Near ZERO Emission 近零排放

Spring Issue 春季刊 | 2017

第三届广东国际CCUS专家研讨会在广州召开

The 3rd Guangdong International CCUS Workshop Successfully Held in Guangzhou

国际CCUS技术发展现状

The Status of Global CCUS Technology Development

在低油价下如何开展二氧化碳封存和地质利用工作

How to Carry out CO_2 Storage and Geological Utilisation under Low Oil Prices

英国CCS项目经验分享：聚焦离岸封存

UK CCS Project Experience Sharing

目 录
Contents

第三届广东国际CCUS专家研讨会在广州召开 / 04

The 3rd Guangdong International CCUS Workshop Successfully Held in Guangzhou / 04

国际CCUS技术发展现状 / 20

The Status of Global CCUS Technology Development / 20

在低油价下如何开展二氧化碳封存和地质利用工作 / 29

How to Carry out CO_2 Storage and Geological Utilisation under Low Oil Prices / 29

英国CCS项目经验分享：聚焦离岸封存 / 42

UK CCS Project Experience Sharing / 42

Near ZERO Emission 近零排放 | Spring 2017 春季刊

第三届广东国际CCUS专家研讨会在广州召开

The 3rd Guangdong International CCUS Workshop Successfully Held in Guangzhou

2016年12月12日
Monday, December 12, 2016

2016年12月12-13日，中英(广东)CCUS中心主办、国家应对气候变化战略研究和国际合作中心和CCUS促进中心协办的“第三届广东国际CCUS专家研讨会：推动CCUS技术创新、降低成本和风险”在广州召开。广东省发改委副主任吴道闻、英国驻广州总领事馆总领事卢墨雪、英国驻华大使馆气候变化主管康霖、华润电力华南分公司总经理马力先生、亚洲开发银行可持续发展与气候变化局部门咨询服务处国际顾问Darshak Mehta出席会议并致开幕辞。

On 12-13 December 2016, the 3rd Guangdong International CCUS Workshop: “Accelerating CCUS Technology Innovation, Cost Reduction and Risk Mitigation” was successfully held in Guangzhou by the UK-China (Guangdong) CCUS Centre and co-organised by the National Center for Climate Change Strategy and International Cooperation (NCSC) and the China CCUS Centre. Mr Daowen Wu, Deputy Director of the Development and Reform Commission of Guangdong Province, Mr Matthew Rous, Consul-General of the British Consulate General Guangzhou, Mr Neal Carlin, Head of Energy and Climate Change, British Embassy Beijing, Mr Li Ma, General Manager of the South China Branch of China Resources Power (CRP) and Mr Darshak Mehta, International Consultant, SDAS, Sustainable Development and Climate Change Department, Asian Development Bank (ADB) each addressed the opening session of the workshop.

吴道闻先生，

广东省发展和改革委员会副主任

Mr Daowen Wu,
Deputy Director of Development and Reform Commission of Guangdong Province

“广东作为国家低碳试点省和碳排放权交易试点省，在应对气候变化工作中取得显著成效。CCUS作为最重要的减排技术之一，对于大幅度降低单位生产总值的能源和碳排放强度、实现低碳发展有重要的意义。”广东省发改委副主任吴道闻表示，“广东依托中英(广东)CCUS中心围绕技术产业化、示范CCUS融资和产业化等重点领域开展了多项实际工作，有力地推动了我省CCUS的前期工作。目前在制度创新方面，广东将结合现有电力体制改革工作，对开展CCUS的单位给予适当的支持，从政策上对企业给予适当的引导。”

Mr Daowen Wu said, “As the national low carbon pilot province and carbon emissions trading pilot, Guangdong has gained remarkable achievements in combating climate change. As one of the most important carbon emissions reduction technologies, CCUS is essential to substantially lower the energy and carbon intensity per unit of GDP and realise low carbon development. Based on the UK-China (Guangdong) CCUS Centre, Guangdong has conducted a number of projects on CCUS technology industrialization, financing and demonstration etc. which has effectively promoted preliminary CCUS work in Guangdong. At present, in terms of system innovation, Guangdong, in combination with the existing reform of the electric power system, will give appropriate support and policy guidance to enterprises carrying out CCUS.

卢墨雪先生，

英国驻广州总领事馆总领事

Mr Matthew Rous,
Consul-general of British Consulate General Guangzhou

“三年来，在国家发改委和广东省发改委的关心下，经过无数参与方的共同努力，CCUS前期研究取得了重大进展，我们正在研究在南海进行海底地质封存的可行性，以及二氧化碳封存、运输以及工业利用的初期路线图。”英国驻广州总领事馆总领事卢墨雪表示，发展CCUS、共同应对气候变化，已经在人类社会形成了广泛共识。英中两国为了应对气候变化，推动能源转型，在广东、华南开展了形式多样的合作，包括海上风电、碳排放权交易、绿色金融、可持续城镇化等。中心为CCUS领域专业人士提供了交流平台，希望中心能为CCUS事业以及相关产业的进一步发展继续做出积极的贡献。

Mr Matthew Rous said “Over the past three years, with the support of the National Development and Reform Commission and the Development and Reform Commission of Guangdong Province, through the joint efforts of many participants, major progress has been made in preliminary studies on CCUS. Currently, we are studying the feasibility of geologic storage under the South China Sea and a roadmap of carbon dioxide storage, transport and industrial utilisation. Human society has reached a broad consensus on developing CCUS and jointly combating climate change. The UK and China have cooperated in various areas including offshore wind, carbon emissions trading, green finance, sustainable urbanization etc. in Guangdong and in South China to promote energy transformation and to deal with climate change. The Centre provides a communication platform for professionals in the CCUS field. I look forward to further contributions by the Centre in the development of CCUS and relevant industries.

康霖先生，

英国驻华大使馆气候变化主管

Mr Neal Carlin,
Head of Energy and Climate Change, British Embassy Beijing

英国驻华大使馆气候变化主管康霖指出，有些人认为化石燃料仍是能源结构中不可缺的一部分，CCUS是实现两摄氏度温升目标的一项关键技术。他说，“今年，英国除了支持中英（广东）CCUS中心之外，还帮助在北京建立国家CCUS中心，支持新疆项目、四川碳封存项目的发展，并通过亚行信托基金提供了3500万英镑，支持中国大规模CCUS的发展。

Mr Neal Carlin said that some people still consider fossil fuels as an essential part of the energy mix, so CCUS is the key to limit the global average temperature rise to below 2℃. He said that the UK has supported not only the Centre but also the China CCUS Centre, carbon storage projects in Xinjiang and Sichuan, and the large-scale deployment of CCUS in China with £35m through the ADB’s trust fund.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

马力先生，

华润电力华南分公司总经理

Mr Li Ma,
General Manager of South China Branch of China Resources Power

华润电力华南分公司总经理马力先生说，“从2013年起，中心与华润电力多次就燃煤电厂的CCUS进行研讨，今年8月完成了碳捕集测试平台可行性研究报告的编制工作。如果报告评审通过，意味着CCUS将步入真正的实施阶段，根据计划，测试平台将于2017年开工建设。”

他说，“我们也在全力推动海丰电厂三、四号机组的申报、核准，为CCUS工作真正跨入实施应用提供保障。作为目前华南五省唯一的CCUS示范单位，华润海丰电厂任重道远。我们希望借助CCUS技术不断创新、降低成本和风险，卓有成效的推动项目落地，为广东省低碳产业化进程做出良好示范。”

Mr Li Ma said the Centre has discussed with China Resource Power many times on CCUS in coal-fired power plants. In August this year the feasibility study for a carbon capture test platform was completed. Once the report has passed review, CCUS will move into the real implementation stage and construction is planned to start in 2017.

He stated, “We are also making best efforts to promote the declaration and approval of Units 3&4 in Haifeng Power Plant to provide a guaranteed application for CCUS. As the only CCUS demonstration organisation in the five provinces in South China, the Haifeng Power Plant shoulders heavy responsibilities and still has a long way to go. We hope that we can demonstrate low carbon industrialization in Guangdong province with the help of CCUS technology innovation, cost and risk reduction and effective project implementation.”

Darshak Mehta先生，

亚洲开发银行可持续发展与气候变化局部门咨询服务处国际顾问

Mr Darshak Mehta, International Consultant, SDAS, Sustainable Development and Climate Change Department, Asian Development Bank (ADB)

亚洲开发银行可持续发展与气候变化局部门咨询服务处国际顾问Darshak Mehta发言说，中国在温室气体减排方面取得极大进展，提出了到2030年的宏伟目标。对于亚洲开发银行来说，我们内部有一个基金支持CCUS，同时在广州、上海、印尼建立CCS卓越中心。未来会通过中心支持一些技术框架和规范的建立，为减少温室气体排放做贡献。

Mr Darshak Mehta said "China has made great progress in greenhouse gas emissions reduction and set an ambitious goal for 2030. ADB has set up a CCUS fund and also supports the development of Centers of Excellence in Guangzhou, Shanghai and Indonesia. In the future, ADB will contribute to greenhouse gas emissions reduction through the establishment of technical frameworks and specifications for the Centers.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

Charles Hendry 教授，

爱丁堡大学访问教授，英国前能源与气候变化大臣

Prof Charles Hendry, Visiting Professor of the University of Edinburgh and Former UK State Minister of Energy and Climate Change

致辞结束后，英国前能源与气候变化大臣、爱丁堡大学Charles Hendry教授作关于"化石能源的未来"的主旨演讲。他说，中英（广东）CCUS中心把来自爱丁堡大学和其他高校的专家聚集在一起，进一步推动未来的变革。我们可以看到，世界各国的一些大公司、投资者、区域政策的决策者和最大化石燃料排放国都在朝着低碳的方向发展。20年之后，化石燃料仍然占全部能源生产的45%，如果要实现应对气候变化的目标，我们要认识到化石燃料清洁化的重要性，以更大的努力来推动CCUS的发展。在这个领域当中，我们必须要加强合作，分享我们的专业技能和资源。

After the opening address, Professor Charles Hendry, Visiting Professor of the University of Edinburgh and former UK State Minister of Energy and Climate Change, gave a keynote speech on the future of fossil fuels. He considered this workshop as an opportunity to bring together the experts from the University of Edinburgh and other universities and organisations to further promote changes in the future. "As we can see, some large companies, regional policy decision-makers, investors from all countries in the world including the largest fossil fuel users are heading towards low carbon development. Fossil fuels will still comprise 45% of energy production in the next 20 years, and we must recognize CCUS' s important role in combating climate change and make greater efforts to advance its development. In this field, we must work together and share our expertise and resources."

罗必雄先生，

前中英（广东）CCUS中心主任，广东省电力设计研究院院长

Mr Bixiong Luo, Former Director of UK-China (Guangdong) CCUS Centre, General Manager of Guangdong Electric Power Design Institute (GEDI)

前中英（广东）CCUS中心主任罗必雄先生从平台建设、推动示范项目、课题研究、国际交流、网站及刊物宣传方面回顾了中心三年的发展历程。他介绍，中心完成了国内首个大型电厂项目碳捕集预留报告以及碳捕集测试平台可研报告；开展了碳捕集与碳交易衔接、离岸碳封存、二氧化碳利用相关项目；与东莞市政府、爱丁堡大学、香港大学、上海交通大学、东莞理工学院等单位在科研、办学、培训方面进行合作探讨；同时出版多份报告。

罗主任说，中心通过积极开展国际交流和合作，已经成为有国际影响力的平台，并对国内外机构在CCUS与清洁煤研究方面的合作、助力产业化发展方面起到了积极的推动作用。

Mr Bixiong Luo, the Former Director of the UK-China (Guangdong) CCUS Centre, briefly reviewed the development of the Centre in the past three years concerning platform building, demonstration projects research, international communications, web sites, publications, and outreaches. He said that the Centre has completed the first in China the report on carbon capture ready of a large scale power plant and the feasibility report for the carbon capture test platform. It has carried out projects concerning linking carbon capture and carbon emissions trading, offshore carbon storage and CO_2 utilisation. It has also discussed opportunities for cooperation in scientific research, education and training with the Dongguan municipal government, the University of Edinburgh, Hong Kong University, Shanghai Jiaotong University and Dongguan University of Technology.

Mr Luo said that the Centre has gradually built its international influence through active international communication and cooperation, and promoted cooperation amongst organisations at home and abroad in the industrialization of CCUS and clean coal.

梁希博士，

中英（广东）CCUS中心秘书长，
爱丁堡大学商业与气候变化中心主任、能源金融副教授

Dr Xi Liang, Secretary General of UK-China (Guangdong) CCUS Centre, Director of Centre for Business and Climate Change, Senior Lecturer in Energy Finance, University of Edinburgh

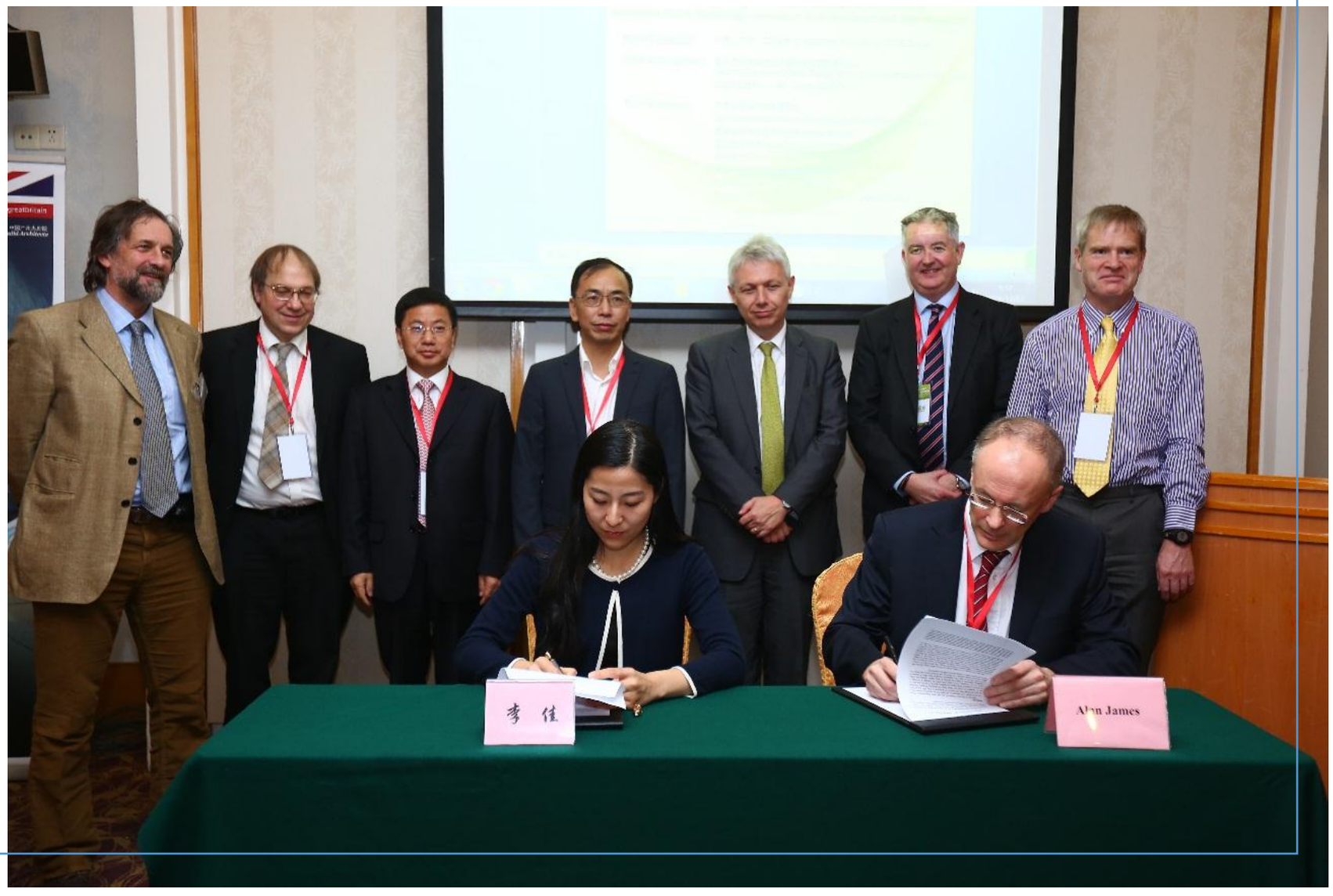
中心秘书长梁希博士对中心管理委员会、顾问委员会、各参与企业和政府在过去三年给予的大力支持表示感谢。他表示，未来将不断完善管理制度，也会继续聆听各方的意见来推动工作。

Dr Xi Liang, Secretary General of the Centre, chaired the opening session and expressed his gratitude for the support of the Centre Management Committee, Advisory Committee, enterprises and the government over the past three years. He promised that he would continue to improve the management systems of the Centre and listen to the opinions of all the parties to promote the Centre’ s work.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

随后，英国企业Pale Blue Dot能源公司与中心在会上签订合作协议。

The Centre then signed a collaboration MOU with the UK enterprise Pale Blue Dot Energy on behalf of the attendees of the workshop.



朱和平先生，

华润电力控股有限公司华南大区发展部开发总监

Mr Heping Zhu, Chief Development Officer of Planning Department, South China Region, China Resources Power Holdings

朱和平先生简要介绍了华润电力海丰电厂CCUS示范项目的进展，他说道：“华润海丰电厂是在广东省发改委指导下的CCUS示范项目的牵头单位，自2013年6月始，与英国爱丁堡大学及广东省电力设计研究院合作，同步开展了CCUS示范项目研究工作。”

据他介绍，海丰电厂CCUS示范项目分三步进行：一、已开展3、4号机组CCUS接口预留的可研工作，该可研报告已于2015年3月通过专家评审；二、2015年3月至2016年12月：在华润海丰电厂已投运机组上开展CCUS小型测试创新平台研究，中英(广东)CCUS中心已完成可研报告送审稿；三、在2017年至2018年完成CCUS小型测试平台的投资立项、建设及测试成果的第三方考核认定。

Following the signing ceremony, Mr Heping Zhu, Chief Development Officer of Planning Department, South China Region, China Resources Power Holdings, said, “The CRP Haifeng Plant is the leading organization for CCUS demonstration supported by the Development and Reform Commission of Guangdong Province, and we have been researching the CCUS demonstration project with the University of Edinburgh and Guangdong Electric Power Design Institute since June 2013.”

He said that CCUS demonstration is being carried out in three steps: first, the feasibility study to make Units 3&4 CCUS ready was completed in March 2015; second, the feasibility report on the carbon capture test platform in the operating units of the Haifeng Plant was submitted to CRP in December 2016; and third, the investment, project construction and the third-party inspection of the test results will be completed in 2017-2018.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

李佳教授，

中英（广东）CCUS中心技术总监，
谢菲尔德大学访问教授，Pale Blue Dot能源公司亚洲区CCS顾问

Prof Jia Li, Technical Director of UK–China (Guangdong) CCUS Centre, Visiting Professor of The University of Sheffield, Asia CCS Advisor of Pale Blue Dot Energy

中心技术总监李佳教授和中科院南海所李鹏春副教授分别从捕集和封存方面展示了广东省发改委低碳发展专项资金支持的大型碳捕集预可行性研究项目的成果。

李佳教授介绍说，主要通过电脑建模对百万千瓦机组的能效进行分析，同时为将来的二氧化碳捕集设计一套流程。研究发现，一台机组的改造成本大约为10亿；全省大概有40%的电厂有必要改造，而且不会对电厂效益产生太大的影响。2020年前可能有10%的电厂需要改造，2021-2030年中国有峰值的控制，中国可能有更多的电厂需进行改造。

Professor Jia Li and Associate Professor Pengchun Li reported the findings of the capture and storage parts of a project supported by the Development and Reform Commission of Guangdong Province with a Special Fund for Low Carbon Development.

Professor Jia Li said that the energy efficiency of a 1000MW unit was studied through computer modeling, and its future carbon capture process was designed. It was found that the retrofit cost of a 1000MW unit is around 1billion RMB; and about 40% of the power plants in Guangdong will need to be retrofitted with limited effect on their economic performance. In order to fulfill China’ s promise to peak its emissions by 2030, 10% of the power plants will need to be retrofitted by 2020 and more will be needed during 2021-2030.

李鹏春副教授，

中科院南海海洋研究所

Associate Prof Pengchun Li, South China Sea Institute of Oceanology (SCSIO), Chinese Academy of Sciences (CAS)

李鹏春教授介绍说，项目开展了珠江口盆地已开发油田的碳封存场地适宜性评价和筛选，认为珠江口盆地的HZ21-1和HZ32-2两个油田及XJ24-3上方咸水层可作为示范工程中实施碳封存的候选场地。同时，通过初步模拟认为近30个油层适合CO_2-EOR和碳封存；对现有海上油田开发设施了调研，认为CCS再利用可行性较高。

Professor Pengchun Li said that the site screening and suitability analysis have been completed for the producing oil fields in Pearl River Mouth Basin. The HZ21-1 and HZ32-2 oil fields and the saline aquifers above the XJ24-3 oil field are selected as candidate sites for CO_2 storage in the demonstration project. Preliminary simulation indicates that about 30 oil reservoirs were suitable technically for CO_2-EOR and carbon storage. The feasibility of reuse existing offshore oil exploitation facilities was studied, and positive result was obtained.

梁希博士，

中英（广东）CCUS中心秘书长，
爱丁堡大学商业与气候变化中心主任、能源金融副教授

Dr Xi Liang, Secretary General of UK-China (Guangdong) CCUS Centre, Director of Centre for Business and Climate Change, Senior Lecturer in Energy Finance, University of Edinburgh

CCUS中心梁希博士展示了广东省发改委低碳发展专项资金把CCUS纳入碳市场项目的成果。

梁博士说，项目主要对碳排放交易整个体系和监管方式、项目管理部门进行梳理，研究如何合法合理地将碳减排纳入碳交易体系，并对广东省早期示范项目的管理方法进行建议。碳市场能支持CCUS项目的潜在方式包括通过CCUS控排企业进行排放控制，另外配额拍卖产生的财政收入可用于支持CCUS工作。他还建议，根据二氧化碳的最终用途，发放除碳交易外的二氧化碳运输、封存相关的证书。如果能把二氧化碳封存纳入绿色电力证书体系，也有利于推动CCUS工作。

Dr Xi Liang concluded the meeting with the findings of the research on Linking CCUS and Carbon Markets in Guangdong. The project was supported by the Development and Reform Commission of Guangdong Province with the Special Fund for Low Carbon Development.

He said the project focused on reorganising the whole system, the regulatory approach, and the project managing departments of carbon emissions traders in order to find out how to reasonably and legally include carbon emissions reduction in the carbon emissions trading system, and to provide suggestions for managing early stage demonstration projects in Guangdong. CCUS projects might potentially receive support from the carbon market through emission controls on key emission enterprises and revenue from auctioning allowances. He also suggested issuing carbon transport and storage related certificates according to the end use of the CO_2. Linking CO_2 storage and the green power certification system would also promote CCUS deployment.

国际CCUS技术发展现状

The Status of Global CCUS Technology Development

12月12日举办的第三届广东国际CCUS专家研讨会上，各国代表介绍了国际CCUS技术发展状况，并就国际CCUS技术发展的经验和技术水平进行讨论。

The 3rd Guangdong International CCUS Workshop, held by UK-China (Guangdong) CCUS Centre on 12 December 2016, discussed the international experiences and technical status of CCUS technologies.

Sam Tam先生，

美国能源部化石能源办公室中国首席代表

Dr. Sam Tam, China Chief Representative, Office of Fossil Energy, US DOE

美国能源部Sam Tam先生介绍道，“为了让化石能源更加清洁，美国环保部当前主要关注能效和碳捕集与封存技术，未来我们需要从工业捕集二氧化碳，才能达到预定的气候目标。美国当前主要有两个途径，一是一体化，把不同的技术和现有的电厂整合起来，创造更多经济价值；二是在研发方面，通过与不同地区和组织建立合作伙伴关系，参与到CCUS工作中，研发新的技术，降低成本。 “我们希望在清洁能源上加强合作，同时，也希望能够将化石能源和可再生能源结合起来，解决规模经济的问题。”

Mr. Sam Tam from the U.S. Department of Energy said “In order to make fossil energy cleaner, the United States Department of Energy now focuses on energy efficiency and carbon capture and storage technology. We need to capture carbon dioxide from industry to reach the climate target in the future. The U.S. is integrating different technologies into existing power plants to boost their economic value; and participating in CCUS through partnerships with various regional organizations to develop new technologies and reduce cost.,” He went on to say , “we hope to strengthen cooperation in clean energy, and at the same time, solve problems in economies of scale for both fossil fuels and renewable energy."

Eddy Chui先生，
加拿大自然资源部化石燃料主任

Mr Eddy Chui,
Director of Fossil Fuels, Natural Resources Canada, Government of Canada

As Mr. Eddy Chui from Natural Resources Canada introduced his organization by saying “Since 2008, the Canadian Federal and Provincial Governments have invested large amounts of money in CCUS projects. Canada owns a series of large-scale demonstration projects, such as the Alberta Carbon Trunk project, and a series of post combustion carbon capture and carbon dioxide utilisation projects. In addition to that, we have also carried out some small scale laboratory tests in Canada. We have established extensive cooperative relationships with different organizations to further accelerate the CCUS development.”

加拿大自然资源部的Eddy Chui先生随后介绍道：“从2008年开始，加拿大联邦政府和省政府在CCUS项目上投入了大量资金。加拿大有一系列的大规模示范项目，如亚伯达省碳干线项目，还有一系列燃烧后碳捕集技术、二氧化碳利用项目等。除此之外，我们还开展了一些小的试验项目。我们与不同组织建立了广泛的合作关系，力图进一步加快CCUS工作的推进。”

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

Jon Gibbins教授，
中英（广东）CCUS中心副主任

Prof Jon Gibbins,
Deputy Director of UK–China (Guangdong) CCUS Centre

Prof. Jon Gibbins described the status of UK CCUS technology at the workshop, by saying "nearly 300 world-class experts, universities and research institutions are involved in the UKCCS Research Centre which was established by government agencies and national energy organisations. The center aims at scaling up CCUS projects and reducing unit costs at the same time. During this process, we set up a system that has developed a series of technologies. In the power industry, CCUS and natural gas power generation cost reduction is very important. In the field of biomass and other energy resources we also hope to reduce the carbon emissions. In the UK, we largely try to reduce the cost of CCUS through large scale clustering of carbon dioxide transport and storage. As a research institution of the university, we look forward to continually providing technical and training support in the future."

英国Jon Gibbins教授介绍英国CCUS技术进展时说，“英国碳捕集与封存研究中心有近300个世界级的专家，还有大学和研究机构的参与。这个中心由多个政府机构和国家级能源机构成立，旨在扩大项目规模的同时降低单位成本。在这个过程中，我们建立了一个系统，发展出很多技术。在电力行业中，CCUS和天然气发电成本下降非常重要；在生物质领域，我们也希望能减少其碳排放。英国希望能通过大型二氧化碳运输和封存集群来大规模降低CCUS的成本。作为一个大学的研究机构，我们希望能为未来不断提供技术和培训支持。”

Tony Zhang博士，
全球碳捕集与封存研究院高级顾问

Dr Tony Zhang,
Senior Advisor of Global CCS Institute (GCCSI)

全球碳捕集与封存研究院的Tony Zhang先生对澳大利亚的CCUS技术进行介绍，他说：“澳洲是化石能源大国，发电以黑煤、褐煤为主，澳洲政府重视碳减排和CCUS工作，在近些年投入了大量资金用于CCUS技术研究和开发，意在让CCUS不再局限于电力行业，同时集中控制成本。澳大利亚的项目有捕集，也有封存。捕集方面包括化学吸收、物理吸附和膜技术；封存方面，澳大利亚潜力巨大。”

Mr. Tony Zhang from Global CCS Institute described Australian CCUS technologies and said: “Australia is a large fossil energy power generation country relying on black coal and lignite. The Australian government attaches great importance to reducing carbon emissions and developing CCUS. In recent years, the Australian government has provided large amounts of funds for the research and development of CCUS technology to untie CCUS and the power industry and to control project cost in a centralised way. The CCUS projects developed in Australia include capture projects using chemical absorption, physical adsorption and membrane technologies as well as storage projects with great potential.”

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

林千果教授，
CCUS促进中心主任

Prof Qianguo Lin, Director of China CCUS Centre

“就中国CCUS的现状而言，一是技术发展，过去几年来科技部引导中国研发机构，支持了多个CCUS相关计划。整体上，中国CCUS技术已经有了全面的发展，也有一定的技术储备。二是项目方面，基于过去若干年的研究，也储备了相当多的项目，我认为中国已做好了工业示范方面的储备。三是政策方面，目前需要思考政策与项目如何共同推动和相互作用，结合起来发展。” 林千果教授说：“在国际合作上，我们有亚洲开发银行为代表支持的两个中心，多边和双边开展的合作非常多，这些国际合作有利于推动中国CCUS的发展。未来在推动CCUS项目商业化发展方面，我希望能从国家层面统筹这些合作，把中国的CCUS推进到商业化示范项目阶段。”

Prof. Qianguo Lin said that “As to China’ s CCS status, in terms of technology development, the Ministry of Science and Technology has supported some research institutions to develop multiple CCUS projects, which has laid the technical foundation with comprehensive development. In terms of projects, China is positioned to demonstrate industrial CCS based on the research and projects developed over the past years. With respect to policy, we need to consider how policies and projects can mutually develop and interact with each other.” He went on to say “in terms of international cooperation, multilateral and bilateral cooperations have been conducted to promote the development of CCUS in China. The Asian Development Bank has supported two CCS centres in Shanghai and Guangdong. In the long term, I hope these cooperations can be planned overall on a national level to promote the CCUS commercial demonstration.”

讨论环节

◆ 在随后的讨论环节，Sam Tam说道：“我们的使命是要信息共享，尤其是在中国。中国是一个绝佳商业化验证的地方，作为美国政府来说，我们也希望能促进这些活动。我们需要做很多游说的工作，让美国公司分享信息；我们以前成功的做到这一点，以后也还会做。”

In the following discussion sction, Sam Tam said: "our mission is to share information, especially in China, a perfectly suitable place for commercial verification. The government of the United States is willing to promote these activities. We need to do a lot of lobbying work to enable American companies to share information, we have successfully done this before, and we will do it again in the future."

◆ Eddy Chui认为：“在大规模示范上面我们有很多体验，希望分享这些好的经验和教训，互相帮助，以更快的实施CCUS。”

Eddy Chui said that: "we have gained a lot of experiences in large-scale demonstration, so we can consider how to share these experiences and lessons, and help each other to implement CCUS more quickly."

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

◆ Jon Gibbins表示：“大家都对海上封存感兴趣，在这个领域挑战与机遇并存，期待中英两国在这个领域有更多合作。同时，我希望能有更多CCUS研发、推广和实践上的合作。我们有很多CCUS理论上的研究和试点，希望以后有更多的商业化项目。”

Jon Gibbins stated: "we are interested in offshore storage which is characterised with both challenges and opportunities. Hopefully, the UK and China will cooperate more in this field, especially in CCUS research, deployment and implementation. We have done a lot of CCUS theoretical research and pilot projects, aiming to develop more commercial scale projects in the future."

◆ Tony Zhang说：“CCUS是一项长期的工作，很多在运行的项目都是从成本比较低的领域一步步拓展到其他领域；与此同时，政府、企业也通过投资降低捕集技术和全链条运营的成本，并在政策方面做工作，逐步降低总体成本。另外，我们应更大力地进行宣传和推动，扩大参与范围，争取更好的政策条件。对于中国，更多的是加强国际合作，把好的技术和经验引进来，把中国的技术和经验真正放在国际舞台上发展。”

Tony Zhang said that "CCUS is a long-term cause with many operating projects gradually deploying from the relatively low cost industry to other sectors; at the same time, the government and enterprises are reducing the cost of capture technology and whole chain operation through investment, and using policies to gradually reduce the overall cost of CCUS. In addition, we should devote more efforts to publicize and promote CCUS to get more industries and enterprises involved for better policy support. For China, we should focus more on strengthening international cooperation to bring in advanced technologies and experiences from overseas and to enhance international competitiveness."

邓广义女士，

中英（广东）CCUS中心管理委员会委员

Ms Guangyi Deng,
Management Board Member of UK-China (Guangdong) CCUS Centre

中心委员会成员邓广义女士对与会嘉宾的到来表示感谢，并说：“CCUS是在能源结构调整和节能减排的基础上进一步深度减排的重要技术路径之一，中英（广东）CCUS中心已成立三年，致力于工程应用推动和转化，下午的会议将对国内首个碳捕集测试平台进行评审，希望通过这个平台对国内外技术从创新型、多样性、示范性和大规模可推广方面进行研究。”

Ms. Guangyi Deng, Member of the Committee of the Centre, expressed her gratitude to the attendees of the workshop and said: "CCUS is one of the most important paths for deep decarbonisation on the basis of energy structure optimization, and energy conservation. The UK-China (Guangdong) CCUS Centre has been established for three years and is committed to promoting CCUS projects and applied technology. The afternoon session will be set for reviewing the research outcome of the first carbon capture test platform in China which focuses on the research of technologies at home and abroad from the aspect of innovation, diversity and large-scale demonstration."

在低油价下如何开展二氧化碳封存和地质利用工作?

How to Carry Out CO_2 Storage and Geological Utilisation under Low Oil Prices?

12月12日下午，在第三届广东国际CCUS专家研讨会上，来自中英（广东）CCUS 中心、苏格兰 CCS 中心、中科院武汉岩土所、全球碳捕集与封存研究院、中国石油大学、天津大学、新疆大学等机构的多位专家分享了世界各地二氧化碳封存及利用工作的进展，会上还就油价对碳封存及利用的影响和中国碳封存示范的驱动力展开热烈讨论。

CCUS experts from the UK-China (Guangdong) CCUS Centre, Scottish CCS Centre, Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Global Carbon Capture and Storage Institute, China University of Petroleum, Tianjin University, Xinjiang University and other institutions gathered in Guangzhou for the 3rd Guangdong International CCUS Workshop held by the UK-China (Guangdong) CCUS Centre on December 12th, 2016. They shared the work in progress on CO_2 storage and utilisation around the world, with a focus on how it is the influenced by the oil price and the driving factors for carbon storage demonstration in China.

王志教授，

天津大学化工学院

Prof Zhi Wang, School of Chemical Engineering, Tianjin University

首先，天津大学化工学院的王志教授介绍了该校高性能CO_2分离膜及膜过程研究。他表示，目前的CO_2分离膜技术主要应用于天然气净化，而在沼气和合成气净化领域还处在实验室研究阶段，主要原因是经济性不高。对此，王教授在天津大学课题组从事将近20年的研究，主要针对膜材料开发，制膜工艺以及膜过程设计。

First, Prof. Zhi Wang from the School of Chemical Engineering of Tianjin University described their research on the high performance CO_2 membrane and its separation process. He said that the current CO_2 membrane separation technology is mainly used in natural gas purification and it is still in the stage of laboratory research for use by the biogas and synthesis gas purification industry because it is not yet economic. In this regard, Prof. Wang, with his research team from Tianjin University, have studied the development of membrane materials, membrane manufacturing technology and membrane process design for nearly 20 years.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

该课题组已研究出选择透过性高、耐热、耐压、耐酸和抗氧化的分离膜，使用哌嗪作为交联剂，在一张膜里联合多种透过机制，通过将纳米材料垂直于膜排列构建高速通道，提高膜的性能。此外，用羧酸根为载体的CO_2分离膜，表现出良好的抗氧化性和耐酸性。设计膜过程时，适当提高进料侧压力，并降低渗透侧压力，既能提高推动力，也保证了较高的渗透率。

据王教授介绍，课题组成功开发了多种分离性能处于目前世界先进甚至领先水平的新型膜材料、高性能膜组件及膜分离示范装置；建立气体传递模型，研究了界面聚合成膜机理及"制膜-结构-性能"关系。他们设计出用于烟道气、合成气、沼气脱碳的膜过程，其技术具有良好的经济性。

他还补充道，与传统化学吸收法相比，膜分离装置占地面积小，而且他们的技术能耗降低了30%，具有很大的优势。

The research team has developed a highly selective and permeable, and heat-, pressure-, acid- and oxidation-resistant separation membrane which used piperazine as the crosslinking agent. They then improved the performance of the membrane through applying a variety of permeating mechanisms that the vertically aligned nanomaterials formed a high speed channel. In addition, a membrane with carboxylate as the carrier of CO_2 shows good oxidation and acid resistance. When designing the membrane process, they found that appropriately increasing the pressure on the feed side and reducing the pressure on the permeation side can boost the driving force and ensure high permeability.

According to Prof. Wang, the research team has developed several types of advanced , perhaps world-leading, new membrane materials, and membrane module and membrane separation demonstration devices with high separation performance. They have also built a gas transfer model to study the mechanism of interfacial polymerization and the relationship between “membrane manufacturing, membrane structure and membrane performance”. They have designed an economic membrane separation process that can be used in flue gas, synthesis gas and methane decarbonisation.

He added that, compared with the traditional chemical absorption method, a membrane separation device has the great advantages of requiring a smaller area and 30% lower energy consumption.

马湘山博士，

全球碳捕集与封存研究院中国区经理

Dr Xiangshan Ma,
Manager of China Office, GCCSI

全球碳捕集与封存研究院的马湘山教授对目前国际二氧化碳封存工作进展进行回顾，他表示，封存涉及到复杂的水文、地球化学等知识，最基本的三种类型是深部盐水层封存、二氧化碳驱油和废弃油气田封存，需要考虑封存能力、注入量和安全性问题。

Prof. Xiangshan Ma from the Global Carbon Capture and Storage Institute reviewed the status of international carbon storage. He said that storage requires complex hydrological, geochemical and other knowledge. The most common methods used are deep saline aquifer storage, CO_2-EOR, and depleted oil and gas reservoir storage, which need to consider the storage capacity, injecting volume and safety issues.

他说，要实现两摄氏度以内的温升目标，到2050年之前需要封存950亿吨二氧化碳。在地质封存领域，中、美是两个较大的市场，废弃油气田的封存能力为7000亿吨，中东、亚洲、欧洲的潜力最大。在对CCUS整体资源的评估方面，美国、日本、欧洲已完成的研究显示前景很好。美国总体封存能力较大，为2-21万亿吨，巴西是2万亿吨，中国是1.570万亿吨。注入方面，中国处在起步阶段，相较美国、加拿大、澳大利亚这些国家还有很多工作要做，这也是未来工作的重点。而封存方法需要各国根据自身情况和地质构造来考虑，因地制宜。

国际上比较知名的封存项目包括，巴西的CO_2-EOR、挪威的海底直接注入封存、堤岸CO_2-EOR和深部咸水层项目、日本的深部咸水层封存、法国的碳酸岩背斜注入封存等。

针对安全和碳泄漏问题，已在空中、地表、浅层、深层都做较多研究。从注入来说，现在没有任何技术障碍，需要的是国际合作和资金、政策支撑。

He said, in order to realize the two degree scenario, 95 billion tons of carbon dioxide needs to be stored by 2050. In the field of geological storage, China and the U.S. are large markets with a total storage capacity of 700 billion tons in depleted oil fields; the Middle East, Asia and Europe have the greatest potential. The U.S., Japan and Europe have completed research on evaluating overall CCUS resources which show good prospects. The overall storage capacity is as large as 2-21 trillion tons in the U.S., 2 trillion tons in Brazil , and 1.57 trillion tons in China. For the injection part of the process, compared with the U.S., Canada and Australia, China is still in the early stages and has a lot of work to do. For the storage part of the process, each country should consider their own conditions and geological structures when deciding on the storage methods.

Relatively well-known international storage projects include the Brazil CO_2-EOR project, the Norwegian seabed direct injection and storage project, the Boundary Dam CO_2-EOR and deep saline aquifer storage project, Japan deep saline aquifer storage project, and the French carbonate anticline injection project, etc.

The storage security issue has been studied in the air, and at the earth's surface, shallow and deep layers. Currently, there is no technical barrier for CO_2 injection, but international cooperation, funding, and policy support are needed.

李小春教授，

中科院武汉岩土力学研究所，中英（广东）CCUS中心顾问

Prof Xiaochun Li, Institute of Rock and Soil Mechanics (IRSM), CAS, Consultant of UK-China (Guangdong) CCUS Centre

中科院武汉岩土所的李小春教授回顾了国内二氧化碳封存工作的进展。

目前正在开发的二氧化碳地质利用和封存包括枯竭油气田封存、强化采油，强化煤层气开采、咸水层封存。目前这些技术仍在开发，理论封存容量很大。中国科技部发布的碳捕集与封存路线图中，计划在2015年开展全流程中试示范，到2030年实现产业化，并对集成系统的规模（大于30万吨）、成本（不超过350元/吨）和能耗指标（增加不能超过25%）做出规定。

Prof. Xiaochun Li from the Wuhan Institute of Rock and Soil Mechanics, Chinese Academy of Sciences reviewed progress on CO_2 storage in China.

The CO_2 geological utilisation and storage being developed now mainly focus on depleted oil and gas fields, CO_2-EOR, ECBM and saline aquifer storage. These technologies are still in development, and the theoretical storage capacity is huge. The Carbon Capture and Storage Roadmap released by the Chinese Ministry of Science and Technology planned to carry out the pilot demonstration in 2015 and achieve industrialization by 2030, and it also set the standards for the scale of the integrated system (above 300 thousand tons), cost (no more than 350 yuan/t) and energy consumption (an increment of no more than 25%).

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

到目前为止，国内的CCUS项目包括4个燃烧后捕集项目，包括MEA和MSA，中石化已完成MSA100万吨预可研；1个富氧燃烧项目，由华中科技大学运营，规模为35兆瓦；2个燃烧前项目和4个工业分离项目。

CCUS封存量巨大，选择多样，目前主要是驱水和驱油，要达到2020年的目标，工程规模应普遍缩减，考虑融资激励机制、监管问题。从政府层面来说，路线图上应体现适当的激励，目标制定应充分，考虑能耗惩罚和成本；示范工程和监管应起到相互作用；开发第二代技术。从企业层面来说，要选择合适的封存技术路线，注重系统集成与风险管理。

So far, domestic CCUS projects include 4 post-combustion capture projects, including MEA and MSA projects, with a pre-feasibility study on the million-ton MSA project completed by Sinopec; 135MW oxy-fuel combustion project operated by Huazhong University of Science and Technology; 2 pre-combustion projects and 4 industrial separation projects.

The most commonly used methods to use and store huge amounts of CO_2 are enhanced water recovery and enhanced oil recovery. To achieve the 2020 target, financial incentives and regulatory mechanisms must be improved, while the project scale should be generally reduced. From the perspective of government, the roadmap should include the following messages: appropriate incentives, complete preset targets with considerations on costs and energy penalties. The demonstration projects should take account of the regulations; and second generation technologies should be developed. For enterprises, they should choose a suitable storage technology and focus on system integration and risk management.

周蒂教授，

中英（广东）CCUS中心顾问

Prof Di Zhou,
Consultant of UK-China (Guangdong) CCUS Centre

中英（广东）CCUS 中心顾问周蒂教授接着介绍了广东省离岸封存研究工作的进展。她说，前期的主要研究成果表现在几个方面：1、确认了广东省二氧化碳封存的基本形式是离岸封存；2、确认了珠江口盆地具有优良的封存条件；3、早期封存机会在于利用已开发油田，可以利用现有设备和一些资料，这些不但可以降低封存成本，还能缩短准备封存项目所需的时间；4、提出了2个油田和1个油田上方咸水层作为候选封存场地；5、对HZ21-1油田进行了初步模拟研究。

到目前为止，所有工作都基于已发表的资料，其详细程度和完整程度比较差，所以很多结论都存在大的不确定性。因此，未来要加强与中海油合作，首先为中心的示范项目选出一个好的封存场地，并评估其安全性、容量和设备可利用性，利用更新的、完整的油田资料进行模拟研究，制定初步的工程方案和预算。

Prof. Di Zhou, advisor of the UK-China (Guangdong) CCUS Centre, gave a briefing on the offshore CO_2 storage work in Guangdong. As Prof. Zhou said, the major outcomes of the preliminary research are: 1. Offshore CO_2 storage is the basic form of storage for Guangdong; 2. The Pearl River Mouth Basin (PRMB) has large storage potential; 3. Early opportunities lie in existing oil fields with existing infrastructure and data, which can be used to reduce costs and save time; 4. 2 oil fields and 1 saline aquifer are proposed as candidate sites; 5. Primary modeling has been conducted for the HZ21-1 field.

Until now, all the work is based on published data which is neither detailed nor complete, so many conclusions are of large uncertainty. Consequently the Centre will strengthen the cooperation with CNOOC, utilize complete and updated field data to finalize the site selection, to evaluate its safety, capacity and infrastructure availability, and to work out a preliminary project plan and budget estimation.

Stuart Haszeldine教授，

苏格兰CCS中心主任

Prof Stuart Haszeldine,
Director of Scottish CCS Centre (SCCS)

苏格兰CCS中心的Stuart Haszeldine教授介绍了过去10-15年北海碳封存活动与进展。他的团队利用已有的信息对整个北海进行绘图，在大陆架进行封存选址。他认为，CCUS整个链条要被打破，捕集和运输、封存要交给不同的公司来做，这样能提高商业应用效率，也能分离风险。英国开发的第一个项目应由国家承担风险。目前封存的商业利益比较小，因此一定要有封存市场。降低CCUS的成本的方法包括形成捕集和封存集群，这样可以共享基础设施；还可以建立一个二氧化碳的交易链条，分担风险和成本，但要确保有稳定的二氧化碳来源。

Prof. Stuart Haszeldine from the Scottish CCS Centre introduced the carbon storage activities and progress over the past 10 to 15 years in the North Sea. His team used existing information to develop a storage atlas of the North Sea and to select storage sites along the continental shelf. He thinks that the CCUS chain needs to be broken, which means different companies should be responsible for the capture, transport and storage parts to improve the efficiency of commercial applications and to separate the risks. The risk of the first project developed in the UK will be borne by the government. As for now, the commercial interests of the storage projects are relatively low, so the market should be developed. The measures for reducing the cost of CCUS include building capture and storage clusters, sharing infrastructure, and establishing a carbon trading chain to share the risk and cost, and to ensure a stable supply of carbon dioxide.

师庆三副教授，

新疆大学地质
与矿业工程学院资源勘查系

Associate Prof Qingsan Shi,
Resource Prospection, Geological and Mining Engineering School,
Xinjiang University

新疆大学的师庆三副教授介绍了新疆的CCUS发展现状。新疆资源异常丰富，二氧化碳地质储层的分布面积广（包括三大盆地咸水层、油藏、气藏和不可开采煤层），储层物理性能较好、自然条件适宜、CO_2排放量大的工业相对集中、油气勘探程度相对较高，有利于开展 CO_2地质封存。尤其是塔里木、准噶尔和吐哈盆地油气资源丰富，油品性质好，易于实现CO_2的混相驱。新疆实施CO_2埋存和驱油等一体化发展的CO_2封存潜力约为40亿吨。

Associate professor Qingsan Shi of the Xinjiang University described current CCUS developments in Xinjiang. He said Xinjiang has rich resources and favorable geological storage conditions, including saline aquifers, oil reservoirs, gas reservoirs and unminable coal seams with good physical properties in three sedimentary basins, a suitable natural environment, relatively centralised large industrial CO_2 emission sources, and highly explored oil and gas fields. In particular, the Tarim, Junggar and Tuha basins have rich oil and gas resources with good oil quality, which can facilitate CO_2 miscible flooding. The potential capacity of integrated development of CO_2 storage and enhanced oil recovery in Xinjiang is about 4 billion tons of CO_2.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

目前新疆正在进行的CCUS项目有敦华克拉玛依石化厂碳捕集及提高石油采收率项目、中石油克拉玛依石化公司甲醇厂PSA驰放气10万吨/年二氧化碳液化捕集项目、中石化塔河炼化PSA驰放气10万吨/年二氧化碳捕集、8000万方/年氮气空分项目、新疆广汇新能源公司年产138万吨甲醇、84万吨二甲醚、5.5 亿立方米煤制液化天然气项目。

新疆的化石能源资源非常丰富，碳源非常丰富且集中，人口密度非常低，因此项目建设和运营成本比较低；但也面临一些问题，比如捕集、运输、封存企业的利益在CCUS的产业链中如何保障，EOR的封存效率如何评价，全社会、全流程的产业链利益怎么分配结算，未来碳交易体系方法论如何与CCUS-EOR相结合，政府如何在全社会层面推动CCUS技术发展等。

The CCUS projects under development in Xinjiang include (i) the Dunhua Karamay Petrochemical Plant carbon capture and enhanced oil recovery project, (ii) the 100,000 tpa PetroChina Karamay Petrochemical Co. methanol plant PSA exhausted gas carbon dioxide liquefaction and capture project, (iii) Sinopec Tahe Refinery PSA exhausted gas 100,000 tpa carbon dioxide capture and 80 million m3/y nitrogen air separation project, and (iv) the Xinjiang Guanghui New Energy Co. coal to liquefied natural gas (LNG) project with an annual output of 1.38 million tons of methanol, 0.84 million tons of dimethyl ether and 550 million cubic meters of LNG.

The rich fossil energy resources, centralised carbon sources and low density population lead to relatively low construction and operation cost for CCUS projects in Xinjiang. However, challenges also exist, such as ensuring the benefits of capture, transport and storage for enterprises along the CCUS chain, evaluating the storage efficiency of EOR operations, distributing and settling the interests of entire society along the whole industrial process chain, combing the carbon trading system and CCUS-EOR in the future, and how the government can accelerate the development of CCUS technology in the society level, etc.

彭勃教授，

中国石油大学（北京）提高采收率研究院

Prof Bo Peng,
EOR Research Institute, China University of Petroleum (Beijing)

中国石油大学的彭勃教授阐述了他对油价变化对封存可行性影响的看法。石油行业的二氧化碳排放的计算覆盖到油气田开发、储运、炼制环节，包括直接排放和间接排放，受到电厂规模和类型的影响。而中国石油系统的二氧化碳封存潜力远远大于系统的排放总量。中国石油工业在碳减排过程中，除了把自身排放的二氧化碳消耗掉，还能通过某种方式给全社会的碳减排做贡献，这也是CCUS的驱动力之一。

但是，中国的CCUS缺少立法和政策，政府没有大量资金投入，外部资金支持不足，融资机制未建立。在低油价环境下，与其他驱油方式相比CO_2-EOR技术新、成本高，石油公司不愿应用。CO_2-EOR的优势在于能与碳市场结合，解开CCUS封存市场的动力，实际上就在于碳价。

Prof. Bo Peng form the China University of Petroleum shared his view on the influence of oil price changes on storage feasibility. The carbon dioxide emissions of petroleum industry from oil and gas exploration, transportation and refining, including direct and indirect emissions, are affected by the size and type of power plant. The CO_2 storage potential of the petroleum system is far greater than the total emissions in China. The oil industry can wipe out their own carbon emissions, and also contribute to the carbon emission reductions of the whole society through certain ways, which is one of the driving forces of CCUS.

However, in China, CCUS is lack of legislation, policy, government investment and external funding, and financing mechanism. Compared with other flooding methods, CO_2-EOR technology is relatively new and requires higher cost, so the oil companies are reluctant to apply this method under low oil prices. The advantage of CO_2-EOR is it can be combined with carbon market to unlock the driving force of CCUS storage market . Thus the carbon price is the key to unlock the CO_2 storage market.

介绍结束后，参会专家及代表就中国二氧化碳封存示范的驱动力展开讨论，主要集中在4个问题：1、驱动力不足的原因是什么？2、需要什么样的驱动力？3、激活驱动力的机会和策略是什么？4、科学界和企业界为此可以做哪些努力？

After the presentation, the experts and attendees discussed the driving forces for CO_2 storage demonstration in China, mainly focusing on 4 questions: 1. What is the motivation for CO_2 storage? 2. what kind of driving forces do we need? 3. what are the opportunities and strategies to activate the driving forces? 4.What can science and business field do to help with that?

李小春教授，

中科院武汉岩土力学研究所，中英（广东）CCUS中心顾问

Prof Xiaochun Li, Institute of Rock and Soil Mechanics (IRSM), CAS, Consultant of UK-China (Guangdong) CCUS Centre

李小春教授总结道，动力不足的原因主要是政策推动、经济拉动和技术发展的力度不够。而内因是技术的相对竞争力弱，CCUS的成本与其它减排技术相比较高，技术发展也不成熟。另外，CCUS的协同效应没有风能、太阳能好，随着政策推移、规模扩大，加上气候变化的目标要求，政策驱动力会慢慢成熟。

重新获得动力的机会包括支持陕西、新疆等特定地区的发展，或是找到好的示范项目，找到更好的商业模式。

As Prof. Xiaochun Li concluded, The lack of motivation is mainly due to the lack of policy, economy and technology driving forces. And the internal cause is the relative weak competitiveness, high cost and immature technology of CCUS compared to other emission reduction technologies. In addition, the synergistic effect of CCUS is not as good as wind and solar energy. With the policy development, scale-up of the technology, and the pressure from climate change targets, the driving force of policy will gradually become mature.

The opportunity to promote the storage development includes supporting the development of Shaanxi, Xinjiang and other specific areas, or finding other good demonstration projects and better business models.

英国CCS项目经验分享：聚焦离岸封存

UK CCS Project Experience Sharing

中心邀请英国Pale Blue Dot公司的Sam Gomersall先生和Alan James先生分享他们在CCS项目上的经验，PBD在英国进行了很多CCS的研究，包括协助英国政府做一些整体的规划，以及对现在正在举行投标的项目进行总体的设计和布局。Pale Blue Dot对于CCS在中国发展的前景非常看好，并期待双方的合作。

Mr. Sam Gomersall and Mr. Alan James from UK Pale Blue Dot (PBD) shared their experiences on Carbon Capture and Storage (CCS) at the invitation of the UK-China (Guangdong) CCUS Centre. PBD is working on many CCS research and development projects, including assisting the UK government on general planning. PBD confidently expects to be able to cooperate with China.

Alan James先生，

Pale Blue Dot能源公司总经理

Mr Alan James, Managing Director, Pale Blue Dot Energy

Alan James先生首先介绍了PBD公司的业务范围以及英国正在进行的CCS项目。Pale Blue Dot公司业务主要有三个方面：碳捕集和封存、石油和天然气转换以及寻求其他新能源。PBD在碳捕集和封存上面进行了很多研究工作和案例开发，包括CCS商业成本估算与经济性。

英国现在正在进行三个项目研究，包括苏格兰的清洁能源项目、天然气氢的生产项目，以及Teesside地区的一个小规模项目。在过去十几年中，英国进行过六个FEED方面的研究。

First, Mr. Alan James introduced the scope of PBD’ s business and the on-going CCS projects in the UK. These include oil and gas conversion and seeking for other new energy forms. Many research projects and cases have been developed on CCS, including commercial cost estimation and economy.

Currently, the UK is carrying on 3 research projects: Clean Energy Project in Scotland, Hydrogen Production from Natural Gas, and a small scale project in Teesside. In the past decade, the UK has completed 6 FEED studies.

由英国政府和苏格兰政府共同进行的Caledonia清洁能源项目可行性研究，包括燃烧前IGCC工厂570兆瓦的低碳发电，该项目每年可捕集二氧化碳380万吨，通过天然气传输管线把二氧化碳送到北海。二氧化碳经过进一步压缩，通过另一个管线传送到海上场地进行离岸封存。使用现有管线进行二氧化碳离岸封存可以降低成本。

Amec项目从挪威或者欧洲大陆中部获取二氧化碳，目前进入可研阶段，预计2017年完成。Teesside地区是一个工业密集区，包括制造厂、炼油厂、加工厂，此处的二氧化碳排放较为严重。在2015年，PBD通过在四个地方收集的数据，对该地区进行了海上封存可能性以及二氧化碳利用可能性的研究。

Acorn项目，是从天然气厂的天然气中捕集二氧化碳，生产的天然气并入英国天然气网络中。在2007年到2008年开展了两个前端工程项目。在2015年年末开展的两个项目，一个计划在天然气电厂进行燃烧后捕集与压缩，并运输到一个枯竭的海上油气田进行封存；另外一个是富氧燃烧项目，计划在英国一个大规模碳排放地区建设一个新的管道。

之前英国CCS主要针对燃煤和燃气电厂进行二氧化碳的捕集和封存，以及进行工业二氧化碳捕集，包括水泥厂、钢铁厂、炼油厂。此后将会利用氢来脱碳，同时计划对供热系统以及整个交通运输部门进行二氧化碳的捕集和封存。在北英格兰，PBD将推出一些低压的氢替代天然气进行制热。

CCS对于能源的转型非常重要。没有CCS，整个减排的成本将更高。

The feasibility study on the Caledonia Clean Energy Project is being conducted by the UK and Scottish governments. It includes a pre-combustion 570 MW low-carbon power generation project, which can capture 3.8 million ton CO_2 per year and transfer it to the North Sea by a natural gas pipeline. The CO_2 will be compressed and transported for offshore storage using another offshore pipeline. Using existed pipelines can reduce the cost of CO_2 offshore storage.

The Amec Project captures CO_2 from Norway or central Europe. The project is currently under feasibility study and is expected to be completed in 2017. Teesside is an industrial area of manufacturing plants, refineries and processing factories which cause heavy emissions of CO_2. In 2015, PBD conducted a regional study on the feasibility of offshore storage and CO_2 utilisation according to the data from 4 areas.

Project Acorn is a project to capture CO_2 from natural gas which is joined into the UK natural gas network. Two front-end engineering projects were developed in 2007 and 2008. Another two projects were developed in 2015, one planned to carry out post-combustion CCS in a natural gas plant, transport and store the CO_2 in a depleted oil and gas field; the other is an oxy-fuel combustion project, where there are plans to construct a new pipeline in an area of large-scale emissions in the UK.

CCS in the UK has been mainly focussed on carbon capture and storage in thermal power plants, and industrial carbon capture in cement and steel plants and refineries. In the future, hydrogen will be used for decarbonisation. Meanwhile, there are plans to develop CCS in heating systems and the transportation sector in the UK. In northern England, PBD is promoting heating with low-pressure hydrogen instead of natural gas.

CCS is a key point of energy transformation. The cost of mitigation will increase without CCS.

Sam Gomersall先生，

Pale Blue Dot能源公司
商务总监

Mr Sam Gomersall,
Commercial Director, Pale Blue Dot Energy

Sam Gomersall先生介绍了能源技术研究院（ETI）对2030年碳捕集和封存情况的分析。ETI是英国的一个公共和私人合作伙伴机构，研究重心是研发新的低碳技术支持能源转型。ETI一部分资金由商业机构提供，一部分资金来自政府。

气候变化委员会的研究显示，发电部门（包括燃气电厂）要首先进行脱碳，因为成本最低，燃气电厂必须脱碳。为了应对气候变化，截止2030年，每千瓦时的碳排放应减少到30g。根据政府的预测，2030年时需要进行10GW二氧化碳捕集与封存。二氧化碳驱油（EOR）会带来额外的附加值，EOR的发展主要集中关注于苏格兰东部的Peterhead区域和另外一个区域的二氧化碳排放源；而中部和西部等地区则是均衡发展。二氧化碳捕集量预计将持续增长，预计2030年时将达到5000万吨。经过ETI研究分析，在2030年实现10GW的CCS是可行的。PBD目前也开展对英国二氧化碳的封存地进行评估，以应对气候变化。

Mr. Sam Gormersall introduced the Energy Technologies Institute (ETI) which conducted an analysis on the status of CCS in 2030. ETI is a UK public private partnership institute with a research focus on innovative low-carbon technology to support energy transformation. Its funding is partly from commercial organisations and partly from government.

As shown by research carried out by the Climate Change Committee, decarbonisation should first be conducted in the power generation section because of its low cost, including gas power plants. CO_2 produced from power generation should not exceed 30g/kWh in 2030 to mitigate against climate change. As estimated by the government, there needs to be 10GW of CCS by 2030. CO_2-EOR will bring added value. The development of EOR is centralised mainly in the Peterhead and other areas of CO_2 emissions in Eastern Scotland, but balanced in the middle and western regions. The amount of CO_2 captured will continuously increase and will reach 50 million tons in 2030. As estimated by ETI, it is possible to achieve 10GW CCS in 2030. PBD is also working on an assessment of CO_2 storage in the UK.

Alan James先生介绍了英国战略性封存评估项目（由ETI、英国能源和气候变化部、Axis Well公司联合支持）。该项目的目的是通过给行业提供可信的信息（例如二氧化碳气源数量）以建立强有力的CCS项目，并降低项目成本，最终达到100英镑/兆瓦时。

项目预计在10个月内，初步从600多个封存场地中筛选5个具有潜力的场地，并对这5个场地进行了完整的规划，如研究成本、设计等。截止2016年第二季度，PBD对579个场地进行了筛选与评估，并在提供9亿吨封存能力方面取得了实质性的进展。这些数据可以从英国国家数据储存库中搜索到。为了推进项目，首先要确定每一个场地的规模、管线长度与封存深度。根据IEA指南，PBD针对这些要素设定了一些标准。筛选的场地不仅代表了英国不同的地理位置，而且在技术上也体现了多样性。场地类型包括两个废弃的油气田（约占英国资源潜力的12%）以及三个咸水层（约占资源潜力的88%-90%）。基于假设的二氧化碳资料数据，PBD对5个场地进行了模拟以查看注入表现。PBD会对每一个地区可能的二氧化碳产出、运输、管线或者平台，以及现金流、时间顺序、运营成本、生命周期成本等做出预测。

Mr. Alan James introduced a UK strategic storage assessment project supported by ETI, DECC and Axis Well. The project aims to set up competitive CCS projects and lower the cost to £100/MWh by providing reliable information (e.g. the amount and location of potential CO_2 sources)

The project plans to screen and select 5 potential sites from over 600 sites, and develop complete design and planning for those 5 sites, including the cost of research and design. By the second quarter of 2016, PBD had screened and evaluated 579 sites, and made substantial progress with storage capacity of 900 million tons. All this data can be accessed in the UK national database. To further develop the project, the scale of each site first needs to be determined, as well as the length of the pipeline and the depth of the storage. PBD uses standards for these factors according to the IEA Guide. The selected sites should be representative to diverse geology and technology. The sites include 2 depleted oil and gas fields (about 12% of UK resource potential) and 3 saline aquifers (about 88%-90% of UK resource potential). PBD has set up simulation models of the 5 sites to check their injection performance according to hypothetical CO_2 data, including potential CO_2 output, transportation and the use of pipeline or platform in each site, and also the cash flow, time sequence, operation cost and life-cycle cost, etc.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

英国主要有三个FEED研究，其中黄金眼的CCS容量最大，达两亿吨，后续增加达到7.1G吨。场地的CO_2封存潜力共有7.8G吨。

PDB项目包括在Forties油田的5口井和另外一个地方的4口井，以及二氧化碳预留，总容量为3亿吨。在黄金眼储存地有6000万吨的潜力；以目前的封存效率19%，预计Bunter的封存容量达2.8亿吨，两个枯竭油气田（Viking和Hamiton），可以封存大量的二氧化碳。Hamiton距海岸线只有30公里，封存效率是70%，计划每年注入500万吨。成本最低的是枯竭油气田的咸水层，封存容量可达5.2亿吨二氧化碳。如果所有的项目都得到开发，生命周期最大的成本是设施成本和运营成本（即平台的资本支出，包括供热、监测、井的运营、维护、金融成本），以及钻井和修井的成本。

在该项目中，PBD将在筛选的封存地制定较详细的二氧化碳封存方案，封存潜力预计在2020年达到1.6亿吨。被选中两个封存地需要进一步钻探；在环境政策合适情况下，预计可以很快实施。项目的风险涉及到废弃井的完整性，即封存安全性。项目预计成本是14-15英镑/吨（相当于6.9英镑/兆瓦），其中包括海上二氧化碳运输和封存的成本。

There are currently 3 FEED studies in the UK. The CCS capacity in Golden Eye is the largest one, with 200Mt to begin with, rising to 7.1Gt. The total CO_2 storage potential is 7.8Gt.

PBD' s projects include 5 wells in the Forties Field and 4 wells in another site, and CO_2 readiness, with a total capacity of 300mt. The storage potential at the Golden Eye site is 60mt. The storage capacity in Bunter is expected to be 280mt with current storage efficiency of 19%. The 2 depleted oil and gas fields, Viking and Hamiton, can be used for large scale CO_2 storage. The cheapest way is to store CO_2 in saline structures of depleted oil and gas fields, where the CO_2 storage potential is up to 520mt. If all the projects are conducted, the prime life-cycle costs will consist of facility and operational costs (which is the capital expenditure on the platform, including cost of heating, monitoring, operation and maintenance of wells, and financial cost), and the cost of drilling and well repairing.

PBD will make more detailed CO_2 storage plans for the selected storage sites. The storage potential is expected to be 160Mt in 2020. The 2 selected sites need further drilling which will be conducted when the environmental policy is appropriate. The estimated project cost is £14-15/t (about £6.9/MW), with the offshore CO_2 transportation and storage cost included.

在对以上三个报告的讨论环节中，中科院南海所周蒂教授对PBD公司CCS项目提出了“封存效率是否由计算得出的、模拟参数如何考虑不同地区压力情况、如何获得石油公司AXIS数据”等问题。PBD公司Alan James回答，项目的封存效率是计算得出的，在项目计划时，通过模拟估算封存容量，除以面积可以得出封存效率；对于模拟参数，项目中只有两个地方压力较低，其他封存地是按照最初压力运营，项目的5个封存地情况各不相同，PBD希望提供的项目研究成果可以为一些条件比较类似的情况参考利用；能够获得石油公司AXIS数据库的使用权要归功于英国环境和气候保护部，该部门规定在公司申请“石油许可”时必须公布相关信息，英国有国家一级数据库可供用户登陆获取相应的信息，其中包括很多石油公司的数据。英国石油公司的数据保密期为5-6年，之后将进入公知领域。

中心技术总监李佳教授提出了“设计距离和潜在封存量对运输成本的影响、选择一个封存点的其他因素、封存效率对成本的影响”等问题。Alan James回答道，PBD在估算运输成本和设计从岸边到封存地点的管线时假设了3种二氧化碳供应情况，每一个封存点都会产生不同的排放。对于效率只有6%的封存点，需要更多的油井才能注入等量二氧化碳，相对成本也更高。

In the discussion section, Professor Di Zhou first raised her concerns: “Is storage efficiency obtained by calculation? The pressure of different region needs to be taken into account for the simulation. How do you get AXIS data from an oil company?” Mr. Alan James replied that the storage efficiency is calculated by storage capacity, estimated by simulation, divided by area; as to simulation parameters, only 2 sites have low pressure in this project, other sites are operated under original pressure. The situation in the 5 sites is different, and PBD expects the research output of these projects can be applied in similar situations. He went on to say that according to the UK Environment and Climate Change Department regulations, the information and data referred to are required to be published when applying for the “Oil Permissions”. The oil company’s data confidentiality is limited to 5-6 years, after which it is made public. Hence it is possible to access the AXIS database of the oil companies.

Jia Li, technical director of the Center raised questions concerning the effects of the design distance and potential storage in the transport cost report, other considerations for a storage point, and the impact of the storage efficiency on the cost. Mr. Alan James answered that PBD assumed 3 supply possibilities in relation to CO_2 transport costs, and pipeline was designed from shore to offshore storage sites. Each site will give different emission levels. For the storage site with 6% efficiency, more wells are required to inject the same amount of CO_2, and the cost is relatively higher.

周蒂教授，

中英（广东）CCUS中心顾问

Prof Di Zhou, Consultant of UK-China (Guangdong) CCUS Centre

对于英国前能源与气候变化大臣Charles Hendry先生提出的“基础设施对于北海地区是否重要，废旧设施对CCS封存是否有用” 等问题，Alan James回答道：早期低成本项目非常重要的三个关键基础设施之一是管道。黄金眼的管道使用了6-7年时间，可以用于CCS。但是Viking的管道已经使用25年，考虑到压力因素，不能再利用。需要考虑到基础设施的老化可能对再利用带来的风险。

中科院南海所周蒂教授询问：英国首个海上封存点将于何时开始正常运作？英国爱丁堡大学Stuart Haszeldine教授回答道，英国Acorn项目是利用现有的设施和设备开展CCS，由于很多设备和数据都已经有储备，因此设计时间短。目前的困难在于英国政府与石油公司还未进行充分的对话沟通。

Prof. Charles Hendry, former UK State Minister for Energy and Climate Change, asked: “If the existing infrastructure is important in the North Sea region, and could be useful for CCS?” Mr. Alan James replied that one of the three critical infrastructures for early low-cost projects is the pipeline. The pipeline to Golden Eye has been used for 6-7 years and can be applied to CCS, but the pipeline to Viking has been used for 25 years and cannot be reused because of the pressure. At the same time, when using existing pipelines should also take into account the risk of degradation by the reuse of the infrastructure.

Professor Di Zhou asked, “When will the first offshore storage site in UK be in operation?” Professor Stuart Haszeldine from the University of Edinburgh answered that project Acorn uses existed facilities and equipment for CCS, hence it has a short design phase. But the problem is that the UK government and oil companies still need to communicate further.

Sam Gomersall先生介绍了英国Acorn项目。Acorn项目位于苏格兰东北部，目标是开发低成本、全流程的CCS项目。在英国北海的东部有非常多封存场地，苏格兰具有较强的封存潜力。Acorn项目将作为催化剂推动炼油厂和苏格兰中部化工厂的二氧化碳捕集。

黄金眼项目利用在英国苏格兰Peterhead的一个现有天然气工厂的现有捕集设施，并利用现有的管道将二氧化碳运输到离岸封存地。还有其他封存的选择，例如通到北海中部的废弃油气田管道。在苏格兰有很多的现有管道以及海上基础设施和平台，例如黄金眼平台，其现有的两条管道将从油气运营公司获得退役许可，预计5-6年之后将不能使用，因此PBD希望能够加速Acorn项目的进程，赶在管道退役之前利用管道进行CCS。

Mr. Sam Gomersall introduced the Acorn project. Project Acorn is located in the northeast of Scotland, and supports the development of low-cost full-chain CCS projects. There are many storage sites in the east of the UK' s North Sea. Scotland has very strong storage potential. Acorn will serve as a catalyst to promote carbon capture in refineries and chemical plants in central Scotland.

Golden Eye uses the capture facilities of an existing natural gas plant in Peterhead, Scotland, and uses an existing pipeline for CO_2 transport to the storage site. There are other storage options, for example, a pipeline going towards the depleted oil and gas fields in the middle of the North Sea. There is a lot of existing infrastructure such as pipelines and offshore platforms, e.g. the Golden Eye platform. Two pipelines connecting this platform are about to get retirement approval from the oil and gas company, and will not be usable after a further 5-6 years. Consequently PBD wants to promote the Acorn project so that the pipelines can be used for CCS before their retirement.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

PBD在1月份向欧盟正式提交融资申请，以对英国天然气公司和壳牌公司的油气田开展推动CCS技术发展的Acron项目，预算280万欧元，进行18个月可行性研究。Acorn项目的合作伙伴包括爱丁堡大学、挪威BELLONA等。该项目首先要获得一些数据，对工厂可用设施进行分析，并进行详细的封存地筛选，为项目制定发展方向，设计一个较好的方案，并且还会进行知识传播。目前英国有很多封存监管框架，项目的推进涉及到很多监管许可认证。对该项目的可行性研究将为在英国和欧洲开展CCS提供可行的方案，评估再利用油气基础设施的可行性，保护现有的油气基础设施以便能在CCS中进一步利用。

PBD计划在英国进行早期CCS项目，开发和实施最可行的发展方案。由比较小型的项目开始，经过证实其可行性后再进行更大规模的项目，要更好的使用现有捕集装置、利用海上的管线以节约成本。PBD下一步将申请欧盟方面的资金资助，同时也希望中国能够参与到这个项目中。

In January 2016, PBD officially applied to the EU for financing the Acorn project for CCS technology development in BG and Shell' s oil and gas fields. The budget is about 2.8 million euro and the feasibility study will take 18 months. The project will collect data, analyze the usability of existing infrastructure, further screen the storage sites, setup a development plan, and popularize CCS knowledge. There are good regulatory frameworks for storage in the UK, and many regulatory approvals are required to promote the project. The feasibility study will be used as a development plan for the feasibility of CCS elsewhere in UK and Europe. It will assess the feasibility of the reuse of oil and gas infrastructure, and protect the existing oil and gas infrastructure for further use in CCS.

PBD plans to conduct early CCS projects in UK, as well as to develop and deploy the most feasible plan.They will start with relatively small scale projects and, after the verification of their feasibility, will continue with larger scale projects. PBD will use existing capture devices and offshore pipelines to save cost. Furthermore, PBD will apply for funding from the EU, and expects China could also participate in these projects.

Alan James先生总结了对于CCS发展最重要的六点：

1.对二氧化碳封存，要考虑二氧化碳的供应量、注入率、最大运输距离等。

2.每一个项目，都需要做到计划、计划、再计划，然后才落实到纸面上；任何一个复杂的项目都可以从周密的计划中受益。

3.每一个封存场地都要有一份指南，要有资源数据库。

4.预期的封存场地要有明确的定义，要了解其大小和类型。IEA的指南主要是为陆上CCS项目制定的，海上的经济性情景并不一样，使用该指南时要非常谨慎。PBD的经验是，对于一个CCS项目，在不知道是否能够一直推进的情况下，要有备选的封存地，以及一个后备方案。

5.数据的可获得性是PBD进行封存地筛选的非常重要的因素。国家数据系统对CCS研究来说非常重要。从封存运营者的角度来说，有些来自于石油公司的数据，可能要跟他们签署保密协定才能获得。如果一个场地的数据不足，可能需要耗费很多时间去补救。

Mr. Alan James concluded with the following 6 key points concerning CCS:

1. The amount of CO_2 supply, injection rate, and the maximum transport distance for CO_2 need to be considered for CO_2 storage.

2. For every project, everything needs to be planned, re-planned, and planned again before it is put down on paper. Any complex project always benefits from a well thought out plan.

3. There should be a manual for each storage site, and also a database of the resources available.

4. The proposed storage site should be defined, and its size and type to be known. The IEA's Guide is mainly for onshore CCS projects, which have different economics to those offshore. Take this into account when using the Guide. In PBD’ s experience, if it is not sure whether a CCS project can keep progressing, an alternative storage site should be prepared, as well as a backup plan.

5. Access to data is an important issue for PBD in selecting storage sites. The national database is very important for CCS research. For the storage operator, some data from the oil company might only be obtained after signing a confidentiality agreement.

6.行业的关注也非常重要。要用标准的商业方法降低风险。对于任何一个复杂的项目来说，由专业人士专注研发领域，由运营人士关注商业，同时也需要其他利益相关者提供建议。

在对上述报告的讨论环节，中科院南海所的周蒂教授提出以下问题：Acorn项目的规模（封存容量）？项目预算成本是否会增加？资金筹集来源？对此，Alan James回答，项目的CO_2注入率是25-40万吨/年，预计需要一口注入井。最低注入量是PBD基于目前谈判设定的，是在获得足够利益相关方兴趣情况下使项目运行下去的最低设计标准。项目实际的成本要进一步研究；在利用现有管道情况下，可行性研究中估算的项目成本大约是2-3亿英镑，如果要替代现有管道，成本将增加一亿英镑。对于资金的筹集，苏格兰政府会提供资金进行该项目的开展。

6. The industry's attention is also very important. Use standard business methods to reduce risk. For any complex project, professionals focus on R&D, operators focus on business, but other stakeholders also need to provide suggestions.

In the discussion section, Professor Di Zhou raised her concerns on “What is the scale of project Acorn? Will the estimated cost increase? What are the funding sources?” Mr. Alan James responded that the annual amount of CO_2 supplied and injected will be 250,000-400,000 tons. The minimum injection was set by PBD based on current negotiations. It is the minimum design criteria to run the project taking into account the interest of the Stakeholders. The estimated cost of the project in the feasibility study is about £200-300 million, and it will increase by £100 million if the existing pipelines need to be replaced. The Scottish government will provide funding for the project.

Near ZERO Emission 近零排放
Spring Issue
2017 | 春季刊

美国能源部中国首席代表Sam Tam先生则希望了解PBD对于二氧化碳的注入和封存监测的看法。对此，Alan James表示，该项目的注入井经过完整的设计，在注入的时候可以监测井温和压力，地下的监测会进行重复三维地震，和挪威国家实验室监测方式一样，是PBD主要采用的监测方式。

中科院南海所的周蒂教授则对“项目封存地的筛选、最低封存容量、封存地封存时间与潜力”等提出问题。Alan James先生回答，项目筛选的标准并非场地封存容量。根据以前的研究，主要标准是二氧化碳供应率达到500-800万吨/年。Stuart Haszeldine教授回答，如果要让燃煤电厂进行二氧化碳捕集和海上封存，则必须思考封存地潜力是否足以容纳几千万吨的二氧化碳。而PBD选择的5个封存地的目的是为了支持将来更大的项目，容量能够封存1-2个天然气电厂的二氧化碳，且运行10-20年。

Mr. Sam Tam, China Chief Representative of USDOE, was interested to know PBD’s opinion on CO_2 injection and storage monitoring. Mr Alan James replied that the injection well was fully designed; it can monitor the temperature and pressure of the well during the injection, and underground monitoring will be done mainly by repeated 3D seismic survey, the same as that carried out by Norway’s national lab.

Professor Stuart Haszeldine answered the remaining questions by saying that if a coal-fired power plant wants to deploy carbon capture and offshore storage, it has to consider if the storage capacity of the site could load dozens of million tons of CO_2. PBD has selected 5 sites to support future larger scale projects with storage capacity sufficient for CO_2 captured from 1-2 natural gas power plants running for 10-20 years. The injection efficiency is affected by injection performance, but the number of injection wells should also be taken into account.

对于周蒂教授对于注入率的提问，Stuart Haszeldine教授回答，注入率受注入性能的影响，同时也要考虑注入井的运行数量，例如一个砂岩中可以设立几个注入井，则影响因素一是每口井的注入率，二是一个地块有多少口井，这也会受到封存质量的影响。

而对于与中国项目的相关性，Sam Gomersall表示，希望PBD能进一步探索中英（广东）CCUS中心进行合作的方法与途径。PBD有一些潜在的封存区域可以与中心共同进行评估，也会探索更多和中心合作的机会，希望一些组织也愿意参加到合作项目中。希望能够对海上二氧化碳的运输和封存问题进行研究，能在该项目中和中方建立起合作伙伴关系。

Professor Di Zhou had questions on the selection of storage sites, the minimum storage amount, the storage duration, and the injection rate of the sites. Mr. Alan James answered that the main criteria for site screening is not the storage capacity, but is the CO_2 injection rate which could reach 500-800 million tons annually.

As Mr. Sam Gomersall said, PBD wants to explore further the way and approach to cooperate with the UK-China (Guangdong) CCUS Centre. There are some potential storage sites that PBD would like to co-access with the Centre and to explore more opportunities to work with the Centre. We hope that other organisations could join the cooperation. He also wants to study offshore CO_2 transportation and storage, and wishes to establish a partnership with China to carry it out.

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

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.

支持单位：
Supporting Institutes

中华人民共和国国家发展和改革委员会 National Development and Reform Commission
英国驻广州总领事馆
The Scottish Government
广东省发展和改革委员会 DEVELOPMENT AND REFORM COMMISSION OF GUANGDONG PROVINCE
Department of Energy & Climate Change
Scottish Enterprise

中心发起会员：
Founding Members

中国能建广东院 ENERGY CHINA GEDI
UKCCS RESEARCH CENTRE
SCCS
GLOBAL CCS INSTITUTE
CIMC
華潤電力 CR Power
cnooc
Howden
ALSTOM
Shell Cansolv
DNV·GL
中国科学院南海海洋研究所
中国科学院广州能源研究所
UNIVERSITY OF EDINBURGH Business School
linkschina 领先财纳

中英（广东）CCUS中心，中国能建集团广东省电力设计研究院D区2楼，广东省广州市科学城天丰路1号
UK-China (Guangdong) CCUS Centre, 2nd Floor, Zone D, Guangdong Electric Power Design Institute, No.1 Tianfeng Road, Guangzhou, Guangdong, China