2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

中国 · 新疆 · 乌鲁木齐　2014.9.18　Urumqi · Xinjiang · China

主办方 | Sponsors

美国驻华大使馆商务处
The U.S. Foreign Commercial Service

美国能源部
The U.S. Department of Energy

美国贸易发展署
The U.S. Trade and Development Agency (USTDA)

美国国务院
The U.S. Department of State

承办方 | Organizers

美国空气净化任务组织
Clean Air Task Force

美国国家标准学会
American National Standards Institute(ANSI)

2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

Content目录

Agenda
会议议程

2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

Date/Venue:

Luxemon Xinjiang Yin Du Hotel
No. 179 West Xihong Road，Urumqi，Xinjiang，P.R. China
September 18th, 2014

Sponsors:

The U.S. Foreign Commercial Service
The U.S. Department of Energy
The U.S. Trade and Development Agency (USTDA)
U.S. Department of State

Organizers:

Clean Air Task Force
American National Standards Institute(ANSI)

Agenda

Thursday, September 18
Xinjiang, One-Day CCUS Workshop

10:00	**Introduction of Trade Companies to VIPs by Ambassador**
10:00 – 10:30	**Welcoming Remarks by Ambassador/Xinjiang Gov. Officials**
10:30 – 10:50	**Tea Break**
10:50 – 11:30	**Opening of Workshop Remarks** Bradley Harker, Commercial Officer, FCS Nicholas Carlson, Department of Energy Office, US Embassy NDRC / Xinjiang DRC – TBC Verinda Fike, Country Manager, East Asia, USTDA
11:30	**Theme of Workshop** **Creating a Strong CCUS Industry in Xinjiang –** John Thompson, Clean Air Task Force
12:15 – 13:45	**Xinjiang Business Opportunity Presentations** ● **Early opportunities of CCUS Deployment in Xinjiang –** LI Jun, Wuhan Institute of Rock and Soil Mechanics ● **Reducing CO_2 Emissions – and Helping Finance CO_2**

Capture Projects – Through Geological Sequestration of Injected CO_2 for Enhanced Oil Recovery (EOR) – Eric Redman, Summit Power

- **US CO_2 EOR projects and assessing the potential for CCUS development in Xinjiang** – Sue Hovorka, Texas Bureau of Economic Geology

13:45 – 15:30 **Lunch**

15:30 – 17:00 **Business Opportunity Panel**

Panelists react to the information in previous presentations, describe what they see as the Xinjiang opportunity, and discuss their projects and joint US-China CCUS work.
Moderator – Frank Chou, Clean Air Task Force
Panelists:

- "Preliminary Study of Xinjiang CCUS Technology Roadmap" – Qingshan SHI, Xinjiang University
- "CCUS Practice and Understanding of Yanchang Petroleum " – Xisen ZHAO, Shaanxi Yanchang Petroleum (Group) Co., Ltd
- Hongjun GU –PetroChina Xinjiang Oilfield Research Institute of Petroleum Exploration and Development
- "Maximizing EOR Opportunities and CO_2 Storage Potential in Xinjiang" – Bruce Hill, Clean Air Task Force

17:00 – 17:30 **Tea Break**

17:30 – 18:30 **Projects/Technology**

Three presentations to discuss important technologies or projects underway/planned in Xinjiang:

- "Oxy-combustion and Xinjiang Province CCUS" – Mark Schoenfield and Catherine Chen, Jupiter Oxygen
- Presentation on Xinjiang CCUS Project: Great Point Energy
- "TRIG™: A Unique Gasification Technology for Low Rank Coal and Carbon Management" – Qianlin ZHUANG, KBR

18:30 – 18:40 **Summary of Follow-up Actions**

18:40 – 19:00 **Wrap-up Presentation by Important China / US Official**

19:00 **Networking Dinner**

**All Chinese Government and company representatives as well as the U.S. delegation are invited to attend the networking dinner.*

2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

Luxemon Xinjiang Yin Du Hotel (Red “A” marked in map below)
Address: No. 179 West Xihong Road，Urumqi，Xinjiang，P.R. China
Tel: (86 991) 4580158
Fax: (86 991) 4511767

2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

时间/地点:

新疆尊茂银都酒店
乌鲁木齐西虹西路 179 号
2014年9月18日

主办单位:

美国驻华大使馆商务处
美国能源部
美国贸易发展署
美国国务院

承办单位:

美国净化空气任务组织
美国国家标准学会

研讨会议程

10:00 **美国驻华大使向参会贵宾介绍与会美国公司**

10:00-10:30 **美国驻华大使及当地政府领导致欢迎辞**

10:30-10:50 **茶歇和交流**

10:50-11:30 **研讨会开幕发言**
美国驻华使馆商务处商务领事韩博韬
美国能源部中国办公室副主任倪康森
中国国家发改委或新疆发改委发言 (待确认)
美国贸易发展署东亚国家经理Verinda Fike

11:30 **主旨发言**
在新疆开创一个强大的碳捕集利用与封存行业
美国净化空气任务组织John Thompson

12:15-13:45 **新疆商业发展**

- **新疆CCUS早期示范机遇**–中国科学院武汉岩土力学研究所李俊
- **通过注入二氧化碳提高石油采收率的地质封存减少二氧化碳排放并助力碳捕集项目融资**–美国高峰电力公司Eric Redman

- **美国二氧化碳提高采油率项目及新疆CCUS开发潜力评价–**
  美国德州地质和经济局Sue Hovorka

13:45–15:30 **自助午餐和交流**

15:30–17:00 **商业机会小组讨论**

介绍各自中美CCUS合作项目，以及对上午分享话题和新疆商业机会的进一步探讨

主持人：美国净化空气任务组织-周禧

小组讨论成员：

- “新疆CCUS技术路线图初步研究”–新疆大学师庆三
- “延长石油集团CCUS实践与认识”–陕西延长石油集团有限责任公司研究院副院长赵习森
- 中石油新疆油田公司勘探开发研究院顾鸿君
- “新疆地区提高采收率和二氧化碳封存的机遇与潜力”–美国净化空气任务组织代表Bruce Hill

17:00-17:30 **茶歇和交流**

17:30-18:30 **项目和技术**

探讨在新疆地区开展或正在计划中的重要项目或技术

- “富氧燃烧和新疆地区CCUS”–朱庇特氧气公司Mark Schoenfield和陈静
- 新疆CCUS项目：巨点能源
- “TRIG™：适用于低质煤和碳管理的独特气化技术” –凯洛格布朗路特公司庄前林

18:30-18:40 **后续行动总结**

18:40-19:00 **美国/中国领导总结发言**

19:00 **交流晚宴**

*欢迎所有中美双方与会代表参加

新疆尊茂银都酒店(红点处为会议酒店位置)
中国新疆乌鲁木齐西虹西路179号
电话: (0991) 4580158
传真: (0991) 4511767

预定联系人:
王爽人(豪华大床房800元/晚)
手机: 13659933578
邮箱: 13659933578@139.com

有单位预算有限，可选择周边经济酒店
1. 如家快捷酒店(乌鲁木齐西北路店)
乌鲁木齐市沙依巴克区西虹西路156号 ，近西北路。会议酒店马路对面。
酒店电话：(0991)-4549888-9
房价：199元起

地图上红标为会议酒店

2. 乌鲁木齐新美酒店
沙依巴克区西北路1085号，近西虹西路
酒店电话：(0991) 456 6888
房价：230元起

地图上红标为会议酒店

Speaker Biographies
演讲人介绍

Eric ("Ric") Redman
President & CEO, Summit Power Group

Eric Redman is President & CEO of Summit Power Group and its subsidiary, Summit Carbon Capture, which is developing power plants with CO_2 capture, including for enhanced oil recovery (EOR). He helps lead Summit's efforts on coal gasification with carbon capture, including the Texas Clean Energy Project (TCEP), and carbon capture from natural gas and other technologies. He works with several national environmental groups on climate matters, and leads Summit's carbon capture projects abroad, including the proposed Captain Clean Energy Project, a TCEP successor project in Scotland.

Mr. Redman formerly chaired the Clean Energy Technology group at a major international law firm. He was a legislative aide to U.S. Senator Warren Magnuson (D-WA) and wrote *The Dance of Legislation*, a best-selling account of Congressional enactment of the National Health Service Corps. He was educated at Harvard College, Oxford University (as a Rhodes Scholar), and Harvard Law School. Now a "recovering lawyer," he was chosen for Best Lawyers in America for energy matters in 2007, 2008, and 2009. He is active in conservation organizations, is a member of the Executive Committee of the Gasification Technologies Council (GTC) Board of Directors, and is a lifelong resident of Seattle, Washington.

艾瑞克（"瑞克"）·瑞德曼 Eric ("Ric") Redman
顶峰电力集团总裁兼首席执行官

艾瑞克·瑞德曼是顶峰电力集团（Summit Power Group）及其子公司顶峰碳捕捉公司（SummitCarbon Capture）的总裁兼首席执行官。该公司正在建立具有二氧化碳捕捉能力且可用于提高石油开采率（EOR）的发电厂。在他的协助领导下，顶峰集团努力推动得克萨斯州清洁能源项目（Texas Clean Energy Project, TCEP）等结合碳捕捉技术的煤炭气化项目，并积极研发天然气碳捕捉及其他技术。他与多个全国环保组织合作，致力于解决气候问题；并领导顶峰集团的海外碳捕捉项目，其中包括提议中的船长清洁能源项目（Captain Clean Energy Project），亦即TCEP在苏格兰的后续项目。

瑞德曼先生曾经在一家主要的国际法律事务所负责其清洁能源技术团队。他为美国国会参议员沃伦·马格努森（Warren Magnuson，华盛顿州民主党人）

担任过立法助手，并出版过畅销书《立法之舞》，介绍国会如何立法建立国家卫生服务队。他在哈佛大学、牛津大学（作为“罗德学者”）以及哈佛法学院完成学业。他曾于2007年、2008年及2009年入选能源事务方面的“美国最佳律师”，现在则是一位“正在恢复元气的律师”。瑞德曼先生积极参与自然保护组织工作，是气化技术协会（Gasification Technologies Council）董事会执行委员会成员。他一直居住在美国华盛顿州西雅图。

Jun Li

Assistant professor at institute of Rock and Soil mechanics, Chinese Academy of Sciences

Jun Li is assistant professor at institute of Rock and Soil mechincs (IRSM), Chinese Academy of Sciences. Jun Li joined the CO_2 geologic storage team at IRSM in 2013. He mainly works on basin scale CO_2 storage capacity evaluation in China based on geologic modeling, and numerical simulation of reactive transport in porous media. Jun Li recieved BS degree of applied mathematics from Xidian university in Xi'an China, 2007. He holds Ph.D of geochimistry from institute of Geology and Geophysics, Chinese Academy of Sciences. His Ph.D work focuses on thermodynamic modeling of gas-water-salt-rock interactions to high temperature and pressure, and the application in reservoir simulation.

李俊

中国科学院武汉岩土力学研究所助理研究员

李俊是中国科学院武汉岩土力学研究所助理研究员。李俊与2013年加入武汉岩土所CO_2地质封存组。他目前的主要工作集中在基于地质建模的盆地CO_2封存容量评估，以及多孔介质流体运移的数值模拟。李俊于2007年获得西安电子科技大学应用数学学士学位，2013年获得中科院地质与地球物理研究所地球化学博士学位。其博士工作集中在高温高压条件下水-气-盐-岩的热力学建模并将热力学模型应用于地下储层流体运移数值模拟。

John W. Thompson

Director Fossil Transition, Clean Air Task Force (CATF)

2014 U.S.-China CCUS Workshop Xinjiang
2014 新疆中美碳捕集利用与封存研讨会

John Thompson directs the Clean Air Task Force's Fossil Transition Project. As Director, Mr. Thompson fosters low-carbon fossil solutions by endorsing environmentally sound commercial projects, facilitating the transfer of innovative, low-carbon coal and fossil technology between the U.S. and China, and developing US federal policies that promote enhanced oil recovery and limit greenhouse gas emissions from power plants.

Mr. Thompson is a frequent presenter on fossil technology and sequestration at conferences both in the United States, China and Europe. In the past, he has served on numerous advisory panels including the Technologies Subcommittee of the Western Governors' Association, US EPA's Advanced Coal Working Group, and the Coal Gasification Work Group of the Powering the Plains Project. In 2012, he began serving on the National Coal Council, a Department of Energy advisory body.

Mr. Thompson holds a B. S. in chemical engineering from the University of Illinois, Champaign-Urbana, as well as an M.B.A. from Olin School of Business at Washington University in Saint Louis.

约翰 W. 汤普森

空气净化任务组织化石转型总监

约翰 W. 汤普森是空气净化任务组织化石转型项目的总负责人。作为项目总监，汤普森先生致力促进技术上具有可靠性、环境友好型的商业化项目，并以此促进化石能源低碳化，他致力与增进低碳的、创新的化石能源技术在中美和美国各州之间的技术转移和政策支持。尤其是在提高石油采油率和电厂温室气体减排方面、

汤普生先生在美国、欧洲和中国都是积极的参与并作为专家主持了多个二氧化碳捕集和封存的化石能源技术会议。他还曾服务于多个咨询委员会，包括美国西部州长技术委员会协会、 美国环保署先进煤炭工作小组，以及平原电力项目的煤气化技术委员会。从2012年开始，他还为国家煤炭局、美国能源部下属机构提供咨询服务。

汤普森先生持有美国伊利诺伊大学厄巴纳香槟分校化学工程学士学位，以及圣路易斯华盛顿大学奥林商学院的 MBA。

H. Frank Chou
Director, Texas Operations, Clean Air Task Force (CATF)

As the Director of Texas Operations for Clean Air Task Force, Dr. Frank Chou facilitates business partnerships between US and China for development of carbon capture, utilization and storage (CCUS) technology and shale fracking technology. He assists Chinese companies that are looking to collaborate with US-based companies and experts on the development of utilization strategies for the captured carbon dioxide, particularly in enhanced oil recovery (EOR) operations, by conducting training in China and site visits in the US. He has been working with the energy industry, academics and NGO's to form a low carbon energy hub in Texas. He is also involved in introducing the best practices for environmental protection in shale fracking to China.

With a background in mechanical engineering and over thirty years of work experience in the engineering, procurement and construction business sectors of the petro-chemical industry, Frank managed major capital projects for Shell Oil, Dow Chemical, and led mechanical engineering for capital projects for Fluor and M. W. Kellogg. He has worked on projects including chemical, refinery, oil exploration and wind power, in the US, Canada, China and South America. He has a track record of executing projects under budget and on schedule.

Frank holds a BS in mechanical engineering from National Taiwan University, and an MSME and a Ph. D. from West Virginia University.

周禧
空气净化任务组织德克萨斯州业务总监

作为空气净化任务组织的德克萨斯州业务总监，周禧博士促进了美国和中国在碳捕捉，利用与封存（CCUS）技术以及页岩压裂技术方面的商业合作关系。通过在中国开展的培训与在美国促成的实地考察，他帮助了中美两国公司进行合作，寻求二氧化碳的利用策略，特别是在提高采油效率（EOR）方面，谋求双方专家共事。他同时在德州推动能源工业界，学术界和非营利组织成

立一个低碳能源中心。他还帮助将与页岩压裂有关的环保最佳实践方法引进了中国。

周先生的本行是机械工程，他在石油化工行业的工程设计，采购以及建筑领域拥有三十多年的工作经验，他为壳牌石油和陶氏化学管理过大型资本项目，并且主导过福陆公司和凯洛格公司资本项目的机械工程设计。他涉足的项目领域包括化工，炼油，石油勘探和风力，地区包括美国，加拿大，中国和南美。他执行的项目都有在预算内按时完成的良好记录。

周先生拥有国立台湾大学机械工程学士学位，以及西弗吉尼亚大学机械工程硕士和博士学位。

Dr. Bruce Hill
Chief Geologist, Clean Air Task Force (CATF)

Dr. Hill is Chief Geologist for Clean Air Task Force (CATF). Dr. Hill has worked for CATF since 2000 and is presently focused on the development of domestic and international policy for deep geologic carbon storage, and unconventional oil and gas. His work focuses on carbon dioxide storage during enhanced oil recovery in the U.S. and China and includes a 2013 paper published on geologic carbon storage in depleted oilfields. He is a member of the International Standards Organization technical committee ISO TC 265 on carbon capture and storage. In the area of unconventional oil and gas, Dr. Hill focuses on disseminating best environmental practices in the U.S. and China. He received his Ph.D. in geology from Stanford University and his B.A. in geology from University of Vermont.

Clean Air Task Force is a non-profit organization dedicated to addressing global air pollution and climate change through research, advocacy and private sector collaboration.

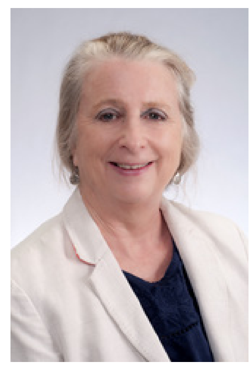
布鲁斯 希尔
空气净化任务组织首席地质家

希尔博士是空气净化任务组织(CATF)首席地质学家。希尔博士自 2000 年任职于空气净化任务组织，他目前的重点关注领域是国内和国际深层地质碳封存、非常规石油和天然气的国内和国际政策。他的工作主重点包括中国和美国开展二氧化碳地质封存和强化采油，在 2013 年还专门发表了关于废弃油田地质封存的论文。他是国际标准化组织技术委员会 ISO TC 265 碳捕集和封存组的成员。在非常规石油和天然气领域，希尔博士的工作重点是传播在中国和美国的环境保护最佳实践。他持有佛蒙特大学地质学学士学位和斯坦福大学地质学博士学位。

空气净化任务组织是非营利组织，致力于通过研究、 宣传和私营部门的协作，解决全球空气污染和气候变化。

Susan D. Hovorka

Principle Investigator, Gulf Coast Carbon Center, Bureau ofEconomic Geology, Jackson School of Geoscience, The University of Texas at Austin



Susan Hovorka is a sedimentologist who works on fluid flow in diverse applications, including water resource protection, oil production, and waste storage. She has led a team working geologic storage of CO2 since 1998, with a focus on field studies, monitoring, and capacity estimation. Projects include saline injection at the Frio Test site and Cranfield Field and EOR studies at SACROC oil field, Cranfield, Hastings and other industrial CO2 utilization projects. She has a long-term commitment to public and educational outreach. She has a BA from Earlham College and a PhD in Geology from The University of Texas at Austin.

苏珊 侯沃卡

资深研究员，德克萨斯大学奥斯汀分校，杰克逊地球科学学院经济地质所墨西哥湾碳中心

苏珊是沉积学专家，专注于流体运动的各种应用，包括水资源保护、石油生产和废物贮存。自1998年以来她带领团队进行二氧化碳地质储存工作，其重点是实地研究、监测和能力评估。从事的项目包括在弗里奥测试点和克兰菲尔德的盐水注入以及在SACROC油田、克兰菲尔德和黑斯廷斯进行提高采收率的研究，还有其他工业二氧化碳综合利用项目。苏珊长期致力于公共事务和

教育的推广。她拥有阿勒姆学院学士学位和德克萨斯大学奥斯汀分校地质学博士学位。

Gu Hongjun
Deputy Director, PetroChina Xinjiang Oilfield Research Institute of Petroleum Exploration and Development

Gu Hongjun worked on several positions in Xinjiang Oilfield Company Development Research Institute including Deputy Director of Dynamic Department, Deputy Chief Geologist, and Director of EOR department, and Deputy Director of recovery and development department, he mainly focus on old oil field development and EOR studies.

Gu Hongjun is mainly engaged in the old oil-field development and EOR technology, he has been responsible for the national tertiary recovery of ASP flooding pilot test in major research projects, fire flooding Group Science and technology research projects and CO2 flooding and sequestration of the junggar basin and other petroleum company research studies (flow redirection), dual drive, polymer flooding and other major research and development pilot project organization and coordination work.

Gu Hongjun has a reservoir engineering degree from the Southwest Petroleum University and he is an on job PhD candidate.

顾鸿君
中石油新疆油田公司勘探开发研究院开发所副所长
顾鸿君先后在新疆油田公司勘探开发研究院动态室任副主任，开发所副总地质师，采收率研究所所长与开发所副所长，主要老油田开发与三次采油研究。
顾鸿君主要从事老油田开发、三次采油技术，先后负责过国家三次采油三元复合驱先导试验重大攻关项目、集团公司科技攻关项目火驱与准噶尔盆地CO2驱油与埋存等攻关研究、中石油股份公司调驱（液流改向）、聚合物驱、二元驱等重大开发试验项目攻关研究与组织协调工作。

顾鸿君毕业于西南石油学院油藏工程专业工学学位，在读博士。

Xisen Zhao

Vice President of the research institute of Shaanxi Yanchang Petroleum (Group) Co., Ltd.

Xisen Zhao, Ph.D., senior engineer; He is currently the Vice President the research institute of Shaanxi Yanchang Petroleum (Group) Co., Ltd. He was graduated from the University of Chinese Academy of Sciences, and majored in petrology, mineralogy, mineral deposit geology. He is in charge of oil and gas field development and enhanced oil recovery technology of the research institute of Shaanxi Yanchang Petroleum (Group) Co., Ltd, responsible for implementation and management of CCUS project of Yanchang Petroleum Company.

Prior to working at Yanchang Petroleum Company, he worked as director of reserves institute and director of natural gas institute in 4th oil plant of Zhongyuan oilfield of Sinopec, chief geologist of Yakela gas field and supervisor of development department in Sinopec Northwest Oilfield Branch, he owns rich experiences in oil and gas exploration, development, energy efficient utilization and reduction.

赵习森

陕西延长石油（集团）有限责任公司研究院副院长

赵习森，博士，高级工程师，现任陕西延长石油（集团）有限责任公司研究院副院长，毕业于中国科学院研究生院岩石学、矿物学、矿床学专业，主管延长石油研究院油气田开发、提高采收率技术等工作，负责延长石油CCUS项目的实施和管理工作。

加入延长石油之前，曾先后担任中石化中原油田采油四厂储量研究所所长、天然气研究所所长，中石化西北油田分公司雅克拉采气厂总地质师、中石化西北油田分公司开发处副处长，具有丰富的油气田勘探、开发、能源高效利用与减排等工作经验。

Shi Qingsan
Director, Department of Geology & Mining Engineering and Resources Exploration, Xinjiang University; Technology Executive, Fuyun County Municipal Government

From 2010, Mr. Shi teaches at the Department of Geology and Mineral Resources in Xinjiang University. He is associate professor and the director of Resource Exploration Department. From 1996 to 2003, Mr. Shi worked for Posts and Telecommunications Industrial Corporation of Xinjiang; he served as the Director of personnel, Marketing Manager and other position.

师庆三
新疆大学地质与矿业工程学院资源勘查系主任
富蕴县人民政府科技副县长
2010年至今，任教于新疆大学地矿学院，资源勘查系主任，副教授。1996-2003年，就职于新疆邮电实业集团总公司，先后任人事部主任、市场部经理等职。自2010年以来主持的科研项目如下：

1、纵向昆盖山地区铜矿成矿特征研究　2012年1月-2014年1月新疆大学博士基金
2、横向　沙力它克能托铜矿普查研究　2011年7月-2012年3月　53万元
3、横向　沙力它克能托铜矿详查研究　2011年7月-2012年3月　347万元
4、横向　奇台县地质遗产申报研究　2011年7月-2012年3月　4万元
5、横向　阿克土麻扎以及江塔克铜矿预查2011年7月-2012年3月44万元

发表文章情况：
近年来在国内外刊物上发表了十余篇论文，其中与第一作者主要学术论文有7篇：

1、Investigations on methods of land cover classification of TM image mountain area　Proceedings of SPIE(English) ISSN：0277786X 2009年5月 Volume 7471 -13
2、Reserch on the cold-island effect with desertification process-baseon the QITAI oasis Proceedings of SPIE (English) ISSN：0277786X2007,11, Volume

6790-0I-1

3、Use of evaportranspiration model balance on energy balance in the Ebinur Lake Wetland Nature Reserve. Proceedings of SPIE (English) ISSN：0277786X 2009,05,7471:OS1-8

4、新疆生态系统服务价值测算与NPP的相关性分析，干旱区地理，ISSN 1000-60602010，33(3):427-433

5、双层模型下艾比湖湿地植物群落蒸散计算，干旱区研究 ISSN1001-46752010,27(6) :933-938

6、绿洲冷岛效应的遥感研究--以奇台绿洲为例. 新疆大学学报(自然科学版)ISSN 1000-2839　2006(3):334-337

7、1982-2006年新疆山地-绿洲-荒漠系统植被覆盖变化时空特征 自然资源学报　ISSN 1000-3037 2011,26(4) :609-618

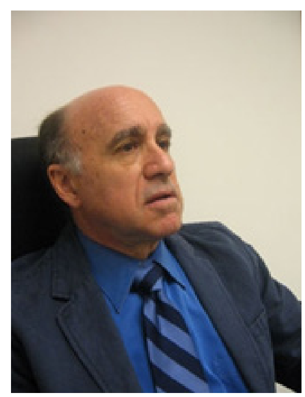
Daniel Goldman

President and Chief Financial Officer, GreatPoint Energy

Daniel Goldman is the President and Chief Financial Officer of GreatPoint Energy with over 25 years of energy industry experience in strategy, corporate and project finance, project development as well as private equity/asset investment and early stage venture investing. In addition to his role in GreatPoint Energy, he is a co-founder and Director of Environmental Entrepreneurs, serves on the board of directors of several clean energy technology companies and advisory board of a large private equity fund based in Hong Kong, and is a member of the Board and Executive Committee of the New England Clean Energy Council. Mr. Goldman is passionate about climate change issues and has focused on advocacy work to bring together investors, policy makers and technology developers to address issues of scale-up and commercialization, among other challenges in the industry. Previously, Mr. Goldman held senior level positions at the private equity fund, New Energy Capital, which he co-founded, InterGen, a Bechtel-Shell joint venture global power development company, and Arthur D. Little, a premier management consulting firm. He received a B.S. from Cornell and an M.Sc. from the London School of Economics. Mr. Goldman serves on the Cornell University Council and on the External Advisory Board to Cornell's Atkinson Center for a Sustainable Future (www.sustainablefuture.cornell.edu/index.php). He lives in Newton, MA and is a competitive road cyclist and tri-athlete in his spare time.

Daniel Goldman
美国巨点能源公司总裁兼首席财务官
Daniel Goldman 是美国巨点能源公司（GPE）的总裁兼CFO，拥有超过25年的能源产业战略、企业、项目融资，项目开发经验，并专注于私募股权/资产投资和早期阶段的风险投资。除了他在GPE扮演的角色外，他还是Environmental Entrepreneurs的联合创始人以及董事，并担任多个清洁能源技术公司的董事，同时列席于一个香港大型私募股权基金的顾问委员会。他是新英格兰清洁能源协会的董事会和执行委员会成员。 Goldman先生热衷于气候变化问题，并一直专注于气候变化问题宣传，召集投资者、政策制定者与技术开发一起解决技术的规模化和商业化问题。在此之前，Goldman先生在他联合创立的私募基金New Energy Capital担任高级职位；并在InterGen和Arthur D. Little担任高级职位。Goldman先生本科毕业于康奈尔大学，硕士毕业于伦敦经济学院。Goldman先生担任康奈尔大学理事会理事和康奈尔大学的阿特金森可持续发展中心外部咨询委员会董事 (www.sustainablefuture.cornell.edu/index.php)。Goldman先生住在马萨诸塞州牛顿市，业余爱好是公路自行车以及铁人三项。

Mark Schoenfield
Senior Vice-President - Operations and General Counsel，Jupiter Oxygen Corporation



Mark Schoenfield is the Senior Vice-President of Operations and General Counsel of Jupiter Oxygen Corporation, an energy technology company with a patented heat transfer technology using oxycombustion for carbon capture, air quality, and energy efficiency for power plants and industrial furnaces.

His primary responsibility is to manage all aspects of the business under the direction of the CEO. Since 2001, Mark has managed the technical and business development of the company for application of its now patented oxy-combustion technology for power plants, industrial furnaces and waste transformation plants. This work has included the development of the Jupiter Oxygen research facilities and oxy-combustion research. Mark testified before Congress in 2007 concerning climate change, environmental and energy security issues, and in 2008 before state legislative committees on energy policy. He continues to work closely with the United States Department of Energy's National Energy Technology Laboratory. In September, 2008, he was a presenter on oxy-combustion technology at the MIT Carbon Capture Forum [as well as a closed high flame temperature oxy-combustion session for MIT combustion faculty and graduate students], and at the 2009 IEA 1st Oxy-Fuel Conference. In September, 2011, Mark will be a presenter at the Clean Coal China Congress. He was the recipient of a Konrad Adenauer Foundation energy study trip to Germany in December, 2008. In 2009, he was a section leader in drafting the National Coal Council policy study for the Secretary of Energy. He is a member of two United States Cabinet level advisory committees: The Secretary of Energy's National Coal Council; 2012: Chair of the Secretary of Commerce's Environmental Technologies Trade Advisory Committee (ETTAC). Mark is the co-author of technical papers concerning energy technology. He served as a member of the Columbia University Earth Institute CCS Task Force. Mark has been an NGO delegate and presenter at UNFCCC climate change conferences, as well as being a presenter and participant at International Energy Agency and other international and domestic meetings and conferences concerning oxy-combustion, energy efficiency and climate change, such as at the National Commission On Energy Policy. His professional activities have included the Business Council For Sustainable Energy and the Alliance To Save Energy. He also is a co-inventor for a pending patent on oxy-combustion technology. In August, 2009, he was appointed by the Secretary of Commerce to the Environmental Technologies Trade Advisory Group.

Mark's past experience includes providing strategic and tactical business advice to businesses as an attorney; being a management consultant; teaching programs on negotiation to major businesses and law firms as well as to other business and legal professionals; being the author or co-author of negotiation and alternative dispute resolution books [one book translated into Chinese and Thai] and articles, managing the litigation/dispute resolution practices of two law firms and being part of their management team for their overall business; and being an associate professor at Northwestern University in the School of Law and the Center for Urban Affairs.

Mark Schoenfield
朱庇特氧气公司高级副总裁和首席律师
Mark Schoenfield是Jupiter Oxygen这家应用热传递富氧燃烧技术进行碳捕捉技术的专利， 提高空气质量，提高电厂和工业熔炉的能效的能源技术公司的高级副总裁和首席律师。

他的主要职责是按照CEO的决策方向负责管理公司所有业务的。自2001年以来，Mark负责管理专利技术富氧燃烧技术在发电厂，工业熔炉和废物转化工厂的应用和业务的开拓和发展。这项工作还包括Jupiter Oxygen的研究设施和富氧燃烧的研究。Mark在2007年与的国会会议，和2008年州立法委员会的会议上回答了有关气候变化，环境，能源安全和能源政策的问题。他一直与美国能源部的国家能源技术实验室有着紧密的工作关系。2008年9月，他在MIT碳捕捉论讨会上介绍了富氧燃烧技术。他在2008年12月获得去德国Konrad Adenauer Foundation能源研究的行程。2009年，他作为主要起草人之一，为能源部长起草国家煤炭协会政策。Mark是有关能源技术论文的合著者。他也是Columbia大学地球协会CCS Task Force的成员。Mark一直是NGO的代表和UNFCCC气候变化大会的演讲者，同时也是国际能源机构和其他国际性和国内会议和大会上，有关富氧燃烧，能源效率和气候变化议题的演讲者和参与者，例如在能源政策方面的国家委员会。他的职业活动还包括在持续发展能源和节约能源的商务理事会。他也是一个对待批的富氧燃烧技术的合作发明者。2009年8月，他被商务部长指派去环境技术贸易咨询部。Mark过去的经历还包括作为律师为企业提供战略的发展计划，也是管理咨询顾问，并在主要的商务活动和律师事务所教授谈判课程，同时也只对其他的商务和法律的专业，也是多种辩论类的书籍和文章的作者和合著者，管理两个律师所的诉讼争端部门，并且参与他们全部业务的管理， 是西北大学法学院和城市事务中心课程的副教授。

Catherine Chen Jing
Director, Market Development of China, Jupiter Oxygen Corporation

Her focus is representing Jupiter Oxygen in China and developing the Chinese market for high flame temperature oxy-combustion, carbon capture and energy saving. Ms. Chen also assists the General Counsel in negotiating contracts. She participated in the July 2011 International CCS Conference jointly organized by Asian Development Bank and NDRC in Beijing, and was a co-presenter at the September 2011 Clean Coal China Conference. Before she joined Jupiter Oxygen in 2010, Ms. Chen had fifteen years of experience in market analysis and industry analysis at multi-national companies and financial institutions as a marketing director and senior manager. She holds a master degree of finance from Capital University of Economics and Business, and a bachelor degree of Art from Xin Jiang University.

陈静
朱庇特氧气公司中国区市场开发总监
陈静女士是Jupiter Oxygen公司中国区市场开发总监。她的主要职责是代表Jupiter Oxygen公司处理在中国的事务并且负责在中国市场推广Jupiter Oxygen公司用于节能减排的高温富氧燃烧技术和碳捕捉技术。陈静女士同时负责协助公司的首席律师商谈任何在中国的商务合同。她曾在2011年7月参加了由中国国家发展改革委员会和亚洲开发银行在北京共同举办的国际CCS论讨会，并作为第二演讲嘉宾出席了2011年9月的中国清洁煤大会。在2010年加入Jupiter Oxygen公司之前，陈女士在金融行业和跨国公司有15年的市场分析和行业分析的工作经验。她拥有北京经济贸易大学的金融学硕士学位，和新疆大学文学学士学位。

Qianlin Zhuang
Chief Technology Licensing Advisor, KBR

Dr. Qianlin Zhuang, currently chief technology licensing advisor to KBR's coal gasification business, has 20+ years of hands-on experience in gasification of hydrocarbons such as coal and biomass (kraft black liquor) and so on. Prior to joining KBR June 2012, he was an independent professional, senior manager for GE's gasification business in China and Asia, project specialist at ChevronTexaco, project developer at Texaco, team leader at the Limerrick Pulp & Paper Center at Univ of New Brunswick of Canada, Professor assistant at Tohoku Univ of Japan, and a lab manager at Institute of Coal Chemistry, Chinese Academy of Sciences. He received his PH.D. on topics about gasification from Tohoku Univ., Japan and Master's on comprehensive utilization of coals from the Institute of Coal

Chemistry, Chinese Academy of Sciences of China

庄前林
KBR煤气化部门首席技术顾问
庄前林博士，现任KBR公司煤气化部门首席技术顾问，从事气化行业逾二十年，经验资深。在2012年6月加入KBR公司以前，庄博士曾在GE公司担任专利技术专家及高级经理，负责中国及亚洲地区气化业务，并在雪佛龙德士古担任项目经理和项目开发，加拿大New Brunswick 大学担任Limerrick Pulp & Paper中心负责人，日本东北大学担任助理教授，并在中国科学院煤化所担任实验室经理。他曾在日本东北大学获得气化博士学位以及中科院煤化所的煤炭综合利用硕士学位。

Company Profile
与会公司简介

Summit Power Group, LLC

- Summit is a 25-year old power plant development company
- Summit's founders: Former US Energy & Interior Secretary Don Hodel & former US DOE Chief Operating Officer Earl Gjelde (both former heads of the U.S. Bonneville Power Administration)
- Eric Redman is President & CEO of Summit Power Group & Summit Carbon Capture
- Summit develops climate-friendly power plants:
    - Wind power (more than 1000 MW in operation)
    - Solar power (including one of California's largest projects)
    - State-of-the-art, high-efficiency natural gas plants
    - Also: Power plants with CO2 capture & sequestration
    - 9,500 MW in operation, 1500 MW in development
- In the U.S., captured CO2 is used for enhanced oil recovery (EOR)
- Summit owns part of a very large Texas oilfield suited to EOR using CO2
- Summit's Texas Clean Energy Project (TCEP) is a joint U.S.-Chinese effort to construct the largest power plant with more than 90% CO_2 capture from coal
- TCEP's captured CO_2 will be used to produce nearly 200 million barrels of oil

美国高峰电力集团

- 高峰电力是有25年历史的电厂项目开发集团
- 高峰电力的创始人：美国前能源部和内政部部长唐纳德 •保罗• 霍德尔以及能源部首席营运官兼内政部副部长杰尔德伯爵共同创立 (两人都曾领导过美国邦纳维尔电力行政管理局)
- 艾瑞克（“瑞克”）•瑞德曼是现任高峰电力集团及旗下碳捕集公司的总裁和首席执行官
- 高峰电力致力于开发气候友好型的电厂
    - 风电 (运营装机容量超过1000 MW)
    - 太阳能发电 (是加利福尼亚州的最大项目之一)
    - 先进、高效的燃气发电厂
    - 电厂的二氧化碳捕集和封存以及捕集二氧化碳用于强化采油(EOR)
    - 现有9,500 MW在运行装机容量，并有1500 MW在开发中
- 在美国捕集到的二氧化碳被用于提高石油采收率
- 高峰电力在德州部分拥有适合于二氧化碳提供石油采收率的大油田
- 高峰电力的德州清洁能源项目(TCEP) 是由中美合作建设的最大规模的电厂，90%的烧煤产生的二氧化碳将被捕集。
- TCEP项目捕集的二氧化碳将被用于增产至少200百万桶原油

GE Power & Water

GE Power & Water is one of the world's leading suppliers of power generation and energy delivery technologies. We provide integrated product and service solutions in all areas of the energy industry including coal, oil, natural gas and nuclear energy; renewable resources such as wind, solar and biogas; and other alternative fuels. In water industry, we provide the world leading separation equipment; membrane & filtration technology; diagnostic tools; mobile water capabilities.

GE-Shenhua Gasification Technology Co., ltd (JV) is a joint venture company by GE and Shenhua. The JV use GE's gasification and Clean coal technology, combine Shenhua's experience in the fields of construction and operation for coal gasification coal-fire power generation station. JV will provide advanced gasification and clean coal technology to promote green development and low carbon emission to protect environment, and will focus on IGCC in China.

GE Mining is committed to solve the world's toughest mining challenges. GE Mining provides propulsion system, mining equipment, mining solutions including power, water and productivity, and mining technology and services. Over 600 mining truck in China are equipped with GE InvertexTM e-drive system. GE Industrea, with office in Beijing and manufacturing site in Shijiazhuang, provides undermining equipment to Chinese mining customers with a focus on safety, efficiency and reliability. GE Mining also helps miners in China to address the productivity and efficiency challenges with mining solutions as diverse as power and water.

Contact Information
Website: www.getransportation.com
Address: 6th floor, West Wing, Hanwei Plaza,
No.7 Guanghua Road, Chaoyang District,
Beijing100004, China
Tel: (86-21) 38773323
Fax: (86-21) 38777504

通用电气能源集团

GE发电和水处理集团是全球领先的发电、气化和能 源技术供应商，集团业务涉及所有的能源领域，包括煤炭、石油、天然气和核电；可再生能源如潮汐能、风能、太阳能和沼气；以及其他新型燃料。在水处理方面，GE提供全球领先的纯净水处理、循环水处理、原水废水处理以及工艺过程处理等设备。

通用电气神华气化技术有限公司（以下简称"合资公司"）是通用电气（以下简称"GE"）与神华集团作为股东共同出资设立，将融合GE在气化及清洁发电方面的先进技术，和神华集团在建设及运营煤气化和燃煤电厂项目方面的丰富经验，通过高效水煤浆加压气化技术，为中国提供先进的清洁煤技术解决方案。合资公司以发展绿色、经济、低碳、环保和可续性为己任，致力于清洁煤技术的研究、开发和应用，现阶段的主营业务是以清洁煤在工业领域应用为基础 的高效水煤浆加压气化技术,并致力于开发具有广阔前景的煤气化联合循环发电项目（IGCC）。

GE矿业致力于解决全球采矿业所面临的最棘手问题，业务范围涉及驱动系统，井工矿设备,并为矿业客户提供电力和水处理方面的解决方案,以及技术与服务。GE矿业的InvertexTM电驱动系统在中国矿用卡车的保有量已经超过600台。GE工创为中国矿业企业提供安全、高效、清洁的井工矿设备，在北京和石家庄分别设有分支机构和制造工厂。GE矿业也提供创新解决方案，满足中国采矿企业对电力、水处理和生产力方面越来越高的要求。

公司联系方式
网址：http://www.ge.com/cn
地址：北京市朝阳区光华路7号
汉威大厦西区6层，邮编：100004
电话： (86-21) 38773323
传真： (86-21) 38777504

Kellogg Brown & Root

Kellogg Brown & Root (KBR) is headquartered in Houston, Texas, also known as the energy capital of the world. The Company employs approximately 27,000 people worldwide. KBR delivers a wide range of services through its Downstream; Gas Monetization; Infrastructure and Minerals; International Government, Defense and Support Services; North American Government and Logistics; Oil and Gas; Power and Industrial; Services; Technology; and Ventures business segments, and differentiates itself as a technology driven engineering, procurement and construction(EPC) company.

KBR has built a proud history and a leading market position in the government and infrastructure sectors by being a low-cost, high-efficiency and absolutely reliable service provider. KBR is also an industry leader in transforming hydrocarbon resources into value across all sectors of the energy and chemicals industries. By designing and constructing energy and petrochemical projects that offer the latest and best process and design technologies, we have established a solid position as a partner to oil and gas operators in meeting the ever-increasing demand for energy. KBR's Technology business offers a range of process technologies such as ammonia synthesis, FCC, coal gasification, chemicals etc to serve the growing demands of respective end-user market.

Contact Information
Website: www.kbr.cn
Address: Unit 802, 8/F, City Champ Tower,
No. 12 Taiyanggong Zhonglu,
Chaoyang District, Beijing,
100028, P.R. China
Tel: 86-10-56572700
Fax: 86-10-56572909

凯洛格布朗路特公司

凯洛格布朗路特公司总部位于名闻世界的能源之都－美国德克萨斯州休斯顿市。公司拥有员工2.7万余名，业务遍及在全球多个国家和地区。作为一家以技术为核心的工程设计、设备采购和施工建设总承包（EPC）公司，KBR可以为能源化工、石油天 然气、基础设施和矿产、国际政府和军事、北美政府与军事、电力工业、工程、技术和投资业务等领 域提供广泛的服务。

作为全球能源与化工行业的领导者之一，KBR一直 致力于研发设计高效节能环保安全的新技术。这些新技术确保了KBR在全球竞争中名列前茅，同时也 确保我们能为客户提供卓越的价值。为了满足我们来自最终用户市场日益增长的需求，KBR技术事业 部提供包括合成氨，FCC催化裂化，煤气化，化工产品等一系列的工艺技术方案。

公司联系方式
网址：www.kbr.cn
地址：中国北京市朝阳区太阳宫中路12号
冠城大厦8层802，100028
电话：86-10-56572700
传真：86-10-56572909

Peabody Energy

Peabody Energy is the world's largest privatesector coal company, lighting lives in countless cities in 23 nations on six continents. Peabody has access to coal in major regions around the world, including the United States, Australia, Mongolia and Venezuela. In 2009, we shipped 244 million tons ofcoal through sales, trading and brokerage activities.

Peabody is proud to represent the rest of the world as the only non-Chinese equity partner in GreenGen, a near-zero emissions power project and carbon research center that is under construction in Tianjin. Peabody also is pursuing partnerships in China that include a large surface mine in Western China and a downstream coal conversion facility with the government of Inner Mongolia.

Peabody is a global leader in clean coal solutions. As a founding member of the U.S.-China Energy Cooperation Program, Peabody seeks to develop clean energy projects in China and shares a vision of advancing energy solutions that strengthen economies, improve lifestyles and advance environmental goals. Through membership in the Executive Committee, Peabody will guide projects that could range from coal-based power generation with carbon capture and storage to smart power grid development to electric cars.

Contact Information
Website: www.peabodyenergy.com
Address: Suite 4201, Beijing Yintai Center,
Tower C, No.2 Jianguomen Wai Avenue
Chaoyang District, Beijing, 100022
Tel: (8610) 85679096
Fax: (8610) 85679100

博地能源

博地能源是全球最大的私营煤炭公司，为六大洲23 个国家的无数城市居民带来电力和光明。博地能源在美国、澳大利亚、蒙古和委内瑞拉等世界主要产 煤区拥有煤矿。2009年，我们通过销售、贸易和代理共输送煤炭2.44亿吨。

博地能源很荣幸成为正在天津建设的近零排放发电 项目和煤炭研究中心－绿色煤电（GreenGen）唯一的非中国本土股权合作人。博地能源还在中国积极 寻求合作机会，包括参与中国西部地区大型露天矿合作项目,以及与内蒙古政府开展下游煤转化设施 方面的合作。博地公司是清洁煤炭解决方案领域的全球领导者。

作为能源合作项目的创始成员，博地能源致力于在 中国开发清洁能源项目，共享先进的能源解决方案，以推动经济发展、改善生活方式和促进环境目 标的实现。作为执行委员会成员，博地能源将对利用碳捕捉和封存技术进行燃煤发电、智能电网及电 动汽车开发等多类项目提供指导。

公司联系方式
网址：www.peabodyenergy.com
地址：北京市朝阳区建外大街2号
银泰中心4201层，邮编：100022
电话：(8610) 85679096
传真：(8610) 85679100

Pelican Energy Consultants

Pelican Energy Consultants, LLC is a full service engineering design firm specializing in the Oil and Gas Sector with offices in the US, China and Africa. Our firm provides multi-discipline engineering design, design-drafting, Project Management, Construction Management and Procurement Services to the Upstream, Midstream and Downstream Oil and Gas sectors. Pelican is a world leader in CO2 Enhanced Oil Recovery Projects and is headquartered in Houston, Texas – USA.

Headquarter Contact Information
Pelican Energy Consultants, LLC
2150 Town Square Place, Suite 250, Sugar Land (Houston), TX 77479, USA。
Ph: 001-713-784-8000
Fax: 001-832-500-2317
Website: www.pelicanenergy.com

美国佩里肯能源公司

美国佩里肯能源公司是一家总部设在美国德州休斯敦市的能源工程设计公司。公司具有雄厚的工程设计实力。 能对石油天燃气行业上游，中游及下游设施提供全方位的服务， 包括机电气以及土木结构的工程设计、制图设计、项目管理、施工管理和采购服务。特别在CO2 驱采油项目设计上，佩里肯公司处于世界领先地位。公司在中国和非洲均设有办事处。

美国佩里肯能源公司总部联系方式
2150 Town Square Place, Suite 250, Sugar Land (Houston), TX 77479, USA。
电话: 001-713-784-8000
传真: 001-832-500-2317
网址: www.pelicanenergy.com

美国佩里肯能源公司北京办事处联系方式
北京朝阳区红军营南路媒体村天畅园7号楼2701室，邮编 100107
电话: 010-64827307转807
传真: 010-64827807转805

Jupiter Oxygen

Jupiter Oxygen Corporation (JOC), a privately held US company, has developed technologies for industrial energy efficiency and cost effective carbon capture from fossil fuel power plants. Jupiter Oxygen's expertise is based on its continued research, development and everyday use of oxy-combustion.

Experiments on and the development of the patented oxy-combustion process began in the mid-1990s as a way to cut fuel costs and lower emissions at an aluminum recycling and manufacturing plant. Jupiter's technology has been in use at the aluminum plant since 1997.

Based on cooperative research and development agreements [CRADA], as well as supported by federal grants, Jupiter Oxygen worked a decade with experts from the National Energy Technology Laboratory (NETL) to develop cost effective carbon capture solutions, obtaining several patents on the joint technology development. The work's focus had been on retrofitting existing coal fired boilers, achieving technology readiness for a demonstration project, allowing for the scale-up of the technology.

Contact Information

Website: www.jupiteroxygen.com
4825 North Scott Street, Suite 200 Schiller Park, Ill. 60176
Fax: 001-847-928-0795

朱庇特氧气公司

朱比特氧气公司（简称JOC），是一家私有美国公司，研究开发了工业领域使用化石燃料的发电厂能源的高效利用和成本有效的碳捕集技术。朱比特的专业是建立在它长期不间断的研发和每日对富氧燃烧使用的基础上。

专利富氧燃烧工艺的开发和实验始于90年代中期，目的是用在铝回收和制造工厂以此来降低燃料成本，降低排放。自1997年以来朱比特的技术已经在铝厂使用。

基于合作研究和开发的协议，同时得益于联邦政府的资金支持，朱比特与国家能源技术实验室的专家们一起合作近十年时间开发了成本合理的碳捕集方案，获得了几项合作开发技术专利。这些工作中心是在改建现有燃煤锅炉，达到为示范项目技术准备就绪阶段，并可将技术使用在规模化的项目中。

联系方式

网址: www.jupiteroxygen.com
4825 North Scott Street, Suite 200 Schiller Park, Ill. 60176
传真: 001-847-928-0795

Air Products and Chemicals, Inc.

Air Products (NYSE:APD) provides atmospheric, process and specialty gases; performance materials; equipment; and technology. For over 70 years, the company has enabled customers to become more productive, energy efficient and sustainable. Recognized as one of the world's most innovative companies by both Thomson Reuters and Forbes magazine, more than 21,000 employees in over 50 countries supply effective solutions to the energy, environment and emerging markets. These include semiconductor materials, refinery hydrogen, coal gasification, natural gas liquefaction, and advanced coatings and adhesives. In fiscal 2013, Air Products had sales of $10.2 billion.

Air Products' technology has been used in a series of OxyFuel and Carbon Capture, Utilization and Storage projects. With Department of Energy's support, the company has successfully begun capturing carbon dioxide from industrial operations and is now using that carbon for enhanced oil recovery (EOR) and securely storing it underground, at Air Products hydrogen production facilities in Port Arthur, Texas. This first-of-a-kind, breakthrough project advances carbon capture, utilization and storage technologies and demonstrates the potential to safely secure carbon dioxide pollution underground while providing an economic benefit and increasing our energy security. At full-scale operation, more than 90 percent of the carbon dioxide from the product stream of two methane steam reformers - or approximately one million metric tons of carbon dioxide per year - will be delivered for sequestration and EOR, which will lead to an estimated annual increase in oil production of 1.6 to 3.1 million barrels from the West Hastings oil field located about 20 miles south of Houston, Texas.

During the US-China Climate Change Working Group conference in July 2014, Air Products signed cooperation agreements with Yanchang Petroleum Group and Shanxi International Energy Group to work on CCS for EOR and Oxyfuel technology respectively.

Contact Information

Website: www.airproducts.com
www.airproducts.com.cn
Address: Rm2810, Beijing Silver Tower,
No.2 North Rd, Dong Sanhuan,
Chaoyang District, Beijing,
100027, P.R. China
Tel: 86-10-64106156
Fax: 86-10-64106153

空气化工产品有限公司

空气产品公司（Air Products, 纽约证券交易所代码：APD）提供空分、工艺和特种气体，功能材料，相关设备及技术。70多年来，公司一直帮助客户提高生产效率和能源效益，以实现可持续性发展。空气产品公司同时被汤森路透和福布斯杂志评为全球最具创新力企业之一，其遍布全球50多个国家和地区的 21000多名员工为能源、环境和新兴市场提供有效的解决方案，包括半导体材料、加氢炼化、煤气化、天然气液化以及先进的涂料和粘合剂等。2013财年度，空气产品公司的销售额为102亿美元。

空气产品公司的专利技术已在一系列世界领先的富氧燃烧和二氧化碳捕捉与封存示范项目中被投入使用。 在美国能源部的支持下，公司在德克萨斯州阿瑟港的制氢装置的二氧化碳捕获项目已成功地实现商业运营并储存于地下用于驱油(EOR)。这一史无前例的项目推进了碳捕获、利用与封存技术的发展，并验证了二氧化碳可以安全地储存于地下以减少污染，同时创造经济利益，提高能源安全。满负荷运营时，来自空气产品公司两套甲烷蒸汽重整装置的90%以上的二氧化碳（每年将近百万吨）都会被用于EOR，可以提高附近油田的采收率约每年160至310万桶。

在2014年7月举行的中美气候变化工作组大会期间，空气产品公司就应用于EOR的碳捕捉与封存以及富氧燃烧技术，分别与延长石油集团和山西国际能源集团签订了合作协议。
燃烧技术，分别与延长石油集团和山西国际能源集团签订了合作协议。

联系方式
网址：www.airproducts.com
www.airproducts.com.cn
地址：中国北京市朝阳区东三环北路2号
南银大厦2810,100027
电话：86-10-64106156
传真：86-10-64106153

GreatPoint Energy

GreatPoint Energy (GPE) is based in Chicago, IL, United States. It has developed a catalytic gasification process (Bluegas™) that effectively convert coal, petroleum coke, and biomass into low cost natural gas. Bluegas™ operates at significantly higher efficiency than competing technologies and benefits from lower capital intensity, much less water consumption, a superior environmental footprint, and ultimately a much lower cost of production. GreatPoint Energy plans to develop, own and operate large-scale Bluegas™ production facilities globally in conjunction with local partners. In addition, by-product carbon dioxide ("CO2"), which is inherently captured as part of the bluegas™ process, can be sequestered or used in enhanced oil recovery ("EOR") to dramatically improve production from depressurized oil fields around the world.

Contact Information
Website: greatpointenergy.com
2215 W. Harrison St. Ste G Chicago, IL 60612
Tel: 312.564.4683

美国巨点能源

GreatPoint Energy(巨点能源，或GPE) 公司总部位于美国芝加哥。GPE开发了蓝气™催化剂水解甲烷化技术，可将煤炭，石油焦，和生物质更有效地转换为清洁且低成本的天然气。与传统技术相比，GPE的蓝气™技术效率更高，对资本投入要求低，显著减少水耗，环境污染影响小，并最终生成更低成本的天然气。GPE计划在全球范围内与本地合作伙伴一起开发并运营商业规模的蓝气™技术煤制天然气工厂。另外，GPE的煤制天然气工艺有能力近乎完全补集生成的CO2，并将其处理成极高纯度的CO2副产品，可被直接利用于油田的二氧化碳驱油，并显著提高石油产率。

联系方式:
网址: greatpointenergy.com
2215 W. Harrison St. Ste G，芝加哥，伊利诺伊，美国。 邮编：60612
电话： +1 312.564.4683

Presentations
演讲文稿

John Thompson - Clean Air Task Force
John Thompson - 美国净化空气任务组织

CCUS Workshop
二氧化碳捕集、利用与封存研讨会

Creating a Strong CCUS Industry in Xinjiang
在新疆建设一个强大的CCUS产业

John Thompson
Director, Fossil Transition Project
Clean Air Task Force
September 18, 2014

约翰·汤普森
化石过渡项目主任
净化空气任务组织
2014年9月18日

About Clean Air Task Force
关于净化空气任务组织

Non-profit organization founded in 1996 dedicated to reducing atmospheric pollution through research, advocacy and private sector collaboration

- ***CCUS:*** EOR to speed CCS development (“U’ stands for utilization)
- ***Policy:*** Incentives for early CCS deployment and CO_2 limits on sources
- ***Partnerships:*** To speed projects (especially US and China)
- ***Communication:*** Shape public discourse to focus on what really counts
- **Projects**: Support coal and gas projects that advance lower emissions

成立于1996年的非营利组织，致力于以研究、宣传并与公司合作的方式减少大气污染

- CCUS：提高采收率以加速二氧化碳捕集与封存（CCS）的发展（“U”代表利用）
- 政策：激励早期CCS的部署和对二氧化碳的限制
- 合作伙伴：为了加快项目实施（尤其是美国和中国）
- 传播：让公共话语专注于真正重要的议题
- 项目：支持能推进低排放的煤炭和天然气项目

网址：
http://www.catf.us
www.fossiltransition.org

2

Three Workshop Themes 研讨会的三个主题

CLEAN AIR TASK FORCE

To create a CCUS industry:

1. Start with sources of CO_2 that avoid high capture costs.
2. Form China-US CCUS business partnerships.
3. Establish a regional network of pipelines and EOR storage sites.

要创建一个CCUS行业：
1. 从能获得低成本的二氧化碳来源入手。
2. 形成中美CCUS商业合作伙伴关系。
3. 建设区域性的管道和EOR储存场所。

3

First Theme 第一个主题

CLEAN AIR TASK FORCE

- To create a CCUS industry, start with sources of CO_2 that avoid high capture costs.
  - Some industries (for example: methanol, fertilizer, ethylene oxide) produce waste streams that are highly concentrated in CO_2.
  - Xinjiang has many *existing* sources of high-purity CO_2 that are ideal for EOR.

- 要创建一个CCUS产业，从能获得低成本的二氧化碳来源入手。
  - 有些行业（例如：甲醇、化肥、环氧乙烷）产生高二氧化碳浓度的废气。
  - 新疆有许多*现成*的高纯度二氧化碳来源，很适合用于EOR。

4

CLEANAIR TASK FORCE

US Examples 美国案例

Dakota Gasification
(Substitute natural gas plant in North Dakota)
达科他气化厂（北达科他州的替代天然气厂）

3 million tons/year of CO_2 sent 205 miles by pipeline for EOR in Canada.
每年有300万吨二氧化碳通过管道输送205英里到加拿大进行EOR。

Coffeyville Fertilizer Plant
(Ammonia and UAN fertilizer plant in Kansas)
科菲维尔化肥厂（堪萨斯的氨和UAN化肥厂）

850,000 tons/year of CO_2 sent 70 miles by pipeline for EOR in Oklahoma.
每年有85万吨二氧化碳通过管道输送70英里到俄克拉何马州进行EOR。

5

CLEANAIR TASK FORCE

Second Theme 第二个主题

- To create a CCUS industry, form China-US CCUS business partnerships.
- US-China partnerships that can establish new pathways to speed CCUS projects that would otherwise stall when difficulties emerge.
- 创建CCUS产业，形成中美CCUS商业合作伙伴关系。
- 美中伙伴关系可以建立新的途径以加快CCUS项目，否则困难出现时项目将停顿

6

CCUS Cooperation Benefits Both Countries
两国同时受益于CCUS合作

US 美国

Innovative, cost-effective technologies.
创新型，技术具有成本效益

EOR experience and technology.
EOR经验与技术

China 中国

EOR experience and technology.
EOR经验与技术

Innovative, cost-effective technology.
创新型，技术具有成本效益

7

Third Theme 第三个主题

- To create a CCUS industry, establish a regional network of pipelines and storage sites.
  - US Examples: Texas, Mississippi, Wyoming
  - US networks often began with natural CO_2 sources, added industrial sources, and now power plant sources are under construction.
  - Existing pipelines and EOR sites attract new CCUS projects.

- 要创建CCUS产业，建设区域性的管道和EOR储存场所
  - 美国的例子：德克萨斯，密西西比，怀俄明
  - 美国网络往往始于天然二氧化碳的来源，后来再加上工业源，现在正在建设电厂的来源。
  - 现有管道和EOR场地吸引新的CCUS项目。

8

CLEANAIR TASK FORCE

Kemper IGCC

Operational in 2015. 65% capture- 3.5 million tons CO2/yr for EOR
2015年运营。65%捕获——为EOR提供350万吨二氧化碳/年

Mississippi
CO_2 Pipelines

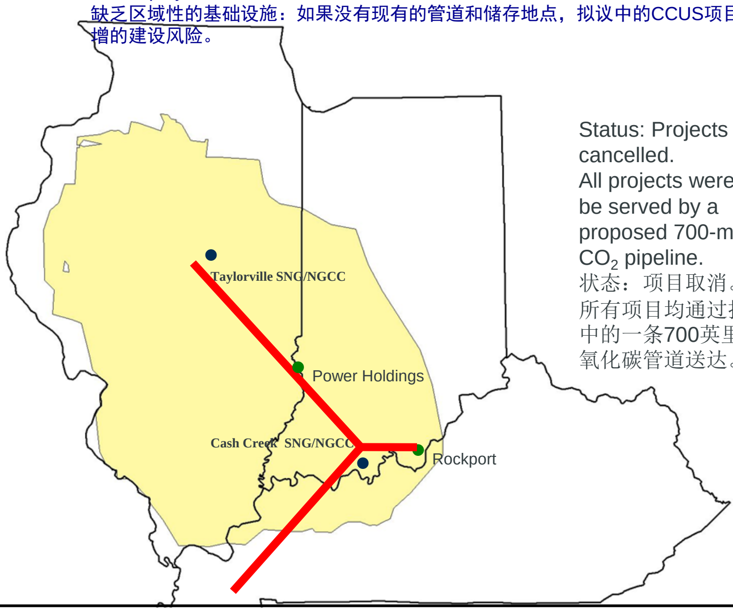
• Kemper

2012 existing
2015 operational

9

CLEANAIR TASK FORCE

Lack of Regional Infrastructure: Without existing pipeline and storage sites, proposed CCUS projects face added construction risks.
缺乏区域性的基础设施：如果没有现有的管道和储存地点，拟议中的CCUS项目面临新增的建设风险。



Status: Projects cancelled.
All projects were to be served by a proposed 700-mile CO_2 pipeline.
状态：项目取消。
所有项目均通过拟议中的一条700英里二氧化碳管道送达。

10

What’ s shared by these themes?
这些主题有何共通之处？

- Each reduces project risk, cost and uncertainty. Each drives innovation that leads to lower costs and better performance.
  - High-purity CO_2 from existing sources— Low cost CO_2 sources lower risks and uncertainties of scaling up EOR in Xinjiang.
  - US-China Partnerships- Brings know-how, financing, and technology that lowers risks and drives innovation.
  - Region-wide pipelines and EOR storage site infrastructure (and expertise)- Reduces the costs of moving from single CCUS projects to many projects that establish a CCUS industry.

- 他们都能降低项目风险、成本和不确定性。都能驱动创新以取得更低的成本和更好的成果。
  - 从现有的来源取得高纯度二氧化碳——低成本的二氧化碳源降低新疆扩大EOR规模时的风险和不确定性。
  - 美中伙伴关系带来经验、融资、技术，以降低风险和推动创新。
  - 区域性的管道和EOR储存场所（和专业知识）——从单一的CCUS项目转到了建立CCUS行业的许多项目，减少了成本。

11

Benefits to a Regional Approach
对新疆整个区域的益处

- CCUS prolongs the life of oil fields in Xinjiang.
- CCUS creates economic growth and prosperity.
- CCUS isolates CO_2 underground, reducing risks from climate change.

- CCUS延长在新疆油田的开采寿命。
- CCUS创造经济增长和繁荣。
- CCUS把二氧化碳隔离在地下，减少气候变化的风险。

12

Xinjiang CO_2-EOR Workshop

新疆CCUS早期示范机遇
Early opportunities of CCUS Deployment in Xinjiang

李小春 Xiaochun, Li
中科院武汉岩土力学研究所
Institute of Rock and Soil Mechanics, Chinese Academy of Sciences
9月18日, 乌鲁木齐, 新疆

Outline

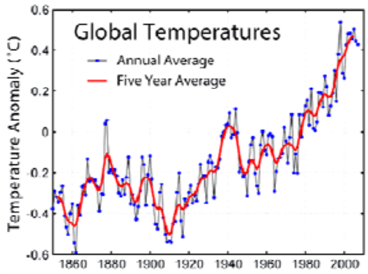
- Introduction of CCUS technologies
- CCUS技术介绍
- Status of CCUS in China
- 中国CCUS技术的现状
- Cost of Early CCUS projects in Xinjiang
- 潜在煤化工CCS项目的成本
- Conclusions and suggestion
- 小结与建议

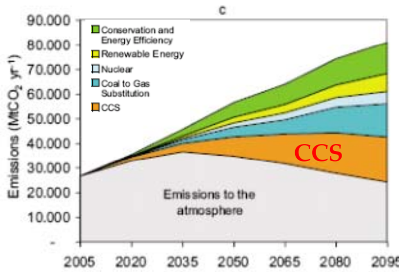
Introduction of CCS technologies

The importance of CCUS

- **The global emission reduction requirements**全球需要减排
- **China emission reduction requirements**

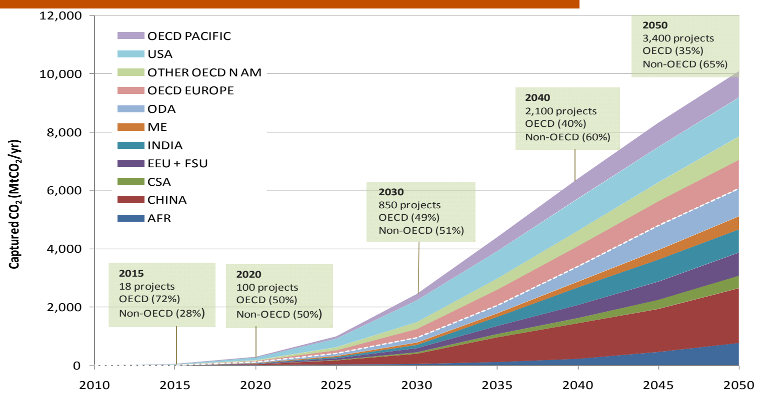
  中国需要减排：我国CO_2排放量已是世界第一，很可能在20~30年之间承担强制减排责任，减排技术储备十分必要
- **Three types:** 节能增效、低碳能源、CCS
- **The role of CCS in the global:** 上述减排技术的组合有助于降低成本，增强能源政策与减排措施的灵活性
- **The role of CCS in China:** 中国以化石能源为主的能源结构。CCS在节能增效、低碳能源充分发挥作用之后化石能源被充分替代之间，发挥“桥梁”或“过渡”作用，确保我国化石能源的清洁、可持续利用。

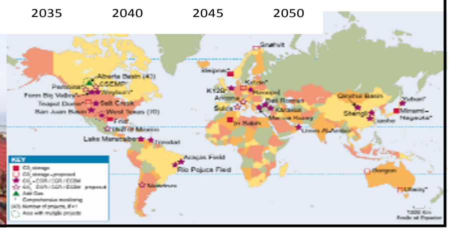




Introduction of CCS technologies

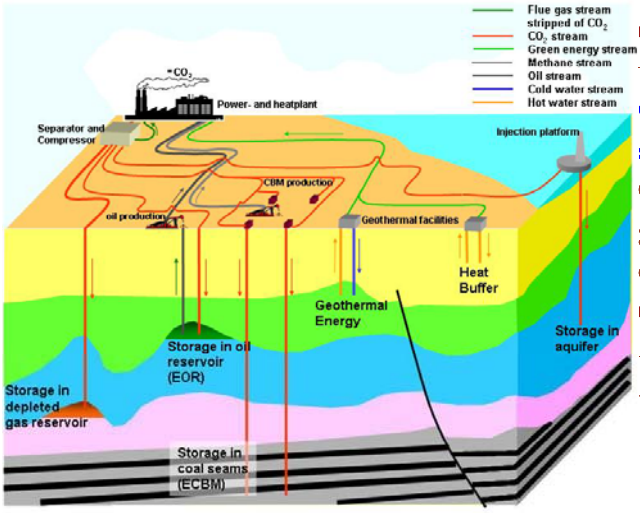
Global Status of CCS-IEA prediction based on CCS Roadmap





Introduction of CCS technologies

CCS system



Schematic map of CCS technologies
From slide of TNO Engine Workshop 7

▪CO_2 geological utilization and storage: **CO_2-EOR; CO_2 aquifer storage;** CO_2-ECBM, CO_2-EGR, and other geological utilization options; CO_2

▪地质利用与封存：**CO_2增采原油，咸水层封存、驱替煤层气、增采天然**气，和其他地质利用类型。

Introduction of CCS technologies

CCS 系统构成

CO_2 Sources (Shenhua PC Project)

Pipeline (web)

CO_2地质封存

CO_2 storage (Yanchang Project)

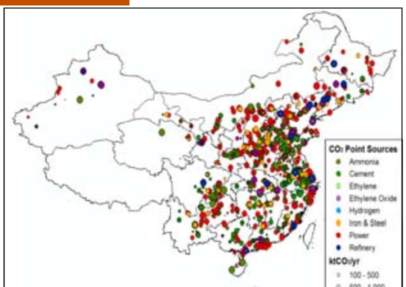
CO_2 capture+ dehydration and compression + transportation (pipeline) + geological utilization and storage
CO_2捕集+ 脱水压缩 +管道运输 + CO_2地质封存

Outline

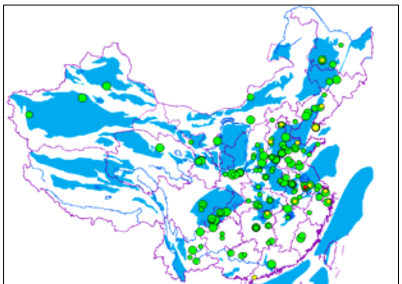
- Introduction of CCUS technologies
- CCUS技术介绍
- **Status of CCUS in China**
- **中国CCUS技术的现状**
- Cost of Early CCUS projects in Xinjiang
- 潜在煤化工CCS项目的成本
- Conclusions and suggestion
- 小结与建议

Status of CCUS in China

CO_2排放源

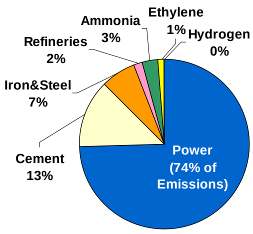


All emission sources



High purity emission sources

- 1600+(>10^5t/a), 3.9Gt in total (2007)
- Emissions from power, cement and iron & steel account for 94%
- 0.1Gt high purity CO_2 ready for storage?

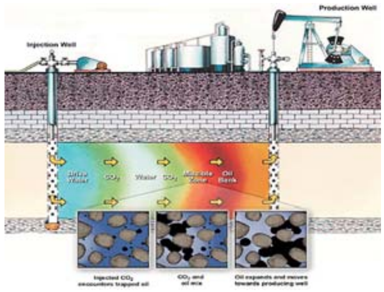


Status of CCUS in China

强化采油的原理与封存容量

强化采油增产与封存容量（Li 等，2009；沈平平等，2010；彭勃，2013）

CO_2-EOR and storage capacity



- 容量：20-192亿吨CO_2
- 增产：8.9亿吨原油以上

- Storage capacity: 2.0-19.2 Gt CO_2
- Additional oil: more than 0.89Gt

Status of CCUS in China

气田封存的原理与封存容量

气田理论封存容量（Li等，2009；宋永臣等，2013）

CO_2-EGR and storage capacity

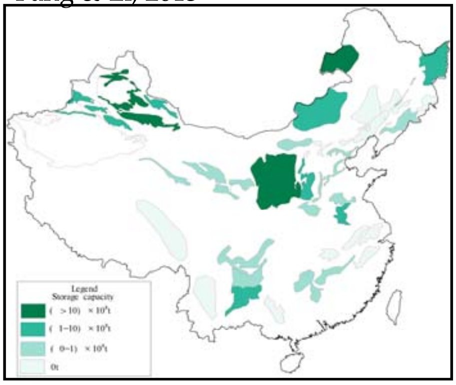
- 23个陆域、6个海域盆地
- 基于探明地质储量
- 封存容量：9.1-45.7亿吨CO_2
- 天然气增产：600-1900亿m^3

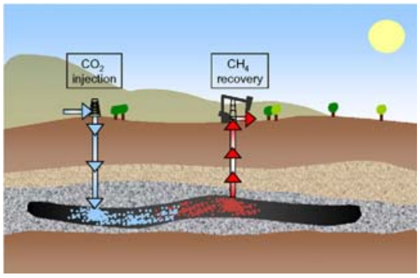
- 23 onshore basin、6 offshore basin
- Capacity Estimate is based o n proven reserve
- Capacity：0.91-4.57GtCO_2
- Additional NG: 60-190Gm^3

Status of CCUS in China

驱煤层气的原理与封存容量

Fang & Li, 2013





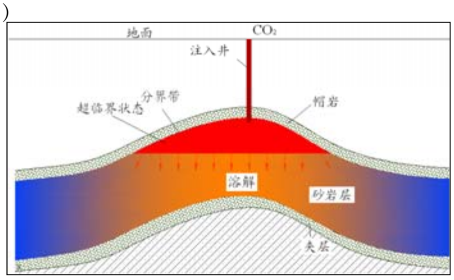
- CSLF评价方法
- 28个煤层气盆地
- 深度范围1000米到2000米
- 假定可用于煤层气储量的10%
- CO_2封存容量为99亿吨
- 煤层气开采潜力13.47万亿m^3

- CSLF method
- 28 basins
- Depth:1000-2000 m
- Assuming 10% of CBM reserve suitable for ECBM
- Capacity: 9.9 Gt CO_2
- CBM production: 13.47 trillion m^3

Status of CCUS in China

咸水层封存的原理与封存容量

咸水层理论封存容量（Li, Wei等，2008年）



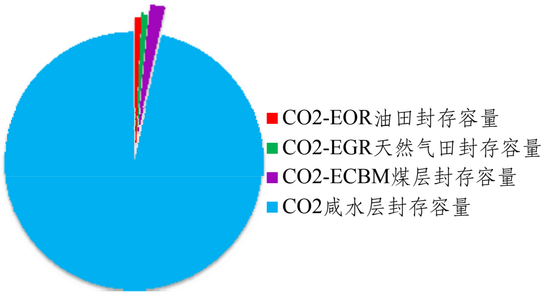
- 封存量大，是大规模深度减排的选项
- 分布广泛，可为大多数省区所用
- 北方靠陆上，东南华南靠近海

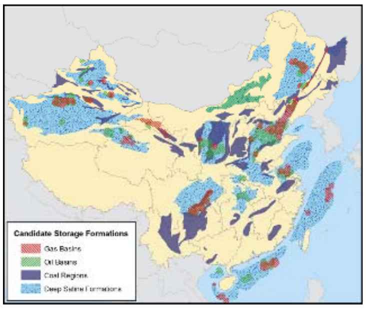
- 方法
  - 假定所有砂岩层用于封存
  - 17陆上、10个近海盆地
  - 采用体积-溶解度方法
  - 深度、砂岩比、孔隙度

盆地尺度理论封存容量： 30660亿吨

Status of CCUS in China

CO_2 封存容量





storage sites in China

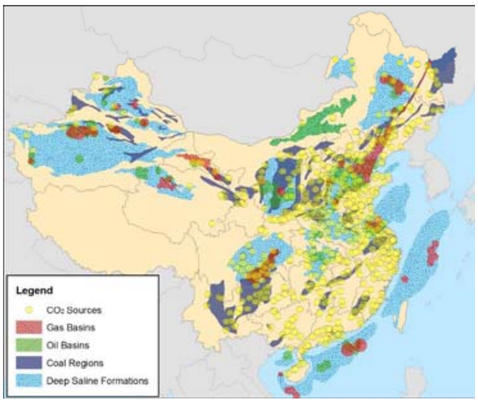
CO_2 地质封存总容量（盆地尺度理论封存容量，Li，2009）

	Total estimated capacity ($MtCO_2$)	Estimated capacity in oilfields by proved OOIP($MtCO_2$)	Estimated capacity in gas fields by proved OGIP($MtCO_2$)	Estimated Capacity in un-mineable coalbed ($MtCO_2$)	Estimated Capacity in deep saline formation ($MtCO_2$)
Onshore	2,380,000	4,600	4,280	12,000	2,280,000
Total	3,088,000	4,800	5,180	12,000	3,066,000

Pacific Northwest
NATIONAL LABORATORY

Status of CCUS in China

不同封存方式的特点



- EOR具有早期机会：可增产石油，我国已有7次试验；
- 气田距离枯竭尚远；
- 驱煤层气技术尚不成熟；
- 咸水层封存是我国大规模和深度减排的主要方式：理论容量占99%，技术比较成熟，地理及规模匹配性好，中南、华南、东南只能依靠咸水层；

Status of CCUS in China

技术成熟度

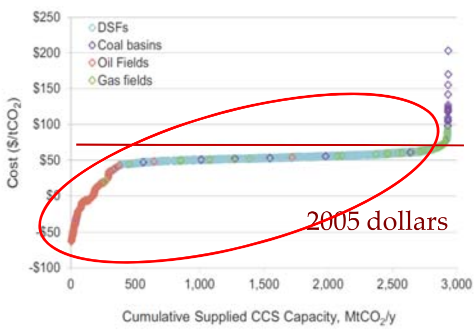
CCS component	CCS technology	Research phase [a]	Demo phase [b]	Economically feasible Under specific conditions [c]	Mature market [d]
Capture	Pre-combustion		★	√	
	Capture Post-combustion		★	√	
	Oxyfuel combustion	★	√		
	Industrial separation (natural gas processing, ammonia production)				★ √
Transportation	Pipeline Transportation		★		√
	Shipping		★	√	
Sequestration	Geological storage Enhanced Oil Recovery			★	√
	Gas or oil fields		★	√	
	Saline formations		★	√	
	Enhanced Coal Bed Methane recovery	★	√		

中国（★）和世界（√）上的CCUS技术研发差距并不是特别大，可以通过技术研发和示范缩小技术差距。

Status of CCUS in China

源汇匹配与成本曲线

- By source-sink matching and cost analysis,源汇匹配分析结果显示:
- There are a number of potential opportunities for low and even negative cost storage options;
- 低成本本的CCS早期机遇;
- The vast majority of storage potential is offered by the large and high capacity deep saline formations at estimated total costs of less than 70US $/ tCO_2 (without capture)
- 大多数CCS项目的总成本低于70US $/$tCO_2$，封存容量主要由$CO_2$-EOR和咸水层贡献。



R.T. Dahowski, Li et al, 2012

8 industry sectors 1600+ sources
4 type of storage options

Status of CCUS in China

中国CCUS 技术路线

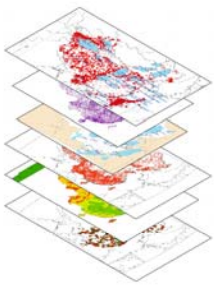
- There are a number of potential opportunities for low and even negative cost storage options;煤化工等高浓度排放源由于其较低的捕集成本，应率先开展捕集、利用与封存全流程技术示范；
- The vast majority of storage potential is offered by the large and high capacity deep saline formations at estimated total costs of less than 70US $/ tCO_2 (without capture). CO_2-EOR and deep saline formations storage are priority 大多数CCS项目的总成本低于70US $/$tCO_2$，封存容量主要由EOR和DSF贡献。
- The deployment of whole process of demonstration projects 全流程示范项目在鄂尔多斯盆地、松辽盆地、渤海湾盆地和准葛尔盆地等有较多的机会，具体示范项目的确定应综合考虑成本、安全、环境等因素。(21st century agenda, MOST, 2011)

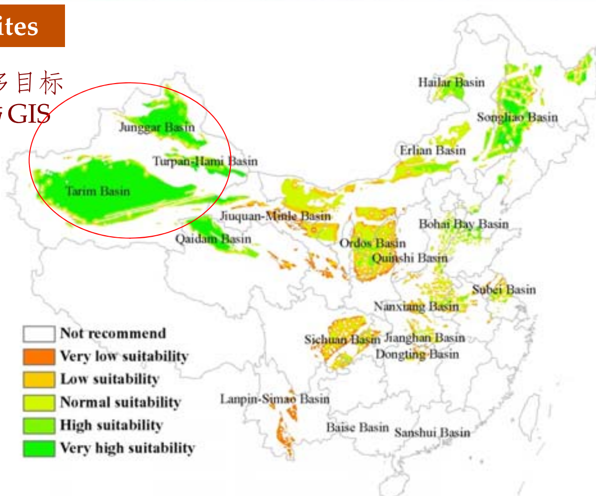
17

Status of CCUS in China

Site suitability of aquifer sites

- 咸水层场地适宜性基于多目标评价方法、 GIS数据库与GIS数据。





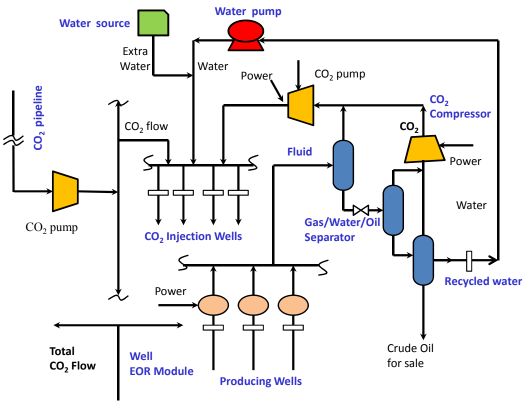
咸水层场地适宜性：
- 大量适宜性较好的陆上咸水层封存场地，主要集中在中国西北和东北部。
- 华东、华北、中南、西南的盆地适宜性较差，原因各有不同。

18

Status of CCUS in China

CO_2-EOR model

Major parameters for deterministic economic evaluation



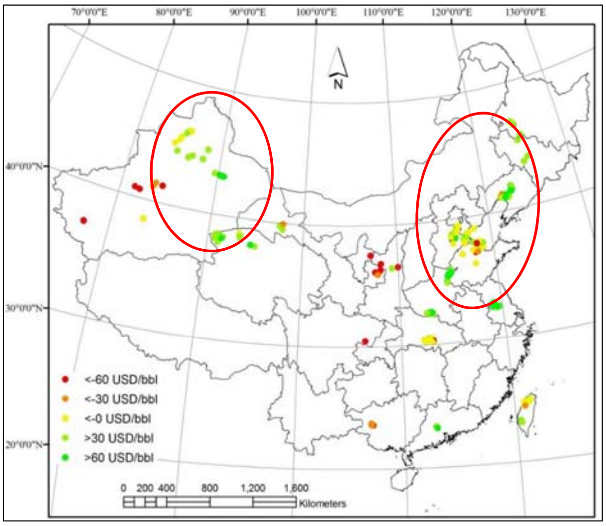
Schematic map of CO_2 EOR activities, modified from report by NETL(2011)

National assessment always use statistic data or empirical data, here use China data to escalate the API data.

Project Parameter	Deterministic Value
First purchase Oil Price ($/STB)	**90.0**
CO_2 Purchase Price ($/t)	**50.0**
CO_2 recycling Costs($/t)	**23.66**
Discount Rate (%)	12
Ratio of New wells to original wells	**0.15**
Other O&M Costs ($/bbl)	Calculated by model
Amortized CAPEX($/bbl)	Calculated by model
EOR project lifetime (year)	12
HCPV injected	0.5
Ratio of CO_2 to water	1:1
Operating Monitoring & Verification ($/a)	Calculated by model
Closure Cost ($)	0
Taxes & Royalties	
Royalty Rate (%)	12.5
Severance Tax Rate (%)	5.0
Ad Valorium Tax Rate (%)	2.0
CO_2 Tax ($/tonne)	0.00
Real Escalation Rates	
Oil Price (%/year)	2
CO_2 Tax (%/year)	0
CO_2 Cost (%/year)	2
CO_2 Processing O&M Cost (%/year)	2
Lifting O&M Cost (%/year)	2
M &V Cost (%/year)	2
Lease O&M Cost (%/year)	2
Capital Cost Escalation Factors	
Drilling & Completion	2
Production Well Equipment	2
Injection Well Equipment	2
Production Lease Equipment	2
CO_2 Processing Equipment	2
Producer Breakdown	
Existing Producers	n_+
New Producers	0
Producer Workovers	n_+

Status of CCUS in China

陆上CO_2地质封存的场地筛选



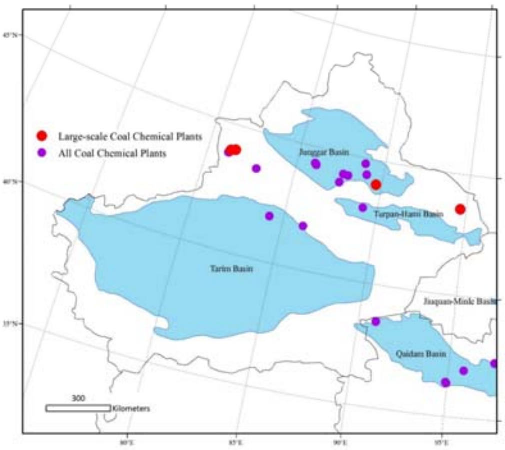
- 高适宜性（有收益）油田，主要在中国东部和西北部。
- CO_2排放源附近的油田可以提供封存空间。

Outline

- Introduction of CCUS technologies
- CCUS技术介绍
- Status of CCUS in China
- 中国CCUS技术的现状
- Cost of Early CCUS projects in Xinjiang
- 潜在煤化工CCS项目的成本
- Conclusions and suggestion
- 小结与建议

Cost Evaluation of CO_2-EOR

Levelized cost distribution of onshore CO_2-EOR in Xinjiang

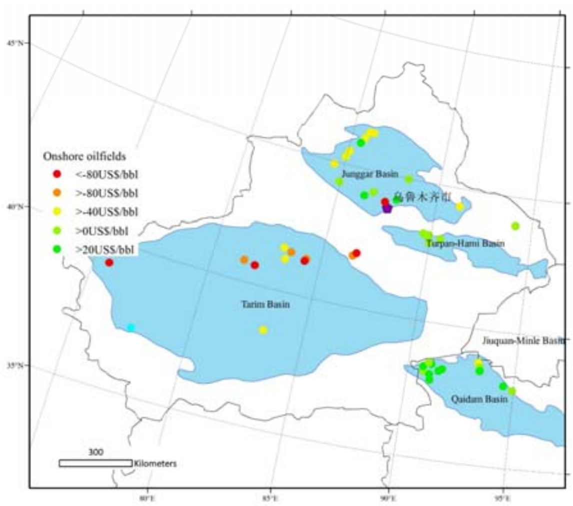


大量的高浓度CO_2排放源，特别是高浓度CO_2排放源。

There are also lots of high-purity CO_2 sources, such as coal chemical factories, and other high purity emission sources.

Cost Evaluation of CO_2-EOR

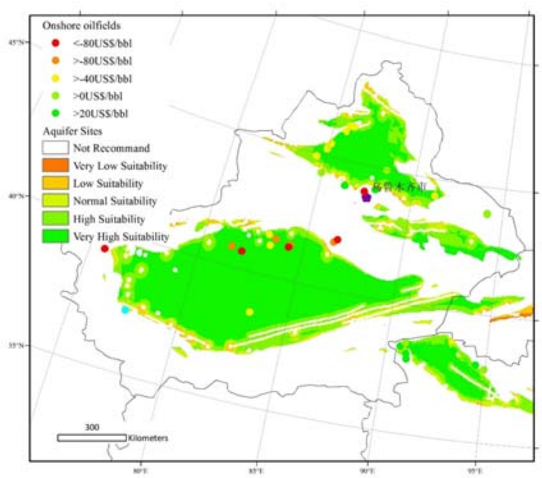
Levelized cost distribution of onshore CO_2-EOR in Xinjiang



- 大量CO_2-EOR机会存在于准葛尔盆地与塔里木盆地。
- The profitable CO_2-EOR are mainly located in the Junggar Basin and Qaidam Basin.
- There are about 300 Mt crude oil can be recovered and 480 Mt CO_2 can be stored underground by CO_2-EOR.

Cost Evaluation of CO_2-EOR

Levelized cost distribution of onshore CO_2-EOR in Xinjiang



- 大量咸水层封存机遇，同时EOR与咸水层联合封存的机遇。
- There are lots of suitable aquifer sites and oil field in Xinjiang. When CO_2-EOR coupled with CO_2 aquifer storage, an optimization between dynamic need of EOR and CO_2 storage capacity can be obtained.

Outline

- Introduction of CCUS technologies
- CCUS技术介绍
- Status of CCUS in China
- 中国CCUS技术的现状
- CO_2 source-sink matching for early opportunities
- 源汇匹配 （早期机遇）
- **Cost of Early CCUS projects in Xinjiang**
- **潜在煤化工CCS项目的成本**
- Conclusions and suggestion
- 小结与建议

Cost of Early CCUS projects in Xinjiang

Main framework of technical-economic

Emission sources

Equipment + operation and maintaining process

Revenue from production

CO_2 capture and compression

CO_2 transportation

CO_2 Storage and utilization

CO_2 Sink

CO_2 carbon tax

Net cash flow= revenue + carbon tax – capture & compression cost – transport cost – storage cost – tax

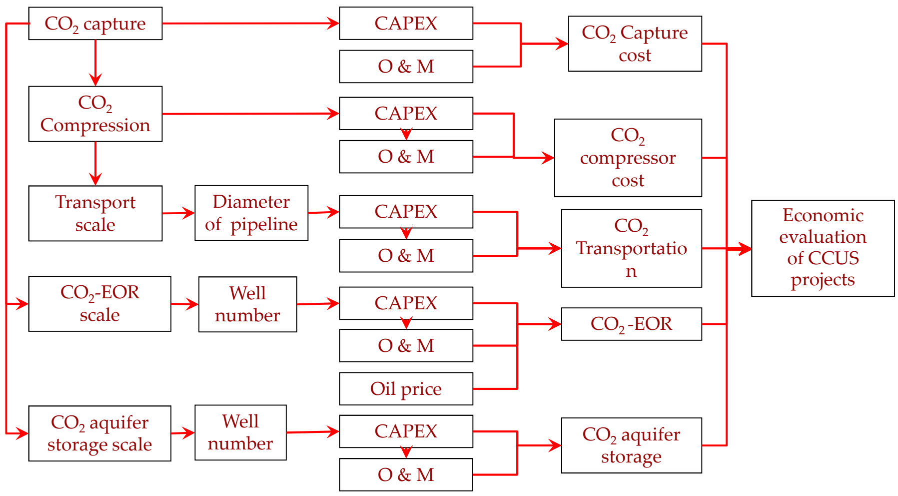
净现值=收益 +碳税- 捕集压缩成本-输送成本-封存成本-税收

Levelized cost = total cost/ the amount of stored CO_2 [$/t]

平准化成本= 总成本/ 封存量 [$/t]

Cost of Early CCUS projects in Xinjiang

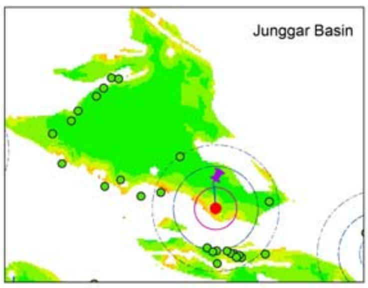
Main framework of economic



Refer to all kind of economic model around world.

Cost of Early CCUS projects in Xinjiang

Cost Evaluation

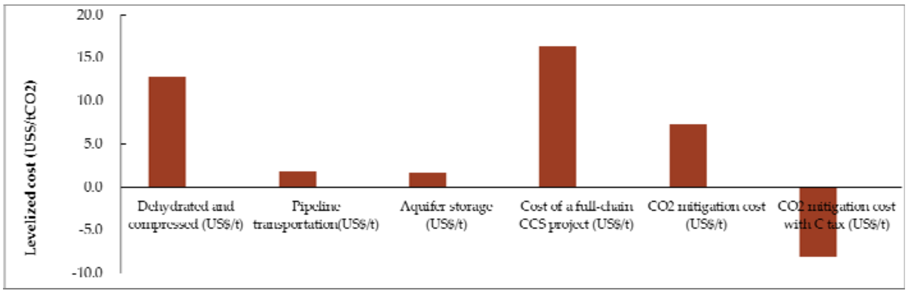


Coefficients	Case 4
Total CO_2 Processed (Mt/a)	1.6
CO_2 to Aquifer Storage (Mt/a)	0.96
CO_2 Sale for EOR (Mt/a)	0.64
Depth(km)	1.8
Gross Thickness(m)	150
Horizontal permeability (mD)	100
Length of pipeline(km)	60
Ratio of production wells to injection wells	0.5
Electricity price(USD/kwh)	0.087
Life cycle(year)	20
Carbon tax (USD/t CO_2)	15
CO_2 sales price to EOR (USD/t CO_2)	20
Discount rate	0.12

Potential CCS project: CO_2-EOR与咸水层封存联合CCUS项目，可以充分利用EOR获益同时实现对EOR过程缓冲。EOR(40%) +咸水层封存(60%)

Cost of Early CCUS projects in Xinjiang

Cost Evaluation



	Capture and compression (USD/t)	Pipeline transportation(USD/t)	Aquifer storage (USD/t)	Total cost of CO2 aquifer storage(USD/t)	Total CO_2 mitigation cost (USD/t)	CO_2 mitigation cost with CO_2 tax (USD/t)
Tarim Basin	12.83	1.78	1.73	16.35	7.28	-8.11

CO_2捕集、运输与CO_2-EOR具有盈利（无特别捕集过程）；全流程CCS项目的综合成本为7.28USD/t，碳税条件下具有收益（15USD/tCO_2税收条件）

29

Barriers to Large-scale Deployment of CCUS

Xinjiang has the potential to deploy CO_2-EOR technologies, however there are many barriers to large-scale deployment of CGS technologies under current condition.

- CO_2源：CO_2 source- not cheap or not available
- 金融：Financial problem- very high investment, high tax rate and financial risk;
- 技术挑战：Technical challenges- high viscosity, high heterogeneity, miscible state, and other problems.
- 技术竞争：Competition with other EOR technologies, CO_2-EOR is not preferred choice without CO_2 mitigation.
- 采矿权：Mineral right – oil and CO_2 space definition;
- 公众态度：Public perception- "not in my backyard"
- 技术研发机制：R &D system in petroleum enterprises- technical barriers.

Outline

- Introduction of CCUS technologies
- CCUS技术介绍
- Status of CCUS in China
- 中国CCUS技术的现状
- Cost of Early CCUS projects in Xinjiang
- 潜在煤化工CCS项目的成本
- Conclusions and suggestion
- 小结与建议

Summary

- There are lots opportunities for CCUS in China .
- ✓ 新疆具有大量的CCUS实施机遇;
- There are some CCUS are with early opportunities for deployment.
- ✓ 部分CCUS具有早期实施机遇(低成本机遇）;
- ✓ There are many barriers to large-scale deployment of CCUS technologies;
- ✓ 实施CCUS仍然有许多障碍需要解决;
- ✓ Further work should be carried out to evaluate techno-economic feature of CCUS project (site-specific data, more precise performance model and cost coefficients).
- ✓ 还需要开展进一步的技术经济分析，基于更加详细的场地资料、技术和成本参数。

Thank you !

Email: Nwei@whrsm.ac.cn

Major references related to this presentation

① Dahowski, R., Davidson, C., Li, X., Wei, N., 2013. Examining CCS Deployment Potential in China Via Application of an Integrated CCS Cost Curve. Energy Procedia 37, 2487-2494.

② Dahowski, R.T., Davidson, C.L., Li, X.C., Wei, N., 2012. A \$70/tCO_2 greenhouse gas mitigation backstop for China's industrial and electric power sectors: Insights from a comprehensive CCS cost curve. International Journal of Greenhouse Gas Control 11, 73-85.

③ Li, X., Wei, N., Bai, B., Liu, Y., Fang, Z., 2008. CO_2 Point Source Emission and Geological Storage Capacity in China. Institute of Rock and Soil Mechanics, Chinese Academy of Sciences Wuhan, Hubei Province, China, pp. 1-27.

④ Li, X., Wei, N., Liu, S., Wang, Q., Gao, S., Wang, Y., Li, H., Ma, W., Cui, Y., Wang, H., 2013. The Economic Evaluation of CO_2-EOR Deployment in China. Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, pp. 1-42.

⑤ Li, X., Wei, N., Liu, S., Wang, Q., Gao, S., Wang, Y., Wang, Y., Li, H., Ma, W., Cui, Y., Wang, H., 2012. Economic Evaluation of CO_2 Geological Storage in Deep Saline Formations in China. Institute of Rock and Soil Mechanics, Chinese Academy of Sciences, Wuhan, Hubei Province, China.

⑥ Wei, N., Gill, M., Crandall, D., McIntyre, D., Wang, Y., Bruner, K., Li, X., Bromhal, G., 2014. CO_2 flooding properties of Liujiagou sandstone: Influence of sub-core scale structure heterogeneity. Greenhouse Gases: Science and Technology 4, 1-19.

⑦ Wei, N., Li, X., Wang, Y., Dahowski, R.T., Davidson, C.L., Bromhal, G.S., 2013. A preliminary sub-basin scale evaluation framework of site suitability for onshore aquifer-based CO_2 storage in China. International Journal of Greenhouse Gas Control 12, 231-246.

Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

Reducing CO_2 Emissions – and Helping Finance CO_2 Capture Projects – Through Geological Sequestration of Injected CO_2 for Enhanced Oil Recovery (EOR)

Presentation by Eric Redman, President & CEO
Summit Power Group, LLC

CCUS Outreach Workshop
Urumqi, Xinjiang Province ● September 18, 2014

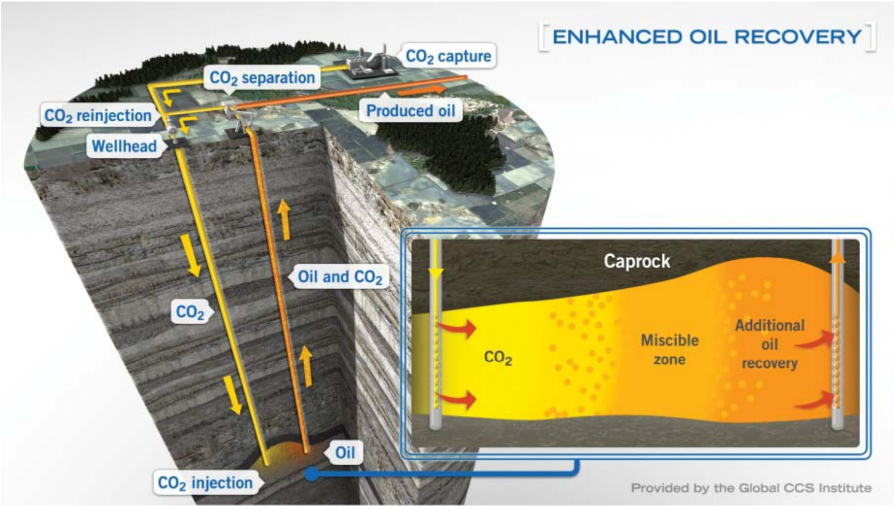
Strictly Private & Confidential

Summit Power Group & Summit Carbon Capture

- Founded twenty-five (25) years ago by Don Hodel (Chairman emeritus), Secretary of Energy & Interior for President Reagan, and Earl Gjelde (Chairman), COO for Hodel at Energy & Under Secretary of Interior
- Types of power projects that Summit develops for itself and others:
  - Renewables: wind projects, solar projects, etc.
  - State-of-the-art natural gas-fired power plants
  - Coal gasification projects with carbon capture – and CO_2 for EOR
  - Post-combustion capture for fuel-burning power plants – & for EOR
- Summit has long-standing relationships with vendors, engineers, contractors, etc. – including new relationships with Chinese engineering and power companies, Chinese banks, and Chinese firms
- Summit projects completed to date: Totaling $9 B (current US dollars) and over 9,500 MW
- Summit CO_2 for EOR projects in development: Will total an additional $7-8 B (US dollars) when completed

2

Use of CO_2 for Enhanced Oil Recovery (EOR)



CO_2 acts as a solvent – oil that is "stuck" to the rock is released 3

Strictly Private & Confidential

EOR can help pay the costs of CO_2 capture

Power Plants:

1 MWh hour of coal combustion power

→

1 ton of CO_2 emitted

or

1 ton of CO_2 captured

Oil Fields:

1 ton of CO_2 injected

→

2-3 barrels of additional oil produced

$$ $$

CO_2

Revenue for CO_2 capture

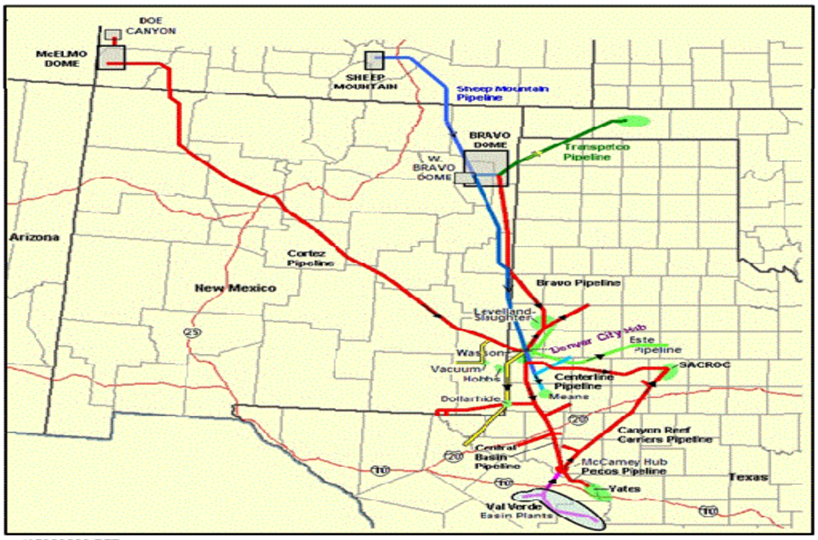
CO_2

4

Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

Strictly Private & Confidential

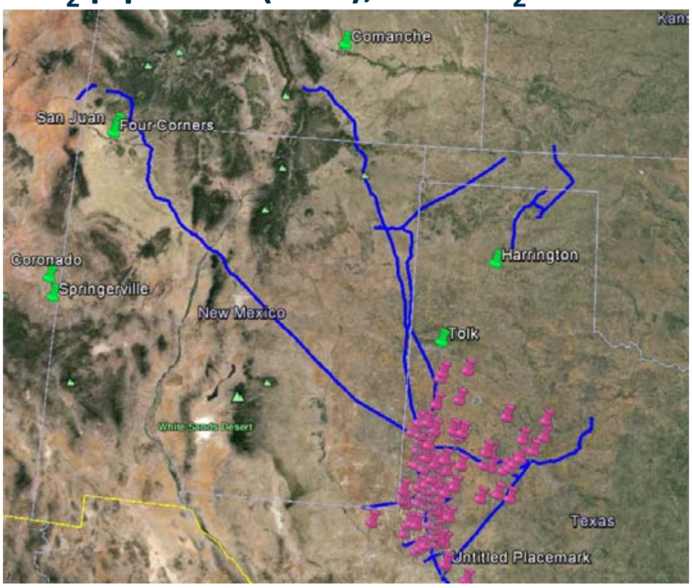
3,000+ Miles of CO_2 for EOR Pipelines Already Exist in the Permian Basin Of West Texas



JAF028238.PPT

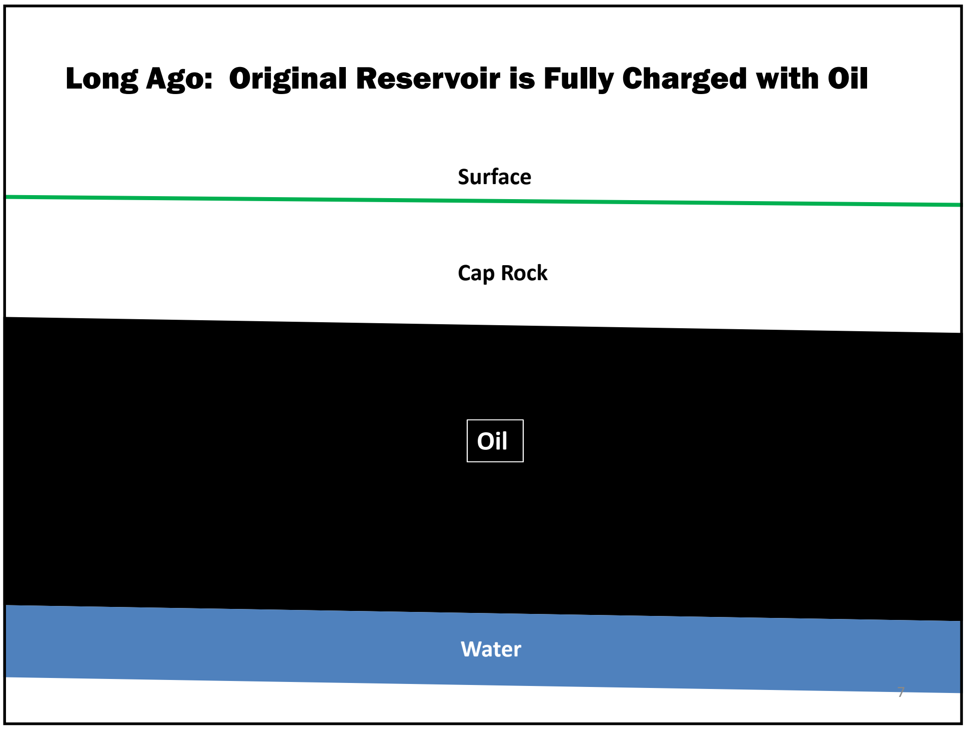
5

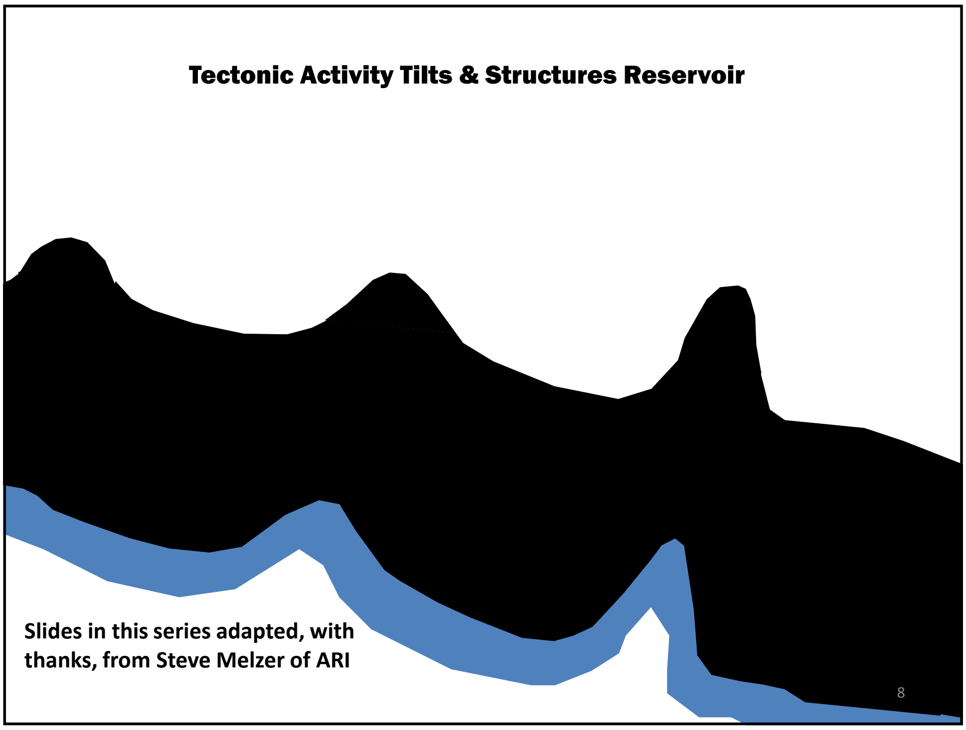
Permian Basin power plants (green), CO_2 pipelines (blue), and CO_2-EOR oilfields (pink)

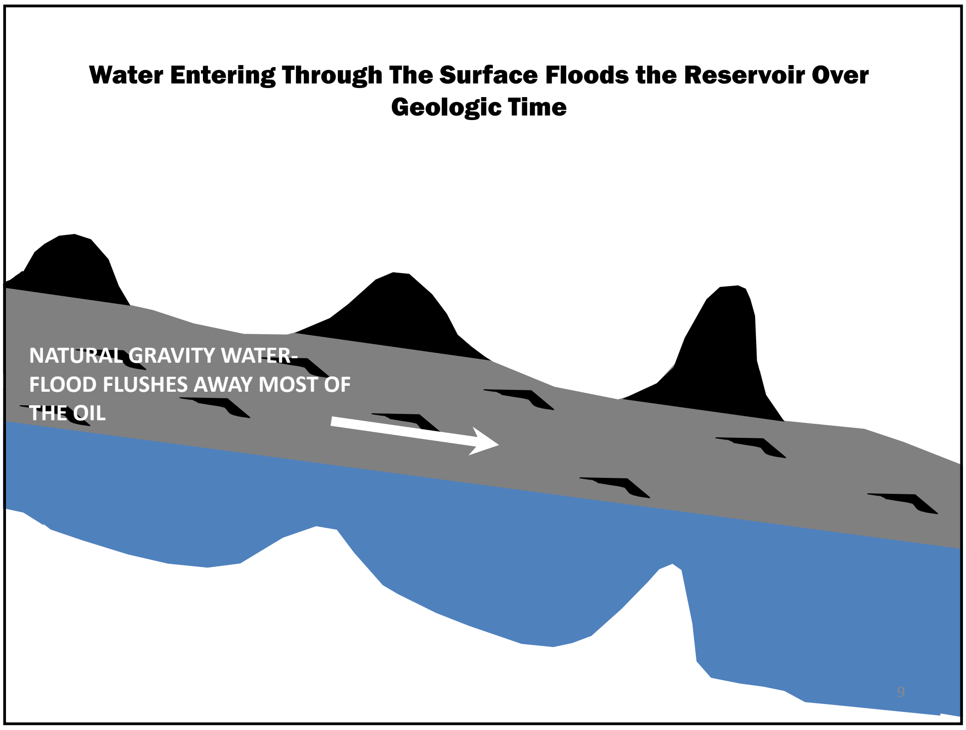


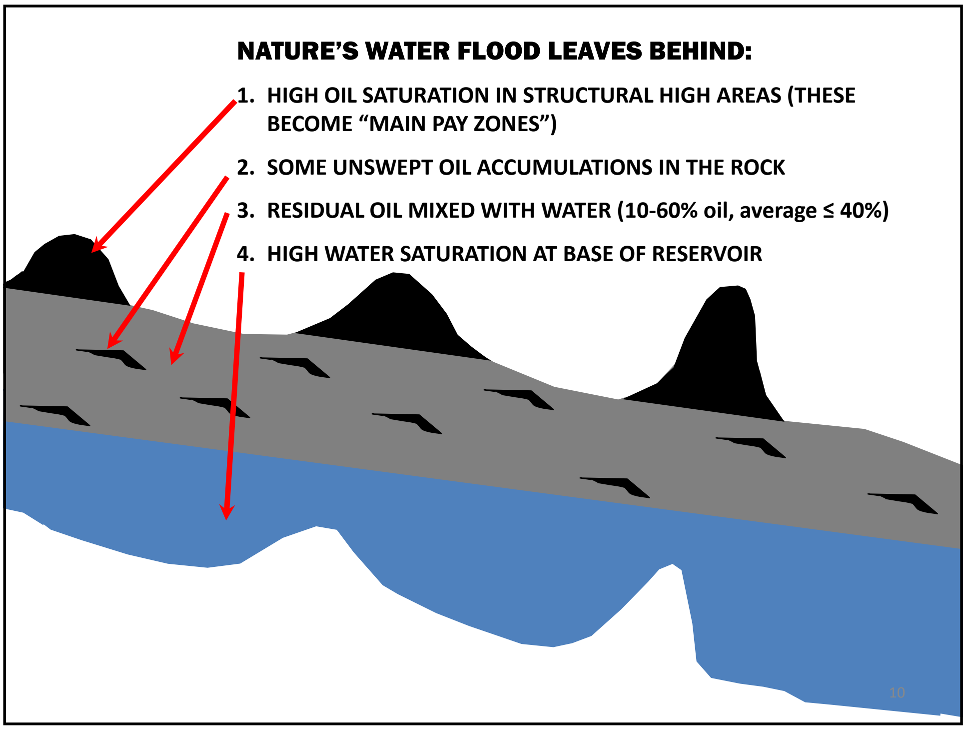
Annual injections of new & recycled CO_2 ≈ 80-100 million tons total (mostly from natural sources)

6

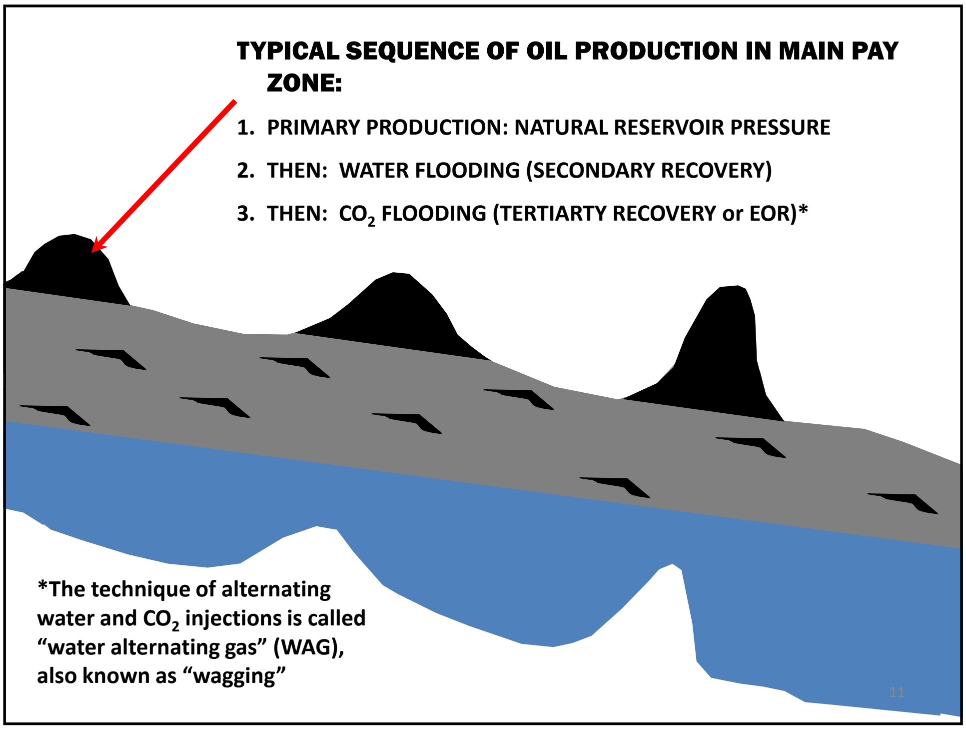

Long Ago: Original Reservoir is Fully Charged with Oil
Surface
Cap Rock
Oil
Water

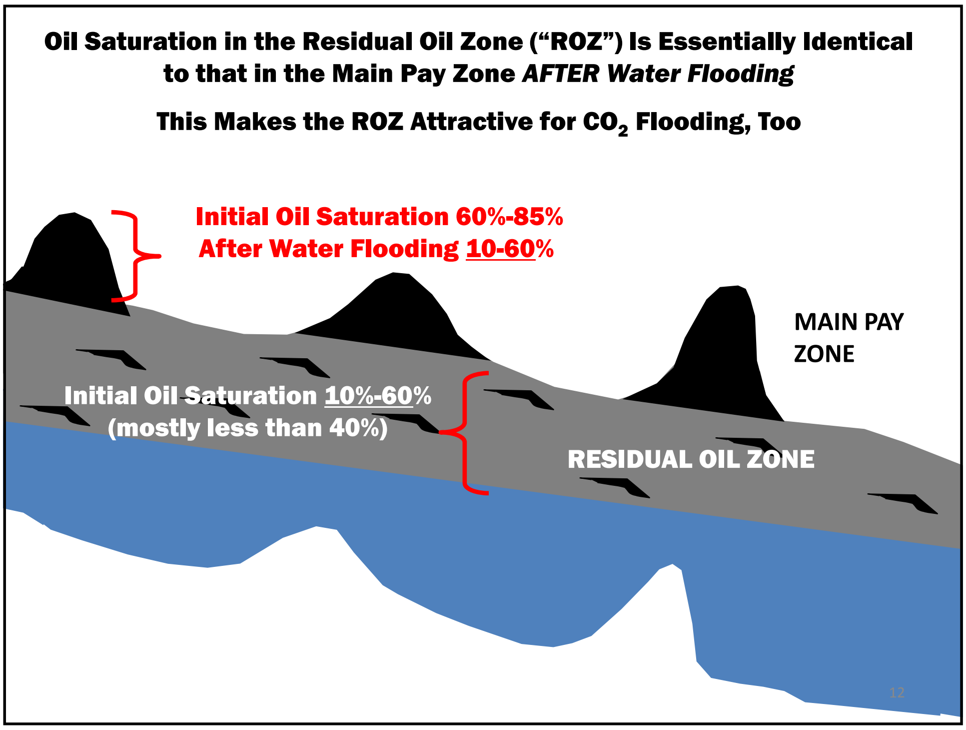

Tectonic Activity Tilts & Structures Reservoir
Slides in this series adapted, with thanks, from Steve Melzer of ARI
8


Water Entering Through The Surface Floods the Reservoir Over Geologic Time
NATURAL GRAVITY WATER-FLOOD FLUSHES AWAY MOST OF THE OIL

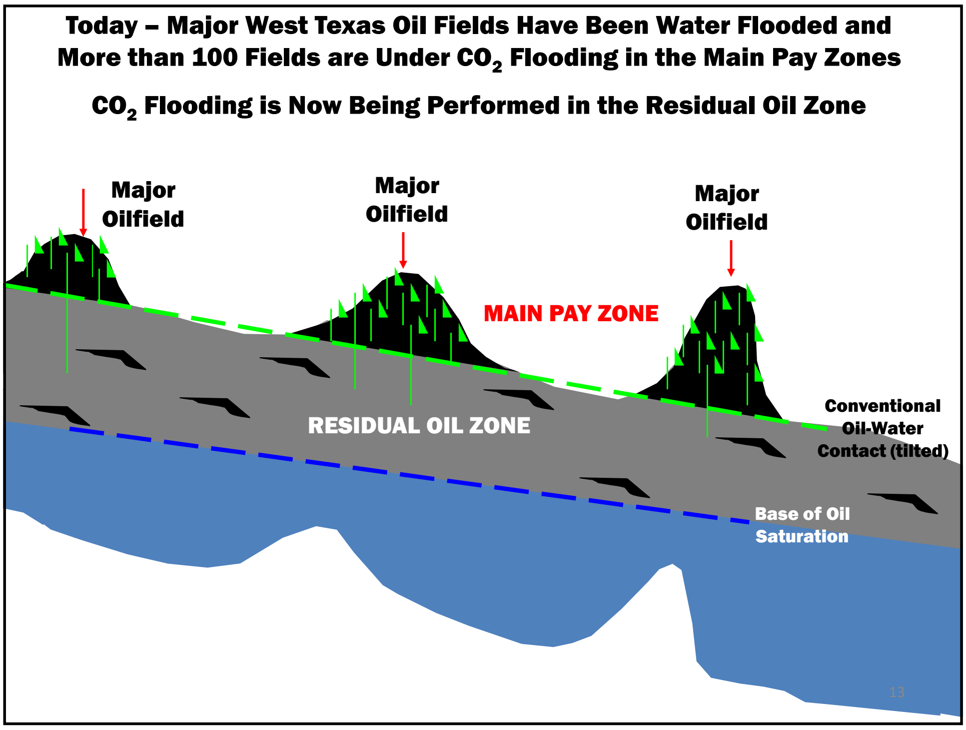

NATURE'S WATER FLOOD LEAVES BEHIND:
1. HIGH OIL SATURATION IN STRUCTURAL HIGH AREAS (THESE BECOME "MAIN PAY ZONES")
2. SOME UNSWEPT OIL ACCUMULATIONS IN THE ROCK
3. RESIDUAL OIL MIXED WITH WATER (10-60% oil, average ≤ 40%)
4. HIGH WATER SATURATION AT BASE OF RESERVOIR

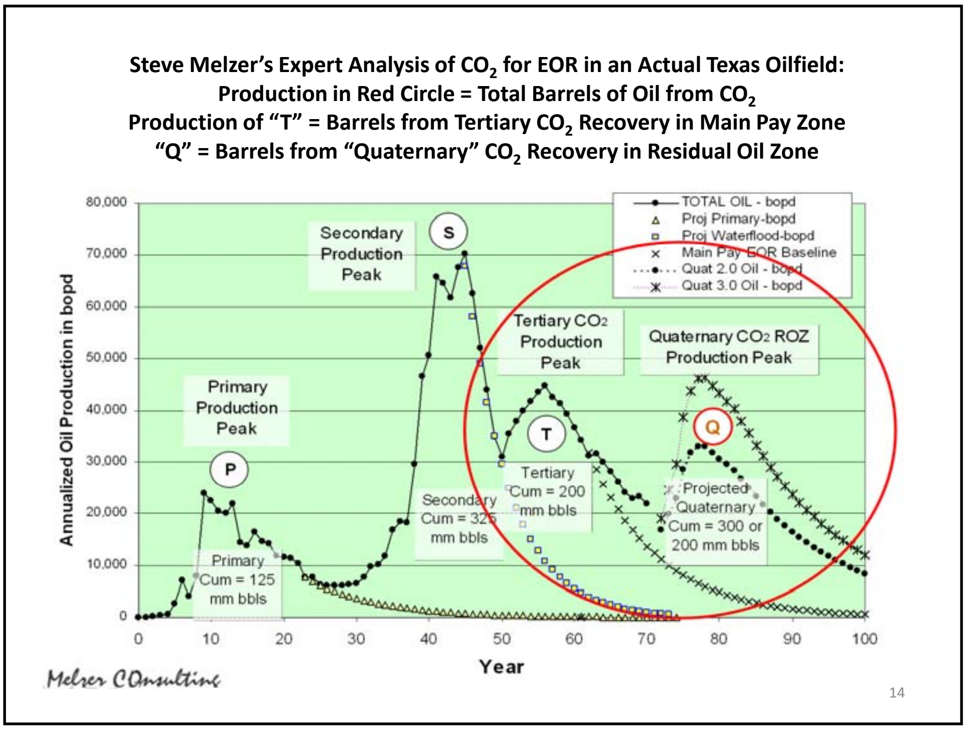
Eric Redman-美国高峰电力公司
Eric Redman-Summit Power





Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

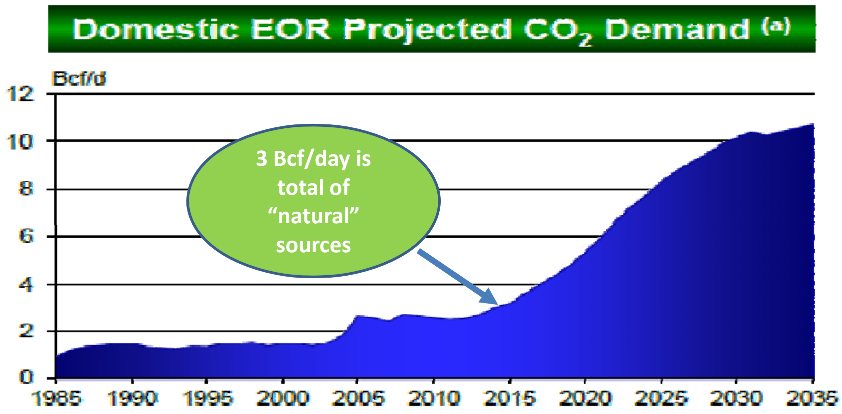




Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

Natural CO_2 supplies can't meet industry demand

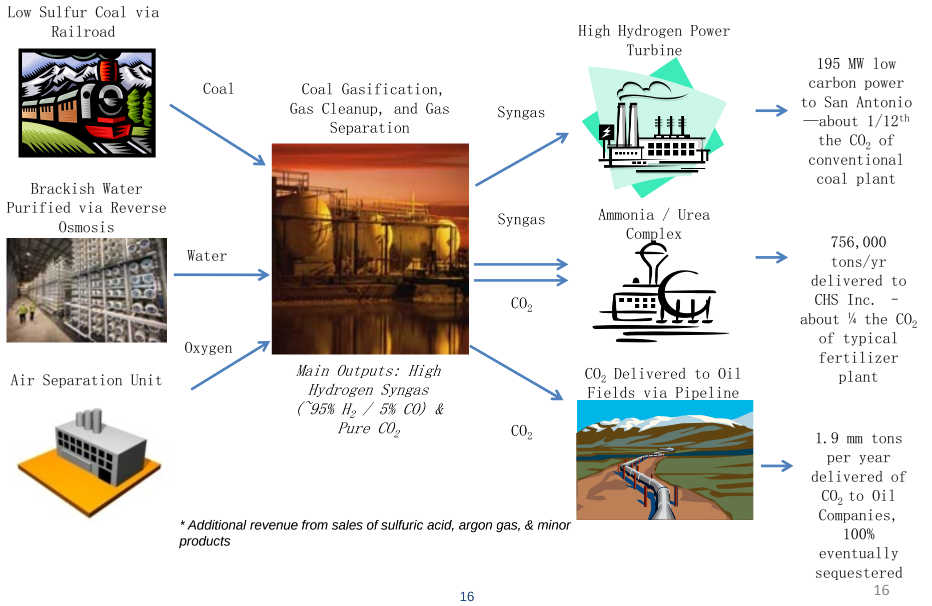
Existing natural CO_2 sources in Texas Gulf, Permian, and Wyoming have capacity of ≈ 3 Bcf/day. Industry and US Government projections call for tripling of demand. Extra supply must come mostly from captured CO_2 (i.e., CCS from industry and power plants). One (1) Bcf/day is ≈ 20 million tons a year. **So Kinder Morgan's chart shows annual demand going from 60 million tons per year to 200 million tons per year.**



Source: Kinder Morgan 2012 Analyst Presentation

15

Summit's Texas Clean Energy Project will turn Coal, Salty Water & Air into Near-Zero Carbon Power, Fertilizer, and Sequestered CO_2 for EOR



* *Additional revenue from sales of sulfuric acid, argon gas, & minor products*

16

16

What Makes the Texas Clean Energy Project (TCEP) Important?

TCEP will be the first power project world wide to:

- Use state of the art technology to gasify coal AND
- Transform the output into two separate gas streams of hydrogen and CO_2 AND
- Sequester more than 90% of the coal's CO_2 permanently AND
- Use the CO_2 commercially in enhanced oil recovery AND
- Demonstrate that this works for both the end use markets of power (lowest carbon content of any hydrocarbon power plant) and chemicals AND
- Pair China & the U.S. in funding & building a full-scale CO_2 capture power plant

Siemens Gasifiers in Ningxia, China

Linde Rectisol® CO_2 Separation

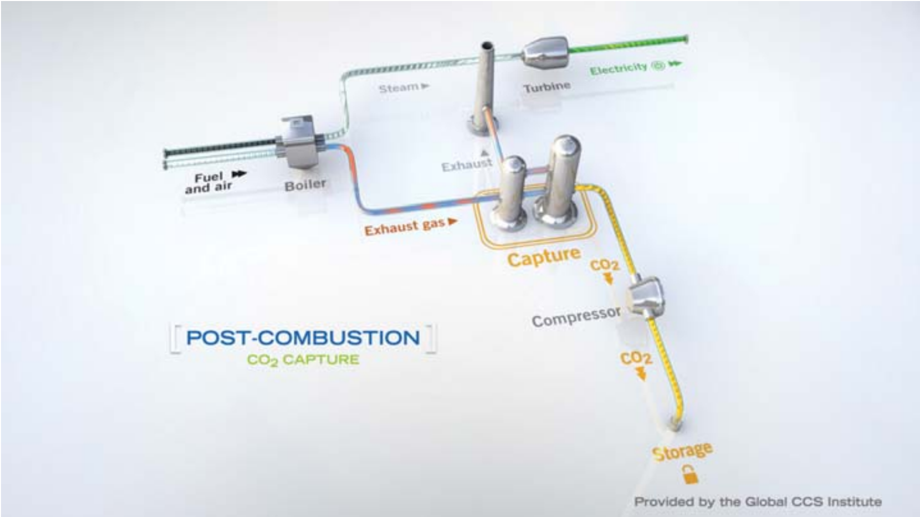
17

World's largest gasification project: In Ningxia

China leads the world in coal gasification for chemical products. China can lead the world in CO_2 capture from coal gasification, too. Why not oil production from captured CO_2 (EOR)? And low-carbon electric power from coal gasification?

18

CO_2 Can Also Be Captured from Coal-Burning Plants, including via Retrofitting those Plants. Capturing CO_2 from Flue Gas (Exhaust) of a Combustion Plant is Called "Post-Combustion Capture" (PCC).



19

Some active post-combustion capture projects

Project Name	Location	Fuel	Equipment Provider*	Status	Notes
Plant Barry	US (Alabama)	Coal	MITSUBISHI	Operating Since June 2011	25 MW Slipstream. No EOR – all sequestered
Boundary Dam	Canada	Coal		Under Construction will be operating Fall 2014	160 MW. 90% capture. CO2 used for EOR.
WA Parish	US (TX)	Coal	MITSUBISHI	Financial closing announced July 2014	250 MW. 90% Capture. CO2 used for EOR
Peterhead	UK (Scotland)	Gas		FEED stage	One of two winners of UK climate competition. Expected to begin operations in 2018

*Other suppliers of proven PCC systems include Huaneng/CERI, Linde/BASF, Fluor, etc.

Linde FLUOR

20

Strictly Private & Confidential

Case Study: W.A. Parish Plant/ NRG Petra Nova

Hilcorp Energy Company

W.A. Parish is among the US's largest power plants, with almost 2,500 MW of coal fired generation and 1,300 MW of gas generation.

NRG formed Petra Nova to pursue integrated (oil and CO_2 capture) PCC projects

Construction begun on PCC project to capture 90% on 250 MW flue gas slipstream

Represents ≈ 1.4 million tons of CO_2 per year

Joined with Hilcorp, a large East Texas oil company, to send CO_2 to West Ranch oil field. Will vastly increase oil production.

Total capital cost supported by JX Nippon, NRG, and US DOE. Also received $250M in debt from Japan Bank for International Cooperation (JBIC) and Mizuho Bank Ltd.

Strictly Private & Confidential

Questions & Answers about CO_2 for EOR

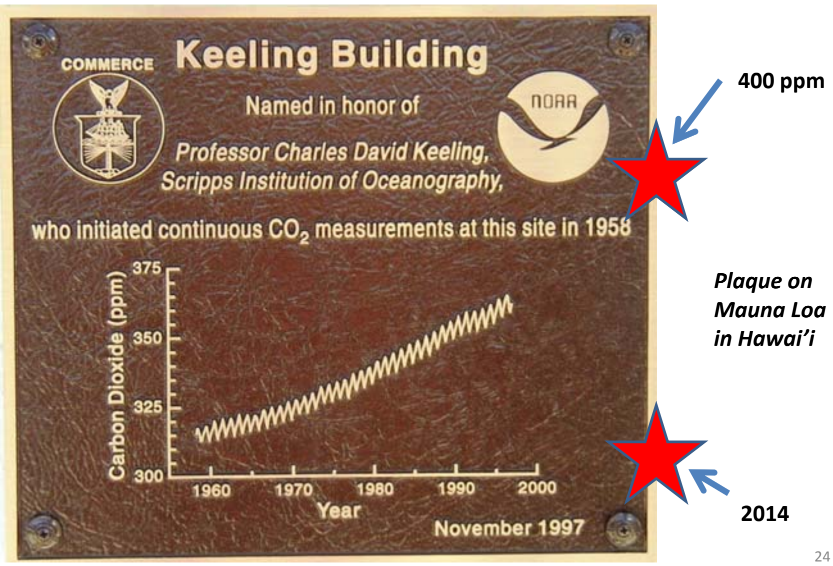
Question	Answer
Do power plants need to capture carbon?	Yes. Power sector is largest source of CO_2. In the U.S., new rules demand huge cut in CO_2 emissions. ***Reduced carbon emissions = high priority in U.S. and China.***
Can power plants capture carbon?	Yes. Huaneng /CERI has captured CO_2 in China. Systems being installed now in North America (Shell & Mitsubishi).
Can oil wells really use CO_2?	Yes. In the US, about 100 million barrels/year come from CO_2 use. China could produce as much or more. China has suitable geology in main pay zones and residual oil zones.
Will oil producers pay for CO_2?	Yes. Current prices about $35-40 per ton in Texas. Lower in some states, potentially higher in other states.
Can CO_2 be transported?	Yes. Already ≈ 5,000 miles of CO_2 pipelines in the U.S.
Does CO_2 for EOR produce permanent carbon sequestration?	Yes. About 50% of the CO_2 remains underground after each injection. CO_2 that comes to the surface with oil is re-compressed and re-injected. Ultimately it all stays down.
Doesn't the produced oil have carbon, too?	Yes. But much less than the CO_2 that's injected. No other oil production method traps CO_2 underground.

Dr. S. Julio Friedmann, US Department of Energy

"Last year, the world used more wind power, solar energy, biomass, and hydro energy than ever before. We also used more coal, oil, natural gas, and nuclear power than ever before. We used more energy in total than ever before."

23

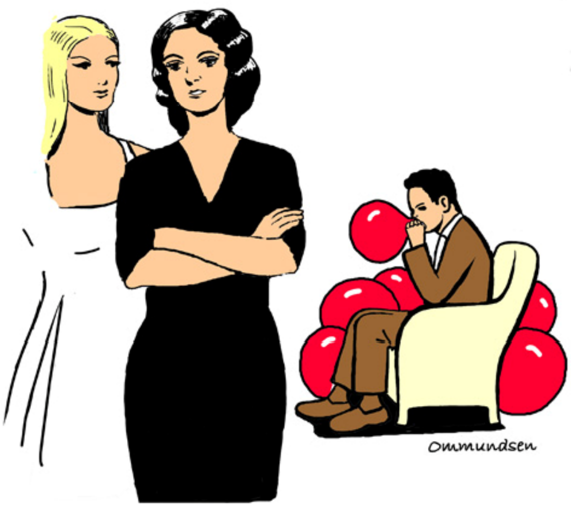
Why CO_2 Sequestration Matters



Plaque on Mauna Loa in Hawai'i

24

Conclusion: CCUS may not be sexy, but it is important for the planet – and it can be profitable



"Frank's into carbon sequestration."

25

谢谢！ Thank you!

Summit Power Group, LLC
83 South King Street
Seattle, Washington 98104

www.summitpower.com
www.texascleanenergyproject.com

26

Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

通过注入二氧化碳驱油的地质封存
减少碳排放及助力二氧化碳捕集项目融资

美国高峰电力公司总裁兼首席执行官
Eric Redman

新疆中美碳捕集利用与封存研讨会
新疆乌鲁木齐 ● 2014年9月18日

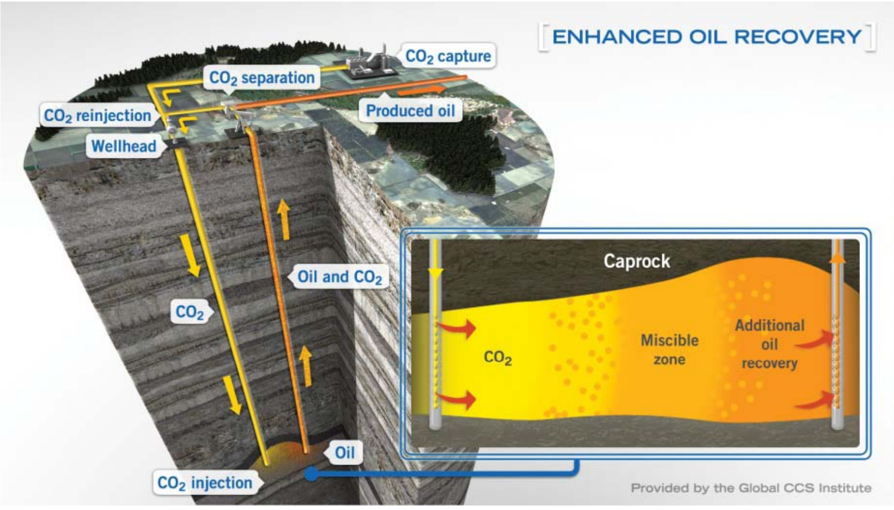
Strictly Private & Confidential

高峰电力集团及高峰电力碳捕集

- **25**年前由里根总统时期能源和内政部长**Don Hodel**先生 **(**现任荣誉主席**)** 和能源部首席运营官及内政部副部长**Earl Gjelde**先生 **(**现任董事会主席**)** 联合创办
- 高峰电力自己开发及为其它公司开发的电力项目类型包括：
  - 可再生能源：风能，太阳能项目等
  - 先进的天然气发电项目
  - 带二氧化碳捕集及驱油的煤气化项目
  - 电厂燃烧后捕集及二氧化碳驱油项目
- 高峰电力和供应商、工程公司等建立了长期的良好合作关系，包括和中国的工程公司、电力公司、银行和其它公司建立的新合作关系
- 截至目前高峰电力已完成的项目：总金额达**90**亿美元（现行美元币值）、总装机容量超过**9500**兆瓦
- 高峰电力开发中的二氧化碳驱油项目：项目完成时总金额将增加**70~80**亿美元

2

二氧化碳驱油



二氧化碳相当于吸附剂-将附着在岩层内的石油释放出来 3

Strictly Private & Confidential

二氧化碳驱油可帮助抵充二氧化碳捕集的成本

电厂：

燃煤电厂发1兆瓦时电

→

排放1吨CO_2

或者

捕集1吨 CO_2

油田：

注入1吨 CO_2

→

增产2-3 加仑的石油

$$

CO_2

CO_2 捕集的收益

$$

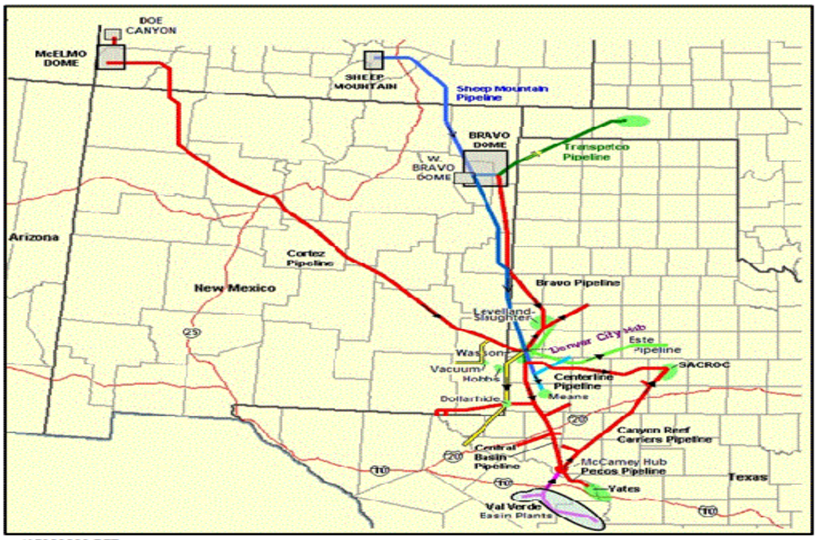
CO_2

4

Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

Strictly Private & Confidential

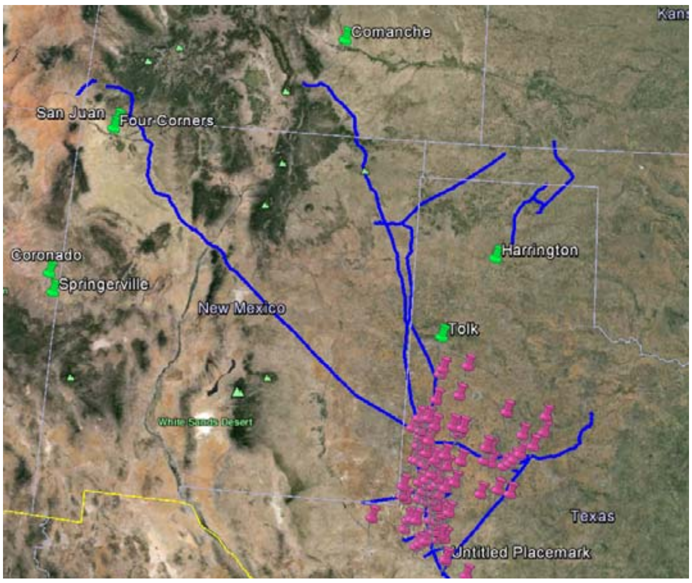
德克萨斯西部的二叠纪盆地中已建设了超过3,000英里的用于二氧化碳驱油的管道



JAF028238.PPT

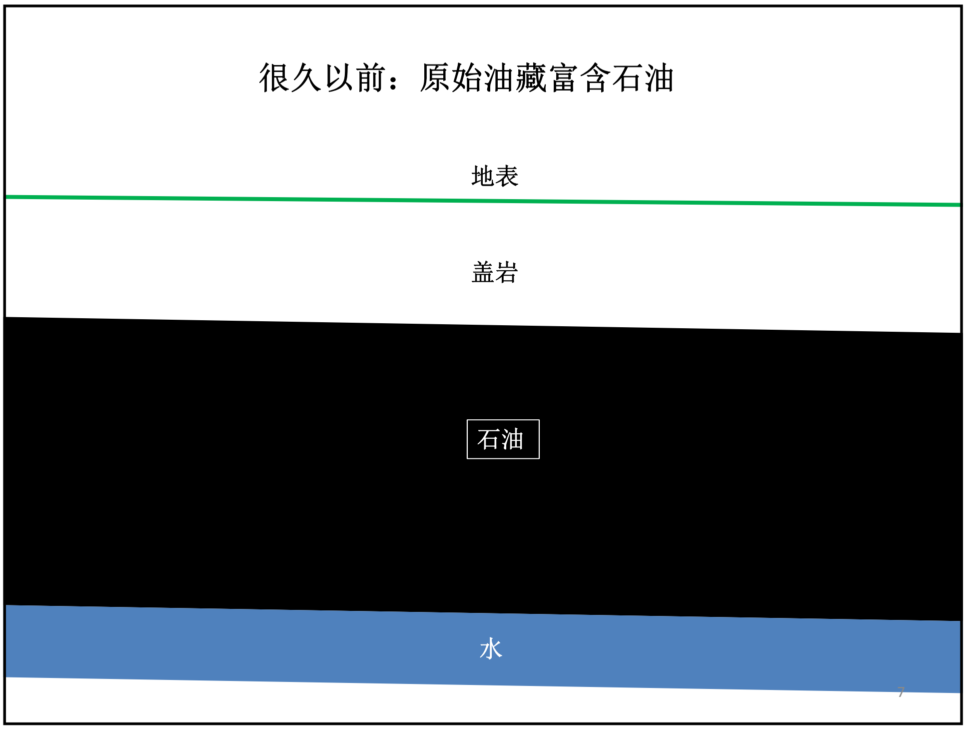
5

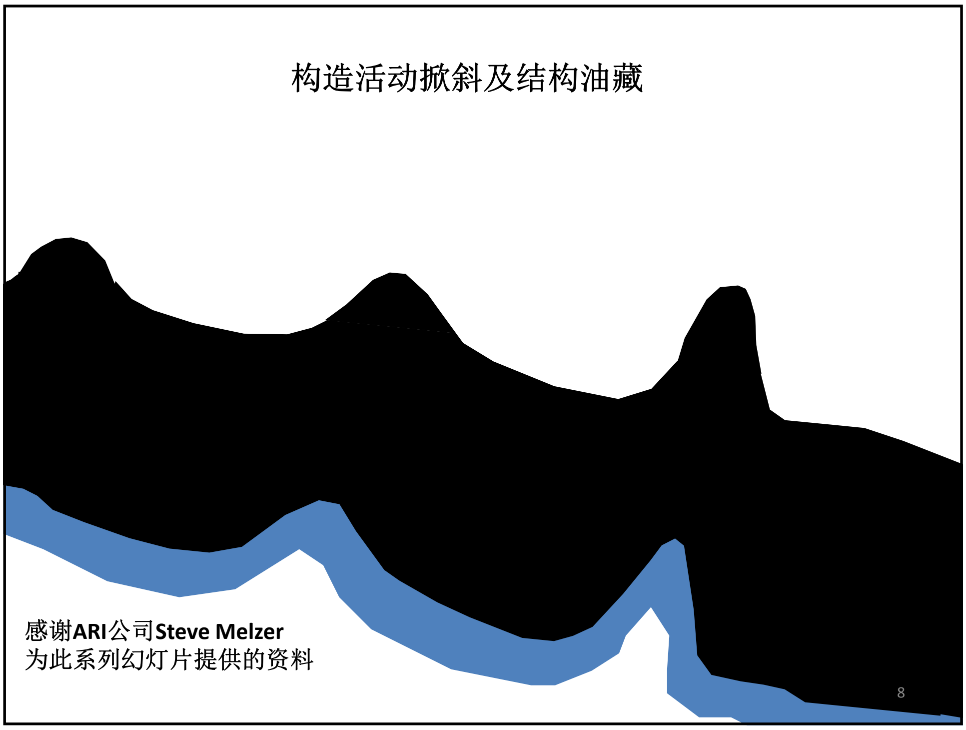
二叠纪盆地中的电厂 (绿色), CO_2 管道 (蓝色), 以及CO_2驱油油田(粉色)

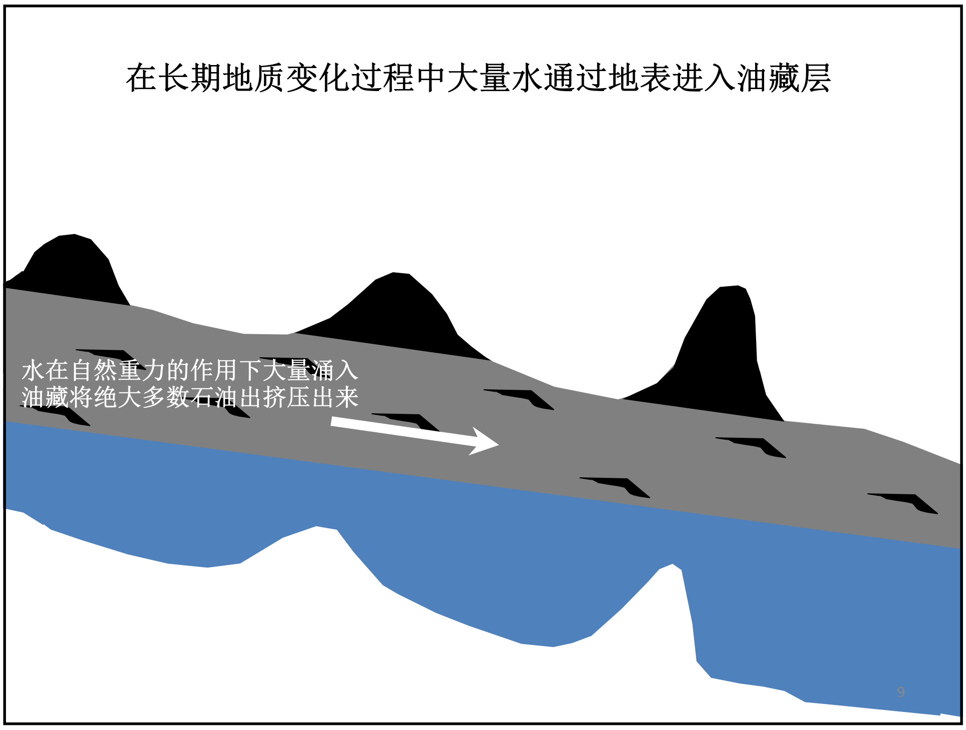


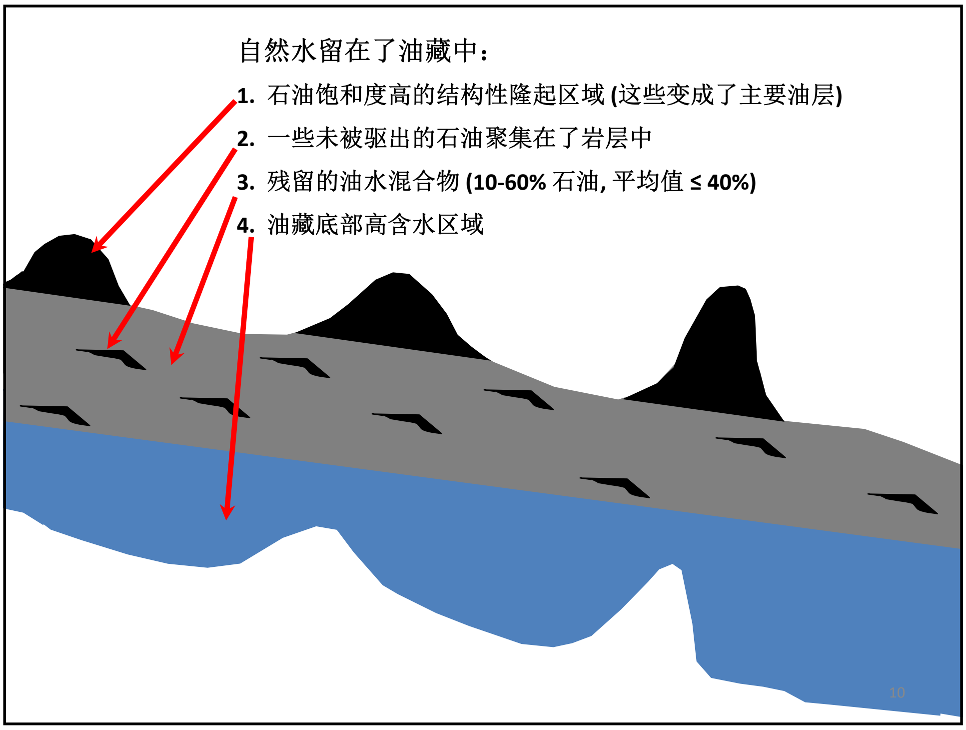
每年新注入及回收 $CO_2 \approx$ 8千万-1亿吨 (绝大部分属天然资源)

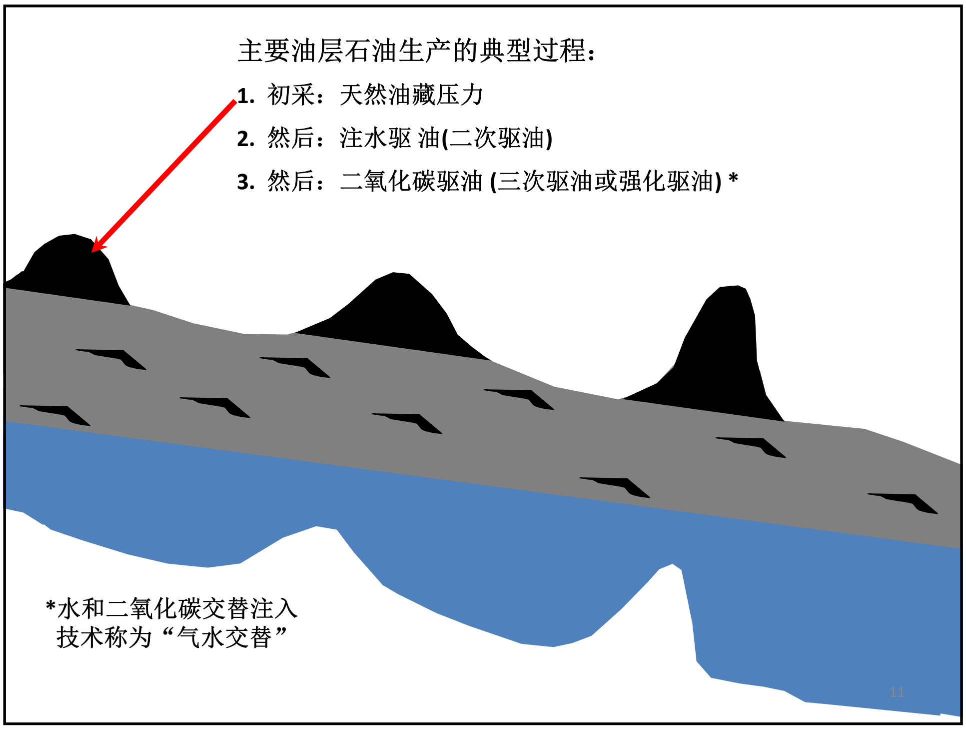
6

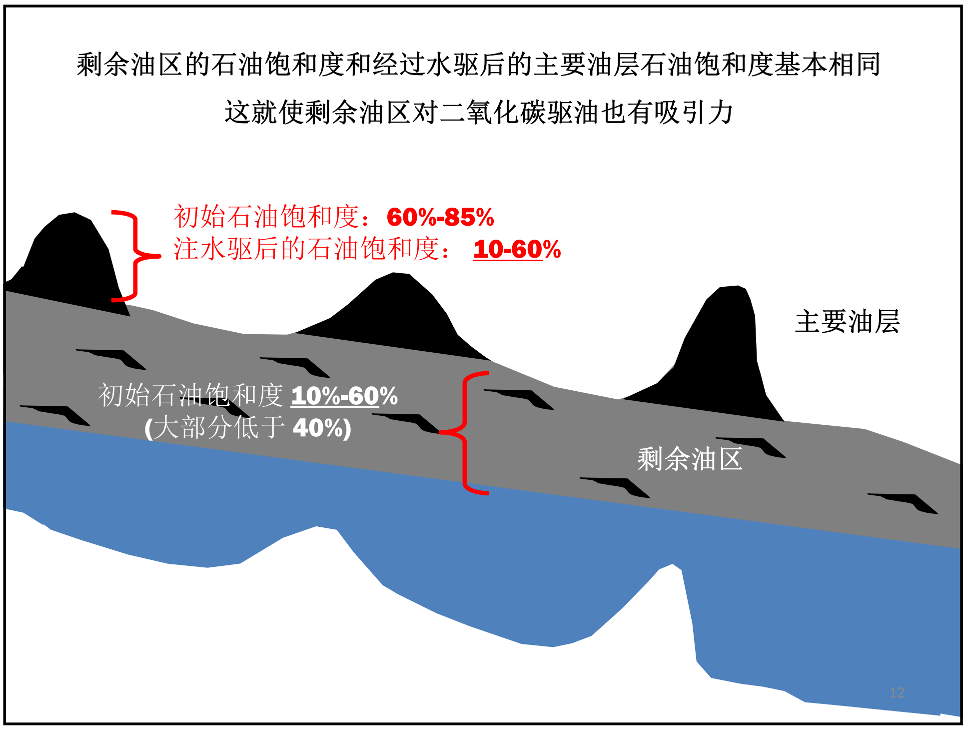

很久以前：原始油藏富含石油
地表
盖岩
石油
水


构造活动掀斜及结构油藏
感谢ARI公司Steve Melzer
为此系列幻灯片提供的资料
8

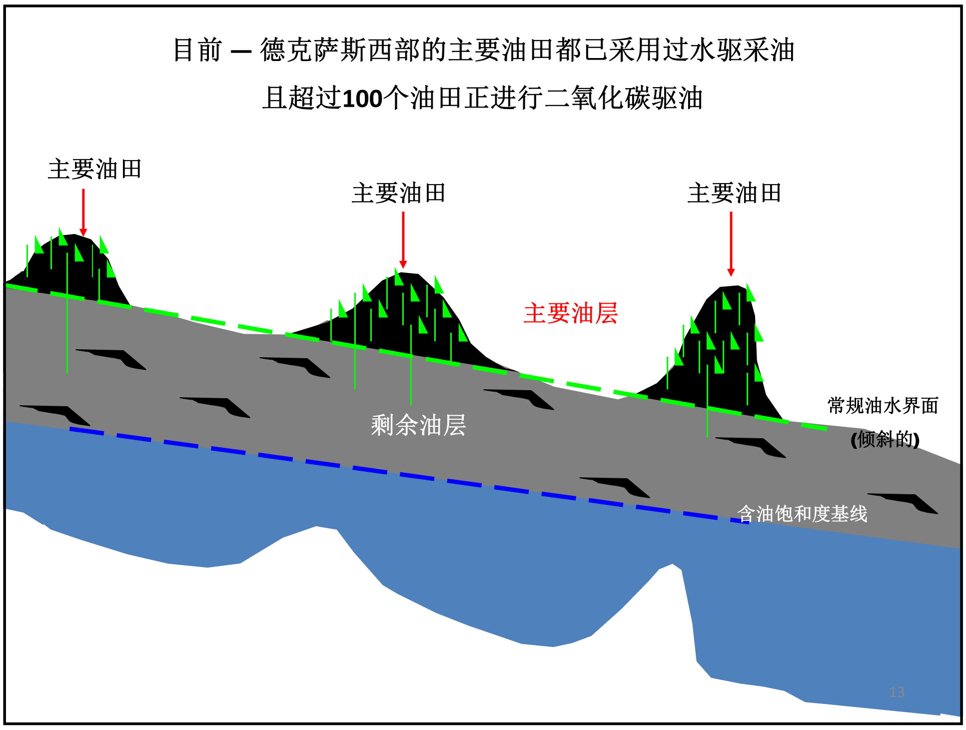

在长期地质变化过程中大量水通过地表进入油藏层
水在自然重力的作用下大量涌入
油藏将绝大多数石油出挤压出来

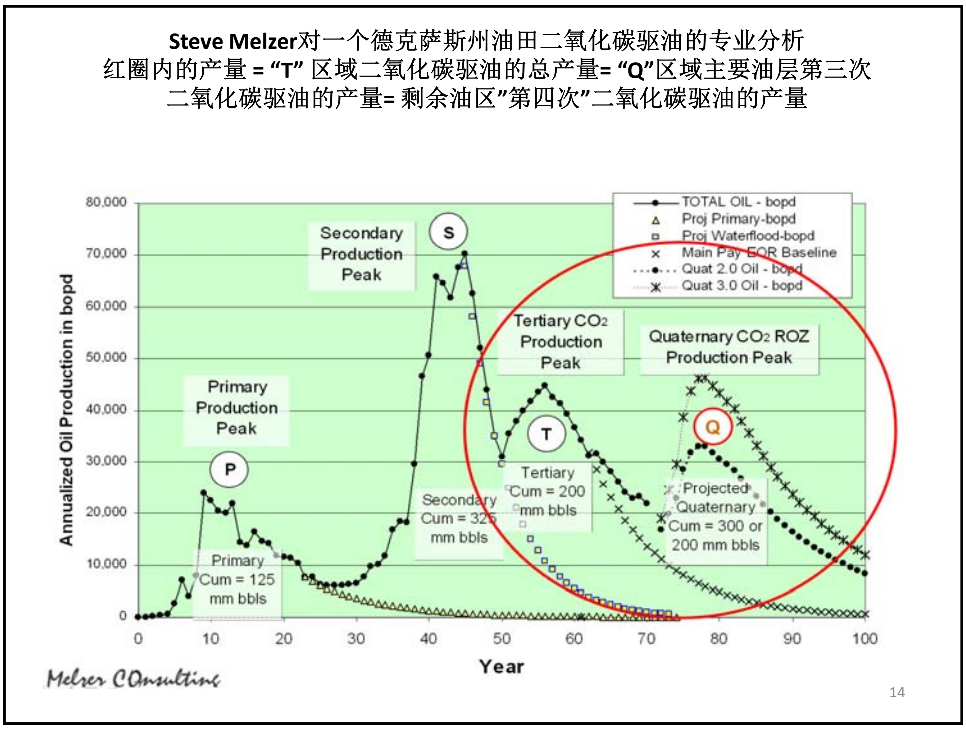

自然水留在了油藏中：
1. 石油饱和度高的结构性隆起区域 (这些变成了主要油层)
2. 一些未被驱出的石油聚集在了岩层中
3. 残留的油水混合物 (10-60% 石油, 平均值 ≤ 40%)
4. 油藏底部高含水区域


主要油层石油生产的典型过程：
1. 初采：天然油藏压力
2. 然后：注水驱 油(二次驱油)
3. 然后：二氧化碳驱油 (三次驱油或强化驱油) *
*水和二氧化碳交替注入
技术称为“气水交替”


剩余油区的石油饱和度和经过水驱后的主要油层石油饱和度基本相同
这就使剩余油区对二氧化碳驱油也有吸引力
初始石油饱和度：60%-85%
注水驱后的石油饱和度： 10-60%
主要油层
初始石油饱和度 10%-60%
(大部分低于 40%)
剩余油区

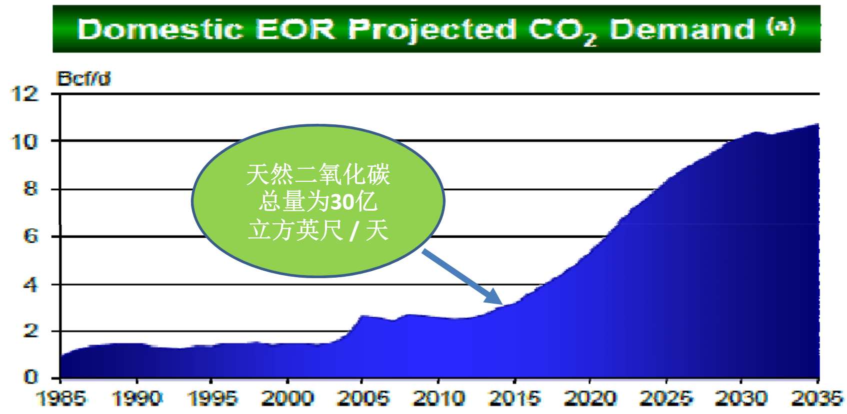
Eric Redman-美国高峰电力公司
Eric Redman-Summit Power





天然的CO_2 供应不能满足工业需求

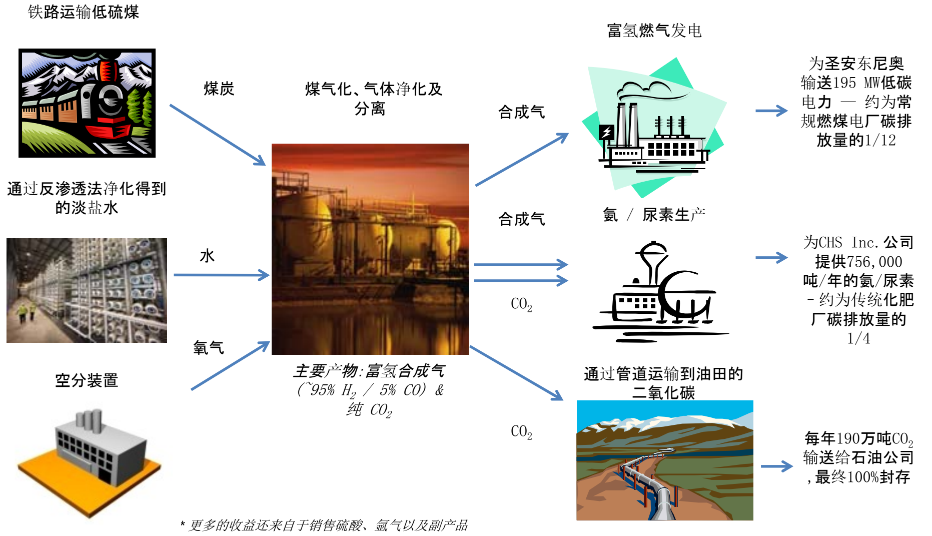
德克萨斯海湾、二叠纪盆地以及怀俄明州现有天然CO_2 来源量 ≈ 30亿立方英尺/ 天。工业界和美国政府预期需求将增长3倍。多余出来的二氧化碳需求必将主要靠捕集的二氧化碳满足 (即来自于工业和电厂的 CCS)。10亿立方英尺 / 天 ≈ 2000万吨 / 年。因此，**Kinder Morgan公司的图表显示二氧化碳的年需求量将从2015年的约6000万吨增长到2035年的约2亿吨。**



来源：Kinder Morgan 2012 年分析师演讲稿

15

高峰电力德州清洁能源项目将煤炭、盐水以及空气转化成近零碳排放电力、肥料以及用于驱油的二氧化碳



16

16

德州清洁能源项目为什么重要?

德州清洁能源项目将是世界范围内首个拥有以下特点的电力项目：

- 运用最先进的煤气化技术
- 同时产生并分离氢气和二氧化碳两种气体
- 永久减排90%以上煤炭利用产生的二氧化碳
- 将二氧化碳应用于驱油实现其商业价值
- 证明同时生产电力（碳排放最低的燃烧碳氢化合物的电力生产）和化工产品是可行的
- 中美合作融资和建设全尺寸二氧化碳捕集电厂

17

中国宁夏西门子气化炉

林德公司Rectisol® CO_2 分离装置

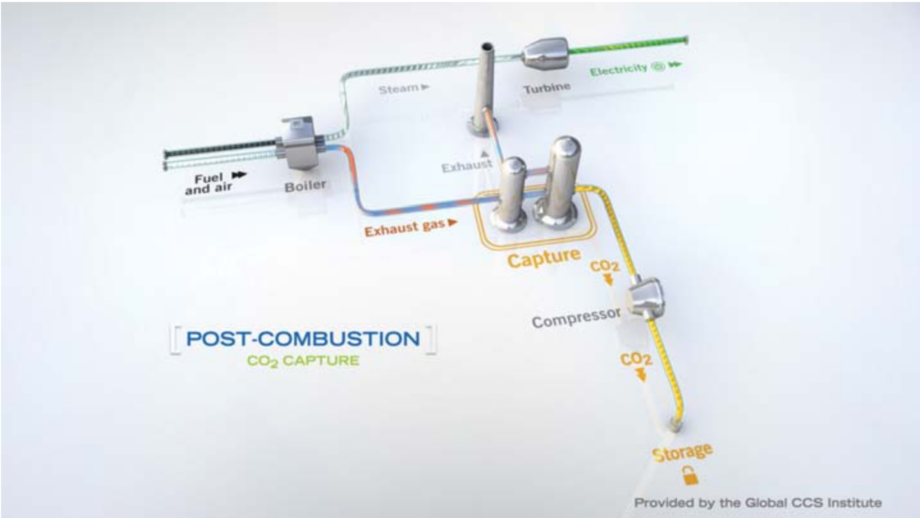
世界最大的煤气化项目：宁夏

中国在煤气化生产化工品方面领先于世界，也能在煤气化捕集二氧化碳方面领先于世界。 为什么不能在用捕集来的二氧化碳驱油和通过煤气化生产低碳电力方面领先于世界呢？

18

Eric Redman-美国高峰电力公司
Eric Redman-Summit Power

二氧化碳同样可以从燃煤电厂中捕集，包括改造现有电厂
从燃煤电厂烟道气中捕集二氧化碳称为“燃烧后捕集”



19

一些活跃的燃烧后捕集项目

项目名	地点	燃料	设备供应商*	现状	备注
Plant Barry	美国 (阿拉巴马)	煤	MITSUBISHI	2011年6月起 开始运行	25 MW 无驱油– 所有二氧化碳封存
Boundary Dam	加拿大	煤		建设中 2014年秋开始运行	160 MW. 90% 二氧化碳捕集 并应用于驱油
WA Parish	美国 (德州)	煤	MITSUBISHI	2014年7月 公布财务性结算	250 MW. 90%二氧化碳捕集 并应用于驱油
Peterhead	英国 (苏格兰)	天然气		可行性研究	英国气候竞赛两个获胜者之一， 预期于2018年开始运行

*其它被验证过的燃烧后捕集系统供应商包括：
华能清洁能源研究院，林德/巴斯夫，福陆等等

Linde FLUOR

20

Strictly Private & Confidential

案例研究: W.A. Parish电厂/ NRG公司Petra Nova

W.A. Parish是美国最大的电厂之一, 拥有约 2,500 MW 燃煤发电以及1,300 MW 燃气发电

Hilcorp Energy Company

NRG 公司组建了Petra Nova 公司以建设一体化（石油和二氧化碳捕集）燃烧后捕集项目。

从250MW 电厂烟道气中捕集超过90%二氧化碳的燃烧后捕集项目已经开建。

每年约捕集140万吨二氧化碳。

与西德克萨斯最大的石油公司Hilcorp合作，将二氧化碳输送至 West Ranch油田，将大幅提高石油产量。

资金支持来自于日本JX Nippon公司, 美国NRG公司, 以及美国能源部。 同时从日本JBIC和Mizuho银行获得了 2.5亿美元贷款。

二氧化碳驱油问答

Strictly Private & Confidential

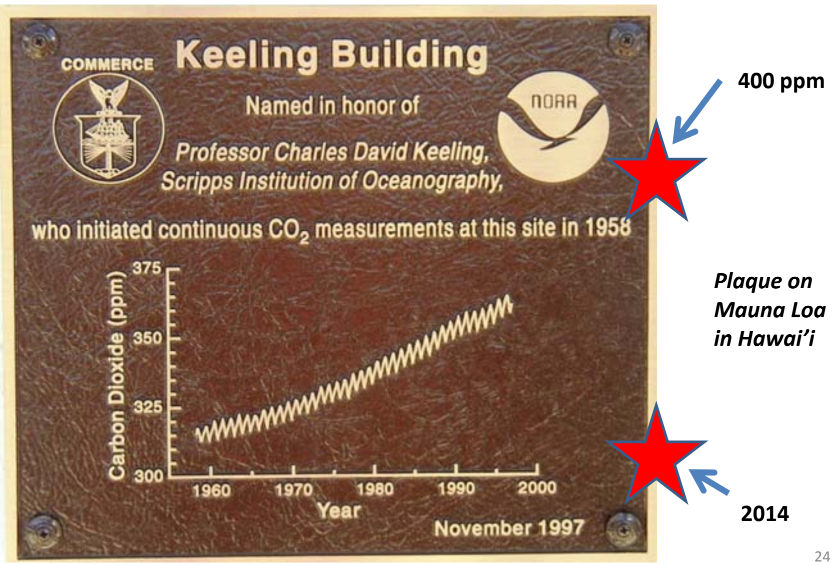
问	答
电厂需要二氧化碳捕集吗?	是的。电厂是二氧化碳最大的排放源。在美国，新的法规要求实现非常大的二氧化碳减排目标。**减少二氧化碳排放是中国和美国的最优先任务。**
电厂能捕集二氧化碳吗?	是的。华能清洁能源研究院已经在中国开展了电厂二氧化碳捕集项目。碳捕集项目现也在北美建设中 (壳牌 & 三菱).
油田能使用二氧化碳吗?	是的。在美国，每年约1亿桶石油生产来自于二氧化碳驱油。中国也能实现同样的产量甚至更多。中国在主要油层和剩余油层有适合的地质条件。
石油开采公司会为二氧化碳付费吗?	是的。德克萨斯州目前的价格是约 35-40美元每吨。在有些州会低一些，有些州可能还会更高。
二氧化碳能运输吗?	是的。美国已经有了约5,000 英里二氧化碳管道。
二氧化碳驱油能实现永久性碳减排吗?	是的。约50%二氧化碳在注入后将留在地下。和石油一起开采出来的二氧化碳将被重复压缩和注入。最终，这些二氧化碳会减少。
生产出的石油是否也含有二氧化碳?	是的。但是比注入的二氧化碳要少很多。并且没有其它的石油开采方法能将二氧化碳封存于地下。

美国能源部
S. Julio Friedmann博士

"去年，全世界使用的风能、太阳能、生物质能以及水电比以往任何时候都多。同时我们使用的煤炭、石油、天然气和核电比以往任何时候也都多。我们使用的能源比以往任何时候都多。"

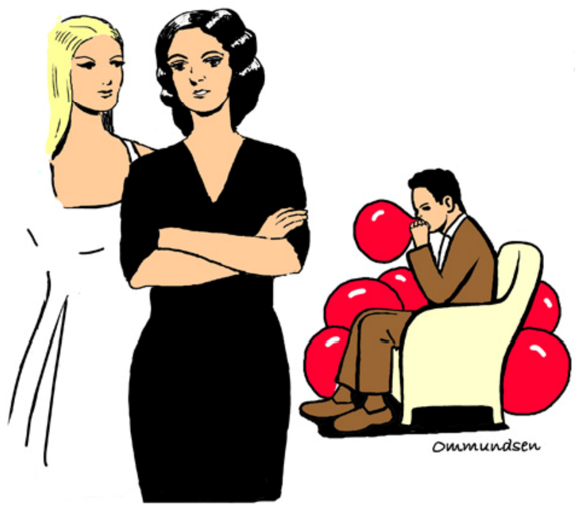
23

二氧化碳封存为什么有意义？



24

小结: 二氧化碳捕集利用和封存可能并不迷人，
但是对于地球却至关重要，并且能盈利



"Frank's into carbon sequestration."

25

谢谢！

美国高峰电力集团
83 South King Street
Seattle, Washington 98104

www.summitpower.com
www.texascleanenergyproject.com

26

US CO_2 EOR Projects and Assessing the Potential for CCUS Development in Xinjiang

美国二氧化碳提高采油率项目以及新疆CCUS开发潜力评价

Susan Hovorka
Gulf Coast Carbon Center
Bureau of Economic Geology
Jackson School of Geosciences
The University of Texas at Austin
Many thanks for Changbing Yang for translation

Presented at **Xinjiang CCUS Outreach Workshop**, Clean Air Task Force, Urumqi, September 18, 2014

Gulf Coast Carbon Center

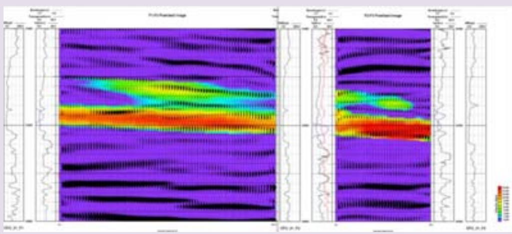
Bureau of Economic Geology

The University of Texas at Austin Jackson School of Geosciences

Outline
报告要点

- How do US EOR projects operate?
- How are US EOR projects developed now?
- What changes may result from capture of CO_2 from anthropogenic sources?
- How might this information be applied to Xinjiang oil production in the future?

- 美国 EOR 项目是如何运行的？
- 目前美国 EOR 项目是如何发展的？
- 二氧化碳的捕捉会导致哪些变化？
- 经来新疆石油生产中如何利用这些信息？

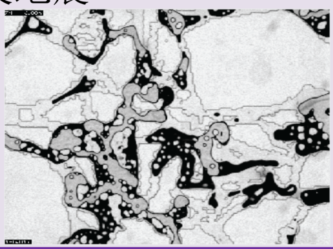


Cross-well inversion showing CO_2 flooding a reservoir, Mississippi

How do US EOR projects operate?
美国 EOR 项目是如何运行的？

- Basics of the CO_2 EOR process
- Distribution of EOR in the US
- Introduction to selected projects
- Role of monitoring and public acceptance
  - Induced seismicity

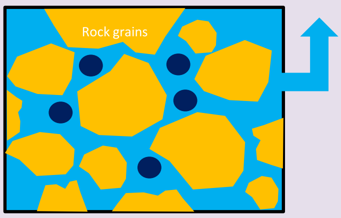
- CO_2 EOR 的基本知识
- EOR 项目在美国的分布
- 典型项目的介绍
- 监测的作用以及公众接受
  - 诱发地震



Micromodel showing oil (black), water (white) and gas (gray) in simulated sand grains. Javadpour 2008

Basics of the CO_2 EOR process(1)
CO_2 EOR 的基本知识（1）

Residual oil will not move to production wells
残余油不会自动流到生产井

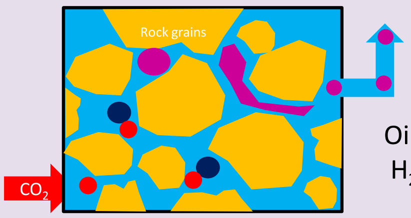


30% Remaining oil is residual, immobile

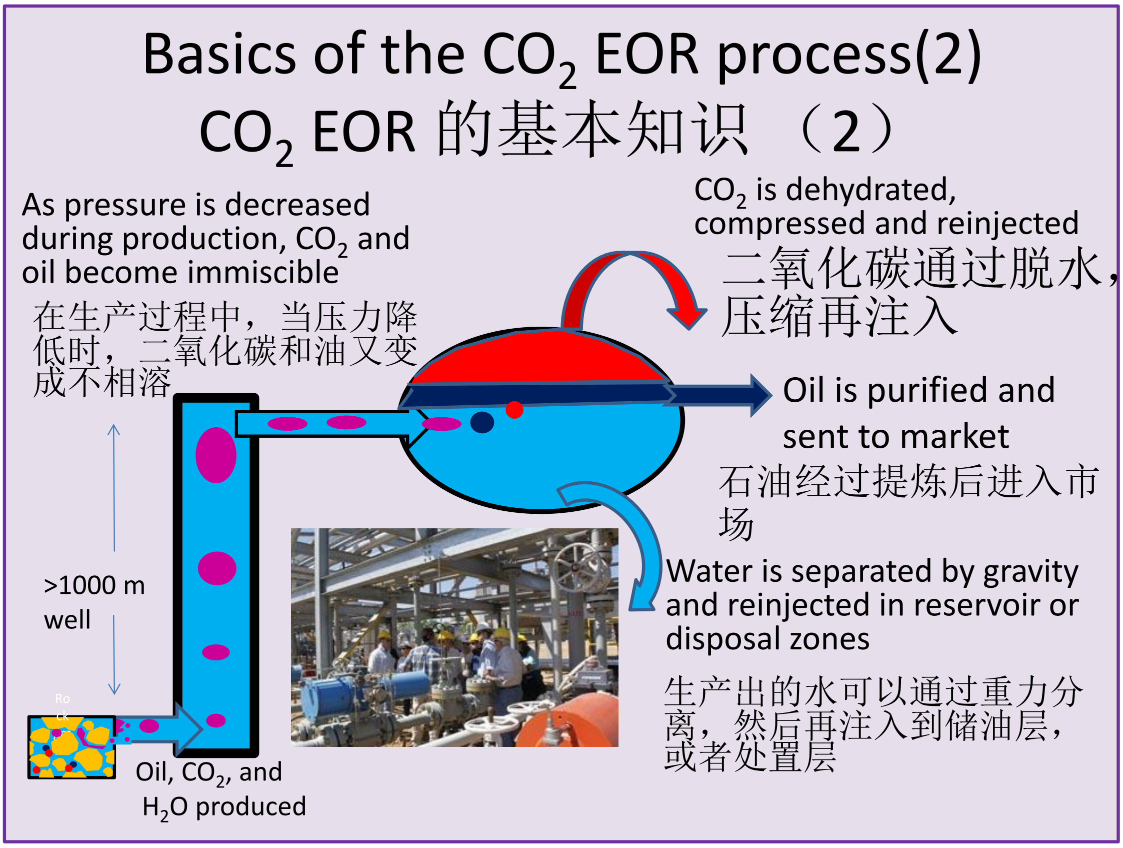
At reservoir pressure, CO_2 is miscible with oil
- Viscosity decrease
- Volume increase

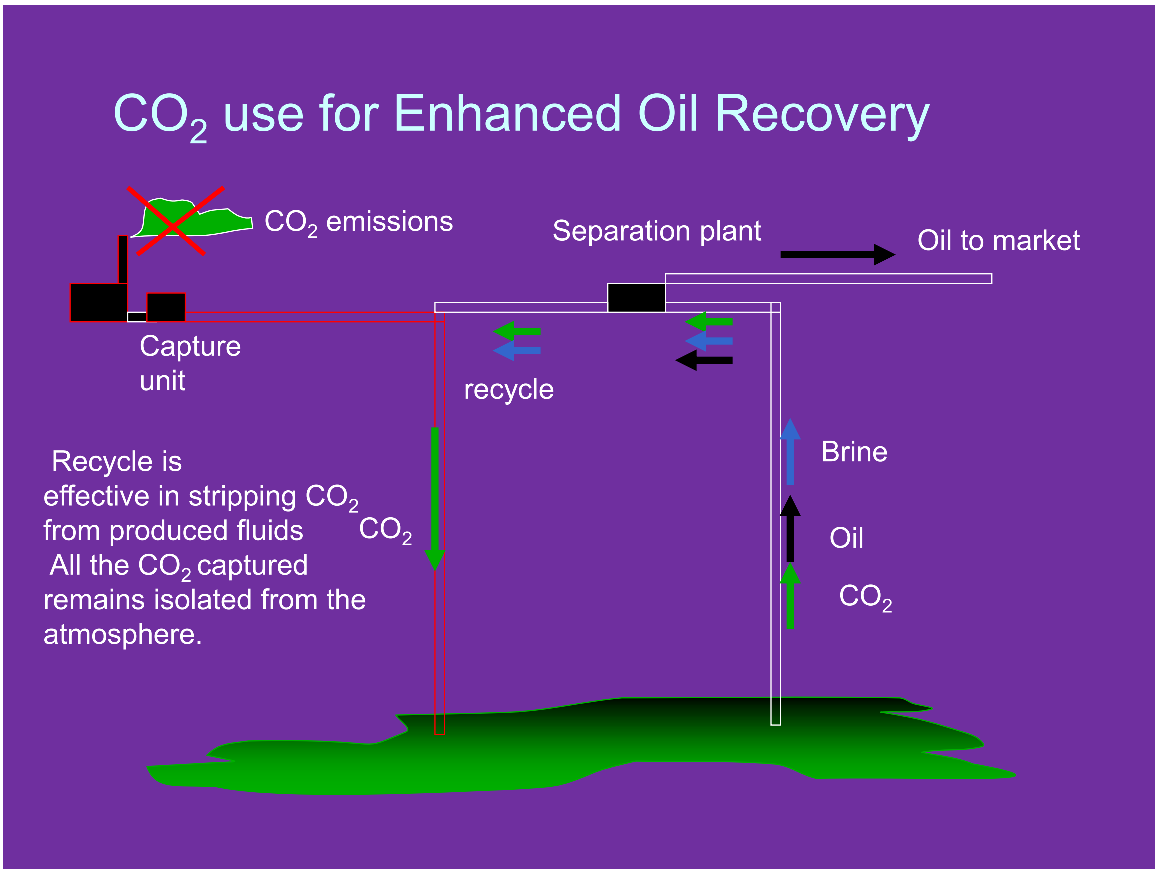
Oil-CO_2 phase can migrate to production wells

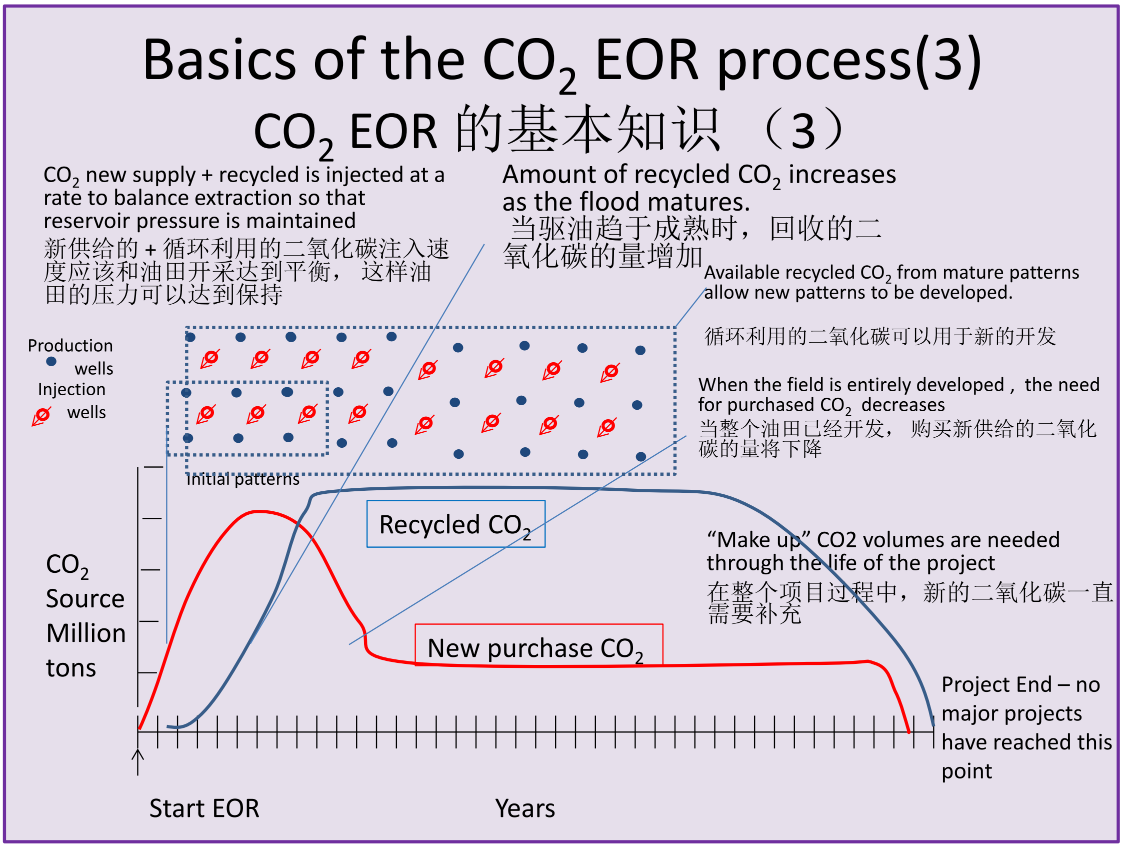
在油层压力下，二氧化碳可以和油混溶
粘滞性降低
体积增加
混溶的油气可以流动到生产井

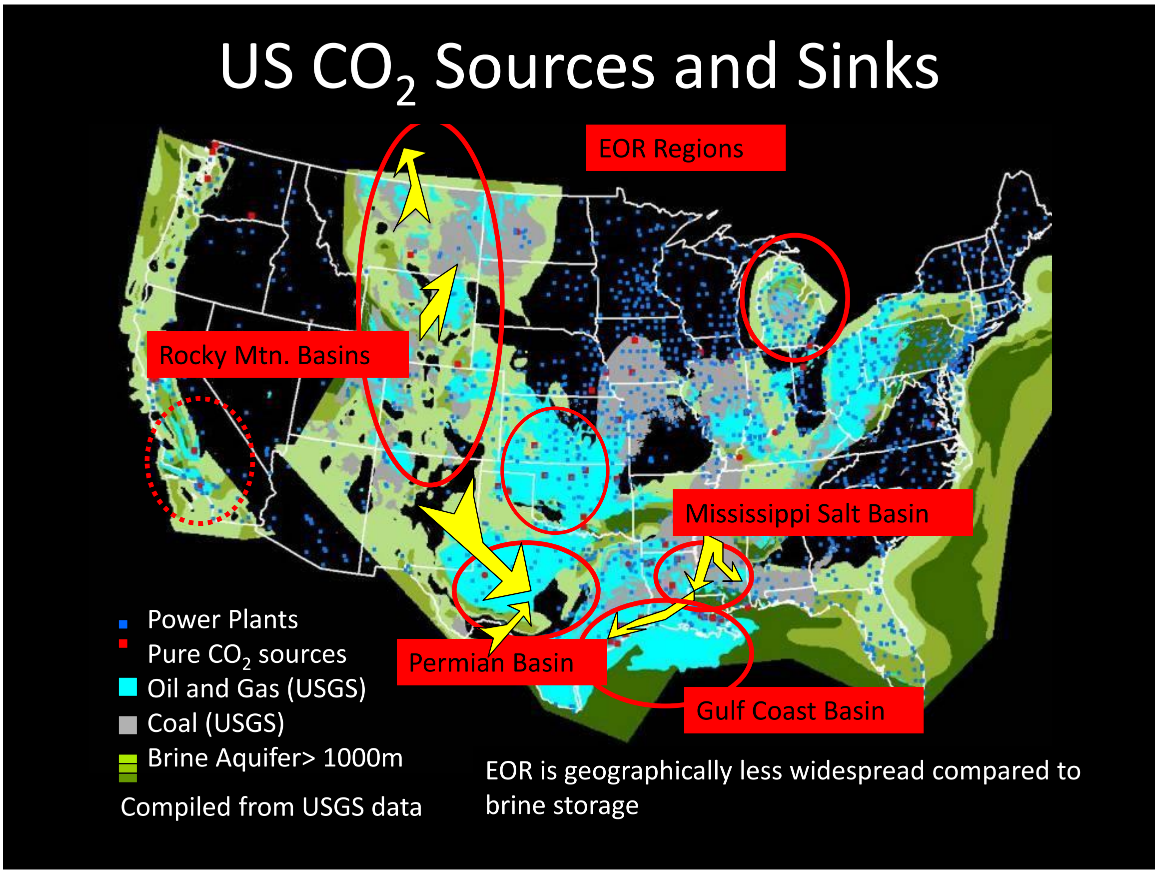


Oil, CO_2, and H_2O produced

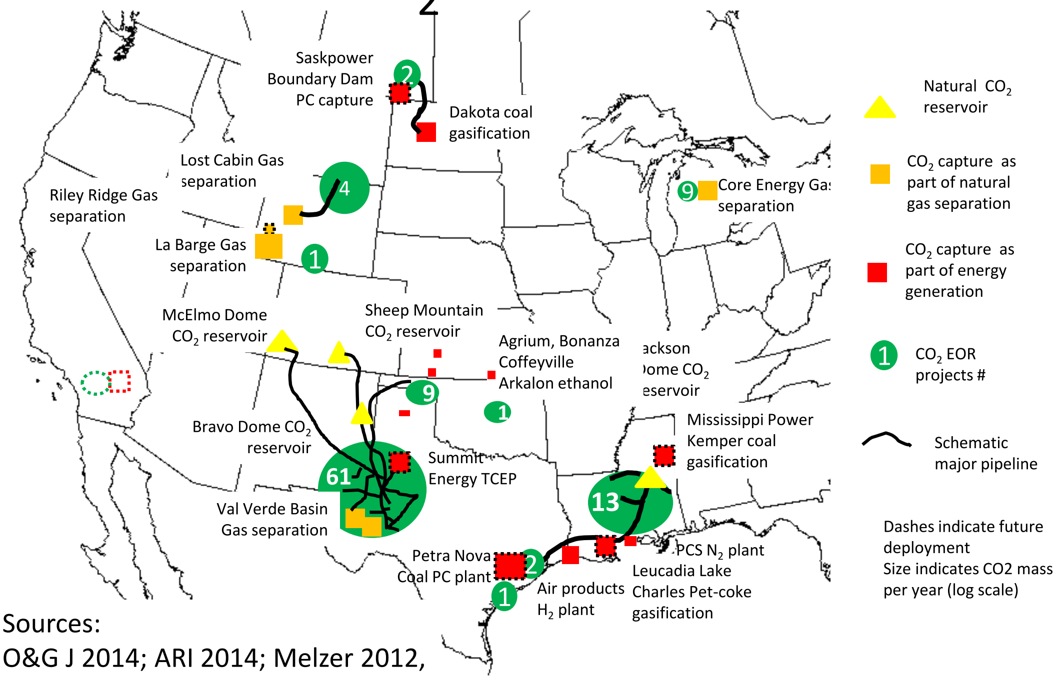

Basics of the CO_2 EOR process(2)
CO_2 EOR 的基本知识 （2）
As pressure is decreased during production, CO_2 and oil become immiscible
在生产过程中，当压力降低时，二氧化碳和油又变成不相溶
CO_2 is dehydrated, compressed and reinjected
二氧化碳通过脱水，压缩再注入
Oil is purified and sent to market
石油经过提炼后进入市场
>1000 m well
Water is separated by gravity and reinjected in reservoir or disposal zones
生产出的水可以通过重力分离，然后再注入到储油层，或者处置层
Oil, CO_2, and H_2O produced


CO_2 use for Enhanced Oil Recovery
CO_2 emissions
Separation plant
Oil to market
Capture unit
recycle
Brine
Oil
CO_2
CO_2
Recycle is effective in stripping CO_2 from produced fluids
All the CO_2 captured remains isolated from the atmosphere.


Basics of the CO_2 EOR process(3)
CO_2 EOR 的基本知识 （3）
CO_2 new supply + recycled is injected at a rate to balance extraction so that reservoir pressure is maintained
新供给的 + 循环利用的二氧化碳注入速度应该和油田开采达到平衡， 这样油田的压力可以达到保持
Amount of recycled CO_2 increases as the flood matures.
当驱油趋于成熟时，回收的二氧化碳的量增加
Available recycled CO_2 from mature patterns allow new patterns to be developed.
循环利用的二氧化碳可以用于新的开发
When the field is entirely developed，the need for purchased CO_2 decreases
当整个油田已经开发， 购买新供给的二氧化碳的量将下降
Production wells
Injection wells
Initial patterns
Recycled CO_2
New purchase CO_2
"Make up" CO2 volumes are needed through the life of the project
在整个项目过程中，新的二氧化碳一直需要补充
CO_2 Source Million tons
Project End – no major projects have reached this point
Start EOR
Years


US CO_2 Sources and Sinks
EOR Regions
Rocky Mtn. Basins
Mississippi Salt Basin
Permian Basin
Gulf Coast Basin
Power Plants
Pure CO_2 sources
Oil and Gas (USGS)
Coal (USGS)
Brine Aquifer> 1000m
Compiled from USGS data
EOR is geographically less widespread compared to brine storage

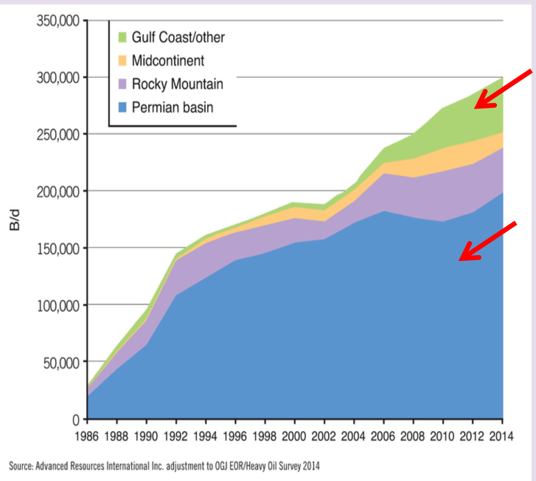
US CO_2 Networks



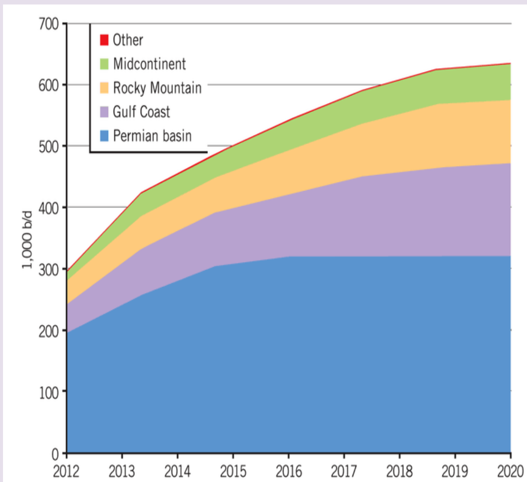
Sources:
O&G J 2014; ARI 2014; Melzer 2012,
Corporate web pages

CO_2-EOR Production by Region

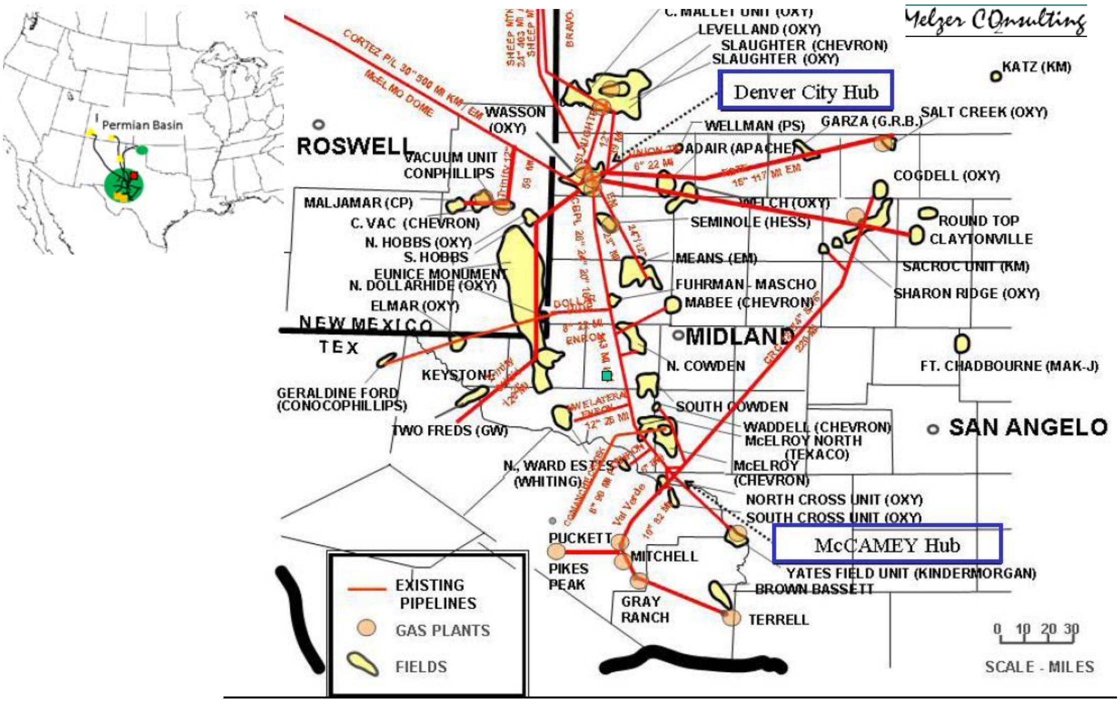
Historical

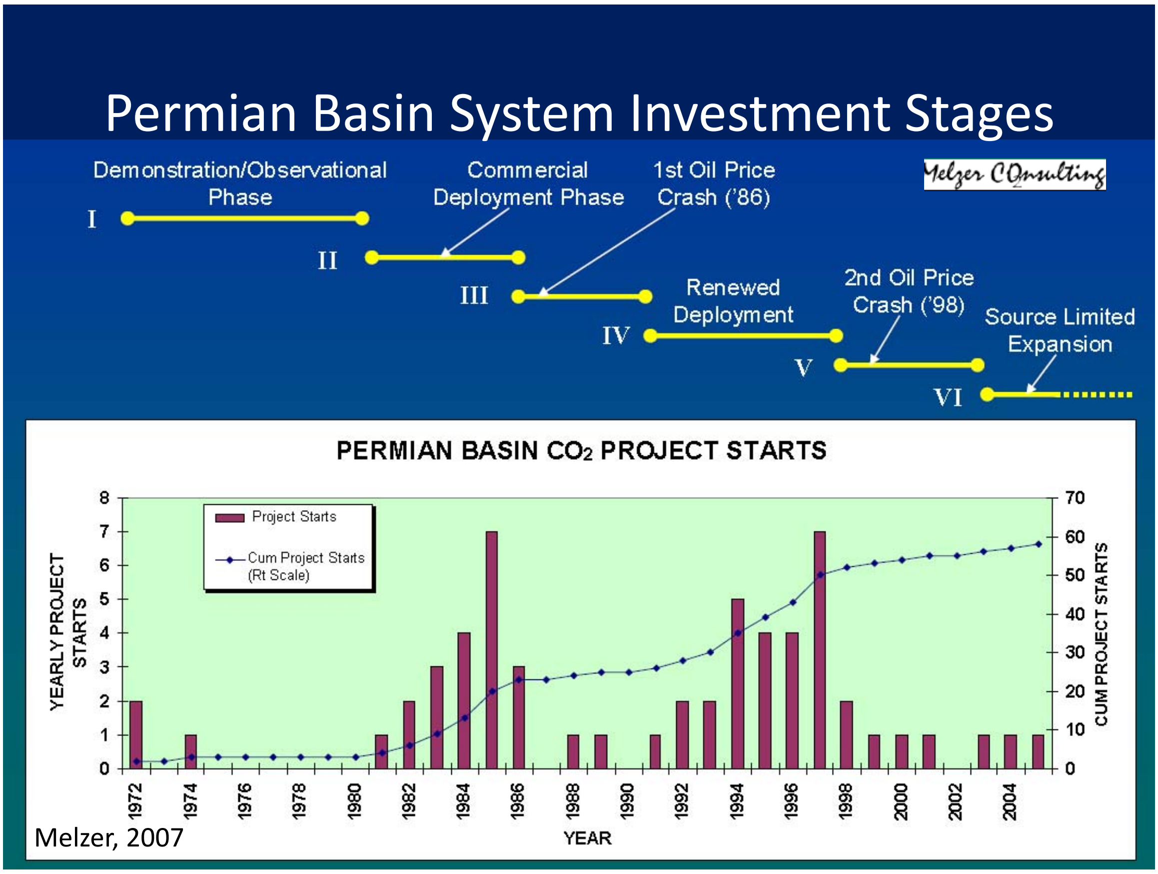


Future Prediction by ARI

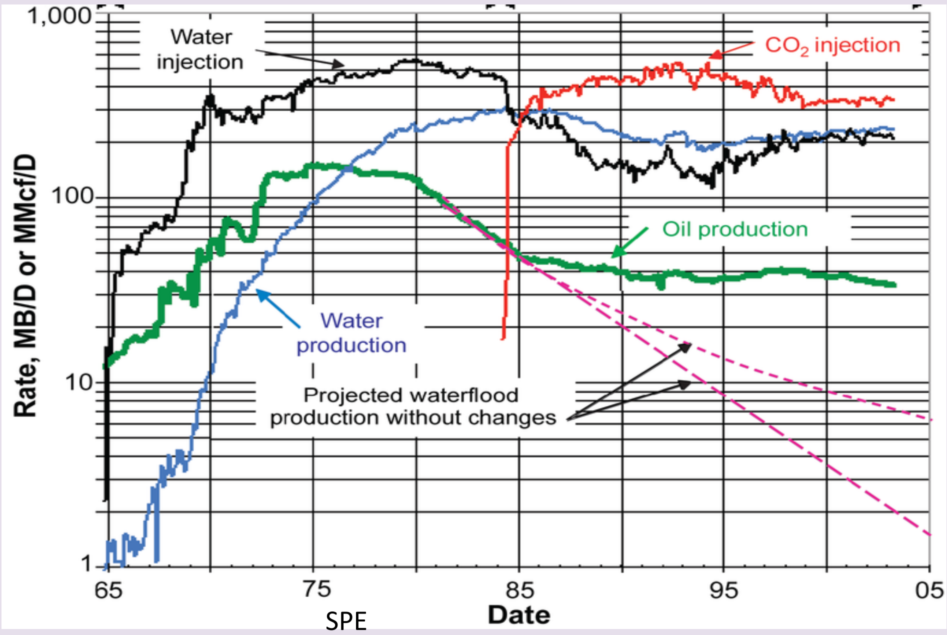


Three Billion Dollar Permian Basin CO_2 Separation Plant and Pipeline Infrastructure



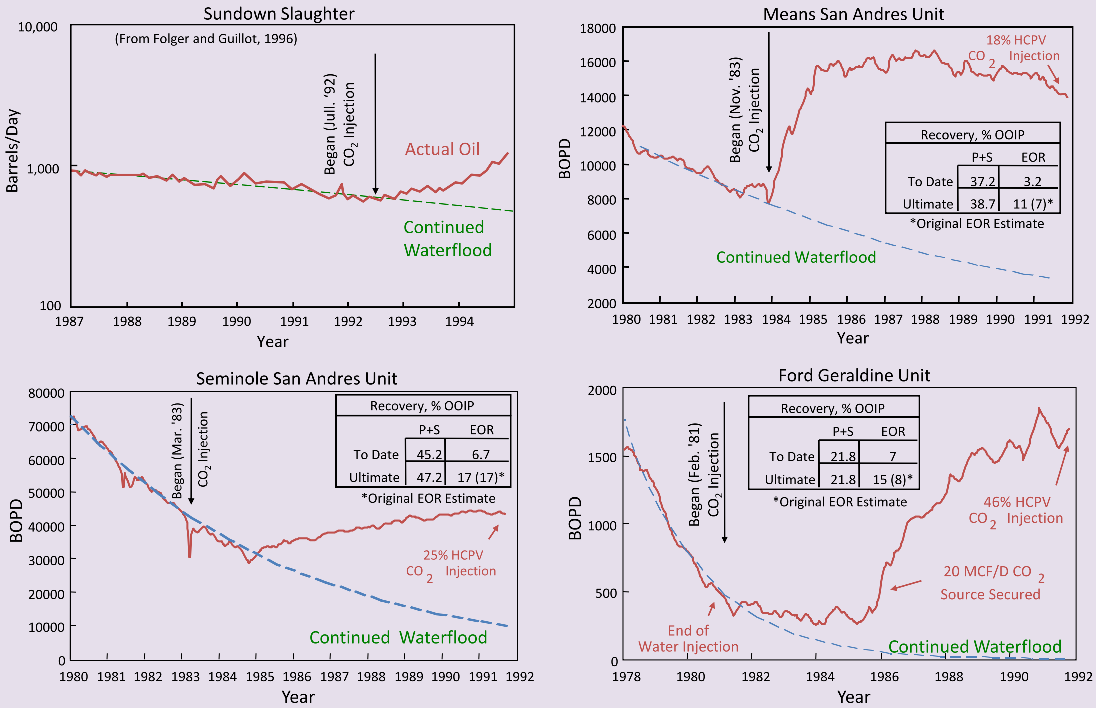


History of Denver Unit of the Wasson Field, West Texas



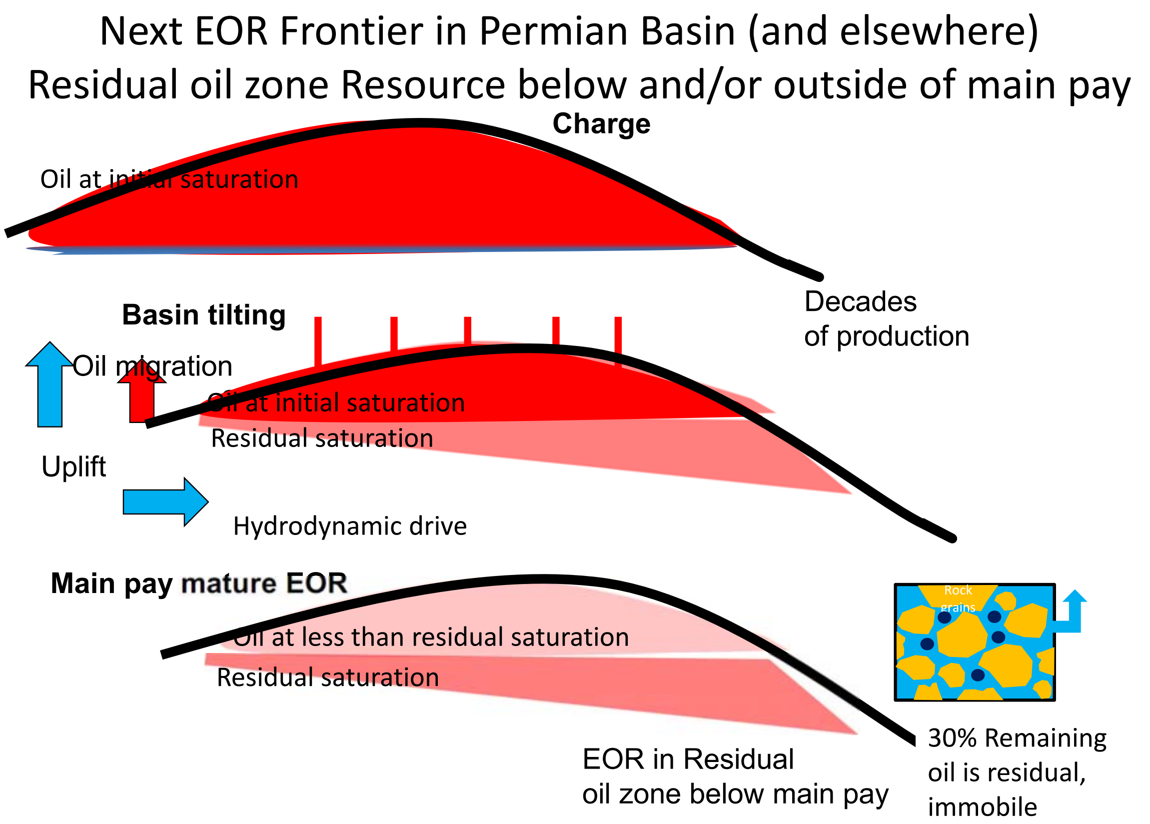
SPE petrowiki.org/File%3AVol5_Page_1296_Image_0001.png

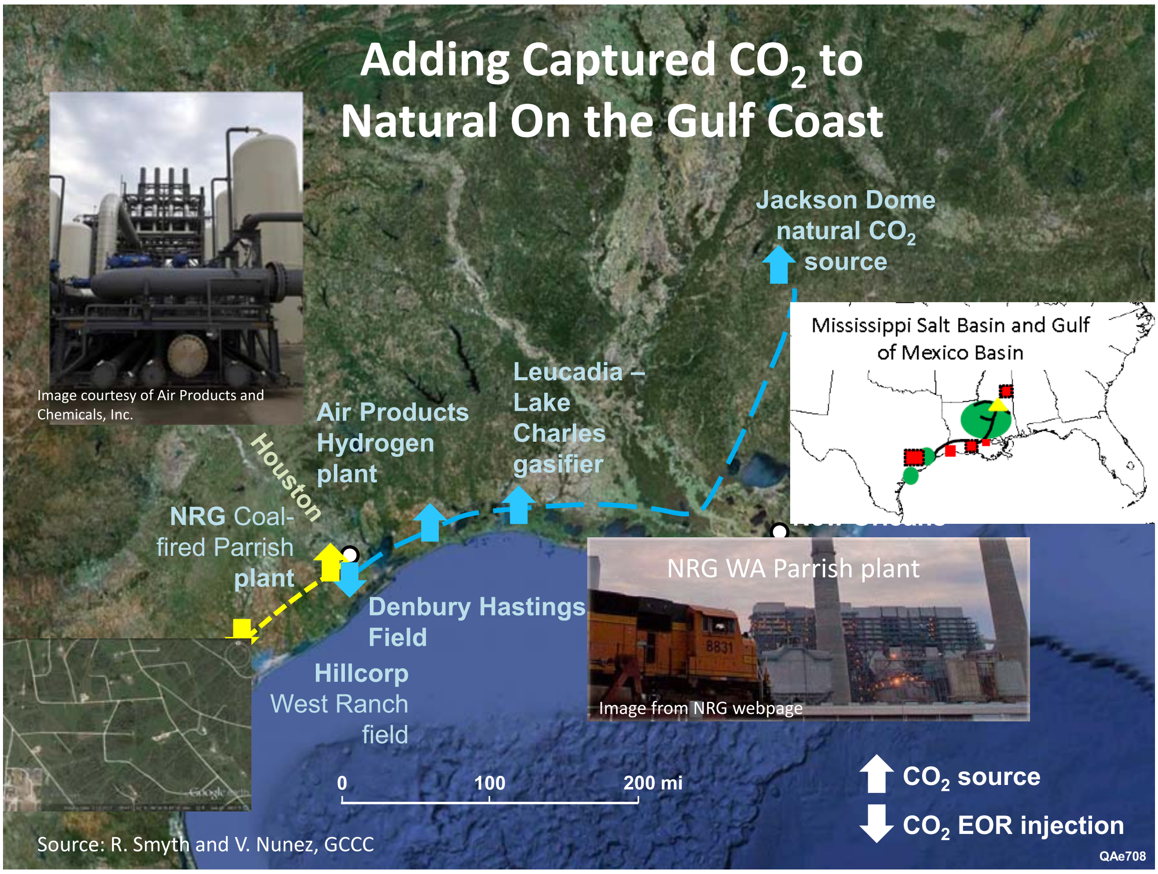
Example CO_2 Floods



Hadlow, 1992 (SPE 24928

Susan Hovorka-Bureau of Economic Geology
Susan Hovorka-美国经济地质局





How are US EOR projects developed now?
目前美国 EOR 项目是如何发展的?

Large productive oilfield, declining production because of decreasing oil mobility
Can be unitized

大的油田,
产油量降低因为原油流动性降低
能够被利用

Economy of scale on pipeline and separation plant
EOR value specific to depletion

管道和分离厂的经济规模
EOR 经济价值, 特别是油田资源的枯竭

Appropriate-size CO_2 source
Economy of scale on pipeline and separation plant

适度规模的CO2源
管道和分离厂的经济规模

Suitable financing

适当的资金来源

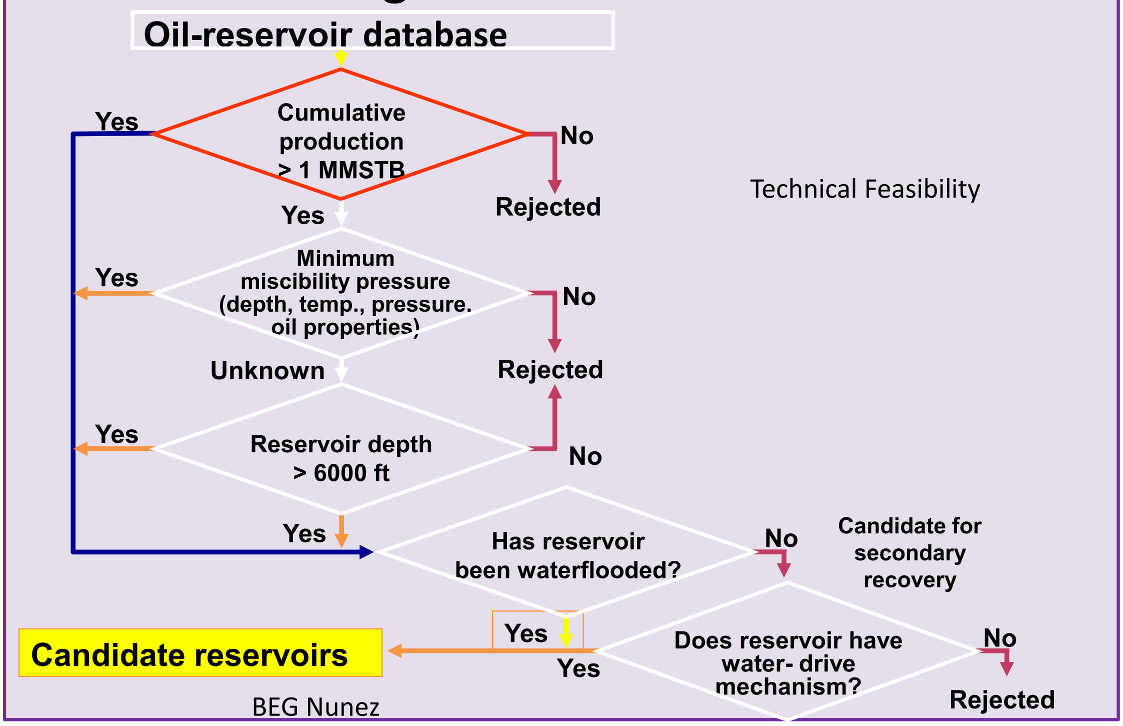
Low risk but relatively slow pay-out

低风险但是获利慢

CO_2-EOR Potential Estimates for the US Gulf Coast

- Developed a multistage quick-look methodology to identifying optimal CO_2 EOR storage sites.
  - Identify miscible CO_2 EOR candidate reservoirs with potential for EOR CO_2 sequestration.
  - Estimate oil recovery and CO_2 sequestration volumes through dimensionless modeling.

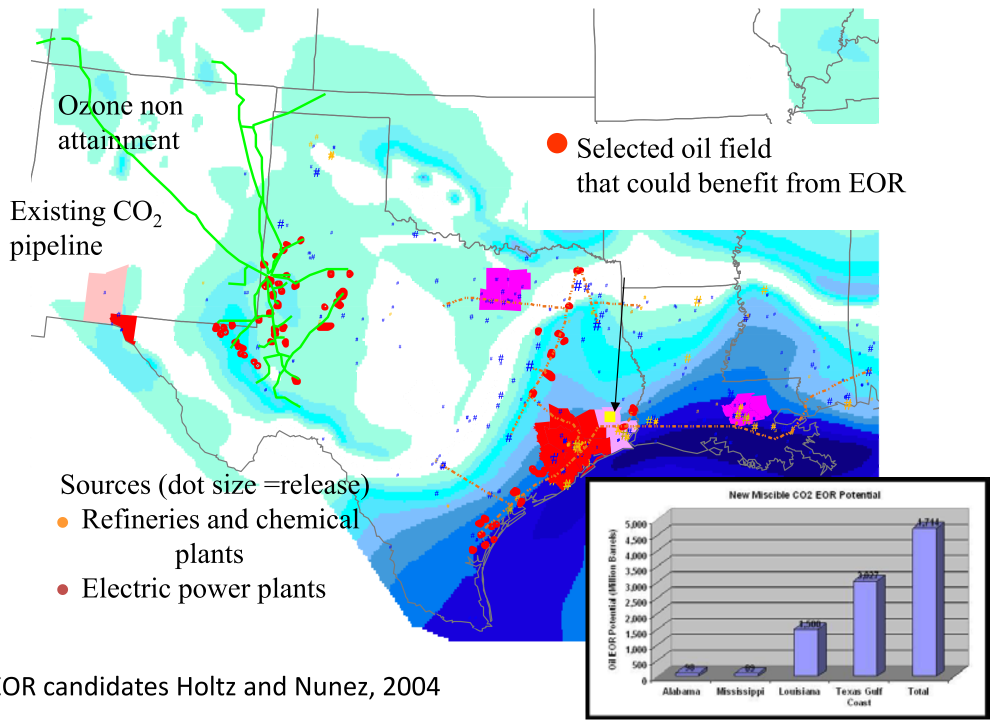
Screening of candidate reservoirs



Technical Feasibility

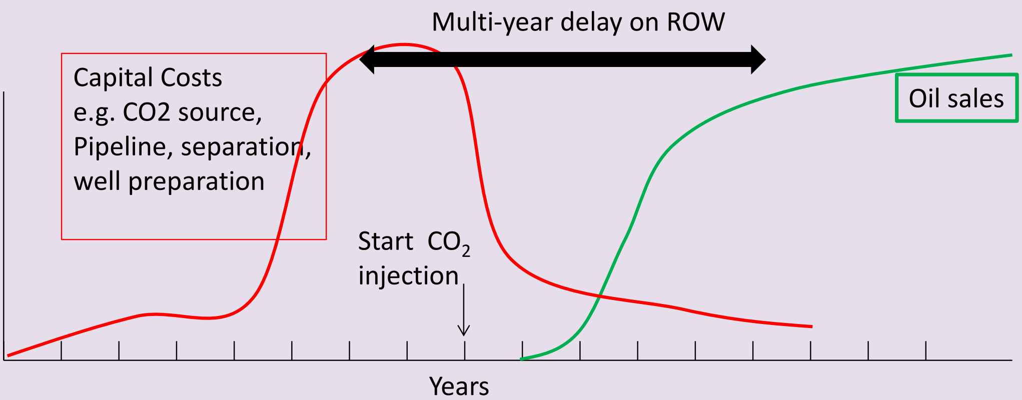
BEG Nunez

Focus on the Gulf Coast



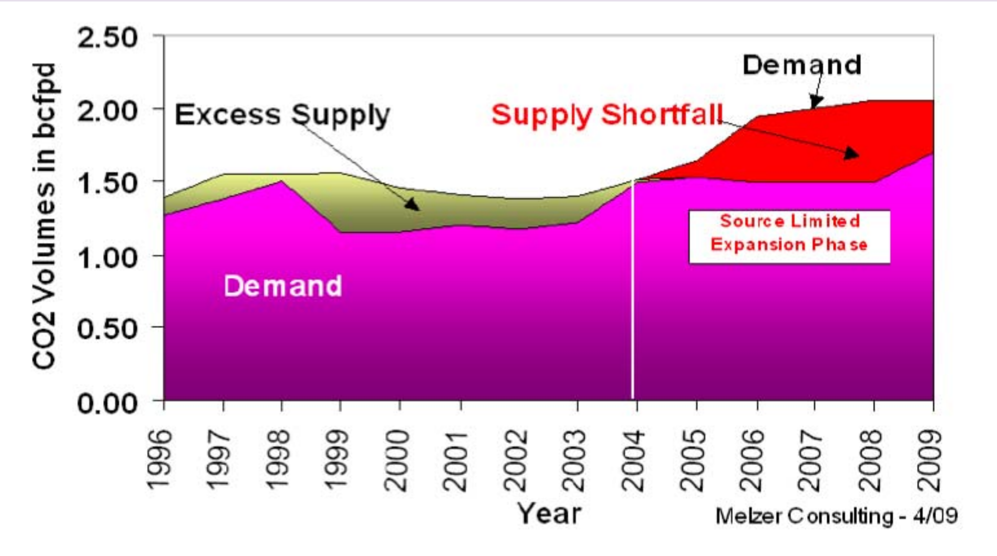
EOR candidates Holtz and Nunez, 2004

Suitable financing is one element limiting CO_2 EOR development
适当的资金来源是制约CO_2 EOR 发展的一个因素

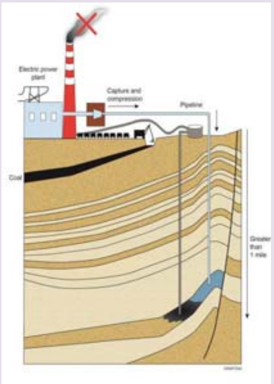


Idealized cost curves for EOR project
EOR项目的理想成本曲线

CO_2 availability is another factor limiting CO_2 EOR development
二氧化碳来源是制约CO2 EOR 发展的另一个因素



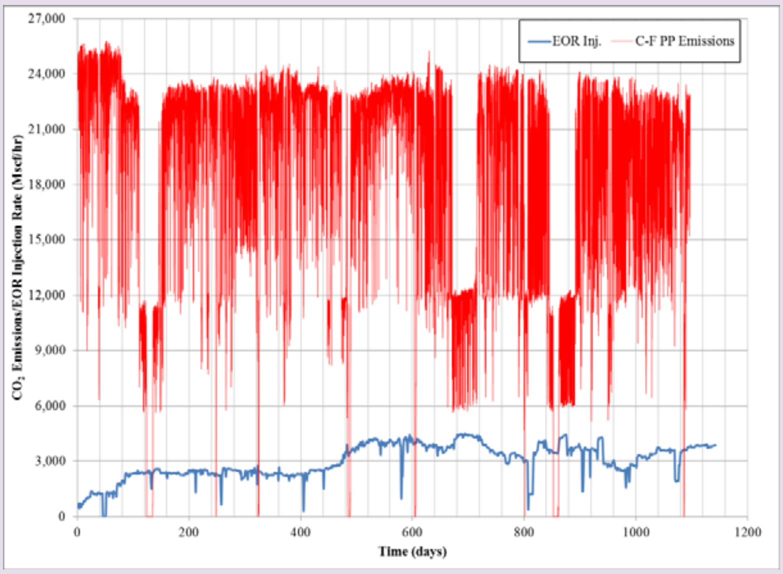
What changes may result from capture of CO_2 from anthropogenic sources?
二氧化碳的捕捉会导致哪些变化？



- CO_2 available in new areas
- CO_2 available larger volumes
- Possible intermittent CO_2 supply (linked to power or other demand)
- Need to document storage permanence

- 二氧化碳可以从新的地区获得
- 获得大量二氧化碳得以可行
- CO_2零星供给 (例如电力或其它需求)
- 记录二氧化碳地质储藏的需要

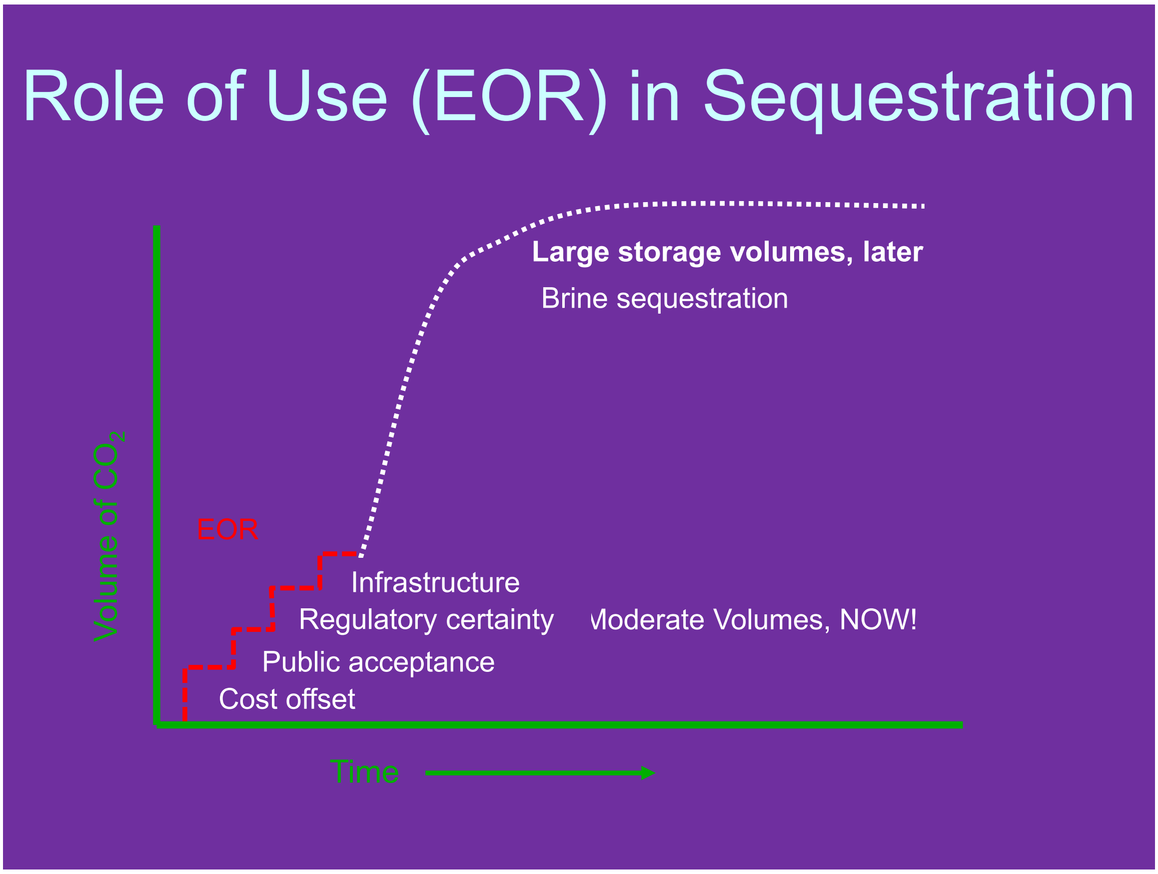
Possible intermittent CO_2 supply
CO_2零星供给

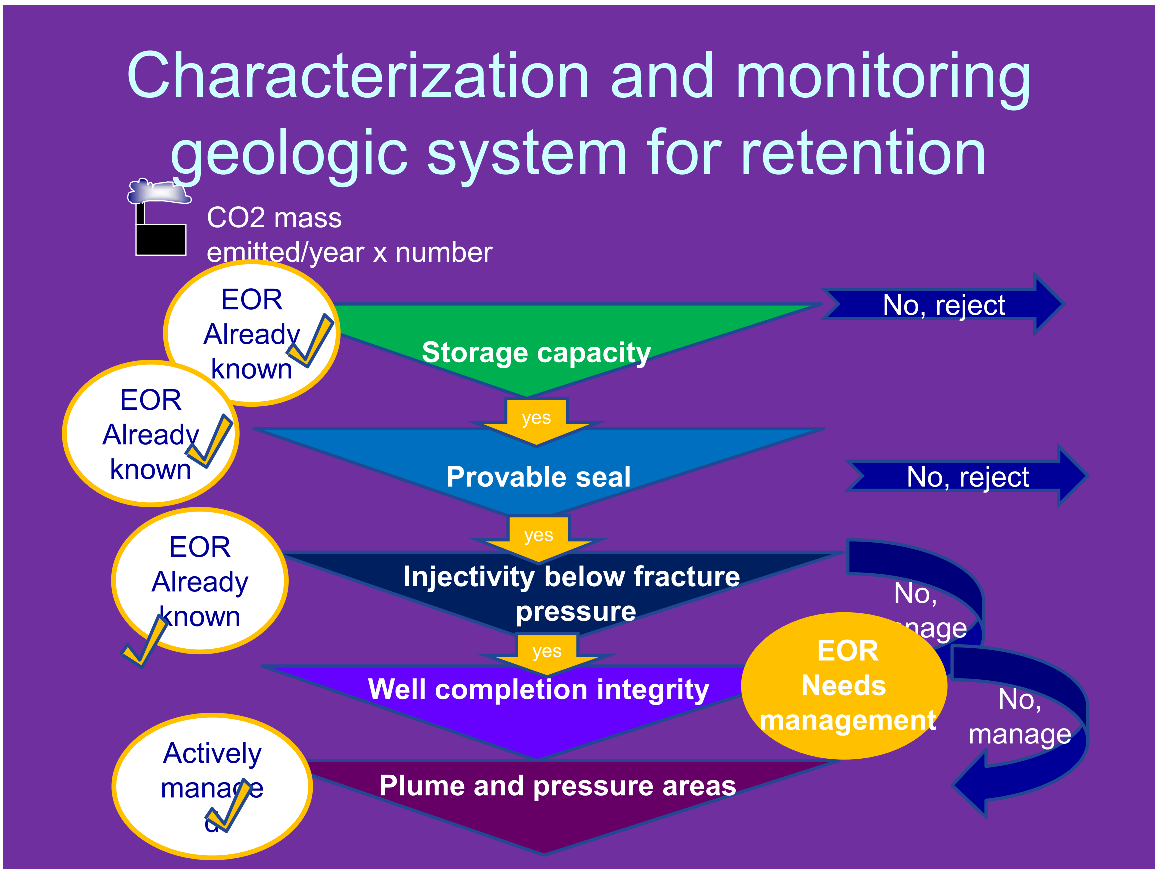


Power plant CO2 emissions can fluctuate. Note they can supply multiple fields (data from Big Brown)

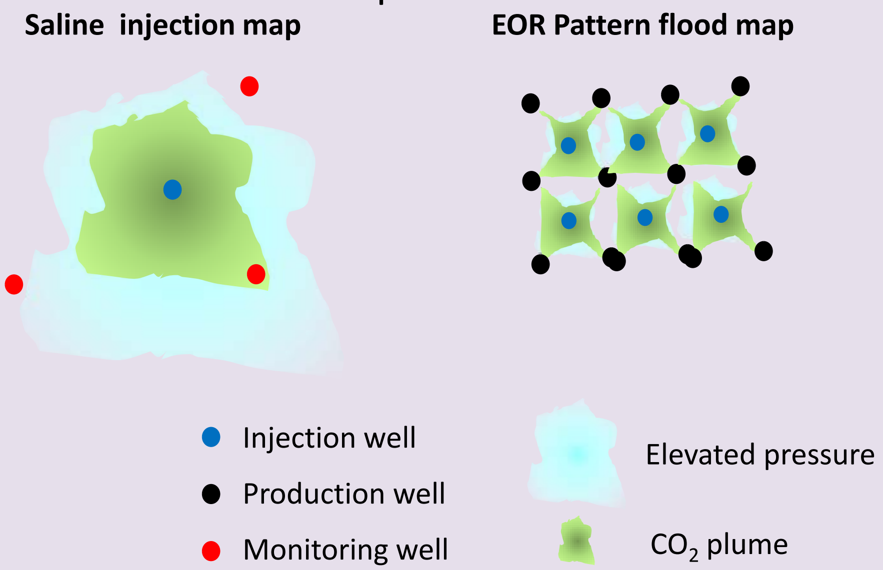
Typical EOR purchases are more steady

Stuart Coleman UT MA thesis

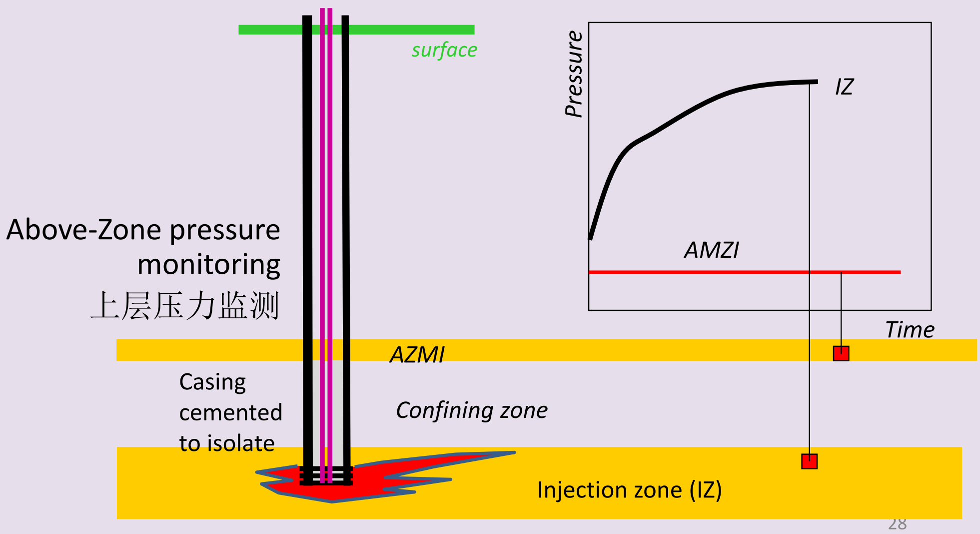

Role of Use (EOR) in Sequestration
Large storage volumes, later
Brine sequestration
Volume of CO2
EOR
Infrastructure
Regulatory certainty
Moderate Volumes, NOW!
Public acceptance
Cost offset
Time


Characterization and monitoring geologic system for retention
CO2 mass emitted/year x number
EOR Already known
Storage capacity
No, reject
yes
EOR Already known
Provable seal
No, reject
yes
EOR Already known
Injectivity below fracture pressure
No, manage
yes
Well completion integrity
EOR Needs management
No, manage
Actively managed
Plume and pressure areas

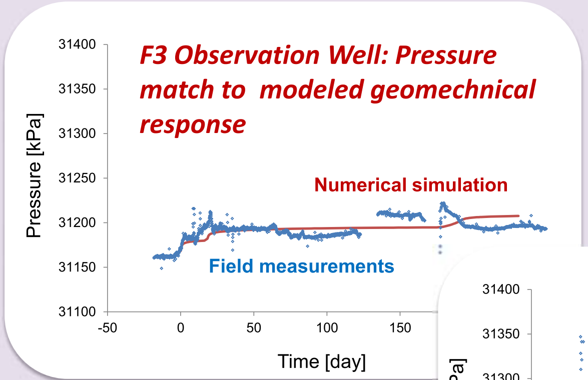
Management of CO_2 During EOR and Limited Area of Pressure Increase: Increased Confidence in Permanence Compared to Saline Sequestration



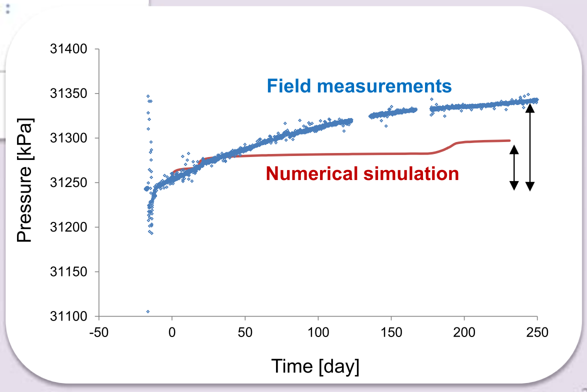
Need to document storage permanence
记录二氧化碳地质储藏的需要



Observed Pressure in AZMI



Hosseini and Kim, BEG, 2014

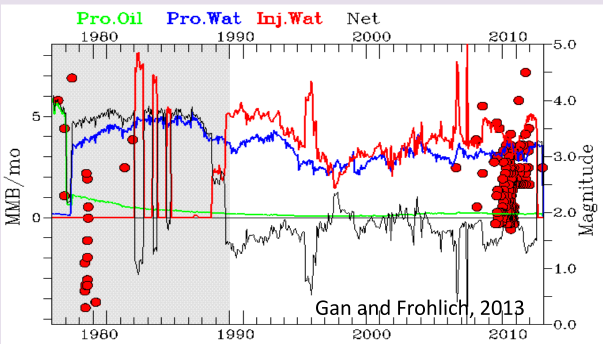


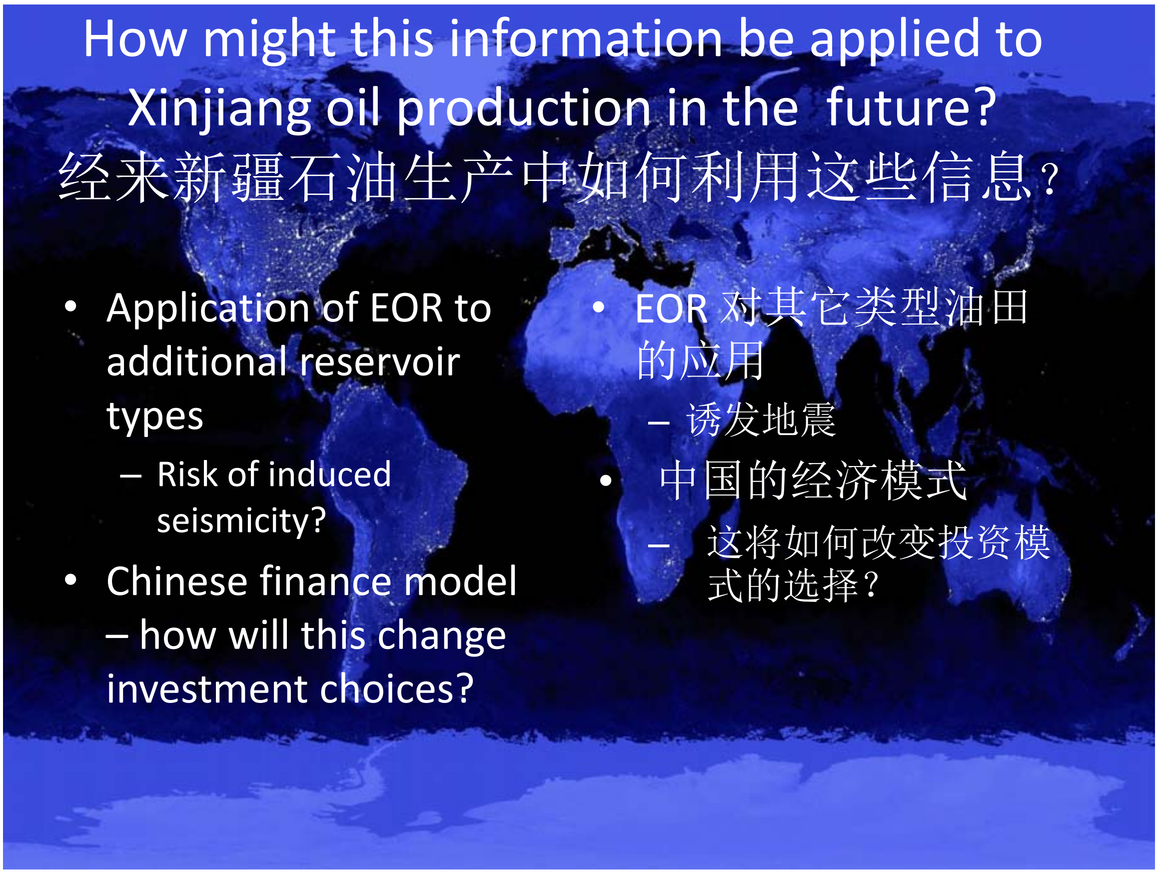
F2 Observation Well: Pressure increase > geomechanical = hydrologic response

29

Risk of Induced Seismicity During EOR

- Historically low – one field (Cogdell, Permian basin), TX has had induced magnitude 2-4 seismicity from water flood and EOR) Davis and Pennington, 1989; Gan and Frohlich, 2013
  - Injection still continues today
- Recent measurements related to large volume EOR injection at Cranfield by RITE, Japan = no detection, Takagishi and others, 2014

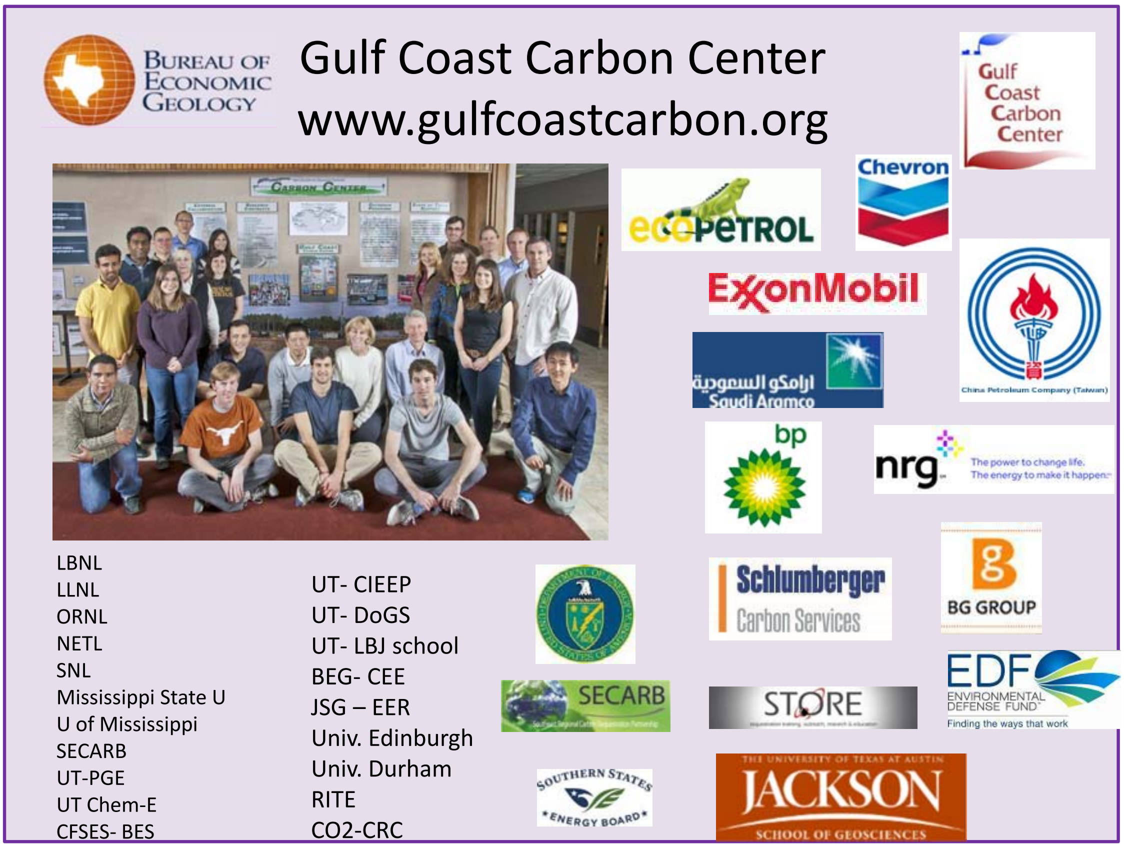




Knowledge Sharing, Public and Technical Outreach

STORE
sequestration training, outreach, research & education

www.gulfcoastcarbon.org
www.storeco2now.com
susan.hovorka@beg.utexas.edu


Bureau of Economic Geology
Gulf Coast Carbon Center
www.gulfcoastcarbon.org
Gulf Coast Carbon Center
ecopetrol
Chevron
ExxonMobil
Saudi Aramco
China Petroleum Company (Taiwan)
bp
nrg
The power to change life.
The energy to make it happen.
LBNL
LLNL
ORNL
NETL
SNL
Mississippi State U
U of Mississippi
SECARB
UT-PGE
UT Chem-E
CFSES- BES
UT- CIEEP
UT- DoGS
UT- LBJ school
BEG- CEE
JSG – EER
Univ. Edinburgh
Univ. Durham
RITE
CO2-CRC
Schlumberger
Carbon Services
BG GROUP
SECARB
STORE
EDF
ENVIRONMENTAL DEFENSE FUND
Finding the ways that work
Southern States Energy Board
The University of Texas at Austin
JACKSON
SCHOOL OF GEOSCIENCES

preliminary study of Xinjiang Carbon dioxide capture, utilization and storage (CCUS) Technology Roadmap

Alex Shi
师 庆 三

Geological and Mining Engineering Institute , Xinjiang University

目录

Outline

1

一、Abstract（摘要）

新疆是资源产出及消费大省，拥有丰富的煤炭、石油及天然气资源，随着经济的快速发展和能源消费的进一步提高，新疆的CO_2排放量上升趋势明显，且增速较快。相对于中国的其他地区，新疆有着源汇毗邻、地广人稀、地质封存潜力大、成本相对较低等明显的优势，有利于二氧化碳的捕集与封存技术的实施，同时缓解新疆这个资源与消耗大省由于CO_2排放所引起的负面效应 。

2

我们前期的主要任务及目标为:

①新疆地区的碳源区域分布以及产能调查;

②新疆地区的碳汇区域调查（构造尺度）;

③新疆地区的碳源和碳汇的源汇匹配研究;

④新疆地区的CCUS政策建议。

3

二、The purpose and significance of Xinjiang CCUS roadmap preliminary study

1、The purpose of Xinjiang CCUS roadmap preliminary study

①To provide basic information of CO_2 emissions scale, distribution, characteristics of emission in Xinjiang；

② To provide basic information of sites of CO_2 storage scale, distribution, and geological characteristics in Xinjiang；

③ To provide basic data for the later implement and technological selection of Xinjiang CCUS project;

④ To provide credible policy recommendations for the CCUS projects in Xinjiang.

4

2、Significance of Xinjiang CCUS study

CCUS research first needs to know the characteristics of CO_2 emission by investigating the actual situation of CO_2 emissions to take effective trapping measures..

The safety of CO_2 sequestration is CCUS final foothold. To some extent，feasibility of storage determines the technical feasibility of CCUS.

CCUS technology provides a practical way to reduce CO_2 emissions in Xinjiang. The preliminary investigation of CCUS technology has a significant and far-reaching significance to the sustainable development of energy, economy and environment and to the great-leap-forward development of Xinjiang.

5

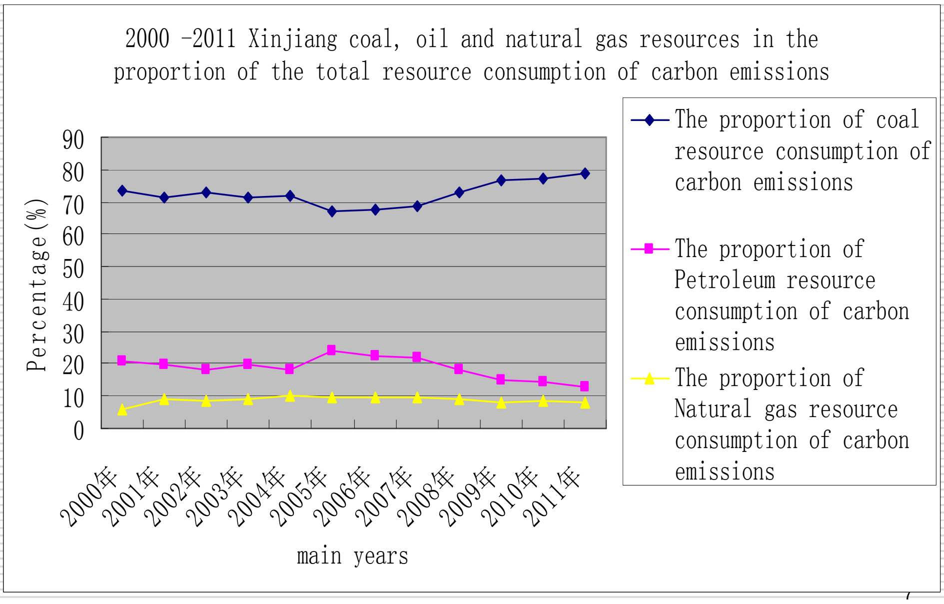
三、Introduction to the main carbon source in Xinjiang

1、Coal-dominated energy structure

a、the estimated reserve of Xinjiang coal resources is **2.19 ×10^{12}t**，accounting for **40.5%** of the national total reserves and ranking **first** in our country. Coal and its related industries are the leading and dominant industries in Xinjiang.

b、the coal resource consumption accounted for **more than 65%** of total carbon emissions in Xinjiang, Showing the carbon emissions produced by coal consumption-based carbon structure (see table 1).

6



2、the thermal power plants based on coal resource

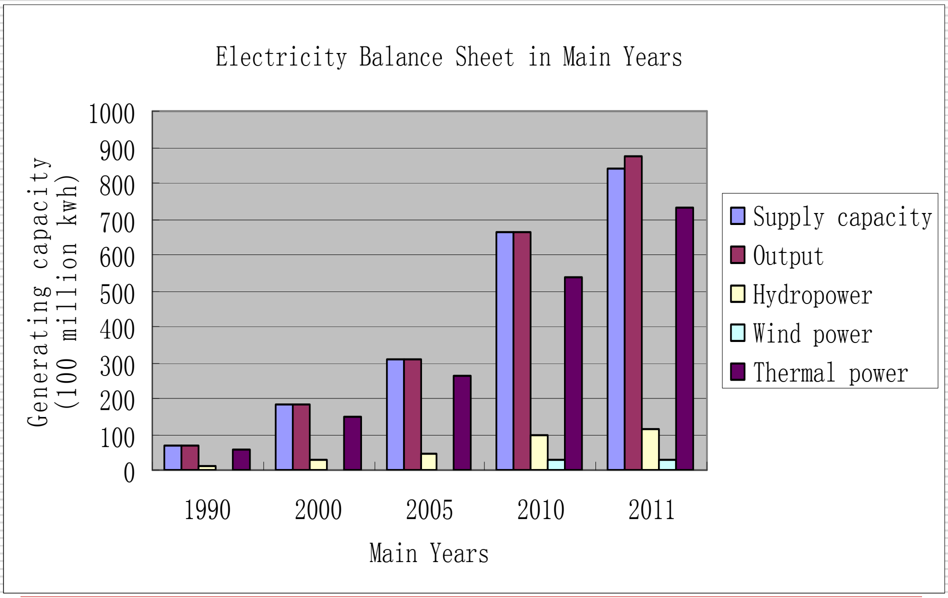
The energy production and consumption structure has a features of coal-based consumption in Xinjiang. The medium-sized thermal power plant generating capacity reached to **732.36×100 million kWh in 2011，** Accounting for **87.28%** of total electricity supply of xinjiang。

新疆主要年份电力平衡表 Xinjiang electric power balance in Main Years

Electricity Balance Sheet in Main Years

单位:亿千瓦小时						(100 million kwh)
项　　目	Item	1990	2000	2005	2010	2011
可供量	Total Energy Available for Consumption	69.79	182.98	310.14	661.96	839.1
生产量	Output	69.79	182.98	310.14	665.06	875.19
水 电	Hydropower	14.25	30.54	46.49	97.07	114.57
风 电	Wind Power	0.08	1.73	2.32	30.02	28.26
火 电	Thermal Power	55.46	150.71	261.33	538.63	732.36

8



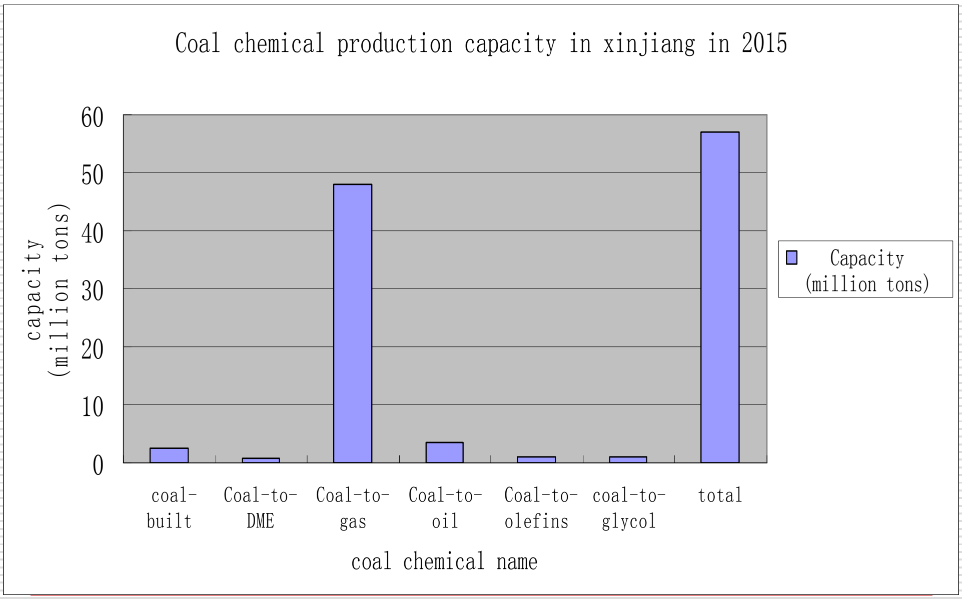
9

3、Coal chemical industry is the focus of development

Coal chemical industry has become an important direction of industrial development in Xinjiang. The coal and natural gas occupies a leading position in Xinjiang coal chemical project.

The 12th Five Year Plan gives a clear descripton of the development of the modern coal chemical industry. The plan declares Ili region and Zhundong Coal Bases as the focus, By 2015, 2.6 million tons of coal-made urea, 0.8 million tons of Coal-to-DME, 60 billion m^3 Coal-to-gas 3.6 million tons of Coal-to-oil, 1 million tons of Coal-to-olefins and 1 million tons of coal-to-glycol will be produced.

10



11

4、Carbon dioxide emissions from other industries

①Cement plant

The cement industry is the greenhouse gas carbon dioxide emitters, are the key areas to address climate change. There are carbon dioxide gas source of cement production process, which produces carbon dioxide gas into the entity unit or the atmosphere in the process By the end of 2012, there had been **78 cement companies** in Xinjiang, with **more than 75 million tons of cement production capacity**.

12

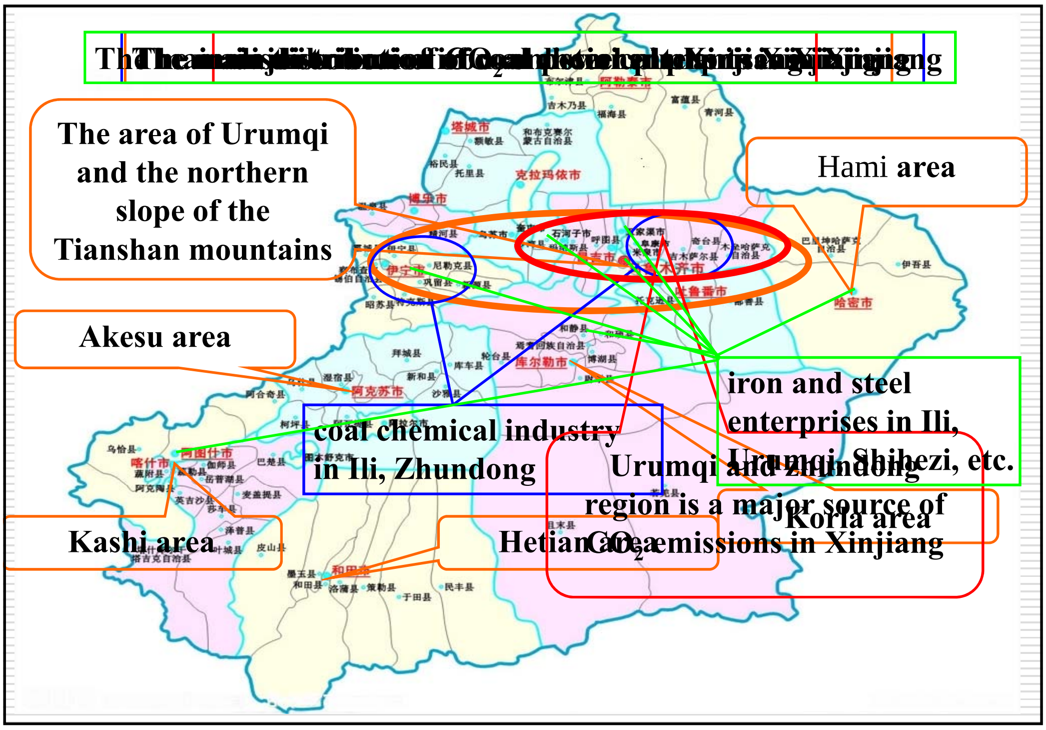
②Steel Works

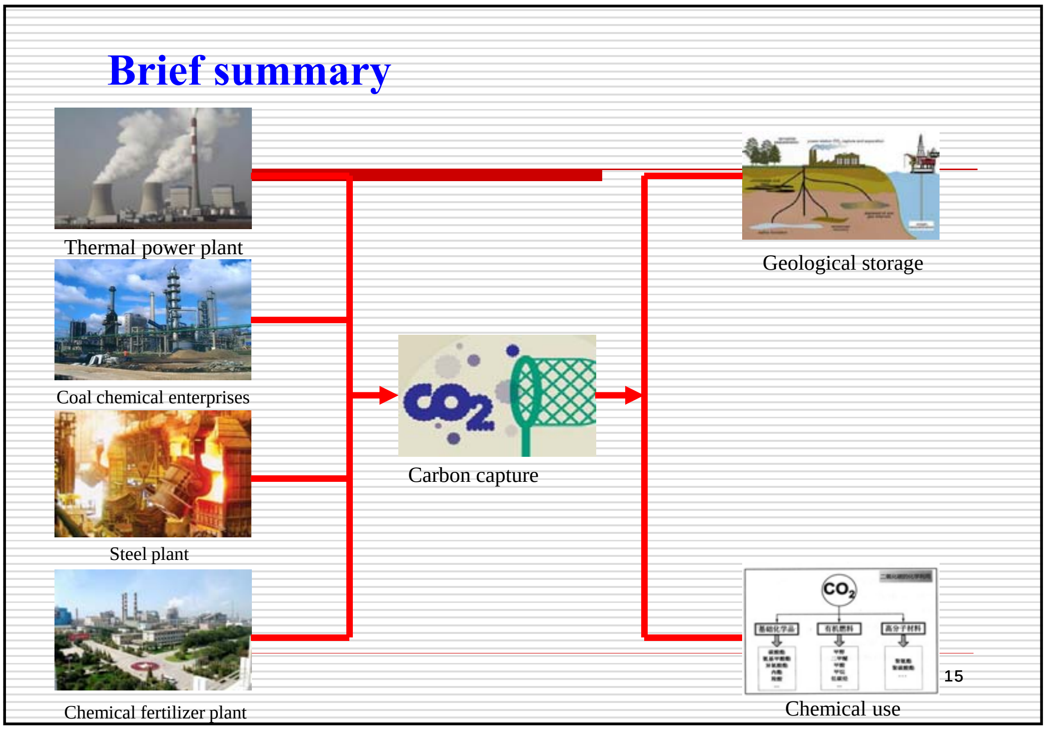
Xinjiang iron and steel industry is the main source of emissions, CO_2 emissions,under the coal chemical industry, electric power system and building materials (mainly cement production) industry, ranking the fourth place. Iron and steel industry arduous task of energy saving, reducing CO_2 emissions has become a problem in Xinjiang during the survival and development of the steel industry must be considered.Xinjiang existing **21 blast furnaces**, blast furnace design production capacity of **19.11million tons**.

③ Other sources

Besides the above industries, there are still other sources of emissions ,such as **fertilizer plants, coking plants.**

13


The area of Urumqi and the northern slope of the Tianshan mountains
Hami area
Akesu area
iron and steel enterprises in Ili, Urumqi, Shihezi, etc.
coal chemical industry in Ili, Zhundong
Urumqi and Zhundong region is a major source of CO_2 emissions in Xinjiang
Korla area
Kashi area
Hetian area

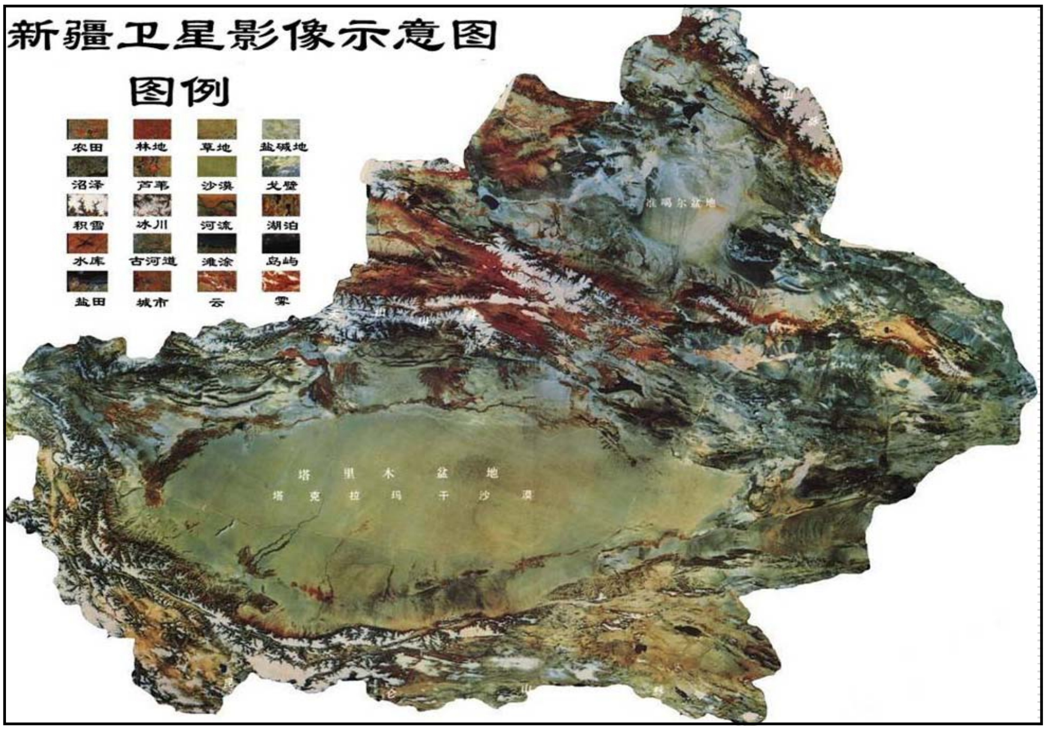

Brief summary
Thermal power plant
Coal chemical enterprises
Steel plant
Chemical fertilizer plant
Carbon capture
Geological storage
Chemical use
15

四、 A brief introduction of major carbon sinks of Xinjiang

1、The overview of the basin

Xinjiang has a unique topogarghy feature, with a landscape pattern of "three mountains sandwiched two basins" .Altai Mountains is in northern. Southern Kunlun Mountains lies in the middle of the Tianshan Mountains in Xinjiang. Xinjiang Tianshan Mountain divides Xinjiang into the halves, Tarim Basin in the southern,and the Junggar Basin in the northern。

16

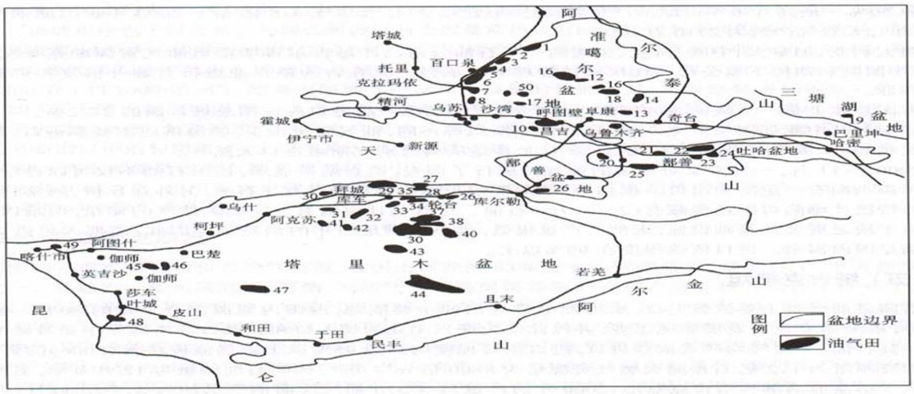


2、target evaluation summary table of Geological storage of carbon dioxide

Index layer	Index sub layer	Target groups
Safety	1、Regional crustal stability	① peak ground acceleration; ② goal target seismic safety; ③ within 25km radius surrounding whether active faults
	2、Cap seal	① the main cover of the depth; ② cap rock; ③ main caprock layer thickness; continuity ④ Continuous cover layer distribution;⑤ penetration;⑥on top of cap the main secondary retention capacity ; ⑦ micro-cap index closed
	3、The possible leakage of CO_2 channel	①The development of the fracture and crack;②the target area whether has other depth greater than 800 m drilling and abandoned wells; ③ fracture that in the existing technical condition was not found
	4、hydrogeological conditions	①The hydrodynamic effect; ②head of state in deep saline aquifers
Reservoir scale	1、reservoir characteristics	① main reservoir depth; ② reservoir rock lithology; ③ thickness of the main reservoir; ④heterogeneity; ⑤ formation water salinity; ⑥ formation pressure coefficient; ⑦ effective reservoir aspect ratio
	2、Reservoir parameters	① porosity; ② penetration
	3、Geological characteristics of geotherm	① geothermal gradient; ② heat flow; ③ surface temperature
	4、Reservoir storage prospects	① effective sequestration;②use fixed number of year
Social and environmental risks	1、Social environment	① population density;②From the residents point distance； ③land use status
	2、Geological environment	①the geological hazard susceptibility;②whether in mining subsidence area, Karst collapse area, land subsidence, desert activity area, volcanic activity area;③Whether below rivers and lakes, the highest water level of reservoir line or floodplain
	3、Nature Area	①Whether accord with city and regional development planning, whether in the agricultural protection areas, nature reserves, scenic areas, heritage conservation areas, drinking water supply planning area and area, water source protection of mineral resources reserves and other zones that need special protection ; ② vegetation condition
	4、Drinking water sources from the relationship and length	① whether the upper reservoir of CO_2 available industrial and agricultural use aquifer; ② whether the main drinking groundwater recharge areas; ③ from rivers, reservoirs and carbon source; ②carbon source distance;③ the mode of transport; ④ the ore condition other surface water sources of drinking length
economic suitability		The size of the carbon source; carbon source distance; the mode of transport; the ore condition

3、Suitable main basins for Xinjiang CO_2 geological sequestration

(1)The main oil and gas basin cases in Xinjiang



新疆主要含油气盆地及主要油气田分布示意图

Distribution sketch of major oil-gas-bearing basins and major oil-gas fields in Xinjiang

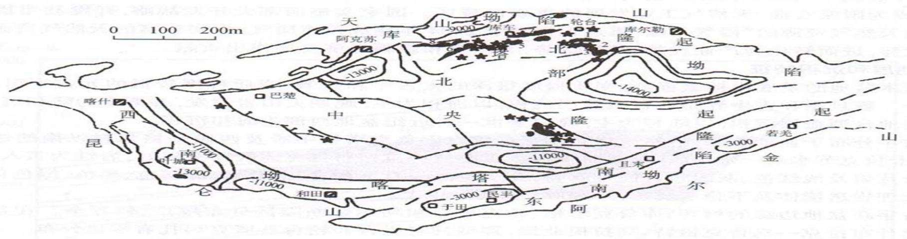
（据康有柱，2006）

油田名称：1—夏子街；2—风城；3—乌尔禾；4—百口泉；5—克拉玛依；6—红山嘴；7—小拐；8—车排子；9—独山子；10—齐古；11—呼图壁；12—三台；13—北三台；14—火烧山；15—五彩湾；16—石西；17—石南；18—彩南；19—北小湖；20—伊拉湖；21—胜金口；22—丘陵；23—鄯善；24—温吉桑；25—乌鲁克；26—宝浪；27—伊奇克里克；28—依南迪那尔；29—克拉 2；30—大宛齐北；31—羊塔克；32—英买 7；33—东河塘；34—雅克拉；35—大涝坝；36—轮台；37—轮南；38—阿克库勒；39—塔河；40—达里亚；41—玉东 2；42—英买 2；43—哈德；44—塔中；45—巴什托；46—亚松迪；47—和田河；48—柯克亚；49—阿克力；50—莫西庄

①Tarim Basin（Tarim Oilfield ）

Tarim Basin→China's largest basin, located between the Tianshan Mountains and the Kunlun Mountains, diamond-shaped outline, is a wholly closed inland basin, an arid inland basin.

Basin area of 560,000 km².



塔里木盆地油气及工业性含油气构造分布图

Distribution of oil-gas and industrial oil-gas-bearing structures in Tarim Basin

（据梁狄刚，1997）

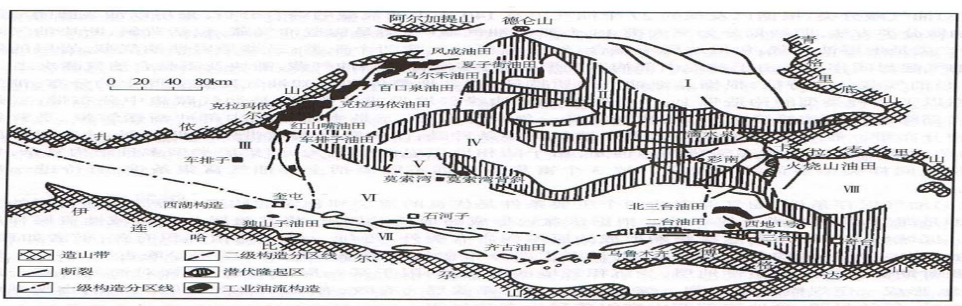
主要油气田名称：1—轮南；2—桑塔木；3—解放渠东；4—吉拉克；5—东河塘；6—英买力 7 号；7—牙哈；8—羊塔克；9—塔中 4 号。★28 个工业性含油气构造

构造单元名称：Ⅰ—北部坳陷；Ⅱ—中央隆起；Ⅲ—西南坳陷；Ⅳ—塔南隆起；Ⅴ—东南断隆

②Junggar Basin （Xinjiang Oilfield）

Junggar Basin→China's second largest basin, located between the Tianshan Mountains and the Altai Mountains, roughly triangular in shape.

Basin area of about 134,000 km².



准噶尔盆地油气田分布略图

Distribution sketch of oil-gas fields in Junggar Basin

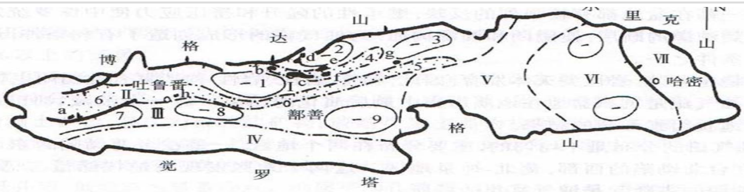
（新疆通志·地质矿产志，2002）

—乌伦古断陷；Ⅱ—三个泉隆起；Ⅲ—西北缘冲断带；Ⅳ—玛湖-漠区坳陷；Ⅴ—中央隆起带；Ⅵ—昌吉坳陷；Ⅶ—乌鲁木齐山前坳陷；Ⅷ—沙（丘河）-奇（台）隆起区

③Turpan - Hami Basin（Turpan-Hami Oilfield）

Turpan - Hami Basin → Located in the eastern part of Xinjiang, is the mountain basin surrounded by the Tianshan Mountains. Lectra north of Bogda and Hal Hill, south of Jueluotage Hill. Basin east to west 600km, north-south width 50-130km.

Basin area of 55,000 km^2.



吐-哈盆地坳陷与油田分区略图

Zoning of depressions and oilfields in Turpan-Hami Basin

（据黄第藩等，1995）

Ⅰ—北部坳陷带：1—台北坳陷；2—丘东坳陷；3—红台坳陷；4—凹中凸起带；Ⅱ—中央隆起带：5—火焰山断裂带；6—肯德
起带；Ⅲ—南部坳陷带：7—托克逊坳陷，8—吐鲁番坳陷，9—塔克泉坳陷；Ⅳ—艾丁湖斜坡带；Ⅴ—嘹墩隆起；Ⅵ—三堡
Ⅶ—哈东隆起；a、b、c、e、f、g、h 为油气聚集区

The main data features of the Basin in Xinjiang

Xinjiang basin characteristics index data table

Evaluation / Basin name	Basin feature						
	Area（10^4km^2）	structure	Burial depth（km）	Faulting	Land surface temperature（℃）	Geothermal gradient（℃/100m）	Heat flow values（mW/m^2）
Junggar Basin	13.4	Aggregation mountain	12	Development, small	6	2.02	42.6
Turpan Hami Basin	5.5	Aggregation mountain	10	Development, big	—	2.5	40.79
Tarim Basin	56	Aggregation mountain	15.5	Concentrated、big	9.6	1.764	46.2

23

Xinjiang basin reservoir characteristics index data table

Xinjiang basin reservoir characteristics index data table

Evaluation index / Basin name	Reservoir characteristics				
	Reservoir thickness （m）	The lithology of reservoir	Reservoir permeability （$10^{-3}m^2$）	Reservoir porosity	Cover layer （%）
Junggar Basin	900	Sandstone, mudstone	8	15	Better
Turpan Hami Basin	500	Sandstone	225	18	Better
Tarim Basin	600	Sandstone	55	15	Better

24

⑵Introduction of major coal basins in Xinjiang

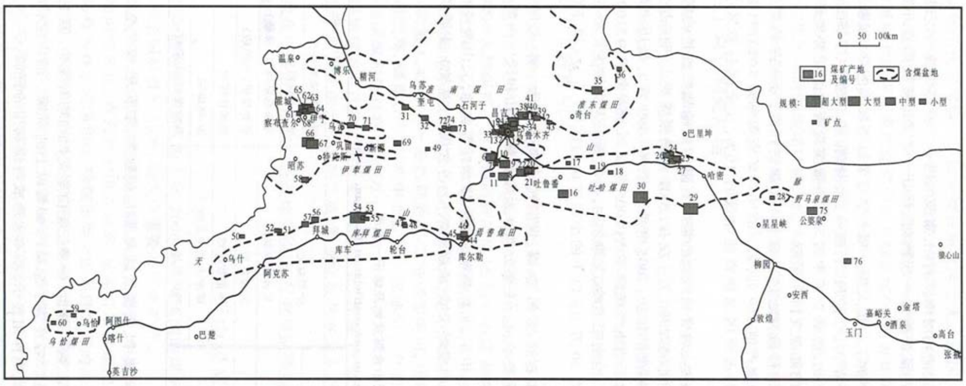
Xinjiang Coal Mesozoic period in each coal and coal-bearing basins in the Upper Triassic and Lower Jurassic coal developmental;

Quasi-Southern coalfield, Tory - Heshentuoluogai, Zhundong coalfield and Turpan-Hami Basin, etc， Coal is mainly produced in the Jurassic Badaowan and Xishanyao coal within the formation, are generally low ash, low sulfur long flame coal, non-caking coal and gas coal.

Yili basin, coal and Yanqi Tabei area, etc， are generally low ash, low sulfur gas coal and long-flame coal;

Wuqia coalfield, southern Tarim Basin, Southwest， Coal is mainly produced in the leaf group Consumerella group and Yang coal-bearing strata, is not caking coal, gas coal, lean coal.

25



中国天山煤矿分布略图

Distribution sketch of coal deposits in Tianshan, China

煤矿产地名称:1—四道岔煤矿区;2—老君庙煤矿区;3—八道湾井田;4—六道湾井田;5—芦草沟井田;6—南山后峡二井田;7—南山三井田;8—艾维尔沟井田;9—南山通沟煤矿区;10—板房沟—头屯河煤矿区;11—南山六井田;12—乌河-白杨河煤矿区;13—桌子山井田;14—西山煤矿区;15—碗窑沟矿区;16—艾丁湖煤矿区;17—七泉湖煤矿区;18—七克台煤矿区;19—科克牙煤矿区;20—柯尔硷四井田;21—柯尔硷煤矿区;22—吐鲁布拉克井田;23—三道岭小黄山煤矿;24—三道岭西山煤矿;25—三道岭沙枣泉井田;26—三道岭砂墩子煤矿区;27—三道岭北泉井田;28—野马泉一井田;29—大南湖煤矿区;30—沙尔湖煤矿区;31—四棵树井田;32—巴音沟煤矿;33—硫黄沟煤矿区;34—铁厂沟井田;35—沙丘河-老君庙煤矿区;36—窝头泉煤矿区;37—小龙口井田;38—三工河煤矿区;39—沙沟井田;40—五工河井田;41—小黄山井田;42—大黄山煤矿区;43—水西沟煤矿区;44—塔什店一井田;45—塔什店煤矿区;46—塔什店二井田;47—阳霞河东岸煤矿;48—阳霞煤矿区;49—古伦沟煤矿;50—萨瓦甫齐煤矿;51—琼库孜巴依煤矿;52—克其克库孜巴依煤矿;53—阿艾煤矿区;54—俄霍布拉克井田;55—比尤勒包谷孜井田;56—库尔阿肯井田;57—别嘎逊摇尔煤矿区;58—铁列克井田;59—康苏井田;60—沙里拜井田;61—南台子煤矿区;62—干沟煤矿区;63—劳艾依图井田;64—皮里青河东区1井田;65—干沟上游一井田;66—达拉地井田;67—库尔捷太煤矿区;68—霍城县煤矿一井田;69—可尔克煤矿区;70—吉伦台煤矿区;71—沙特布拉克煤矿区;72—南山水沟煤矿区;73—南山红沟煤矿区;74—南山石场沟井田;75—吐路-驼马滩矿区;76—金庙沟矿区

中国天山主要煤田、煤产地资源/储量和预测资源量统计表

Resources/reserves of major coalfields and coal producing areas and statistics of forecasting resources in Tianshan, China

含煤区	煤 田	主要煤产地或煤矿区	勘查区数	探明资源储量		资源量(亿 t)	
				资源储量 亿 t	占总量 百分比/%	预测资源量	资源总量
天山北麓含煤区	准南煤田	乌鲁木齐、四棵树、巴音沟、玛纳斯、阜康、柴窝堡-达坂城、后峡	147	279	28.43	1765	2052
		南山煤产地	4	4.59	0.05		
		后峡煤产地	3	3.64	0.37		
	准东煤田	大井将军庙、芦草沟、红沙泉、将军庙、将军戈壁、五彩湾、老君庙、西黑山、黄草湖	2	132.65	13.51	3226	3359
天山含煤区	吐-哈煤田	艾维尔沟、布尔碱-克尔碱、桃树园-可可亚、七克台、三道岭、白杨沟-五堡、伊拉湖、艾丁湖、库木塔格、沙尔湖、中山梁、大南湖、烟墩、骆驼圈子、梧桐窝子、野马泉、碎石梁、鱼尔沟	26	442.67	45.09	5301	5744
	伊宁煤田	南台子、干沟、劳艾依图、喀赞其、皮里青、克尔克、沙特布拉克、胡吉尔台、吉伦台、洪拉海、达拉地	24	23.32	2.38	4270	4293
	尼勒克煤田		5	7.49	0.24	422	429
	昭苏煤田		1	0.48	0.0	115	115
	尤鲁都斯煤田		1	1.36	0.01	137	138
	库米什煤田	古伦沟、巴音沟、塔什店、哈满沟、库米什	1	0.59	0.01	264	264
	焉耆煤田		5	8.46	0.86	958	966
天山南麓含煤区	库拜煤田	阿艾、俄霍布拉克、库尔阿肯、舒善河-喀拉苏、铁列克、阳霞、音西铁热克-台勒曲克、小兰台子、萨瓦甫齐、比尤勒包谷孜	21	18.10	1.84	315	333
	托云煤田	卡拉吉里岗、黑孜苇、康苏、沙里拜、阿根布拉克	4	0.34	0.03		
	孔雀河					1037	1037
总 计			244	920	100	17810	18730

⑶Estimation of CO2 geological storage potential in Xinjiang

①Deep saline aquifers

The method we use to calculate the potential sequestration is Ecofys and Tno-Ting report in 2002 raised, Assuming 1% of deep saline aquifers volume of structural stratigraphic traps, and only 2% of the structural stratigraphic traps can be used as carbon dioxide sequestration. Using the following formula to calculate: $M_{co2ts} = \rho_{co2s} \times A \times H \times 0.01 \times 0.02 \times \varphi / 10^6$

M_{co2ts}---Carbon dioxide in deep saline aquifers buried in theory stock, 10^6t;

ρ_{co2s}---Under the density of carbon dioxide ground conditions, kg/m^3, usually1.977kg/m^3;

A---Basin area of deep saline aquifers located, m^2;

H---The average thickness of the deep saline aquifers, m; Take 0.1 times the thickness of the deposited layer;

φ---Average porosity of the rock deep saline aquifers,%. Take the experience of 0.2 based on relevant information.

28

②CO_2-EOR reservoirs

Jerry Shaw pointed out that, in the use of carbon dioxide for enhanced oil recovery in the stock reservoir buried in theory can be applied to calculate the following two equations:

Before the carbon dioxide breakthrough: $M_{co2to} = \rho_{co2r} \times (E_{RBT} \times N \times B_o)$

After carbon dioxide breakthrough: $M_{co2to} = \rho_{co2r} \times [(E_{RBT} + 0.6(E_{RHCPV} - E_{RBT})]N \times B_o$

M_{co2to}---Carbon dioxide in underground reservoirs theoretical stock, 10^6t;

ρ_{co2r}---Carbon dioxide density at reservoir conditions, kg/m^3;

N---Crude oil reserves, 10^9m^3;

$\mathbf{B_O}$---Crude oil volume factor, m^3/m^3;

$\mathbf{E_{RBT}}$---Recovery of crude oil before breakthrough the carbon dioxide, %;

$\mathbf{E_{RHCPV}}$---Recovery of a hydrocarbon pore volume injection when (HCPV) crude carbon dioxide, %。

29

③Non-mined coal seams

Carbon Sequestration Leadership Forum believe that in the case of coal seam gas has been adsorbed, coal stocks are usually buried in the theoretical calculation of this formula：

$$M_{CO_2tc} = \rho_{CO_2s} \times IGIP$$

M_{CO_2tc}---Carbon dioxide can not be mined coal seams in theory buried stock，10^6t；
ρ_{CO_2s}---Carbon dioxide density under standard conditions，t/m^3，usual 1.977t/m^3；
$IGIP$---Raw coal gas (methane gas) reserves，10^6m^3。

Raw coal gas (methane gas) reserves (IGIP) is calculated by the following formula：

$$IGIP = A \times H \times n_c \times G_c \times (1 - f_a - f_m) / 10^3$$

30

A---Coal basin surface area,，km^2；
H---Effective thickness of coal seams，m；
nc---Coal density, t/m^3, usually taken 1.4t/m^3；
fa---Ash content of coal accounted for coal，%；
fm---Coal's share of coal in the wet mass fraction，%；
Gc---Coalbed gas content (adsorbed amount)m^3（gas）/t（coal）。

Coal bed gas content (adsorption capacity) Gc can be calculated from the Langmuir isotherm equation such as access：

$$G_c = V_L \times \frac{P}{p + p_L}$$

V_L---Langmuir volume，That is the maximum amount of gas adsorbed given temperature seams，m^3/t；
P_L---Langmuir pressure，The maximum amount of gas adsorbed seam when the pressureMPa；
P---The current pressure on the coal seam，MPa。

31

Brief summary :

Three basins in Xinjiang has a huge storage potential, a huge area, and relatively thick reservoir. The size of the basin area directly determines the size of the storage capacity of the basin ,reservoir thickness is also a great influence on the storage capacity. Large oil and gas layer provides CO_2 sequestration sites ,geological reserves of oil and gas from a reflection of the good sedimentation basin and reservoir capacity and traps，It is an important indicator of the basin CO_2 sequestration potential. meanwhile, saline aquifers basin is also a good place sequestration of CO_2.

32

五、Suggestions of Xinjiang CCUS

1、 CCUS Xinjiang is not only a scientific issue, but also the urgent need to solve social and environmental problems.

2、 Government guidance, third-party coordination, commercial mode of operation is CCUS's Xinjiang region to achieve more realistic model.

3、 The need for CO_2 capture project to develop some targeted subsidies or incentives to ensure their implementation have economic viability.

4、CO_2-EOR has obvious geographical advantages and convenience in the implementation of Xinjiang.

33

六、Conclusions and Prospects

Xinjiang has a great potential in the aspect of the implementation of CCUS Technology, source, CO_2 sinks and transport conditions are suitable for the implementation of CCUS technology in Xinjiang.

①Xinjiang is rich in coal resources.

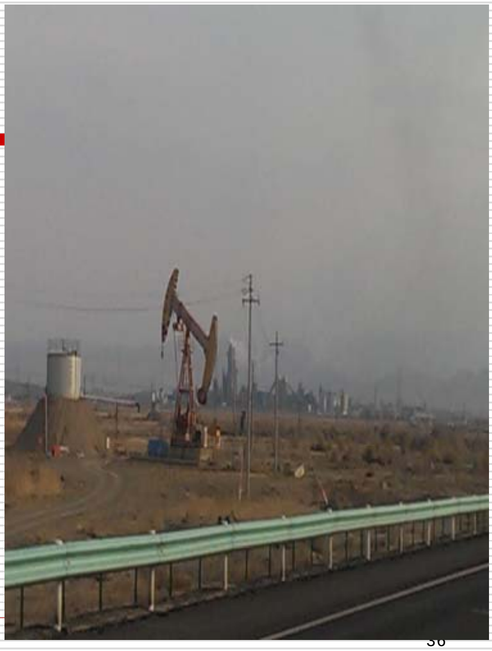
②Xinjiang has China's largest inland basin, and its carbon dioxide geological storage potential is considerable. Especially in the Tarim, Junggar and Turpan-Hami Basin, rich oil and gas resources, easy to implement the CO_2-EOR.

34

③CO_2 emission sources and storage sites for a short distance in Xinjiang . reduce transportation costs will be more conducive to the implementation of CCS technology in Xinjiang.

④Xinjiang CO_2 geological storage with high security. Xinjiang is rich in oil and gas resources, a high level of exploration, a sound geological data, a relatively favorable geological structure, trap condition, not prone to leakage, suitable CO_2 sequestration.

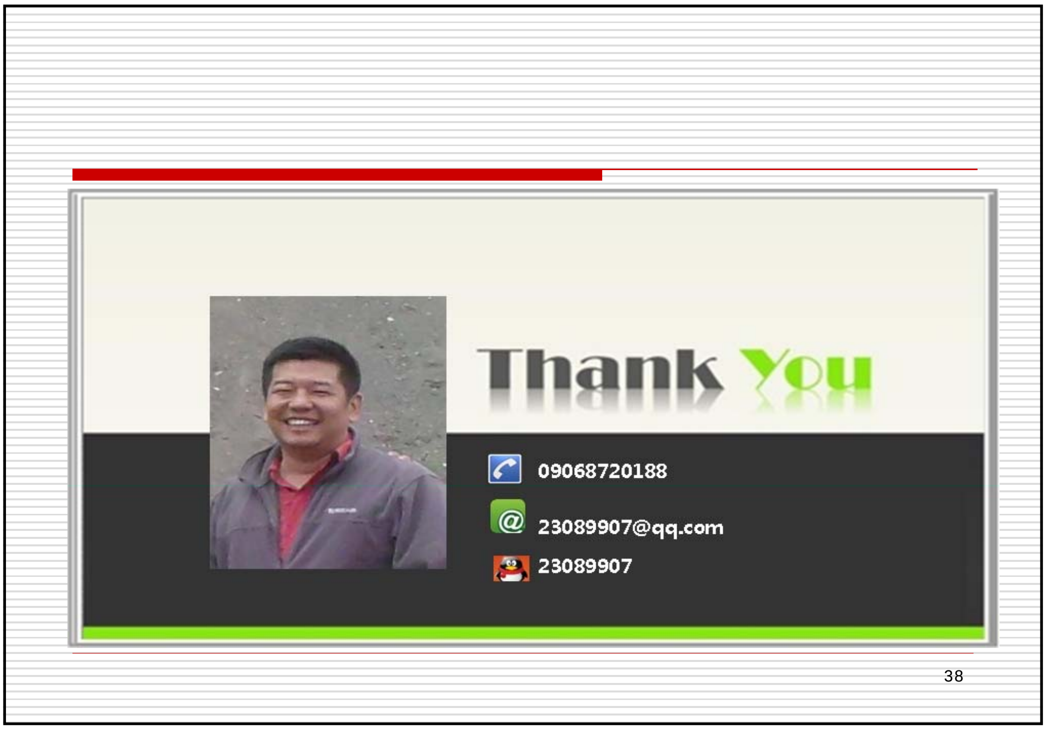
35



36

Further work in the future suitability diagram can be drawn based on the evaluation results， According to the case of sources and sequestration of CO_2 emissions in Xinjiang， Investigation of matches of sources and sinks for Xinjiang. Taking a step forward to improve the results of previous research and gives feasible suggestions summary . so CO_2 geological storage technology really breaking new ground for the country's greenhouse gas emissions cause.

37


Thank You
09068720188
23089907@qq.com
23089907
38

陕西延长石油（集团）有限责任公司

延长石油集团CCUS实践与认识
CCUS Practice and Understanding of Yanchang Petroleum

赵习森
ZHAO XISEN

中国 陕西延长石油（集团）有限责任公司
Shaanxi Yanchang Petroleum (Group) Co., Ltd. China

1

提 纲
(Outline)

2

一、陕北能源资源概况
Energy Resources Background of Shanbei Area

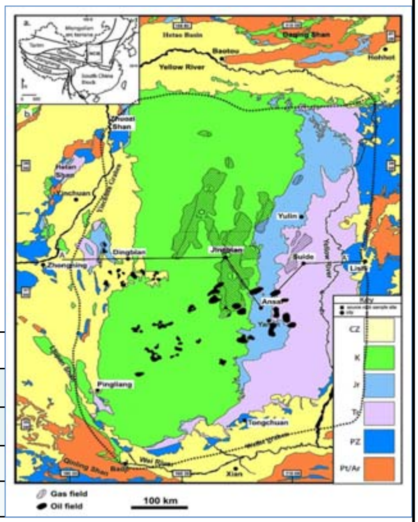
陕北鄂尔多斯盆地有丰富的油、气、煤、盐资源，将是中国最重要的能源化工基地。

The Rich energy resources in Shanbei area, such as oil, gas, coal and salt is full of this area.

It will be the most important energy chemical industry base in China.

陕北主要矿产资源储量表

类型	预计储量	探明储量	全国排名
煤炭（coal）	3980×10^8t	3667×10^8t	NO.1
天然气Gas）	152000×10^8Nm^3	12000×10^8Nm^3	NO.1
石油（Oil）	129×10^8t	19×10^8t	NO.2
盐田	60000×10^8t	8855×10^8t	



二、陕北能源化工面临的主要问题
The Main Problem for Energy and Chemical Industry of Shanbei Area

1、陕北煤化工产业迅速发展：(1)原油加工约1800 万吨/年;(2)甲醇合成约2404 万吨/年;(3) 兰炭约1060 万吨/年;(4)合成氨约90 万吨/年;(5)尿素约82 万吨/年;(6)煤制油125万吨/年；（7）聚烯烃约290 万吨/年；（8）PVC150 万吨/年 。这些项目将产生大量的 CO_2排放，需进行有效的捕集与处理。

2. The coal-chemical industry project under construction and having been built in Shanbei areas.

We need to capture and deal with the abundance CO_2 effectively which release from the above projects .

二、陕北能源化工面临的主要问题
The Main Problem for Energy and Chemical Industry of Shanbei Area

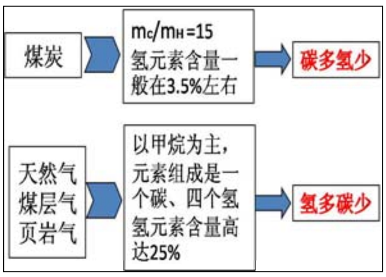
2、油田开发每年需要注入水量约1.3亿方，在陕北半干旱地区矛盾非常突出，同时大量产出污水需要处理，给环境造成很大的压力。

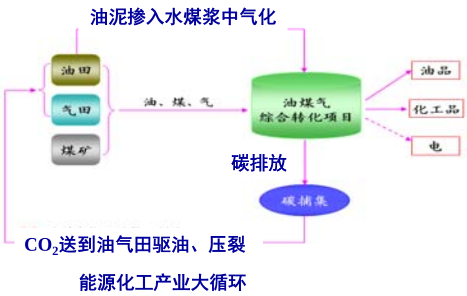
1. It needs water more than 7000×10^4m^3 for EOR every year, then the large amount of sewage should be treated. It put great pressure on environment of Shanbei which is semi-arid area.

5

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

1. 实施碳氢互补提高能源效率，减少CO_2排放 (Carbon-hydrogen comprehensive utilization , reduced carbon emissions)





Yanchang Petroleum comprehensively utilizes multiple resources such as coal, petroleum and natural gas, that realized the carbon-hydrogen complementation and comprehensive utilization of resources, instead of only one kind of resources that will waste abundant energy resource.

6

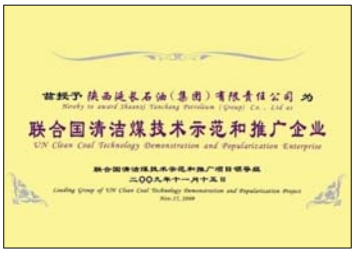
三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

延长石油集团煤化工项目节能减排表
Energy conservation and emissions reduction data tables of Jingbian project by Yanchang Petroleum Group

序号	项 目	本项目 This Project	国际先进 International advanced level	国内先进 domestic advanced level	与国际先进比较 Compared with international level	备注
1	甲醇产量(10kt/a) Methanol production	180	165.35	153.12	+8.86%	原料数量一致
2	相对节约煤炭 Save coal		67.3	79.6		标煤
3	能耗(GJ/t甲醇) Energy consumption	37	48	50	-23.8%	
4	甲醇用水(m³/t甲醇) Water consumption for methanol	4.1	10	15	-59.00%	
5	烯烃用水(m³/t烯烃) Water consumption for olefin	19.8	27	27	-26.67%	
6	CO_2排放(10kt/a) CO_2 emission	285	720	720	-60.42%	
7	SO_2排放(t/a) SO_2 emission	634	1389	1389	-54.36%	
8	废水排放 (m³/H) Wastewater discharge	83.4	252.9	252.9	-67.02%	
9	固废排放(10kt/a) Solid waste discharge	12.82	39.82	39.82	-67.81%	渣场填埋

7

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry



Yanchang Petroleum oil-gas-coal-salt comprehensive transformation model was highly appreciated by specialists and scholars from domestic and overseas at the China international forum of coal conversion high-tech, 11 November 2009. And, this model has be identified as "UN Clean Coal Technology Demonstration and Popularization Project", Yanchang Petroleum Group also has be honored with "UN Clean Coal Technology Demonstration and Popularization Enterprise".

8

三、延长石油在煤化工中的创新
Innovation of Yanchang Petroleum in Coal-chemical Industry

2. 低成本的煤化工二氧化碳捕集技术(Low-cost CO_2 capture)

（1）利用低温甲醇洗技术直接从无硫中压甲醇富液中分离出高纯度的CO_2产品，成本可低至100元左右；
（2）研究利用新的化学吸收法，捕集二氧化碳可大量降低能耗，降低捕集成本。

(1) Using the low temperature methanol washing technology, it can separate the high purity CO_2 from the medium-pressure rich fluid methanol without sulfur, the cost can reduce by CNY100/ton,
(2) Study the other new chemical absorption method to further reduce energy consumption and the cost.

9

四、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

1. 二氧化碳捕集进展（Progress of CO_2 capture）

榆林煤化公司于2012年11月建成了5万吨/年的CO_2捕集装置。**The 50000 ton/year CO_2 capture facility has be built at November 2012 by Shaanxi Yanchang Petroleum Yulin Coal Chemical Company.**

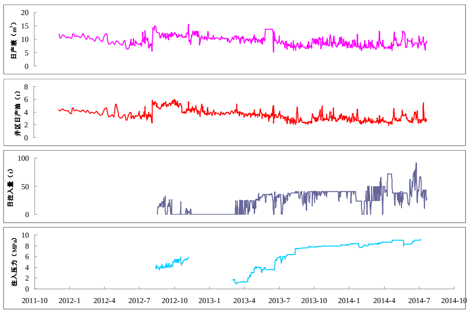
兴化新科气体公司利用先进的工艺技术及装备捕集提纯工业废气，生产8万吨/年食品级液态CO_2。**The 80000 ton/year CO_2 with food grade is produced by Shaanxi Xinhua-Xinke Gas Company, the sub-company of Yanchang Petroleum.**

中煤榆林能化公司2014年启动建设36万吨/年的捕集装置,计划2015年5月建成投产。
The 360000 ton/year CO_2 capture facility construction project has be started by Shaanxi Yanchang China-coal Yulin Energy Chemical Company.

四、延长石油CCUS进展情况
Progress of Yanchang Petroleum CCUS

2. CO_2驱油先导试验（CO_2 EOR）

The area of Jingbian test field. The first stage, we have started 5 wells CO_2 injection, the accumulation CO_2 injection is 18400 tons.



CO_2驱油现场
CO_2 EOR Pilot Test in Jingbian Oil-field

五、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

1. 挑战（Challenge）

（1）CCUS项目的投资成本较大；
（2）不同油藏条件的二氧化碳提高采收率技术还需要进一步研究；
（3） CO_2注入地层后的安全性评估，无系统科学的方法。

（1）The investment of the CCUS project is very large;
（2）The CO_2 EOR technology need further study for different reservoir conditions ;
（3） No systematic and scientific method for the security evaluation after CO_2 injected into the reservoir.

12

五、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

2. 认识（Understanding）

（1）低成本的捕集埋存与高效的提高采收率技术是关键；
（2）鼓励企业开展CCUS工作，应建立相关政策激励机制；
（3）需要碳捕集、利用和封存相关标准规范的制定；
（4）加强国际合作与CCUS技术共享 。

（1）The key point is the low-cost capture technology and the efficient EOR technology；
（2） Explore to establish relevant policy incentive mechanism, and encourage enterprises to participate in CCUS；
（3） Promote the standards for CCUS;
（4）Enhance the international cooperation and technology sharing of CCUS.

13

五、实施CCUS面临的挑战与认识
Challenge And Understanding Faced with CCUS

3. 建议（Suggestions)

（1）先实施CO_2-EOR、EGR和ECBM试验工作，为CO_2埋存积累技术降低埋存成本；
（2）发挥各行业部门的特点和优势，构建广义的CCS-EOR产业链。
（3）通过碳税试点引导和调整碳捕集的积极性。

（1）Start the test of CO_2-EOR, EGR and CBM , technologies accumulate for low-cost CO_2 storage;
（2） Build a broad CCS - EOR industry chain by exerting the advantage and the characteristics from different industry;
（3）Guide and adjust the initiative of CCS by making experiments of "carbon tax".

14

Thank you for your attention!

陕西延长石油(集团)有限责任公司
SHAANXI YANCHANG PETROLEUM(GROUP)CO.,LTD.

15

Bruce Hill-Clean Air Task Force
Bruce Hill-美国净化空气任务组织

Maximizing EOR Opportunities and CO_2 Storage Potential in Xinjiang
新疆：提高采收率和二氧化碳封存的机遇与潜力

CCUS Workshop
Urumqi, China
September 19, 2014

Dr. Bruce Hill
Chief Geologist
Clean Air Task Force, USA

CCUS研讨会
布鲁斯.希尔博士，资深地质学家
美国空气净化任务组织

中国 乌鲁木齐
2014年9月19日

Topics Relevant to CCUS Development in Xinjiang
新疆CCUS发展的相关主题

1. EOR storage will help jump start CO_2 reduction strategies and produce more oil.

2. Next Generation Enhanced Oil Recovery will boost potential of existing fields.

3. Residual Oil Zones (ROZ): A frontier with large oil production and CO_2 storage potential beyond conventional CO_2 EOR.

4. Supercritical CO_2 Pipelines will be needed--and have a safe record.

5. Standards are needed for EOR CO_2 storage and will contribute to improve production.

1. 提高采收率和二氧化碳封存将有助于迅速启动二氧化碳减排战略以及生产更多的石油。

2. 新一代提高采收率技术将提高现有油田的生产潜力。

3. 剩余油区（ROZ）：大规模石油生产和二氧化碳封存潜力的前沿领域，超越了传统的二氧化碳驱油。

4. 需要超临界二氧化碳管道 - 并有安全纪录。

5. 提高采收率和二氧化碳封存需要标准化，这将有助于提高产量。

1. Why EOR-Storage?
为什么要提高采收率和二氧化碳封存?

CLEAN AIR TASK FORCE

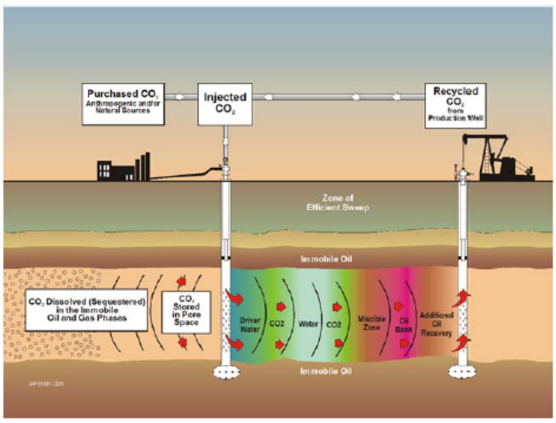
- Uses Proven CO_2 Storage Capacity.
- Uses Existing Transport & Injection Infrastructure.
- Provides Revenue for Expanding CO_2 Capture.
- Will Increase Energy Production & Domestic Security.

- 采用成熟的二氧化碳存储能力。
- 利用现有的运输及注入设施。
- 为扩大二氧化碳的捕集提供资金。
- 将提高能源生产和国内能源安全。

3

Using the Economic Value of CO2-EOR to Accelerate the Deployment of CO2 Capture, Utilization and Storage (CCUS)

Introduction to CO_2-EOR Technology



CO_2-EOR is used to improve oil recovery from deep, light oil fields.

CO_2 is injected at high pressure often with alternating injections of water.

The CO_2 that is produced jointly with the oil is recycled (injected back into the oil reservoir).

At the end of the CO_2-EOR project, ~100% of the purchased CO_2 is stored in the oil field, if the operator closes the oil field at pressure.

4 JAF2012_039.PPT April 23, 2012

Advanced Resources International, Inc.

Bruce Hill-Clean Air Task Force
Bruce Hill-美国净化空气任务组织

A Texas CO_2EOR Field & Recycle Plant.
得克萨斯州二氧化碳提高采收率场地和资源回收厂

While Producing Oil, EOR Stores CO_2
An Example from SACROC, a US EOR Field.
以一个美国提高采收率项目SACROC为例
在产油的同时，提高采收率封存二氧化碳

Field Life Carbon Balance With "Capital Emissions"

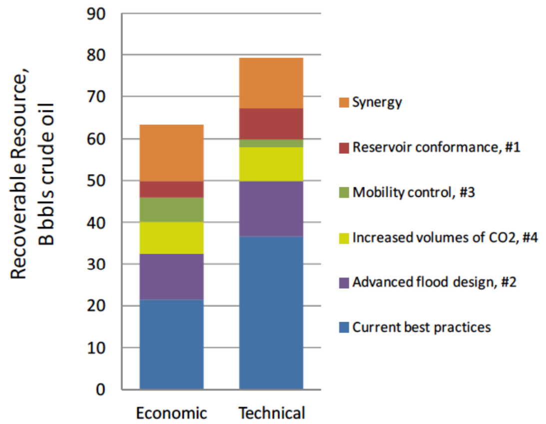
• Purchased	260.0 Mt
• Direct/Indirect Emissions	- 18.5 Mt
• Capital Emissions	- 2.0 Mt
• Total Sequestered	239.5 Mt

Sequestering 92% of purchased injection

Chuck Fox, CO2 Conference 2009

* Does not account for emissions of produced oil.
不计石油产出时的排放

2. Next Generation EOR Technology Can Vastly Increase Oil Production and CO2 Utilization
下一代提高采收率技术可以极大地提高石油产量并利用二氧化碳



7.3 bbls/tonne 桶/吨

NETL

What is Next Generation EOR?
什么是下一代的提高采收率技术？

•Reservoir Conformance is designed to mitigate unproductive CO_2 channeling.

•Advanced Flood Design is designed to target the high volumes of mobile oil remaining in the unswept portion of the reservoir.

•Mobility Control is designed to improve the injection fluid mobility ratio for this moderately viscous oil.

•Increased Volumes of Efficiently Used CO_2 , in combination with Reservoir Conformance enable much more of the reservoir to be efficiently contacted with CO_2.

•油藏一致性旨在缓解非生产性二氧化碳的窜流。

•先进的注水设计针对那些残留在油藏未波及处的大量流动油。

•流动性控制的目的是为这种适度粘性的石油改善注入流体的流动比率。

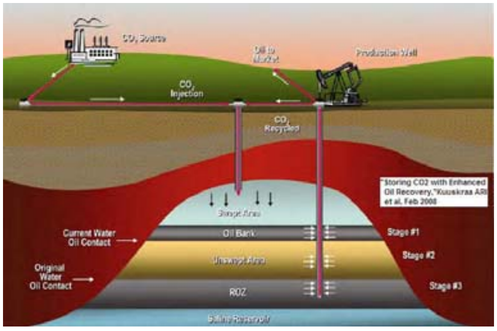
•增加有效利用的二氧化碳，结合油藏一致性，使更多储层有效接触二氧化碳。

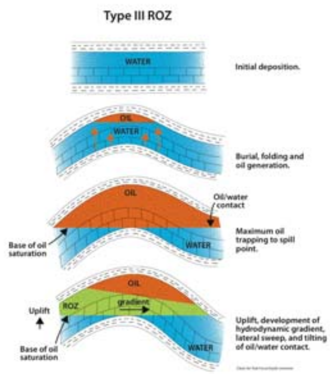
NETL

3. Frontier: Residual Oil Zones (ROZ)
前沿：剩余油区（ROZ）

ROZs are naturally waterflooded zones with oil saturation below the main pay zone.
Oil from ROZs is recoverable with CO_2 EOR methods.

•剩余油区是主油层下方自然水淹的含油层。
•从ROZs采油可以用二氧化碳驱油的方法。





(Image; Joyce Frank, ARI)

Next Generation EOR & ROZ will produce billions of tonnes of oil and require billions of tonnes of supercritical CO_2
新一代提高采收率与ROZ会产生数十亿吨的石油，
并需要数十亿吨超临界的二氧化碳

Using the Economic Value of CO2-EOR to Accelerate the Deployment of CO2 Capture, Utilization and Storage (CCUS)

Oil Recovery and CO_2 Demand/Storage: "Next Generation" CO_2-EOR Technology*

Reservoir Setting	Oil Recovery*** (Billion Barrels)		CO_2 Demand/Storage*** (Billion Metric Tons)	
	Technical	Economic**	Technical	Economic**
L-48 Onshore	104	60	32	17
L-48 Offshore/Alaska	15	7	6	3
Near-Miscible CO_2-EOR	1	*	1	*
ROZ (below fields)****	16	13	7	5
Sub-Total	136	80	46	25
Additional From ROZ "Fairways"	40	20	16	8

*The values for economically recoverable oil and economic CO_2 demand (storage) represent an update to the numbers in the NETL/ARI report "Improving Domestic Energy Security and Lowering CO_2 Emissions with "Next Generation" CO_2-Enhanced Oil Recovery (CO_2-EOR) (June 1, 2011).
**At $85 per barrel oil price and $40 per metric ton CO_2 market price with ROR of 20% (before tax).
***Includes 2.6 billion barrels already being produced or being developed with miscible CO_2-EOR and 2,300 million metric tons of CO_2 use from natural sources and gas processing plants.
**** ROZ resources below existing oilfields in three basins; economics of ROZ resources are preliminary.

10 JAF2012_039.PPT April 23, 2012 Advanced Resources International, Inc.

7.3 bbls/tonne
桶/吨

4. Next Generation EOR will Require Supercritical CO_2 Pipelines
下一代提高采收率技术需要超临界二氧化碳管道

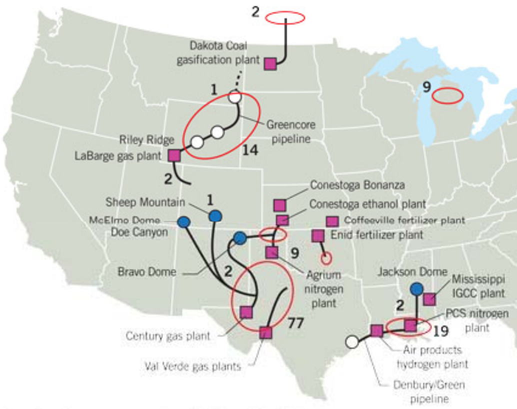
- Supercritical CO_2 pipelines are a mature technology and have been in existence since 1963, (first long distance was 1972) with a safe record in the US.
- 6,400 km of supercritical CO_2 pipelines today in the US, transporting 60+ Mt / year over 500 Mt total.
- Risk lower than for Natural gas pipelines. By comparison, nearly 800,000 kilometers of natural gas and hazardous liquid transmission pipelines cross the United States.
- For safety CO_2 must be near pure, and free of toxic substances such as H_2S; also monitoring for leaks, and protection against overpressure, especially in populated areas.

- 超临界二氧化碳管道是一项成熟的技术，并自1963年以来一直存在(第一个长距离的管道是从1972年开始)，在美国有安全记录。
- 目前美国有6400公里超临界二氧化碳管道，每年输送量超过60M吨，历年输送总量超过500M吨。
- 危险性比天然气管道低。相比之下，穿越美国的天然气和有害液体输送管道长度有近80万公里。
- 出于安全的考虑，二氧化碳必须接近100%的纯净，并且不含有毒物质如H_2S；同时要监测是否有泄漏，并防止超压，尤其是在人口密集的地区。

U.S. Supercritical CO_2 Pipelines and Sources
美国超临界二氧化碳管道和来源

CO_2-EOR OPERATIONS, CO_2 SOURCES: 2014

FIG. 1

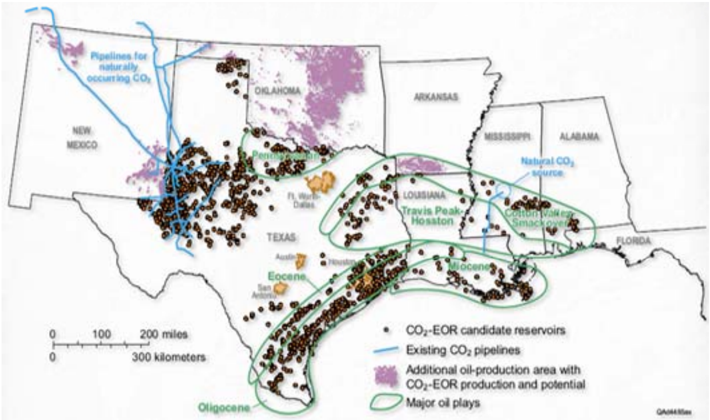


Oil production, 2014	
CO_2 –EOR projects	136
Oil production, 1,000 b/d	300
CO_2 supplies, 2014	
Number of sources	17
• Natural	5
• Industrial	12
CO_2 supply, MMcfd	3.5
• Natural	2.8
• Industrial	0.7

136 Number of CO_2-EOR projects
Natural CO_2 source
Industrial CO_2 source
CO_2 pipeline
CO_2 proposed pipeline

Source: Advanced Resources International Inc. based on OGJ EOR/Heavy Oil Survey 2014 and other sources

Oil Fields and CO_2 Pipelines
Texas and US Gulf Coast
美国德克萨斯州和墨西哥湾沿岸的油田和二氧化碳管道



5. EOR-Storage will Require Best Practices in Site Selection, Site Construction, Operations and Monitoring

提高石油采收率-封存需要场地选择、建设、运营和监控 的最佳实践案例

US Standards for CO_2 Storage

美国二氧化碳封存标准

•U.S. Laws and regulations 美国法规的网上链接
http://www.epa.gov/climatechange/ccs/federal.html

–Underground Injection Control (UIC) rules: protect designated groundwater sources from contamination resulting from injection.

–Greenhouse Gas Reporting Rules: require monitoring reporting and verification of CO2 injected and stored during EOR-storage.

–地下注入控制（UIC）规则：保护指定地下水源免受注水所产生的污染。

–温室气体报告规则：要求在提高采收率与二氧化碳封存阶段监测、报告和核查所注入和储存的二氧化碳。

Enhanced reservoir monitoring is part of next generation EOR and can result in increased oil production. 增强油藏监测是下一代提高采收率技术的一部分，可以增加油产量。

Bruce Hill-Clean Air Task Force
Bruce Hill-美国净化空气任务组织

International Standards
国际标准

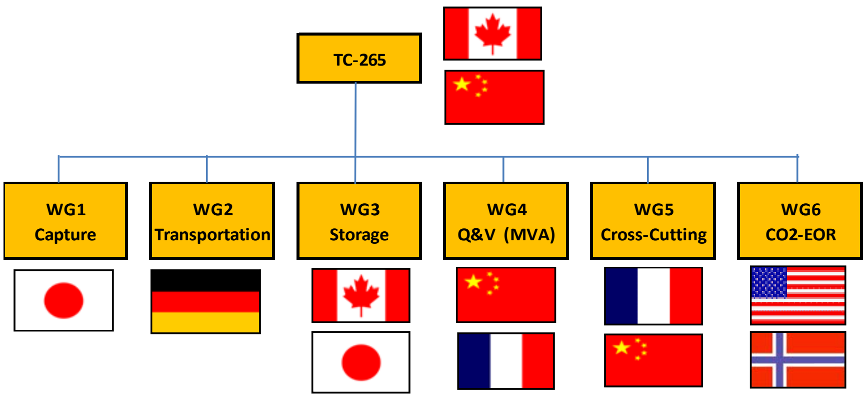
•Canada-US Standard Z-741 for Geologic Storage
•加拿大和美国有关地质封存的Z-741标准
•http://shop.csa.ca/en/canada/design-for-the-environment/z741-12/invt/27034612012

•IPCC Chapter 5 Underground Geological Storage recommendations
•IPCC地下地质封存的建议的第五章
https://www.ipcc.ch/publications_and_data/_reports_carbon_dioxide.htm

•EU CCS Directive
•欧盟CCS指南
•http://ec.europa.eu/clima/policies/lowcarbon/ccs/directive/index_en.htm

•ISO TC 265 International standards committee, chaired by China and Canada. Working Group 6 is developing a Standard for EOR CO2 storage.
•ISO TC 265国际标准委员会，由中国和加拿大担任主席。第六工作组正在开发提高采收率与二氧化碳封存的标准
http://www.iso.org/iso/iso_technical_committee?commid=648607

TC-265 Working Groups
TC-265 工作小组

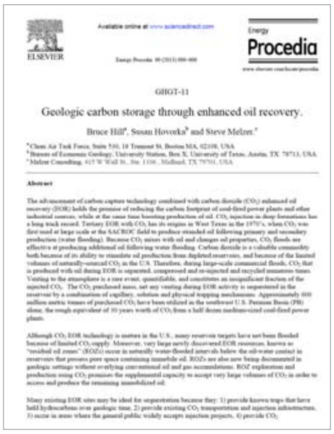


Advanced Resources International, Inc.

Contact Information
净化空气任务组织联系方式

In USA:
Bruce Hill, Chief Geologist
布鲁斯.希尔博士，资深地质学家
bruce@catf.us

In China:
Ming Sung
Chief Representative, Asia Pacific
孙嗣敏博士，亚太区首席代表
mingsung.sung@gmail.com


Available online at www.sciencedirect.com

Energy Procedia

GHGT-11

Geologic carbon storage through enhanced oil recovery.

Bruce Hill[a], Susan Hovorka[b] and Steve Melzer.[c]

Abstract

Oxy-Combustion and Xinjiang Province CCUS

富氧燃烧和新疆自治区的CCUS项目

Xinjiang CCUS Outreach Workshop September 18, 2014

新疆CCUS扩大研讨会 2014年9月18日

JUPITER OXYGEN CORPORATION

JUPITER OXYGEN公司

Jupiter Oxygen Corporation

JupiterOxygen公司

- **JUPITER OXYGEN HAS DEVELOPED AND PATENTED A HIGH FLAME TEMPERATURE OXY-COMBUSTION PROCESS FOR HEAT TRANSFER**
- **Jupiter Oxygen公司研发并拥有高火焰温度氧气燃烧和热传递工艺的专利**
- **Technology Development**
- **技术发展**
- **Patents and Licensing**
- **专利权和专利许可证**
- **Consulting Services**
- **咨询服务**

2

Guanghui New Energy
广汇新能源

- Guanghui New Energy: clean energy, coal-chemical products, power plant retrofits for CCUS with Jupiter Oxygen, and liquid natural gas. It is a subsidiary of Xinjiang Guanghui Industry Investment Group., which also has business interests in coal, oil, real estate, construction (railway), and vehicle servicing.
- 广汇新能源：清洁能源，煤化工产品，为CCUS项目与Jupiter Oxygen公司一同改建的电厂，液化天然气。它是广汇实业投资集团的一个子公司，广汇集团公司同时拥有煤炭，石油，房地产，基础设施建设（铁路）和汽车零售等多种行业经营业务。

3

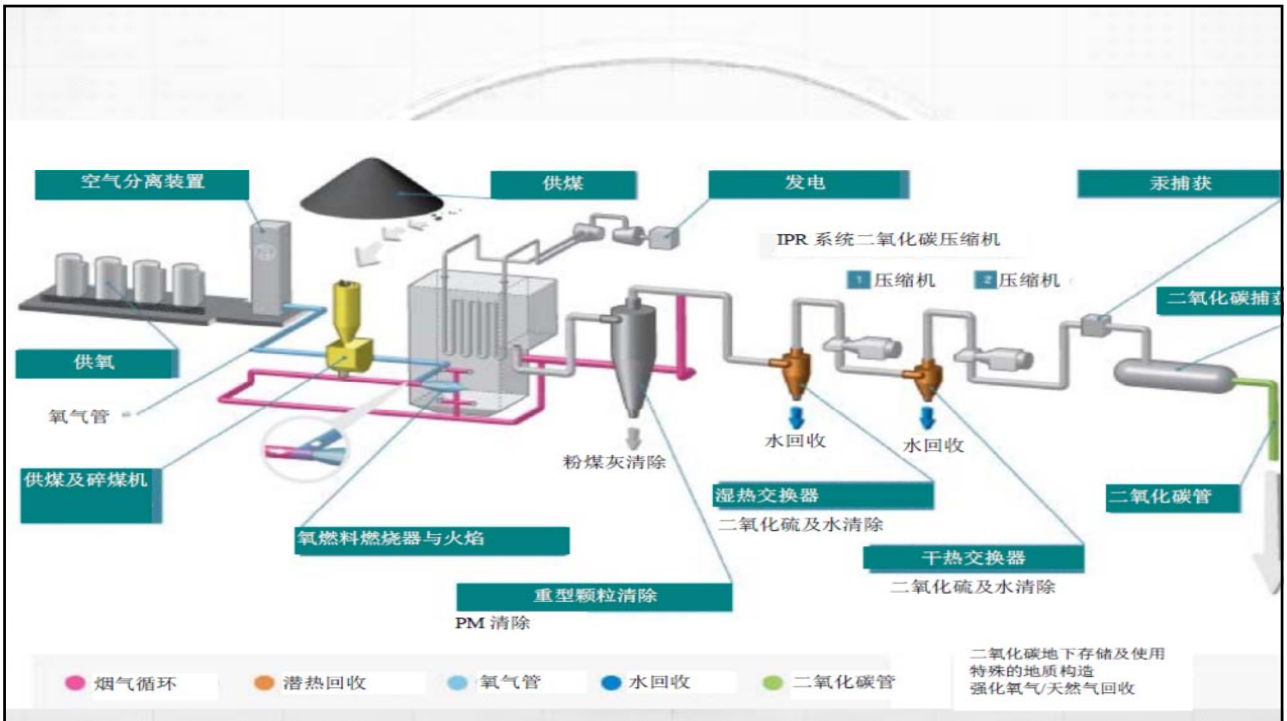
STRATEGIC ALLIANCE 战略联盟

- May 9, 2011
- ２０１１年５月９日

- Xinjiang Guanghui New Energy and JOC
- 新疆广汇新能源公司与JOC公司
- Strategic Alliance for JOC high flame temperature oxy-combustion and carbon capture technologies in China
- 战略联盟为JOC公司在中国推广高火焰富氧燃烧技术和碳捕捉技术

4

JOC-GUANGHUI SIGNING CEREMONY
JOC-广汇签字仪式



OXYGEN SOURCES 氧气源

- Oxygen pipelines
- Cryogenic air separation units
- ASUs – mature commercial technology
- Purchase new or used ASU
- Vendor owned and operated on-site ASU
- 氧气管道
- 低温空气分离装置
- 空分 - 成熟的商用技术
- 购买新的或使用的空分设备
- 卖方全资拥有及现场操作ASU

7

OXY-COMBUSTION ELIMINATES NITROGEN FROM AIR 富氧燃烧将氮从空气中排除

Oxy-combustion uses oxygen instead of air
- 富氧燃烧使用氧气而非空气

Ultra-low NOx at combustion
- 燃烧时只有超低的氮氧化物

No need to separate nitrogen from CO2 for carbon capture
- 无需从捕捉到的CO2中分离氮气

Avoids use of large amounts of chemicals
- 避免大量的化学使用

Nitrogen produced for ECBM
- 排放出的氮气可以用于提高煤层气的产量

8

FLAME TEMPERATURE MATTERS
火焰温度很重要

* Jupiter has patented high flame temperature oxy-combustion
* Jupiter拥有独一无二的高火焰温度富氧燃烧
* Higher flame temperature – 2760 C range
* 高火焰温度达到-2760摄氏度
* Control heat transfer 控制热传递
* Process temperatures = air firing
* Material temperatures = air firing
* 进程温度=周围空气燃烧
* 材料温度=周围空气的燃烧
* Greater radiant heat transfer
* 更多的辐射
* 热传导
* Saves fuel 节省燃料

9

OXY-COMBUSTION富氧燃烧

- Changed boiler gas compared to air firing
  - CO_2-Water Vapor instead of nitrogen
  - Different Radiant Heat Transfer
  - **改变的锅炉气体 与空气燃烧 相比**
    二氧化碳 - 水蒸汽代替氮气
    不同的辐射传热
- CO_2 Purity
- CO_2纯度
- Economics
- 经济性

10

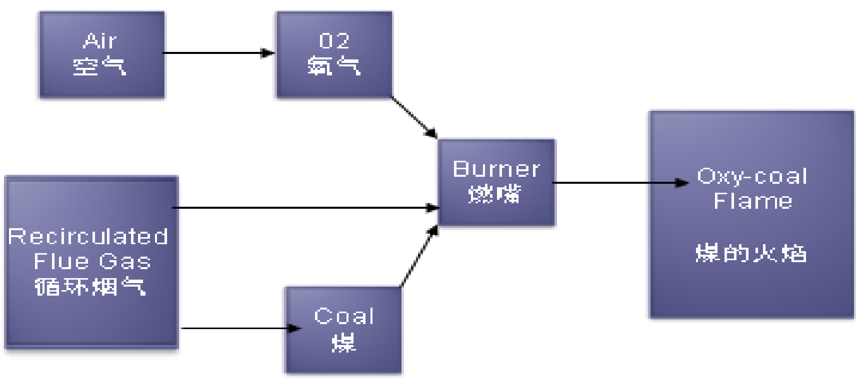
LOWER CAPITAL AND OPERATING COSTS
低的资本投入和运营成本

- Fuel savings with Jupiter's process
- 使用Jupiter的工艺节省燃料
  - -- Lower fuel costs
  - Less fuel = less oxygen needed
  - Less fuel = less carbon dioxide created
  - 燃料成本低
  - 更少的燃料=更少的氧气需求
  - 更少的燃料=产生更少的二氧化碳
- Purer carbon dioxide at the boiler exit
- 从锅炉排出的二氧化碳纯度更高
- Lowers carbon capture costs
- 更低的碳捕捉成本

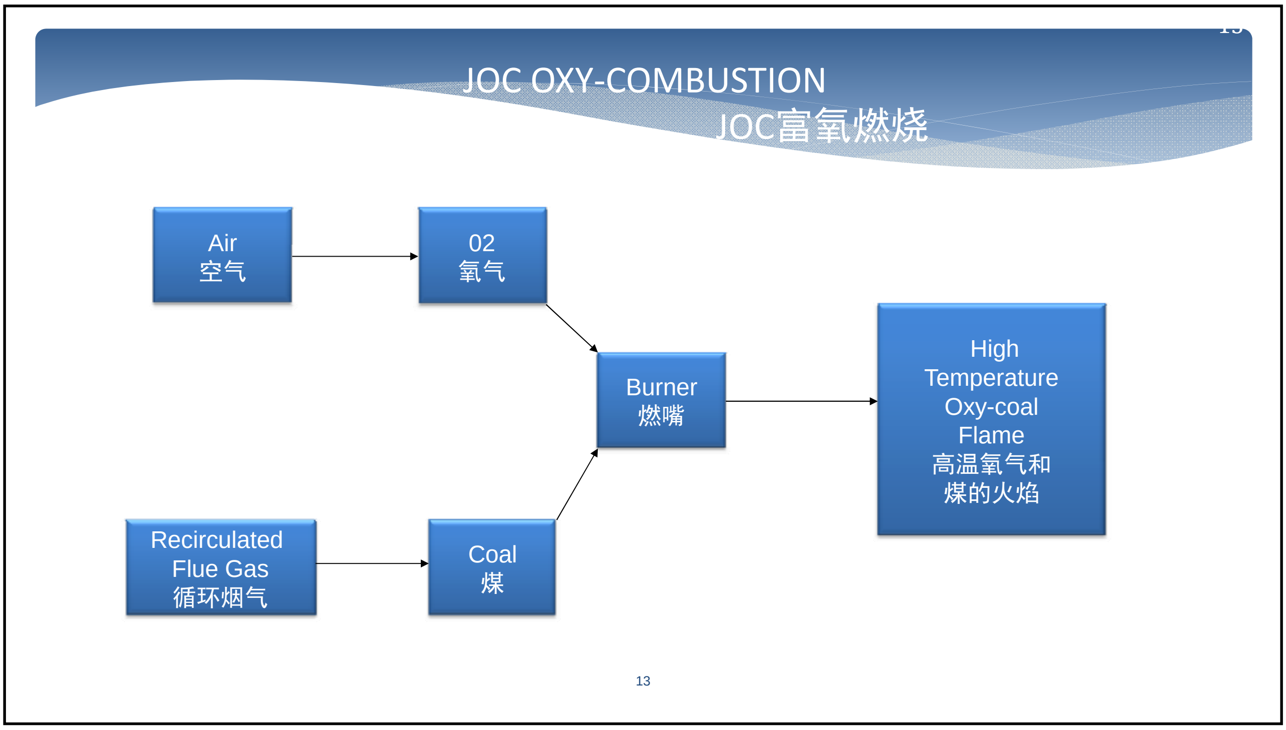
11

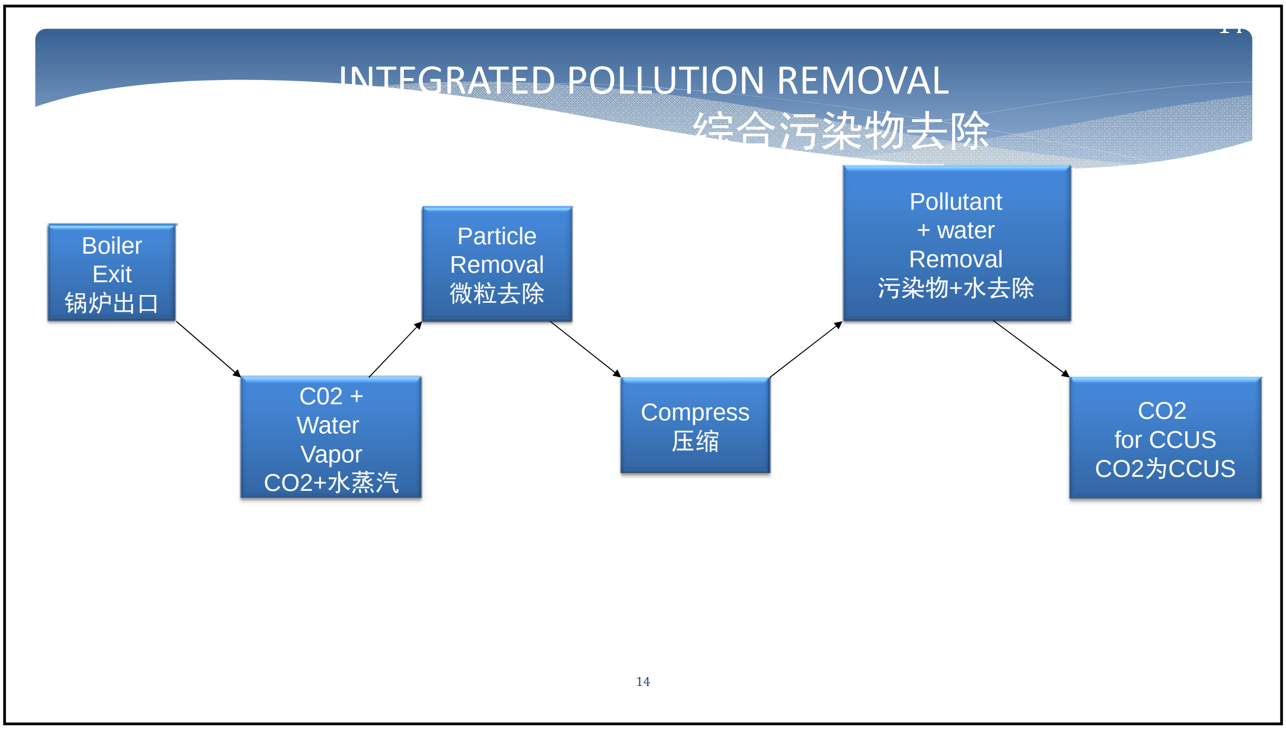
11

OXY-COMBUSTION
富氧燃烧



12


JOC OXY-COMBUSTION
JOC富氧燃烧
Air
空气
02
氧气
Burner
燃嘴
High
Temperature
Oxy-coal
Flame
高温氧气和
煤的火焰
Recirculated
Flue Gas
循环烟气
Coal
煤
13


INTEGRATED POLLUTION REMOVAL
综合污染物去除
Boiler
Exit
锅炉出口
C02 +
Water
Vapor
CO2+水蒸汽
Particle
Removal
微粒去除
Compress
压缩
Pollutant
+ water
Removal
污染物+水去除
CO2
for CCUS
CO2为CCUS
14

Mark Schoenfield-JUPITER OXYGEN CORPORATION
Mark Schoenfield-朱庇特氧气公司

INTEGRATED POLLUTANT REMOVAL
综合污染物去除

- DOE-NETL Carbon Capture System
- 美国能源部-国家能源技术实验室 碳捕捉系统
- Compresses and changes 压缩和变化
  - Flue gas temperature —烟气温度
  - Pressure —压力
- Heat exchangers remove water and S0x
- 换热器除水和SOx
- Filters remove Hg and particulate 过滤器滤除贡和微粒
- 95-100% CO2 capture 95%-100%的CO2被捕捉
- Transport ready carbon capture 碳捕获运输准备就绪
- Jupiter's technology enables combined Jupiter-IPR systems to be:
- Jupiter-IPR技术的结合能使系统更
  - Economical -经济
  - Efficient -高效

15

ADDITIONAL SAVINGS
额外的节省

- Heat Recovery – Compressors
- 热量回收-压缩机
  - -Oxygen plant - 制氧厂
  - ·IPR -污染物综合治理

- Water Recovery – IPR
- ·水回收—IPR
  - ·Exceeds boiler feed water requirements
  - ·超过锅炉给水要求

16

Mark Schoenfield-JUPITER OXYGEN CORPORATION
Mark Schoenfield-朱庇特氧气公司

OXY-COMBUSTION FOR CCUS NOW
现在为CCUS的富氧燃烧

- Retrofits 改造
- Repowering 再发电
- New Units 新装置
- Flame Temperature 火焰温度
- Flue Gas Recirculation 烟道气循环
- Pressure 压力
- Chemical Looping 化学循环
- Circulating Fluidized Bed 循环硫化床

17

THE PATH TO CCUS
CCUS获取路径

- Oxy-combustion: 富氧燃烧
- The best approach to carbon capture
- 是进行碳捕捉的最佳方式

- For both retrofits and new build power plants.
- 适用于改造和新建的电厂

- Also repowering

- CCUS：CO2 and Nitrogen
- CCUS:二氧化碳可以从JOC的技术中得到

18

CCUS PROJECT IN NORTH WEST OF CHINA
CCUS项目在中国西北地区

- **JOC-GUANGHUI CO2 CAPTURE PROJECT**
  JOC-广汇CO2捕集项目

Retrofit 170 MWe power plant with high flame temperature Oxy-combustion with CO2 capture system

- 改建一台170MWe的电厂，将高火焰温度富氧燃烧技术和CO2的捕捉系统应用于改建的电厂
- Retrofit carbinol plant with CO2 capture system
- 改建甲醇煤化工厂，将CO2捕集系统对接
- The project will capture more than 95% of the CO2 produced, resulting in approximately 3,000,000 tons of CO2 which will be 95% pure for CCUS.
- 此项目将捕集到产生的95%的CO2，结果是捕集大约240万吨的纯度在95%以上的CO2用于CCUS

19

19

PROJECT LOCATION
项目地点

- Xinjiang Guanghui New Energy Co. Ltd. carbinol plant installation
- 新疆广汇新能源有限公司 甲醇厂安装
- Naomaohu Zhen, Yiwu County, Hami District, Xinjiang, Autonomous Region, northwest China.
- 中国西北新疆地区哈密地区伊吾县淖毛湖镇

20


HA MI
21


广汇能源
Guanghui Energy
奉献能源 创造和谐
广汇介绍
二〇一一年六月

OXY-COMBUSTION CCUS MARKET BARRIERS 富氧燃烧CCUS市场屏障

- Commercial CCUS practical today
  当今商业化CCUS的实用性
  - CO2 pricing CO2的价格
  - Nitrogen pricing 氮气价格
  - Oil and Gas Market 油气市场

- First/Early Movers 第一个/早期推动者
  - Risk Concerns 风险顾虑
  - Expectations 期望值
  - History of government project support
    US and China 中美两国政府项目支持的历史
  - Need government support for demonstration projects
    需要政府对示范项目的支持

23

CCUS： EOR FOR CHINA OIL FIELD CCUS: EOR技术在中国油田

- CO2 is effective for Enhanced Oil Recovery (EOR)
- CO2是有效的驱油原料
- The big oil fields found mainly in the northeast, northwest and Unit 2 East China.
- 中国较大的油田主要集中在东北，西北和华东地区
- Xinjiang Province has the excellent geography status to implement the economic benefits of EOR through CO2 utilization
- 新疆是最具地理优势的使用CO2运用于EOR，从而实现经济效益的地区

24

CO2-EOR EARLY USAGE
二氧化碳驱油的早期使用

- **Early usage: Improved project profits if significant reservoir continuity**
  早期阶段：如果油藏有显著的持续（开发）性提高项目的收益
- **And a more effective CO2-EOR flood**
  较强效的二氧化碳驱油扩散性
- **Can allow by-pass of traditional re-pressuring flood stage**
  可以能够绕过传统的重新加压扩散的阶段
- **Growing use in US**
  在美国的使用正在增长

PetroChina Xinjiang Oilfields
中石油在新疆的油田

- **JOC and PetroChina in CCUS CO2 EOR discussions**
  JOC与中石油在讨论用二氧化碳进行驱油（封存）的CCUS项目
- **Tu Ha oilfield**
  吐哈油田
- **Initial focus: Qiulin oilfield**
  最初的重点：丘陵油田

CCUS: ENHANCED COAL BED METHANE RECOVERY
CCUS：提高煤层气的产量

- Coal bed methane (CBM) utilization is important to solve the lack of sufficient methane recovery. China is the biggest coal production and consumption country.
- 煤层气的使用是一个重要的解决能源缺乏和低效使用的途径。中国是最大的煤炭生产和消费国。
- CBM is a new clean energy for China.
- 煤层气对中国是一个新的清洁能源
- CO2 and Nitrogen used for ECBM
- CO2和氮气可以用于ECBM

27

27

Early Stage ECBM Tasks
早期提高煤层气的目标

- **ECBM can as much as double methane production.**
ECBM可以尽可能多的使煤层气的产量翻倍。

- **The initial ECBM work is limited to providing information for cost and recovery projections so that proper planning and budgeting can be done.**
基础的ECBM工作限制提供成本消费和煤层气的产出，所以合适的计划和预算应该首先完成。

- **The initial work will take approximately 6 months, including preparation of reports, from the time that the contracts for the work are signed.**
基础的工作大概需要6个月的时间，包括准备报告，时间是从我们签订合同之日算起。

ECBM PROJECT INITIAL TASKS CONTINUED
提高煤层气首要目标持续性

- **It is important that proper data is collected and analyzed from the methane recovery starting as early as possible, so that you can be the most accurately advised concerning ECBM site technical and cost aspects, and have time to consider this before making a decision about when to begin ECBM and whether to start ECBM on a slow incremental basis or a faster schedule.**
- **从煤层气置换的基础工作开始时，合适的数据收集和分析越早开始越好，所以你可以最大程度地准确地建议现场的技术和成本消耗，并且在决定什么时间开始ECBM或者是否在缓慢增加基地或是一个快的日程表开始ECBM前有时间考虑这些。**
- **The early analysis of the initial wells also can assist with those wells for such issues as addressing sand and water coming up with the methane, and in planning and implementing further wells.**
- **早期的基本井的分析同样可以帮助那些用沙子和水置换煤层气时遇到的问题，并且可以计划和完成更远的井。**
- **At the same time, you will need to know the location and projected costs for potential sources and volumes of CO2 and nitrogen so that you can consider this economic information with the economic ECBM site information.**
- **同时，你们将会需要了解如果用二氧化碳和氮气作为潜在的驱气原料，它们的出处和预期的成本从而可以为你们提供经济分析信息和ECBM的经济可行性的现场信息。**

INITIAL ECBM TASKS CONCLUSIONS
首要的提高煤层气的要点

- **Once you consider all of the information and decide when and how to proceed, the remaining engineering, equipment, procurement, installation, and commissioning will take 24-36 months for both the [a] power plant retrofit to provide CO2 and nitrogen, and [b] the ECBM on-site equipment.**
- **一旦你考虑到所有的信息并且决定什么时间如何开始进行，其余的工程，设备，采购，安装和试运营将花费24-36个月来进行a 电厂改建以便提供二氧化碳和氮气 b ECBM的现场设备安装**

- **If you do not have the necessary information for proper decision-making at the right time, it will not be possible to ensure that the project is as economically and technically successful as feasible.**
- **如果你们没有在合适地时间给合适决策制定提供必要的信息，那么（将来的规模化煤层气开发）的经济和技术的可行性分析将不可能成功。**

JOC-156 GEOLOGICAL EXPLORATION TEAM LOI
朱比特公司于156地质队的合作意向书

4/24/14 Urumqi, China: Jupiter Oxygen Corporation and No. 156 Geologic Exploration Team Subordinate to Xinjiang Coalfield Geology Bureau signed a a Letter of Intent for Jupiter Oxygen to provide its high flame temperature oxycombustion and CO2 capture technologies, as well as nitrogen, for an enhanced coalbed methane (ECBM) clean energy project.

新闻头条-2014年4月24日，乌鲁木齐，中国：朱比特氧气公司签订了提高煤层气开发的意向书。详细：朱比特公司和新疆煤田地质局下属156地质勘探大队签订了一份意向书,旨在通过朱比特公司提供的高火焰温度富氧燃烧技术和二氧化碳捕集技术， 还有对氮气的捕集, 将二氧化碳和氮气用于煤层气的（ECBM）这个清洁能源的开发项目。

CCUS NEEDS FAVORABLE GOVERNMENT SUPPORT
CCUS需要政府优惠政策的支持

- **April 2014 US-China Climate Change Working Group Beijing Workshop Discussion: CCUS needs favorable governmental support – see below Regulations**
2014年4月美中两国气候变化工作组在北京的研讨会讨论：CCUS需要优惠的政府支持的政策
  - **Practical and reasonable 务实性和合理性**
  - **Providing Certainty 提供确实的（帮助）**
- **Infrastructure such as pipelines**
基础设施如管道
- **Prevent project barriers by coordination of local, provincial and national approvals**
防止因为当地，省政府和国家在协调时产生项目屏障
- **Avoid undue delay and costs**
避免过度的拖延和成本（消耗）

CO2 Fracking for Natural Gas
二氧化碳液压 破碎法获取天然气

- China is reported to be exploring use of hydraulic fracking to recover natural gas from shale formations
  报道称中国在探索水压破碎法提高页岩层的天然气开发
- Liquid or supercritical CO2 can be used
  液体或是超临界的二氧化碳可以被用来（驱天然气）
- Foam nitrogen in CO2 liquid also can be used
  液态二氧化碳中的泡沫状氮气也可用于（驱气）

Question: Will shale formations be suitable for CO2 sequestration?

问题：页岩层会适合二氧化碳的封存吗？

HARMONIOUS DEVELOPMENT
和谐发展

For the further information, contact:
更多的信息，请联系：

Catherine Chen Jing陈静

Tel：-86-21 6062 7388
Email: catherinechen@jupiteroxygen.com

Director of Development, China市场开发总监，中国
Jupiter Oxygen Corporation Shanghai Representative Office
美国朱比特氧气公司驻上海代表处
Address:8th Floor, IFC, No.8 Century Avenue, Shanghai ,China
地址：中国上海国际金融中心8楼

35

Qianlin Zhuang-KBR
庄前林-凯洛格布朗路特公司

TRIG™: A Unique Gasification Technology for Low Rank Coal and Carbon Management
TRIG™ : 独特的低阶煤气化技术

Urumqi, Xinjiang; September 18, 2014
乌鲁木齐，新疆， 9月18日， 2014年

KBR TECHNOLOGY
KNOW-HOW DELIVERED

KBR at a Glance

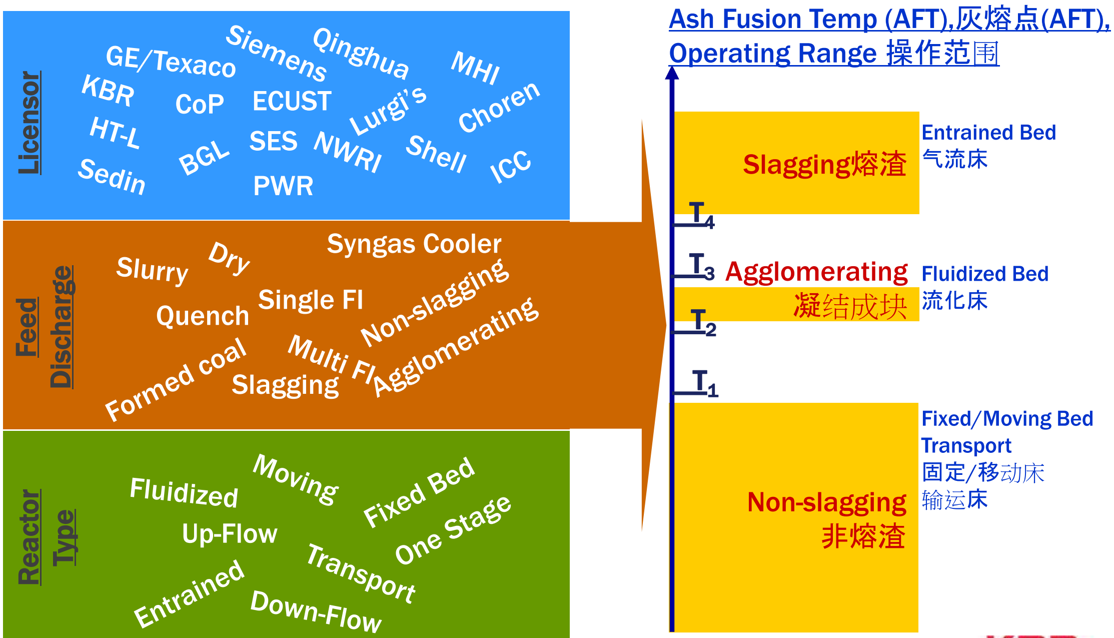
Revenue: Full Year 2013 - $7.28 Billion
年收益（2013年）：72.8亿美元
Backlog: December 31, 2013 - $14.41 Billion
订单储备（2013年12月31日）：144.1亿美元
Headquarters in Houston, Texas
总部在美国德克萨斯州，休斯敦市
~27,000 employees; 70+ countries
~全球27,000位员工遍及70多个国家
KBR is a global engineering, construction, and services company supporting the energy, hydrocarbons, government services, minerals, civil infrastructure, power, industrial, and commercial markets.
KBR是国际性的设计、施工和服务公司，在能源、石油、政府服务、矿山、基础设施、电力、工业和商业领域开展业务。

KBR TECHNOLOGY
KNOW-HOW DELIVERED

KBR Technology Portfolio 技术汇总

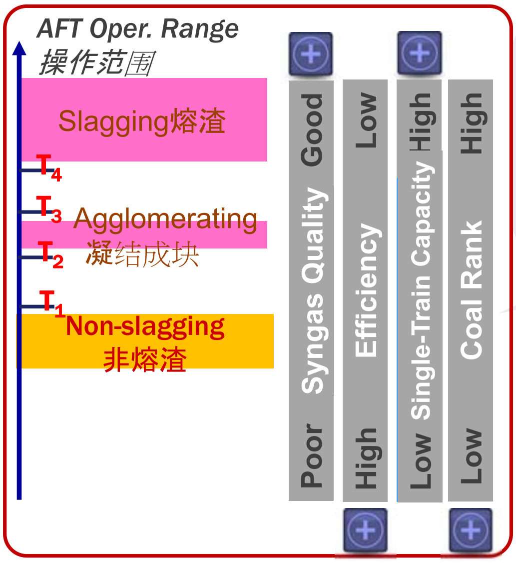
KBR TECHNOLOGY
KNOW-HOW DELIVERED

Coal Gasification Technologies in Marketplace 煤气化技术



KBR TECHNOLOGY
KNOW-HOW DELIVERED

Non-Slagging TRIG Gasification Technology
非熔渣 TRIG™ 气化技术



TRIG has these general characteristics:
TRIG™ 特性:
Good Syngas Quality (+)/合成气品质**好**(+)
High Energy Efficiency (+)/能效**高**(+)
High Single-Train Capacity (+)/单套产能**高**(+)
Suitable for Low-Rank Low-Cost Coals (+)
适合**低阶/价格低**的煤种(+)

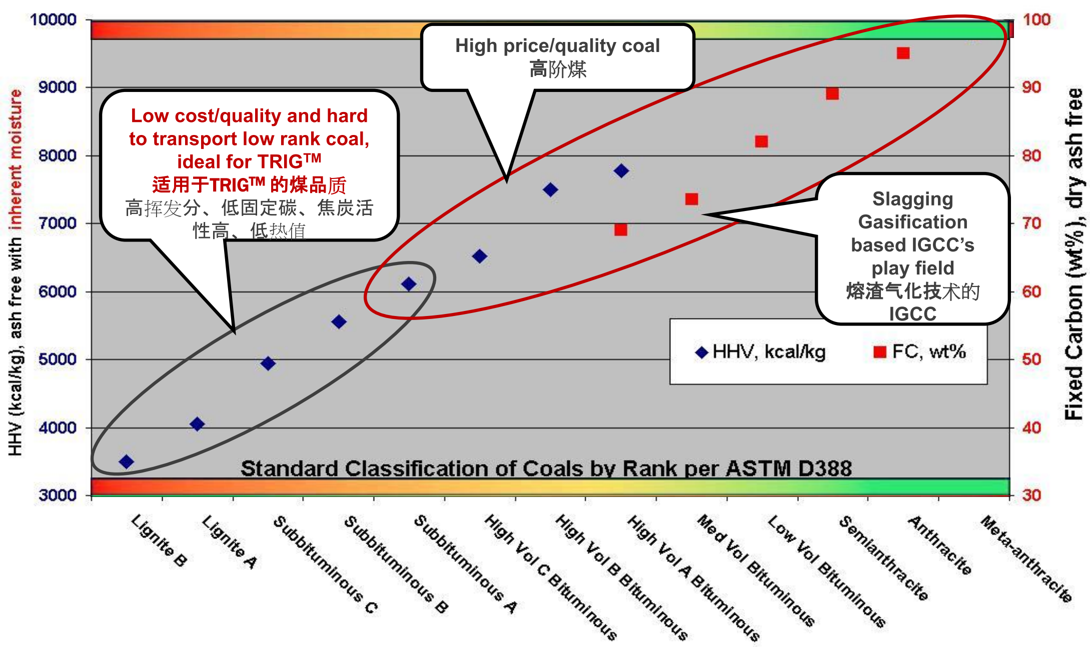
TRIG™, developed for low rank coal, is operated as a non-slagging technology at a well managed moderate temperature range that minimizes formation of hydrocarbons such as tars and oils.

TRIG maintains the positive aspects of slagging gasification technologies while avoiding negatives of other non-slagging technologies
TRIG™ 保留了熔渣气化技术好的方面，又规避了其它非熔渣气化技术不好的方面

KBR
TECHNOLOGY

KNOW-HOW DELIVERED

Strength of TRIG is Utilizing Low Rank Coal
TRIG™的强项就是利用低阶煤



KNOW-HOW DELIVERED

Coal Still Critical for Many Economies
煤炭在不同国家经济体系中的重要位置

Country	Coal Reserves, mm tons*	% World Total*	% LRC*	Reliance of Electricity on Coal 2011**
United States	237,295	22.6	54%	43.1%
Russia	157,010	14.4	69%	15.6%
China	114,500	12.6	46%	79.0%
Australia	76,400	8.9	51%	76.5%
India	60,600	7	7%	67.9%
Germany	40,699	4.7	100%	44.7%
Ukraine	33,873	3.9	55%	38.2%
Kazakhstan	33,600	3.9	36%	81.1%
South Africa	30,156	3.5	0%	92.7%
Serbia	13,770	1.6	100%	74.6%
Colombia	6,746	0.8	6%	3.5%
Canada	6,528	0.8	48%	12.0%
Poland	5,709	0.7	24%	86.5%
Indonesia	5,529	0.6	73%	44.4%
Brazil	4,559	0.5	100%	2.3%
Greece	3,020	0.4	100%	52.3%
Bosnia and Herzegovina	2,853	0.3	83%	70.7%
Mongolia	2,520	0.3	54%	95.1%
Bulgaria	2,366	0.3	100%	54.2%
Turkey	2,343	0.3	77%	28.9%

*Source: * World Energy Council 2011; ** IEA website 2011*

High reliance of power generation on coal
主要依靠煤电

Large low rank coal reserve
大量低阶煤储量

Effective use of low rank coal remains as a challenge
低阶煤的使用仍是难点

KBR TECHNOLOGY
KNOW-HOW DELIVERED

Utilization of large low rank coal reserve
如何高效、环保地利用大量的低阶煤资源

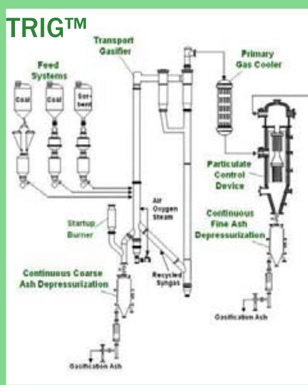
Unlock the value of large reserve of low rank coal from Inner Mongolia and provide electricity, SNG and other chemicals to market place far away

TRIG气化技术高效、环保、可靠地利用巨大储量的低阶煤为全国提供电能、天然气以及其他化工产品。

Low Rank Coals

Economical 经济
Reliable 可靠
Efficient 高效
Environmentally friendly 环保
Use less water 耗水量低

Upstream Feed Prep Processing



BOP

Downstream Processes/Island

Power, SNG
电能、天然气

With carbon management by using available resources for CCUS (EOR, beverage use, other products)

KBR TECHNOLOGY
KNOW-HOW DELIVERED

TRIG 1,000MW IGCC Cost Study

TRIG 100万千瓦 IGCC投资估算

Objective: 目的：

- Develop a Low Rank Coal TRIG IGCC solution for Chinese power sector to effectively utilize the vast reserves of low rank coals
- 为中国电力行业有效利用巨大储量的低阶煤资源开发一套利用低阶煤的TRIG IGCC的解决方案

Results: 结果：

- 43.7% net efficiency
- 43.7%的净效率
- Viable cost of electricity
- 可行的度电成本
- Superior environmental performance
- 优秀的环保指标

Collaborative Effort

KBR TECHNOLOGY KNOW-HOW DELIVERED

SOUTHERN COMPANY

NEPDI

Inner Mongolia Low Rank Coal

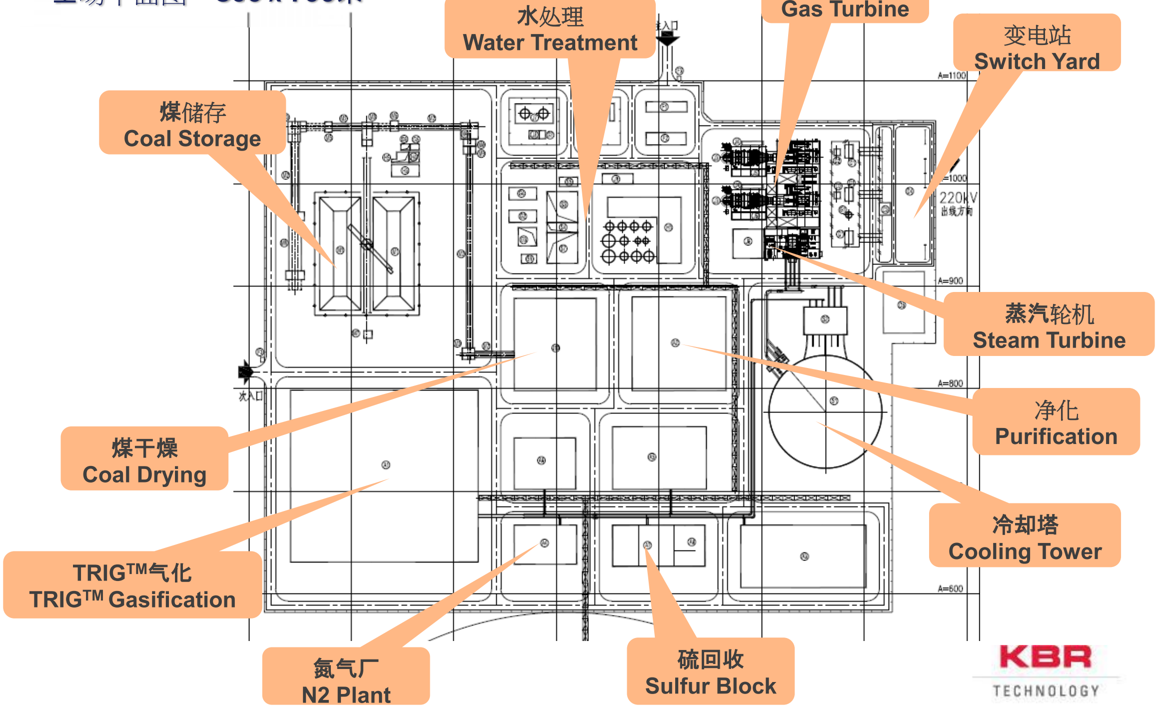
Item	Unit	As Rcv'd	As Fed
LHV	Kcal/kg	3,424	4,157
Moisture	wt.%	34.1	20.0
Ash	wt.%	11.22	13.61
Volatile	wt.%	23.77	28.86
Fixed C.	wt.%	30.93	37.55

 | 9

KBR TECHNOLOGY KNOW-HOW DELIVERED

Low Rank Coal TRIG 800 MW IGCC

- Plot Plan, 500 x 700 m
全场平面图，500 x 700米



 | 10

KBR TECHNOLOGY KNOW-HOW DELIVERED

Low Rank Coal TRIG 800 MW IGCC
- Performance Summary 性能小结

- ✓ LRC TRIG™ IGCC is efficient even though using low rank coal
- ✓ 低阶煤TRIG IGCC 能够高效处理低阶煤

ITEM 参数		UNIT单位	VALUE值
Coal Consumption Rate, as received with 34% Moisture 投煤量，以含水34% 原料煤计		TPD	11,740
Coal Consumption Rate, as fed with 20% Moisture 投煤量，以含水20%入炉煤计		TPD	9,670
Power Output功率输出			
	GT Output/unit燃气轮机输出	MW	295
	ST Output蒸汽轮机输出	MW	424
Combined Cycle Output, Gross联合循环总输出		MW	1,014
Aux. Power Consumption厂用电		MW	166
Power Output, Net净输出		MW	848
Net Heat Rate Of IGCC净热耗		kJ/kWh	8,250
Net Efficiency Of IGCC净效率		%	43.7

Note: Gas turbine performance is estimated based on vendor spec.燃气轮机的性能估算基于供应商提供规格

KBR TECHNOLOGY

 | 11

KNOW-HOW DELIVERED

Low Rank Coal TRIG 800 MW IGCC
- Comparison with Advanced USC in China国内先进的超超临界电厂相比

- ✓ China has made a big stride in building USC using good quality coal
  中国在基于动力煤的超超临界电厂应用取得了巨大进展
- ✓ USC Deployment using low rank coal is underway
  基于低阶煤的超超临界电厂开发在计划中
- ✓ LRC TRIG IGCC is advanced and competitive
  TRIG 低阶煤IGCC展示出其竞争力及先进性能

Parameter参数	Unit单位	LRC TRIG™ IGCC 848 MW	Ultra Supercritical, 1,000 MW (2) 百万千瓦超超临界	NGCC, 9FA Base (1)天然气联合循环
Coal煤		Lignite褐煤	Lignite褐煤	NG天然气
Heating Value as received, LHV 收到基地位热值	kcal/kg	3,424	3,886	
Moisture, as received 收到基水分	%wt	34.1	31.3	n/a
Coal as fed入炉煤水分	%wt	20	23	n/a
Thermal Efficiency 热效率	%	43.7	42.9	55.9

Note: 1 - in operation在运行; 2 - in early development phase前期开发阶段

KNOW-HOW DELIVERED

TRIG IGCC: Superior Environmental Performance
TRIG IGCC: 优秀的环保指标

Significant lower than those of conventional power generation technology

TRIG IGCC的排放指标要远远低于传统发电技术

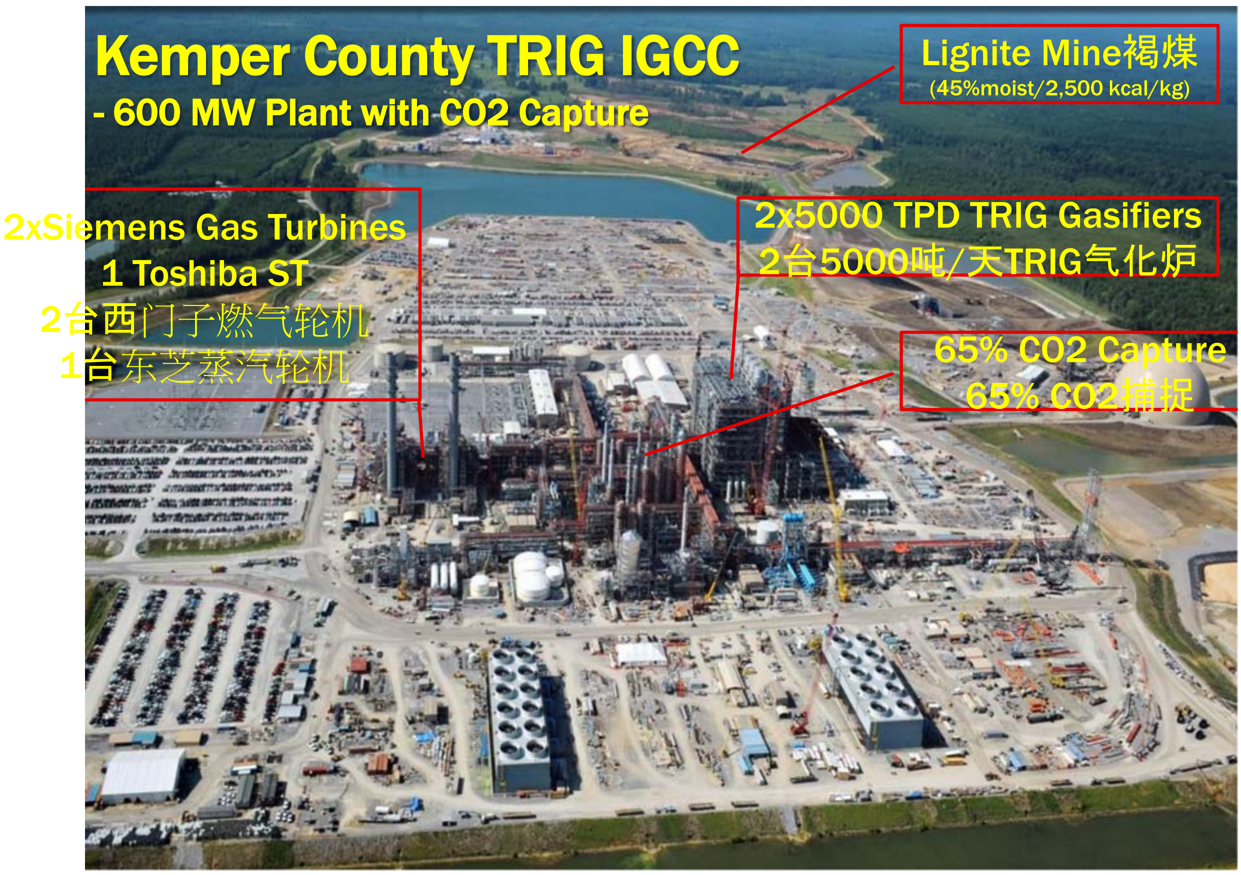
Use less water 耗水量低

Pollutant 污染物	Unit 单位	TRIG IGCC	Current Limits 9 Special Areas 9个特殊地区的要求
SO_2	mg/m^3	<18	50
NOx	mg/m^3	47	100
Mercury汞	mg/m^3	0.001	0.03
Particulate Matter (PM) 颗粒物(PM)	mg/m^3	0.025	20

KBR
TECHNOLOGY

 | 13

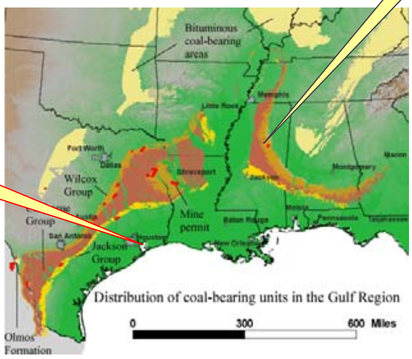
KNOW-HOW DELIVERED

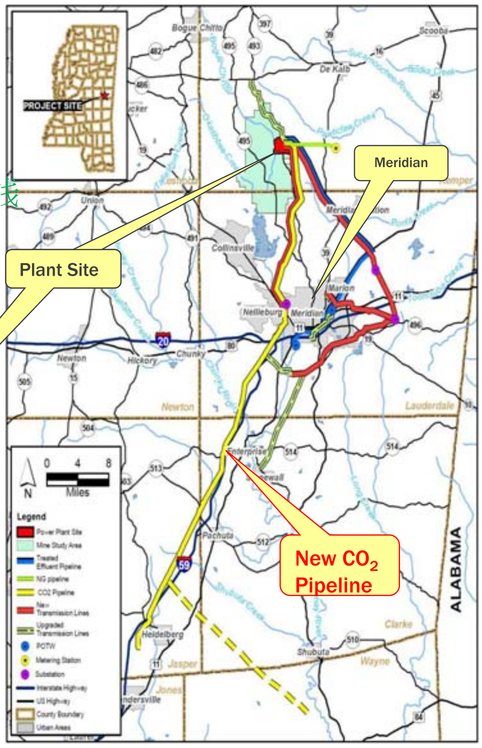


Kemper County TRIG IGCC
- CO_2 Sold for EOR CO_2 用于驱油

Additional Scope:附加工作范围

- ✓ 112 km transmission 112公里输电线路
- ✓ 96 km CO_2 pipeline (for EOR) 96公里CO_2 管线
- ✓ 8 km natural gas pipeline 8公里天然气管线
- ✓ 125 km² mine site. 125平方千米矿区
- ✓ 48 km treated effluent line 48公里污水处理管线





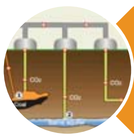
 | 15

KNOW-HOW DELIVERED

KBR – Your partner for Low Carbon Solutions
KBR – 您的低碳解决方案的合作伙伴

TRIG IGCC for efficient use of low rank coal
TRIG IGCC高效清洁利用低阶煤

Extensive experience in Power engineering and construction
电力工程建设方面的丰富经验



Global execution of CO_2 removal and carbon storage projects
全球CO_2捕集和利用项目

KBR TECHNOLOGY

 | 16

KNOW-HOW DELIVERED

Qianlin Zhuang-KBR
庄前林-凯洛格布朗路特公司

Conclusion总结

- ✓ TRIG IGCC is an efficient, cost effective clean coal technology uniquely designed for low rank coals.
  TRIG IGCC 技术是一种专为高效、低成本利用低阶煤开发的清洁煤转化技术
- ✓ Its superior environmental performance and low water usage address an increasing need for many regions or countries
  优越的环保性能以及较低的工艺水耗能够满足多数地区和国家不断增长的需求
- ✓ Its design flexibility for CO_2 Capture will correspond well to future policy for CCUS implementation, technologically and economically
  针对一些国家和地区对于二氧化碳捕集的需求，TRIG IGCC也能够从技术层面以及经济层面而专门设计

 | 17

KBR
TECHNOLOGY
KNOW-HOW DELIVERED

Thank You
谢谢

KBR
TECHNOLOGY

KNOW-HOW DELIVERED