a technician, and then was successively promoted to boiler engineer, deputy director, director, and deputy chief engineer. In July 2008, Mr Zhu was appointed as the deputy director of technology in China Resources Power (Haifeng) Limited. Mr Zhu is an expert in the technical management of power engineering, familiar with the power generation process, with significant management experience and technical knowledge. Mr Zhu has visited US and Japanese companies, and has a good understanding of IGCC and CCUS technologies. Mr Zhu is also the leader of the CCUS demonstration project working group in UK-China (Guangdong) CCUS Centre.

Hyungwoong
Ahn

安詗永是爱丁堡大学碳捕集科学与创新讲师。自从他完成干燥气体吸附的博士论文，他在气体分离过程已经有超过15年经验。安博士曾经是伦敦大学的研究人员。在加入爱丁堡大学前，他曾经在SK能源，韩国最大的炼油厂工作，从事过程设计和仿真。安还牵头英国研究理事会碳捕集在炼油过程技术的项目，和一个韩国资助的煤炭制氢气碳捕集的项目。安发表过35篇论文和10个专利。

Dr Hyungwoong Ahn (HA) is a Science and Innovation Award Lecturer in Carbon Capture in University of Edinburgh (UoE). HA has been working on adsorptive gas separation processes for more than 15 years since he started his PhD study on air drying adsorption systems. HA had been a Research Fellow in UCL working on monolithic adsorption processes for CO2 capture. Before joining the UoE, HA had worked for SK Energy, the largest Korean refining company, on refining process design and simulation. HA led an EPSRC project (EP/J018198/01, Carbon capture in the refining process) and a KETEP-funded project on a Coal-to-H2 process with carbon capture. HA is the author of over 35 refereed research papers and 10 patents.

王健
Jian Wang

王健上海交通大学EMBA硕士在电力行业拥有超过15年市场经验，并且代表豪顿于2010年开始参与国内碳捕集与封存项目。除此之外王健也涉及到环保领域及化工领域的市场开发，在2013年王健被正式任命为豪顿集团的新业务发展经理负责东亚区域。工作外，王健也是一位马拉松运动的爱好者。

Jian Wang was awarded his Master's degree in EMBA from Shanghai Jiao Tong University and has worked in the electric industry for over 15 years. Since 2010 he has participated in the domestic carbon capture and storage project on behalf of Howden. In addition, he is also involved in the market development of environmental protection in the chemical industry. He was appointed as Howden's East Asia regional new business development manager in 2013. Outside the workplace Jian is a marathon enthusiast.

Jon Gibbins

Jon Gibbins 是中英（广东）CCUS中心副主任，英国CCS中心主任。Gibbins教授在煤炭和生物质的气化和燃烧领域的工作经验已逾30年，先后在福斯特惠勒、帝国理工学院和爱丁堡大学任职，自2002年起从事碳捕集与封存相关研究。他目前任职爱丁堡大学电厂工程与碳捕集教授兼英国CCS研究中心（www.ukccsrc.ac.uk）主任。英国CCS研究中心由英国研究理事会支持，以领导并协调所有CCS相关的基础研究的计划，以支持英国能源和气候变化方面的基础科学发展和政府工作。他还在英国及海外参与了多项其它的CCS学术、工业和政府计划，包括英国能源与气候变化部科学顾问小组和CCS发展论坛，并推动了许多CCS媒体报道和推广活动。

Jon Gibbins已经发表了50多篇论文和100多篇关于碳捕集与封存及其相关课题的文章和报告。他力求借助这些碳捕集与封存活动传递一种技术、政策和经济发展的结合，而这些正是将碳捕集与封存迅速推进到可以为全球气候变化减缓作出实际贡献的阶段所必需的。他早期的工作表明，相对常规的电厂有可能适应高效的和具有成本效益的二氧化碳捕集。这被扩展至“捕集预留”概念，这一概念在英国2005年G8领导人提案中首次引起强烈关注。他另外的一些工作（例如透过煤炭利用近零排放www.nzec.info; 中国先进电厂碳捕集方案项目www.capturereadyready.com）已经详述了这些主题，并将捕集技术的研究扩展至在充满弹性的实际的电力市场条件考虑其性能。

Jon Gibbins is the director of UK CCS Research Centre, Deputy Director of UK-China (Guangdong) CCUS Centre. Jon has worked on coal and biomass gasification and combustion for over 30 years, at Foster Wheeler, Imperial College and the University of Edinburgh and on carbon capture and storage (CCS) since 2002. He is currently Professor of Power Plant Engineering and Carbon Capture at the University of Edinburgh and Director of the UK CCS Research Centre (www.ukccsrc.ac.uk), which is supported by Research Councils UK to lead and coordinate a programme of underpinning research on all aspects of CCS in support of basic science and UK government efforts on energy and climate change. He is involved in a number of other academic, industrial and government initiatives on CCS in the UK and overseas, including the DECC Scientific Advisory Group and CCS Development Forum, and has also contributed to a number of media pieces and other outreach activities on CCS.

Jon has authored over 50 papers and more than 100 articles and reports on CCS and related topics. The strategy behind Jon's CCS activities is helping to deliver the combination of technical, policy and economic advances that are required to progress CCS rapidly to the stage where it can make an effective contribution to global climate change mitigation. His early work showed that relatively conventional power plants could be adapted to give efficient and cost-effective CO2 capture. This was extended to the 'capture ready' concept, which first received significant attention as part of the UK's 2005 G8 chair proposals. Additional work (e.g. through NZEC, www.nzec.info; CAPPCCO www.captureready.com) has expanded on these themes and also extended the study of capture technologies to considering their performance under real electricity market conditions, where flexibility is at a premium.

陈澜
Lan Chen

陈澜，男，汉族，1989年7月参加工作，1996年8月加入中国共产党，高级工程师，注册一级建造师。

在中国能源建设集团广东省电力设计研究院工作的25年以来，作为了电气一次工程师、主设人、发电二室副组长，电控室主任，在一线积累了丰富的基层工作经验，2004年12月起，

Lan Chen is director of the UK-China (Guangdong) CCUS Centre, and the Chief Engineer of the China Energy Construction Group Guangdong Electric Power Design Institute (GEDI). Mr Chen has worked in GEDI for more than 25 years, he has been an electrical engineer, chief designer, deputy head of group in power generation department, and electric control room director. He has accumulated much experience in different working areas. Since Dec 2004, he has undertaken a technology managerial role. In this period, as the manager for some

开始承担技术管理工作。期间，作为多个大型项目的项目经理，积累了丰富的工程实践经验，目前任广东省电力设计研究院总工程师。陈总工程师致力于推进碳捕集、储存与利用等新技术在中国能源行业推广与应用，对于通过新技术在能源行业的应用解决中国的污染问题有独到的见解。
陈澜先生也是中英（广东）CCUS产业促进与学术交流中心主任。

major projects, he accumulated significant practical experience. Mr Chen is dedicated to promoting the application of Carbon Capture and Storage technologies, and has a good understanding on how new technologies may address pollution issues in China.

刘练波
Lianbo Liu

刘练波，高级工程师，硕士，英国帝国理工大学访问学者，中国化工学会离子液体专委会委员。2006年毕业于西安热工研究院热能工程专业获得硕士学位；2006年～2007年赴英国帝国理工大学学习。目前就职于中国华能集团清洁能源技术研究院有限公司，温室气体减排工艺与设备研究所所长。主要参与了中国华能集团主持的华能北京热电厂3000~5000t/a CO2捕集示范项目及华能石洞口第二电厂12万吨/年脱碳工程，同时参与了多项针对二氧化碳捕集与封存技术的国家863项目及国际合作项目。迄今，获得国家专利8项，发表论文10余篇，并获得省部级奖项4项，其中中国电力科学技术奖一等奖两项，国家能源科技进步一等奖一项。

Lianbo Liu, a senior engineer and a member of the ionic liquid ad hoc committee of the Chemical Industry And Engineering Society Of China, received his Master's degree on thermal power engineering from Xi'an Thermal Power Research Institute in 2006, and then went to Imperial College as a visiting scholar in 2006-2007. He is now working in the Huaneng Group Clean Energy Technology Research Institute as the director of greenhouse gas emissions reduction technology and equipment research institute. He is one of the primary participants in Huaneng Group's Beijing Thermal Power Plant 3000~5000 t/a CO2 capture demonstration project and Shidongkou Second Power Plant 120,000 t/a decarburization project. Meanwhile, he participated in several of China's "863" projects and international cooperation projects on CO2 capture and storage technology. To date he has 8 national patents, published more than 10 papers, and won 4 provincial or ministerial awards which includes 2 first prizes in China electric power science and technology awards and 1 first prize in the national energy science and technology progress award.

Michael Mel

梅报春是阿尔斯通（中国）投资有限公司的政府事务总监，主要负责阿尔斯通集团在华企业在能源、可持续发展以及环境领域与政府的沟通。他曾在政府工作，在相关领域拥有19年的工作经验。阿尔斯通是全球清洁能源发电、电力传输及轨道交通领域设备和解决方案的主要提供商。

Michael Mei is Director of Government Affairs in Alstom China. He is mainly responsible for engaging with government on environment, sustainability and energy issues for all Alstom businesses in China. Michael has 19 years of professional working experience within the government or engaging with government. Alstom is a major global supplier of clean power generation & transmission, and rail transportation equipment and solutions. As a leading clean low carbon technologies provider, Alstom advocates for a leveling of the playing field and has strong support for carbon pricing, preferably via trading systems. Alstom's offering of low carbon technologies can help our industry customers to realize its emission reduction targets.

魏宁
Ning Wei

魏宁博士，中国科学院岩土力学研究所副教授，主要专注于二氧化碳封存技术的研究，包括可行性研究（封存地点选择、源汇匹配、技术筛选、技术与设备盘点、经济评估、风险分析等）、实验室实验、数值模拟、以及二氧化碳地质封存（主要从事二氧化碳提高石油采收率和二氧化碳含水层封存）现场工作。他是中国科学院青年创新促进会会员。

Dr. Ning Wei is an Associate Professor of the Institute of Rock and Soil Mechanics, Chinese Academy of Sciences (IRSM, CAS). He mainly focuses on CO2 geological storage technologies, including feasibility studies (site selection, source-sink matching, technologies screening, technologies & equipment inventory, economic evaluation, risk analysis, etc.), laboratory experiment, numerical simulation, and field work on CO2 geological storage (mainly on CO2-EOR and CO2 aquifer storage). He is a member of the Youth Innovation Promotion Association in the Chinese Academy of Sciences.

李鹏春
Pengchun Li

男，1978年生，博士，中国科学院南海海洋研究所副研究员，长期从事二氧化碳捕集与封存研究。曾负责主办了中-澳二氧化碳地质封存海洋封存专场国际暑期培训班，主持中国地质调查局地质调查项目“全国浅海沉积盆地二氧化碳地质储存潜力与适宜性评价”，主持国家自然科学基金“CO2高注入压力对海底断层泄露特性的影响机理研究”，在中-英合作的“广东省CCS可行性研究”和“广东ICCUS”项目中担任技术骨干，主要开展南海北部二氧化碳的海洋地质封存潜力评估与潜在封存场地评价研究。曾赴延安、鄂尔多斯、阳江等地考察了二氧化碳驱油、二氧化碳捕集与封存示范工程、海洋生物固碳示范项目。

Pengchun Li is an associate researcher in the South China Sea Institute of Oceanology Chinese Academy of Sciences that has been working on CO2 capture and storage research for years. He hosted the China-Australia carbon dioxide geological sequestration international summer class, the China Geological Survey project - “national shallow sedimentary basin CO2 geological storage potential and suitability assessment”, the Natural Science Foundation of China project “The influence of high CO2 injection pressure on the seabed fault’s leakage features”, and was the technical backbone in UK-China “Guangdong CCS feasibility research” and “Guangdong ICCUS” project which mainly assessed the potential CO2 geologic sequestration capacity and potential sequestration sites in the northern South China Sea. He once went to Yan’an, Ordos and Yangjiang to investigate local CO2 flooding, and to see carbon dioxide capture and storage, and marine biological carbon sequestration demonstration projects.

Per Christer Lund

Per Christer Lund博士出生于挪威斯塔万格市，他在1985年和1992年分别获得挪威科技大学化学工程专业的硕士和博士学位。Per Christer一直任职于能源和环境业务的多个职位，包括研究、软件开发和咨询。
早在1993年，Per Christer就作为一名博士后在日本从事CCS（碳捕集与封存）工作，而且在1997年作为一名研究员在日本的“普贤”核反应堆工作。在其日本博士后学业之后的四年间，Per Christer在能源技术研究院从事开发应用于石油工业和电力市场的动态与随机过程的建模与模拟。

Dr. Per Christer Lund was born in Stavanger, Norway and received his Master (“Sivilingeniør”) and PhD from the Norwegian University of Science and Technology in chemical engineering in 1985 and 1992 respectively. Per Christer has been engaged in the energy and environment business in a variety of positions including research, software development and consulting.

Per Christer has worked on CCS (Carbon Capture and Storage) as a post-doc in Japan as early as 1993 and as research fellow at the Japanese nuclear reactor "Fugen" in 1997. Following his post-doc in Japan, Per Christer worked with development of dynamic and stochastic process modeling and simulation at Institute of Energy Technology (“IFE”) with application towards the petroleum industry and electricity market over a period of 4 years.

他还一直参与北美、印度和欧洲开放电力市场的设计和运营；目前是纳斯达克OMX集团驻加拿大经理兼挪威Nord Pool咨询公司高级副总裁；曾在印度参与设计国内电力批发市场（客户：电力部/印度国家热电集团）、在土耳其设计国家电力批发市场（客户：土耳其输电公司）、以及为爱尔兰和北爱尔兰模拟和启用“全岛”电力市场（客户：爱尔兰电力监管委员会）。他还对来自亚洲国家（韩国、印度、日本、菲律宾、新加坡）的各种客户进行培训并提供咨询。

2006年以来，Per Christer担任挪威驻东京大使馆科技顾问，专门负责挪威与日本之间能源与环境方面的技术研究合作，曾被任命为挪威创新署东京办事处的办公室经理9个月。2011年，Per Christer在日本创办了挪威环境技术中心（NETC）并管理该中心。NETC是由挪威能源与环境技术创新署主办的首个公私伙伴关系项目，并且将挪威船级社、挪威科技工业研究院和挪威国家石油公司纳入合作伙伴。

Per Christer从2014年3月起加入DNV GL集团位于新加坡的清洁技术中心，担任亚洲地区电力市场改革、智能能源系统和可再生能源顾问。Per Christers的学术专长集中于CCS、碳市场、可再生能源，包括风能、能源市场和其他能源主题，如氢气利用和甲烷水合物。

Per Christer has also been involved in design and operation of deregulated electricity markets in North America, India and Europe; as country manager for now NASDAQ OMX in Canada and Senior Vice President at Nord Pool Consulting in Norway. During his two years at Nord Pool Consulting, Per Christer was engaged in designing the intra-state wholesale electricity market in India (client: Ministry of Power/NTPC), design of the national wholesale electricity market in Turkey (client: TEIAS), and modelling and implementation of the “All Island” electricity market for Ireland and Northern Ireland (client: Irish regulator CER). He was also engaged in training and consulting to a variety of clients from Asian countries (Korea, India, Japan, Philippines, Singapore).

Since 2006, Per Christer held the position as Science and Technology Counselor at the Norwegian Embassy in Tokyo, with special responsibility for technology and research collaboration within energy and environment between Norway and Japan. Per Christer was constituted office manager for Innovation Norway’s Tokyo office for a 9 month period. In 2011 Per Christer established and directed the Norwegian Environmental Technology Center (NETC) in Japan. NETC is the first private-public-partnership project hosted by Innovation Norway on energy and environmental technologies, and included DNV, Sintef and Statoil as partners.

From March 2014, Per Christer joined DNV GL’s Clean Technology Center in Singapore, where he will act as a consultant on electricity market reforms, smart energy systems and renewable energy in the Asia region. Per Christers academic expertise centers around CCS and carbon markets; renewable energy including wind; energy markets and other energy topics like hydrogen utilization and methane hydrates.

Peta Ashworth

Peta Ashworth创立了澳大利亚联邦科学与工业研究组织专门从事科学与社会的跨领域研究的“科学融入社会团队”。该团队应用社会科学专业知识来推断人类对全国一致认同的挑战的反应。Ashworth女士已经为澳大利亚联邦科学与工业研究组织管理了数百万美元的研究合同，尤其是在利益相关者对新能源技术的理解和接受方面。作为其工作的一部分，Peta与人合著了《澳大利亚联邦科学与工业研究组织家庭能源节约手册——如何节约能源、省钱和减

Peta Ashworth established CSIRO's Science into Society Group, which specialises in interdisciplinary research at the interface between science and society. The Group applies social science expertise to understand human responses to nationally-identified challenges. Ms Ashworth has managed multi-million dollar research contracts for CSIRO, particularly on stakeholder understanding and acceptance of new energy technologies. As part of her work Peta co-authored The CSIRO Home Energy Saving Handbook - How to save energy, save money and reduce your carbon footprint.

Ms Ashworth's key research interests are how to deliver information to best effect and facilitating dialogue around

少你的碳排放量》。
Ashworth女士的主要研究方向是如何以最佳效果发布信息和促进复杂和有争议问题的对话。作为一名理解气候变化和低排放能源技术公共认知的杰出研究者，她已经获得了国际声誉。Peta目前是澳大利亚联邦科学与工业研究组织科学融入社会团队流媒体负责人、昆士兰大学兼职副教授、人文艺术与社会科学委员会 (CHASS) 副总裁、以及国际能源署温室气体研发社会研究网络主席。

complex and contested issues. She has gained an international reputation as a leading researcher in understanding public perception to climate change and low emission energy technologies. Peta is currently Stream Leader for Technology in Society within the CSIRO Energy Flagship, an Adjunct Associate Professor for the School of Social Science at the University of Queensland, Vice President of the Council of the Humanities Arts and Social Sciences (CHASS) and Chair of the International Energy Agency Greenhouse Gas R&D Social Research Network

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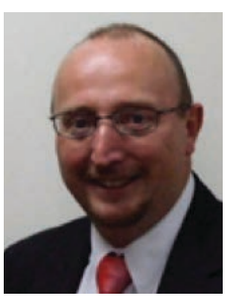

Richard Smith

Richard以技术、多产品、流程和直面商业客户的丰富经验，在支持技术开发商和使涉及广泛市场的新兴工艺为用户和公司产生利益的豪顿集团内部记性国际化运作。他早期的职业专注于与主要用于改变状态的传热旋转机械有关的工程应用和设备试运行。1989年，他进入压缩系统和制造领域，涉及离心机、往复运动机器，服务于食品、制药、金属冶炼、石化、发电和其他重工业。最近，凭借在旋转机械和工业流程技术方面35年的经验，他正在积极主动地开发新流程和市场，包括低碳技术。

With a wealth of technical, multi-product, process and commercial customer-facing experience, Richard operates internationally within Howden Group, supporting Technology Developers and generating both customer and company interest for Emerging Processes across of broad range of markets. His early career focused on application engineering and plant commissioning associated with rotating heat transfer machinery primarily for change of state. In 1989, Richard moved into compression systems and manufacture involving centrifugal and reciprocating machines, serving the food, pharmaceutical, metal refining, petrochemical, power generation and other heavy industry. More recently, and drawing upon 35 years experience of rotating machinery and industrial process technology, Richard is pro-active in the development of new processes and markets including low carbon technologies.

曹孙辉
Sunhui Cao

1987年大学毕业后，进入中国石油林源炼油厂催化裂化车间任操作员，1997-2000年担任生产运行处副处长；2000-2008年历任中国石油大庆炼化公司新项目指挥部 副指挥、聚丙烯厂厂长兼党委书记；2008年加盟中国海油，2013年5月任中海油惠州炼化分公司副总经理。同年4月，他被授予“全国五一劳动奖章”。

Sunhui Cao, who has been awarded the “National May 1st Labour Medal", started his job as the operator of the China National Petro Chemical (CNPC) Linyun Refinery after graduating from University in 1987. From 1997 to 2000, he worked as the deputy director of the operation and production team; from 2000 - 2008, he worked as the Manager of the Polypropylene Plant within CNPC Daqing Refinary. He joined China National Offshore Oil Company (CNOOC) in 2008 and became the Deputy Manager of the CNOOC Huizhou in 2013

Tim Bertels

Tim Bertels一直为壳牌国际公司效力了25年多，在世界各地的壳牌公司担任了几个技术和领导职位，包括在尼日利亚和文莱的合资企业。任务涵盖研发、油气勘探、技术实施、变革管理以及战略与规划。
自2004年以来，Tim把全部工作时间放在二氧化碳管理上，致力于管理和开发壳牌集团的碳捕集与封存项目投资组合。Tim正在把碳管理活动推广到世界各地，从加拿大到欧洲、中东和澳大利亚，在技术和非技术壁垒以及大型一体化CCS项目的交付方面，有其宝贵的见解。
Tim拥有荷兰代尔夫特理工大学采矿工程/地球物理学的理科硕士学位。

Tim Bertels has been working with Shell International for over 25 years, holding several technical and leadership positions in Shell Companies across the world, including joint ventures in Nigeria and Brunei. Assignments covered R&D, O&G Exploration, Technology Implementation, Change Management, and Strategy and Planning.

Since 2004 Tim has worked full-time on CO2 management, focusing on managing and developing the Shell Group's Carbon Capture and Storage (CCS) projects portfolio. Tim is driving carbon management activities across the globe from Canada through Europe, the Middle East and in Australia, gaining valuable insights into the technical and non-technical barriers and enablers to delivery of large-scale integrated CCS projects. Tim holds an MSc degree in Mining Engineering/Geophysics from Delft University of Technology in The Netherlands.

梁希
Xi Liang

梁希博士是中英（广东）CCUS中心秘书长，爱丁堡大学能源金融副教授。他在剑桥大学商学院获得能源经济学博士学位，于2005年在伦敦帝国理工学院开始从事碳捕集与封存研究。梁希博士在最近8年领导或参与了9个碳捕集与封存/气候变化项目，包括英国能源与气候变化部、英国外交和联邦事务部、国际能源署温室气体研发计划以及亚洲开发银行资助的项目。他发表了30多篇有关中国碳捕集与封存的学术论文。在加入爱丁堡大学之前，他曾是埃克塞特大学能源政策学讲师，环境、能源和韧性专业硕士课程联合主任，经济和社会研究委员会西南博士中心负责人。他的主要研究领域是包括碳捕集与封存在内的低碳技术经济学、融资和风险管理。他目前教授硕士研究生能源金融和低碳投资课程。同时梁希博士有丰富的财务咨询经验，是一名特许金融分析师。

Dr Xi Liang is the Secretary General of the UK-China Guangdong CCUS Centre, and a senior lecturer in Energy FInance at the University of Edinburgh. Dr Liang received a PhD in Energy Economics from the Judge Business School, University of Cambridge. He started his CCS research career at Imperial College London in 2005. Xi has led or participated in 9 major CCS / Climate Change projects in the last 8 years, incl. projects funded by UK Department of Energy and Climate Change, UK FCO, IEA GHG, and the Asian Development Bank. Xi has published more than 30 academic papers related to CCS in China. Prior to joining Edinburgh, he was a lecturer in energy policy and the pathway co-director of MRes in Environment, Energy and Resilience at the University of Exeter, and a pathway lead of the ESRC Southwest Doctoral Centre. His main research area was economics, financing and risk management in low carbon technologies, incl. CCS. He is teaching energy finance and low carbon investment for MSc students. Xi has significant financial advisory experiences. Dr Liang is also a Chartered Financial Analyst.

范先锋
Xianfeng Fan

范先锋博士是爱丁堡大学材料与流程学院的高级讲师。他曾是伦敦南岸大学的高级讲师，在加入伦敦南岸大学之前，他是伯明翰大学的研究院。他在中国获得学士和硕士学位，然后在2000年获得伯明翰大学的博士学位。他目前指导一个有8名博士生和一名研究员的研究小组，从事燃烧后二氧化碳捕集、湿层吸收剂和膜的开发、空隙润湿、二氧化碳封存多孔岩石中的多相流动、提高石油采收率、光催化、热能储存相变材料的开发、以及粒子技术，包括流体化、混炼和粒化的研究。
范先锋写作或合著了超过150篇同行评议文章和3篇专著章节。他是《材料科学与化学工程杂志》和《纳米科学与纳米技术》编辑部成员。他还曾被国际会议和论坛多次邀请作为主讲人。他完成的研究工作获得了中国政府和英国铸造工作者协会的奖励。

Dr Xianfeng Fan is a senior lecturer in the Institute for Materials and Processes at the University of Edinburgh (UoE). XF was a Senior Lecturer at London South Bank University. Prior to joining London South Bank University, he was a Research Fellow at the University of Birmingham. XF obtained his Bachelor and Master degrees in China and PhD from the University of Birmingham in 2000. He currently supervises a research team with 8 PhD students and one research fellow, working on post combustion CO2 capture, the development of wetting-layer adsorbents and membrane, pore wetting, multiphase flow in porous rock for CO2 storage and enhanced oil recovery, photocatalysis, and the development of phase changing materials for thermal energy storage, and particle technology including fluidization, mixing and granulation. XF has authored or co-authored over 150 peer reviewed articles and 3 book chapters. He is the editorial board members of “Journal of Materials Science and Chemical Engineering” and “Nanoscience and Nanotechnology”. XF has been invited as a keynote speaker at International conferences and forums. The research work delivered by XF has been rewarded by Chinese government and the Institute of British Foundrymen.

王岩
Yan Wang

华南理工大学知识产权学院教授，第一批公派美国企业管理留学生，美国纽约州立大学 (State University of New York) 硕士，七七级重庆大学计算机工学学士。1988年进入招商局集团；2005年9月出任深圳知识产权局副局长；2010年1月起在国家知识产权局管理司任司长助理；2010年8月被聘为华南理工大学知识产权学院教授。王岩教授目前带领团队主要研究知识产权制度设计、知识产权的价值经营。具体包括：企业IP资产管理与运营、产业标准与联盟、IP服务业、IP投资机制、IP债权与股权融资、资本市场IP要素的制度构建等。

Yan Wang, Professor of Intellectual Property under the School of Intellectual Property, South China University of Science and Technology. Prof Wang gained his master from the State University of New York and his started his undergraduate degree in Computer science at Chong-qing University in 1977. He was the Deputy Director of Shenzhen Intellectual Property Office since 2005 and act as the deputy director of the management division within the State Intellectual Property Office, PRC since 2010. After that he took up the professorship and Dean position at the South China University of Science and Technology.

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