WORLD RESOURCES INSTITUTE

Progress Sharing on Large-scale Integrated CCUS Demonstration Projects in the U.S.A.
美国CCUS大型示范项目进展汇报

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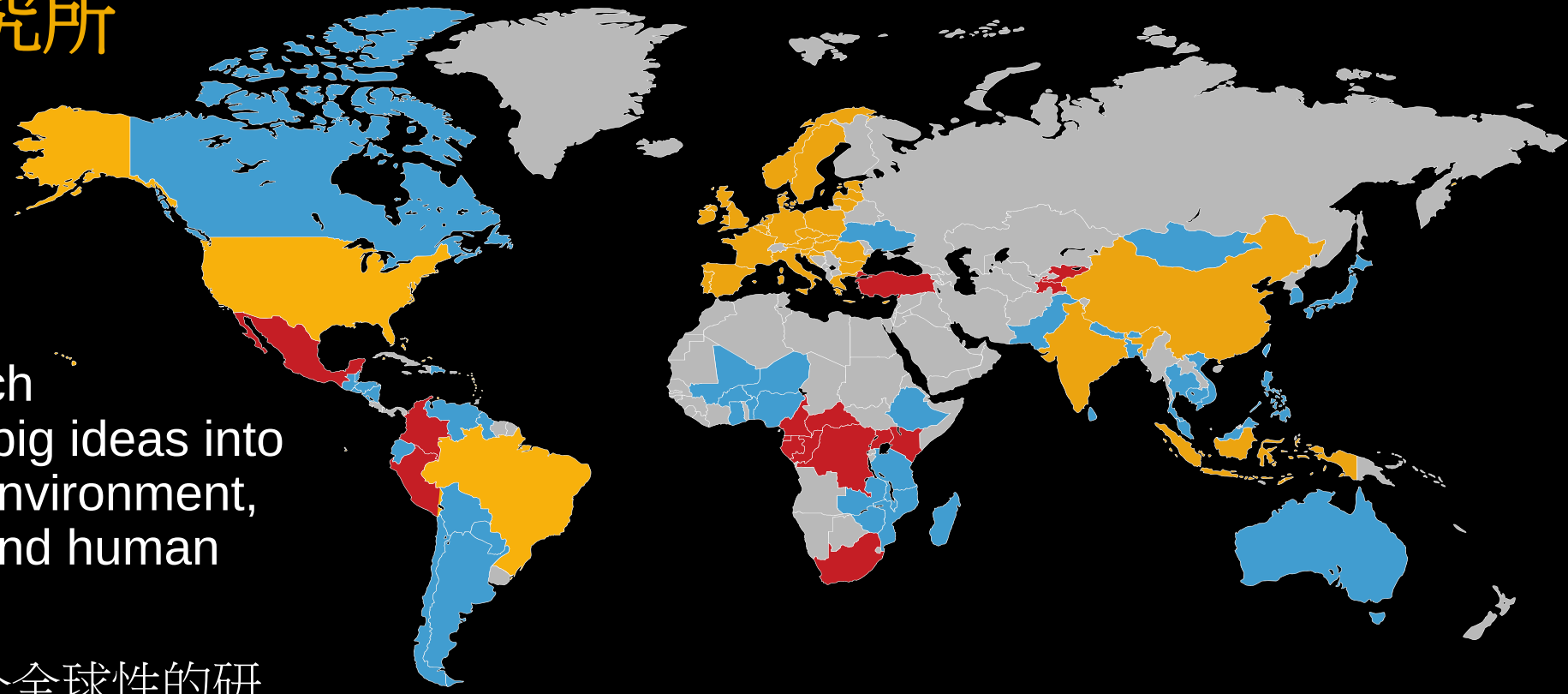


WRI is a global research organization that turns big ideas into action at the nexus of environment, economic opportunity and human well-being.

世界资源研究所是一个全球性的研究机构。我们将环境、经济机遇与人类福祉联系起来，将大型观念转化为行动。

- Institutional 有办公室
- Project staff on the ground and/or project office 有项目及现场员工
- Active partnership 有合作伙伴

Presentation Structure
汇报内容

A. Introducing the U.S. DOE‘s Major Demonstrations Program (MDP)

介绍美国能源部支持CCUS大型示范项目计划

B. Presenting the Progress on the Projects under MDP

分享该计划支持下的项目进展

C. Summarizing & Sharing the Lessons

总结分享相关经验

DOE Major Demonstrations Program
美国能源部主要示范项目计划

Carbon Capture, Utilization and Storage Major Demonstrations 主要示范项目		
•Clean Coal Power Initiative •清洁煤电计划	FutureGen 2.0 •未来电力2.0计划	Industrial CCUS Initiative •工业CCUS示范

Clean Coal Power Initiative I DOE
清洁煤电计划 I 美国能源部

- The Clean Coal Power Initiative (CCPI) is providing co-funding for new coal technologies that can help utilities cut sulfur, nitrogen and mercury pollutants from power plants. Also, some of the early projects demonstrated ways to reduce greenhouse emissions by boosting the efficiency by which coal plants convert coal to electricity or other energy forms.
- 清洁煤电计划（CCPI）为新的煤炭技术提供共同资助，帮助发电厂减少硫、氮和汞污染物。此外，一些早期的项目还通过提高燃煤厂将煤转换为电力或其他能源形式的效率，来减少温室气体排放的方法。

CCUS Demos under CCPI 清洁煤电计划下的CCUS示范项目
Hydrogen Energy California Project 加利福尼亚氢能项目
Petra Nova - W.A. Parish Project Petra Nova - W.A. Parish 项目
Southern Company - Kemper County 南方电力公司-肯珀县项目
Texas Clean Energy Project 德克萨斯清洁能源项目

Source: DOE

FutureGen 2.0 I DOE
未来电力2.0 I 美国能源部

- On August 5, 2010, the Secretary of Energy announced the awarding of $1 billion in Recovery Act funding to the FutureGen Alliance, Ameren Energy Resources, Babcock & Wilcox, and Air Liquide Process & Construction, Inc. to build FutureGen 2.0, a clean coal repowering program and carbon dioxide (CO2) storage network.
- 2010年8月5日，能源部长宣布从美国复兴法案基金中拨款，向FutureGen联盟，Ameren Energy Resources，Babcock＆Wilcox和Air Liquide Process & Construction公司提供10亿美元的资金支持，以构建“未来电力 2.0”——一个清洁煤改造计划和二氧化碳封存网络。

Source: DOE

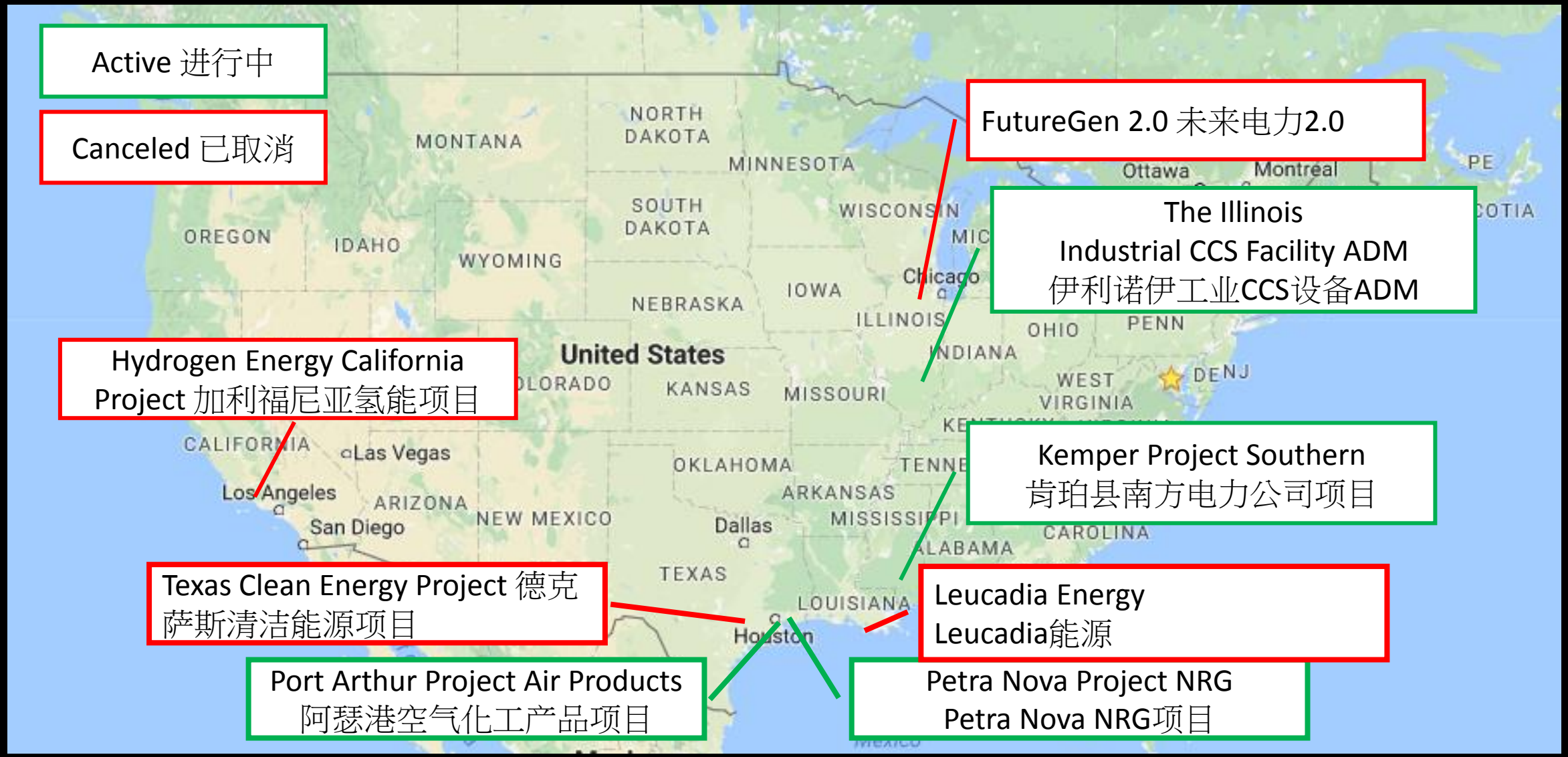
CCS from Industrial Sources I DOE
工业源的碳捕集与封存 I 美国能源部

- In a major step forward in the fight to reduce CO_2 emissions from industrial plants, DOE allocated funds to projects that capture and sequester CO_2 emissions from industrial sources - such as cement plants, chemical plants, refineries, paper mills, and manufacturing facilities - into underground formations.
- 作为减少二氧化碳工业排放斗争中的重要一步，能源部拨出资金用于工业源（如水泥厂、化工厂、炼油厂、造纸厂和制造设施）的二氧化碳捕集与封存。

CCUS Demos under ICCS ICCS下的CCUS样本
Air Products & Chemicals, Inc. 空气化工有限公司项目
Archer Daniels Midland Company Archer Daniels Midland 公司项目
Leucadia Energy Leucadia能源项目

Source: DOE

Project Status 项目状态



The Illinois Industrial CCS Facility I ADM
伊利诺伊工业CCS设施 I ADM

•Project Developer 项目业主

Archer Daniels Midland Company

Archer Daniels Midland 公司

•Project Partners 项目伙伴

The Illinois State Geological Survey, Schlumberger Carbon Services, and Richland Community College

伊利诺伊州地质勘探局、斯伦贝谢服务、里奇兰社区学院

•CO2 Capture Source 二氧化碳来源

ADM corn-to-ethanol plant (greater than 99% purity on a moisture free basis) in Decatur, Illinois

伊利诺伊州迪凯特ADM玉米乙醇厂（在干燥基上CO2纯度高于99%）

•CO2 Storage Site 二氧化碳封存地

Adjacent to ADM corn-to-ethanol plant in Decatur, Illinois

临近伊利诺伊州迪凯特ADM玉米乙醇厂

•Scale 规模

Approximately 1 million tonnes per annum (Mtpa)

约1百万吨/年(Mtpa)

•Starting Year 起始时间

April, 2017

2017年4月

•Storage Information封存地信息

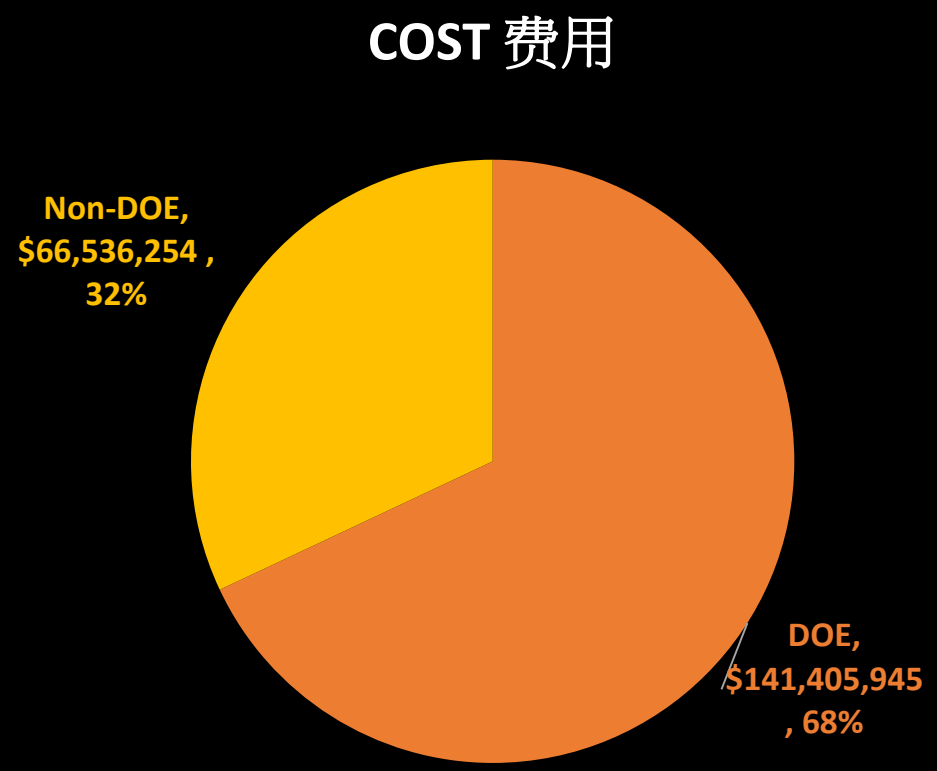
Mount Simon Sandstone at a depth of approximately 2,100 metres

西蒙山砂岩-地平面下约2100米（高渗透率，25%孔隙度）

Source: DOE/NETL

The Illinois Industrial CCS Facility I ADM
伊利诺伊工业CCS设施 I ADM

- Finance 资金



- Project Highlights 项目亮点

The first EPA's Class VI Permit - Underground Injection Control for Geological Sequestration of Carbon Dioxide

第一个获取美国环保署六类井许可 - 二氧化碳地质封存的地下注入管控

- Current Status 目前状况

The ADM project received the U.S. EPA's UIC Class VI injection well permit effective April 7, 2017, and started commercial operations accordingly.

ADM项目的美国环保署UIC六类注入井许可2017年4月7日生效，并开始了商业运营。

Source: DOE/NETL

Petra Nova Project | NRG Energy
Petra Nova 项目 | NRG 能源

•Project Developer 项目业主

A 50/50 joint venture between NRG and JX Nippon Oil & Gas Exploration

NRG 和 JX Nippon的50/50合资

•CO2 Capture Source 二氧化碳捕获来源

Post-combustion Capture - A commercial-scale post-combustion carbon capture facility at NRG's WA Parish generating station southwest of Houston, Texas

燃后捕集-在德克萨斯休斯顿西南的NRG's WA Parish240兆瓦发电厂，商业规模的燃后碳捕集设施

•CO2 Storage Site 二氧化碳储藏地

The captured CO2 will be through an 80 mile pipeline to an operating oil field where it will be utilized for enhanced oil recovery.

捕集的二氧化碳通过80英里的管道输送至一运营中的油田，在那里二氧化碳被用于提高石油采收率

•Scale 规模

1.4 million metric tons of CO2 annually

140万吨CO2/年

•Starting Year 起始时间

January, 2017 ／2017年1月

•Storage Information封存地信息

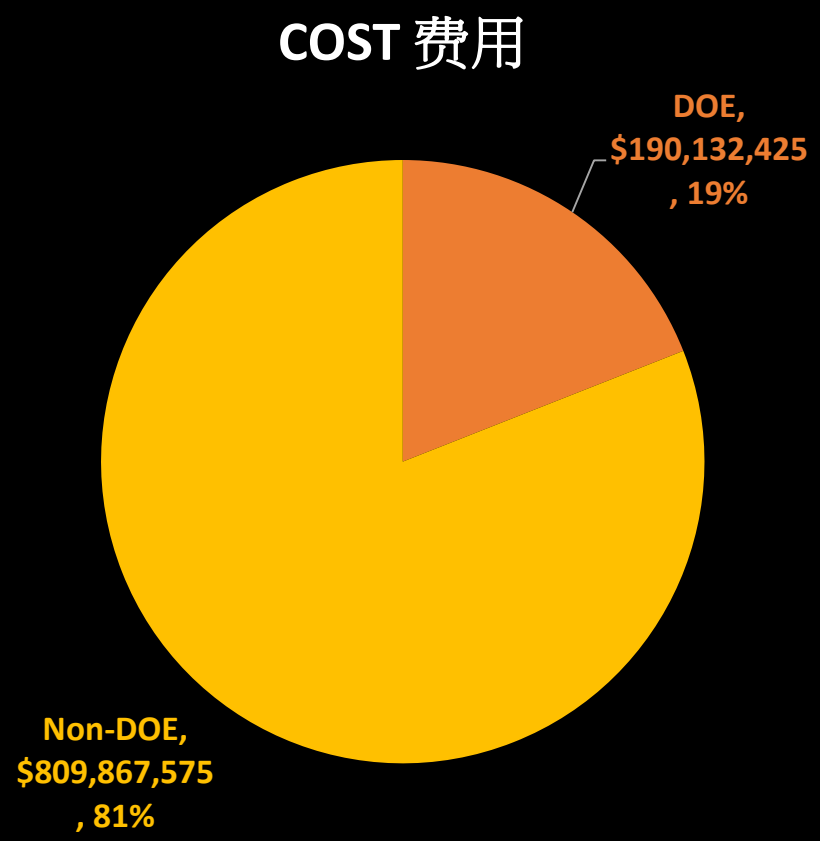
Hilcorp's West Ranch oil field, located near Vanderbilt, Texas / 80-mile pipeline

德克萨斯范德堡附近的Hilcorp's West Ranch油田／80-mile pipeline

Source: DOE/NETL

Petra Nova Project | NRG Energy
Petra Nova 项目 | NRG 能源

- Finance 资金



- Project Highlights 项目亮点
  - ❖ Production at the West Ranch oil field is expected to increase from roughly 500 barrels per day to 15,000 barrels per day.
    预计West Ranch油田的生产将从约500桶/天增加至15000桶/天。
  - ❖ A path forward for existing coal-fired power plants to continue producing energy while meeting environmental sustainability goals.
    提供了现有火力发电厂在继续生产同时实现环境可持续的目标的可行性。
- Current Status 目前状况

  Petra Nova has completed final performance testing and began commercial operation on January 10, 2017.
  Petra Nova已经完成了最后的性能测试，并在2017年1月10日开始商业运营。

Source: DOE/NETL

Kemper County Energy Facility I Southern Company
肯珀县能源设施I 南方电力公司

- **Project Developer 项目业主**

  Southern Company subsidiary Mississippi Power 南方电力公司下属的密西西比能源

- **CO2 Capture Source 二氧化碳捕集来源**

  Pre-combustion Capture - Integrated Gasification Combined Cycle - 582-megawatt electric power plant (At least 65 percent)

  燃前捕集 - 整体煤气化联合循环技术 - 582兆瓦发电能力至少65%的CO2捕集量）

- **Scale 规模**

  Approximately 3 million tonnes per annum

  约3百万吨/年

- **Starting Year 起始时间**

  2017 (expected)

  2017年（预计）

- **Storage Information 封存地信息**

  Enhanced oil recovery in Mississippi/ Approximately 98 kilometres Pipeline

  提高原油采收率/约98千米的运输距离

Source: DOE/NETL

Kemper County Energy Facility I Southern Company
肯珀县能源设施I 南方电力公司

- Finance 资金

$5.94 B	**Cost of plant subject to cost cap (power plant portion of the project)** 受限制的花费（项目的电厂占比）
+ $1.57 B	**Uncapped cost (Mine, CO_2 pipeline, etc.)** 不受限的花费（采矿，二氧化碳，管线等）
= $7.5 B	**Total project cost** 总项目花费
- $3.06 B	**Costs that will not be paid by customers** 不必由消费者支付的费用
- $.137 B	**Additional DOE CCPI2 funding** 附加的DOE CCPI2资金
= $4.3 B	**Total cost eligible for recovery from customers** 消费者的总花费

- Project Highlights 项目亮点

TRIG™ Integrated Gasification Combined Cycle (IGCC) developed by NCCC-Southern Company – a simpler and more robust way for generating power from low-rank coal

由南方电力自行研发的TRIG™整体煤气化联合循环发电系统，提供一种可以更好利用低阶煤的办法

- Current Status 目前状况

Prepare to start commissioning

准备试运行

Source: DOE/NETL/Mississippi Power

Port Arthur Project I Air Products
阿瑟港项目 I 空气化工产品

- **Project Developer项目业主**

  Air Products and Chemicals, Inc.

  空气化工有限公司

- **Project Partners 项目参与者**

  Denbury Resources

  Denbury资源

- **CO2 Capture Source 二氧化碳捕获来源**

  Two world-class scale steam methane reformer (SMR) hydrogen production plants located in Port Arthur, Texas

  位于德克萨斯阿瑟港的制氢厂-甲烷重整制氢

- **CO2 Storage Site 二氧化碳储藏地**

  Enhanced oil recovery.

  二氧化碳被用于提高石油采收率

- **Scale 规模**

  1 million metric tons of CO2 annually

  1百万吨二氧化碳/年

- **Starting Year 起始时间**

  2013

- **Storage Information 储藏信息**

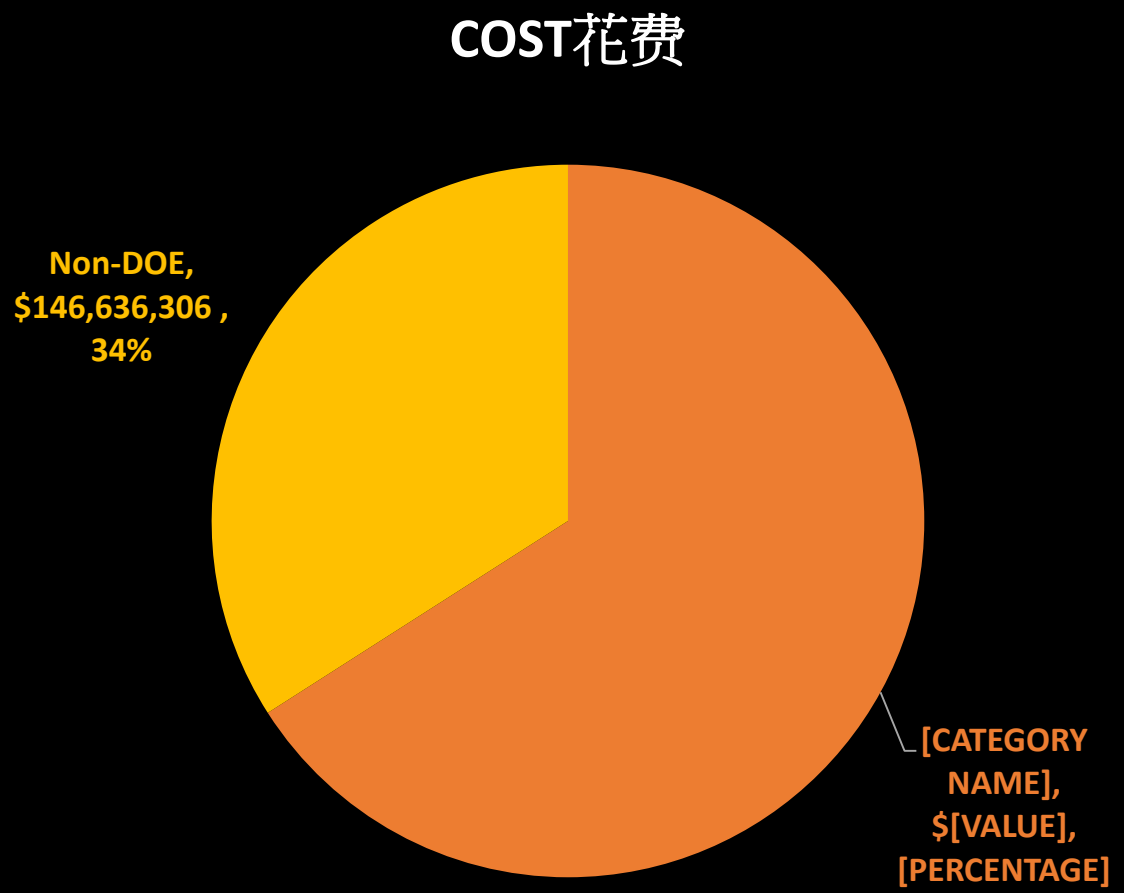
  Texas EOR projects in the West Hastings Field

  在West Hastings Field的德克萨斯EOR项目

Source: DOE/NETL

Port Arthur Project I Air Products
阿瑟港项目 I 空气化工产品公司

- Finance 资金



- Project Highlights 项目亮点

The CO2 used for EOR will result in approximately 1.6 to 3.1 million barrels of additional annual domestic oil production.
CO2-EOR使石油生产每年增长约160万至310万桶。

- Current Status 目前状况

The project has been in commercial operation since early 2013 and continues to successfully capture, store and utilize the produced CO2 stream. Air Products has already successfully captured and stored over 3,640,000 metric tons of CO2 as of April 30, 2017.
2013年初项目开始商业运营并持续成功捕集、储存、利用产生的二氧化碳用于驱油。截至2017不安4月30日，空气化工产品公司已成功捕集并封存超过3,640,000吨的二氧化碳。

Source: DOE/NETL

Lessons Learned
获得的经验

- Technology 技术上 - Relatively Mature 相对成熟
  - The ADM Project ／如此项目捕集源CO2浓度高

- Cost 成本上 - Relatively Low Cost & Public funding Support 相对小，且有公共资金支持
  - ADM项目和Air Products项目均有超过50%总投入的公共资金的支持，大大减小了项目投资人的风险。

- Business Model商业模式 - Available 有可循的商业模式
  - Available EOR / 除了ADM的项目，另外三个都是将捕集的CO2用于驱油，有长期稳定的收入，可以抵消一部分（或全部）捕集运行成本。

Source: DOE/NETL

Lessons Learned
获得的经验

- Be Patient 发展CCS项目需有多年持续的推动

Thank You！
谢谢！

更多经验分享请联系
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