China-US Clean Energy Research Center
Advanced Coal Technology Consortia

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2014-07-11

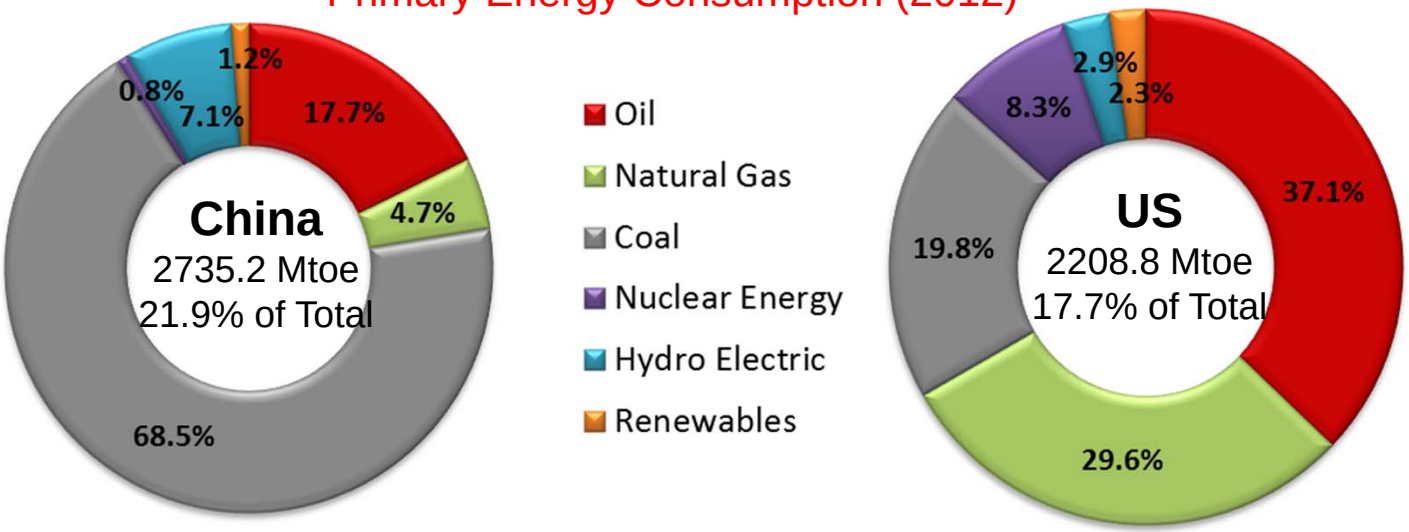
Content

- Background and Orientation
- Progresses and Contributions
- Extension and Deployment
- Planning and Future

Why CCUS?

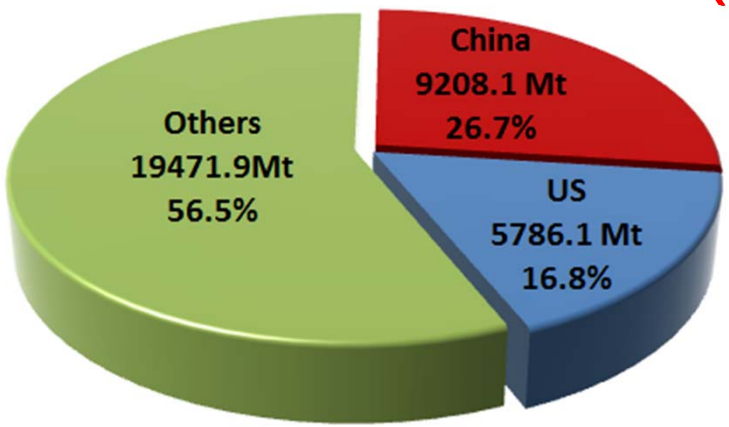
China US Energy Consumption & CO_2 Emissions

Primary Energy Consumption (2012)



Carbon Dioxide Emissions (2012)

The energy consumption and CO_2 emission accounts for more than 40% of the global amount.



BP World Energy Statistics, 2012

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Situation & Opportunities

China promises 40%～45% Reduction in CO2 Emissions per Unit of GDP in 2020 compared with 2005.

President Obama announces new standard on CO2 control: Reduce CO_2 emission by 30% before 2030 to the level of 2005.

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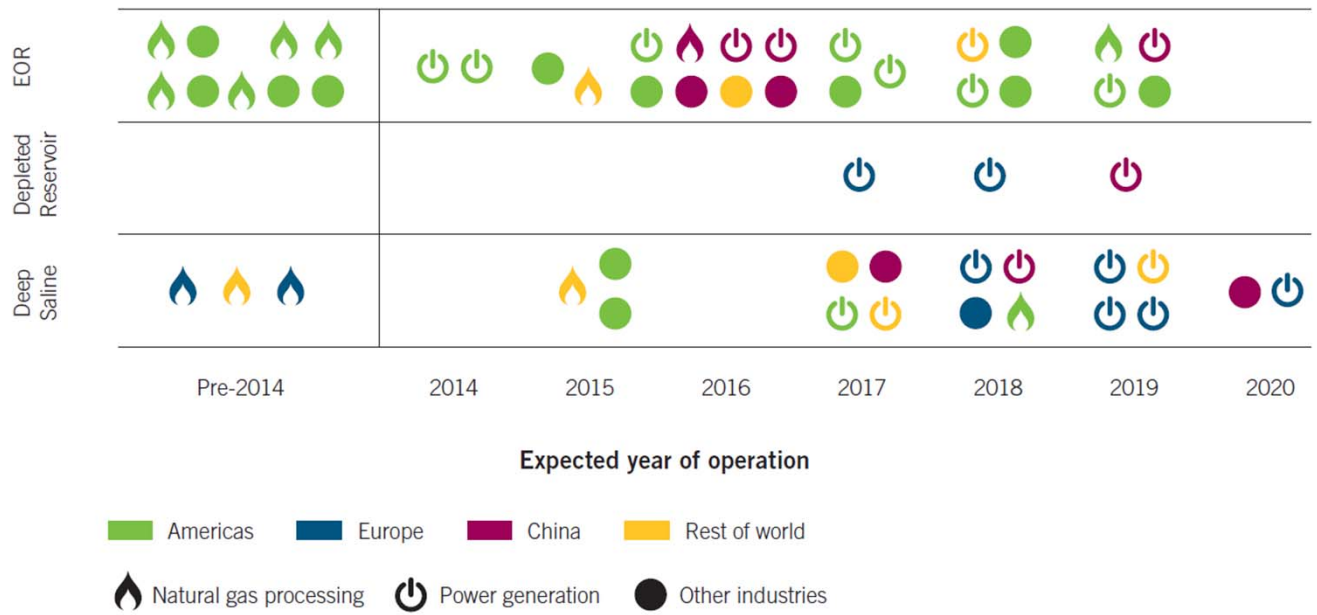
Recognition to CCUS



GCCSI
The Global Status of CCS: February 2014

CCS is essential if we are to keep global temperature increases below two degrees Celsius. It is a vital part of a least cost portfolio of low-carbon technologies required to deal with climate change. In the past few months there have been a series of expert reports acknowledging this reality.

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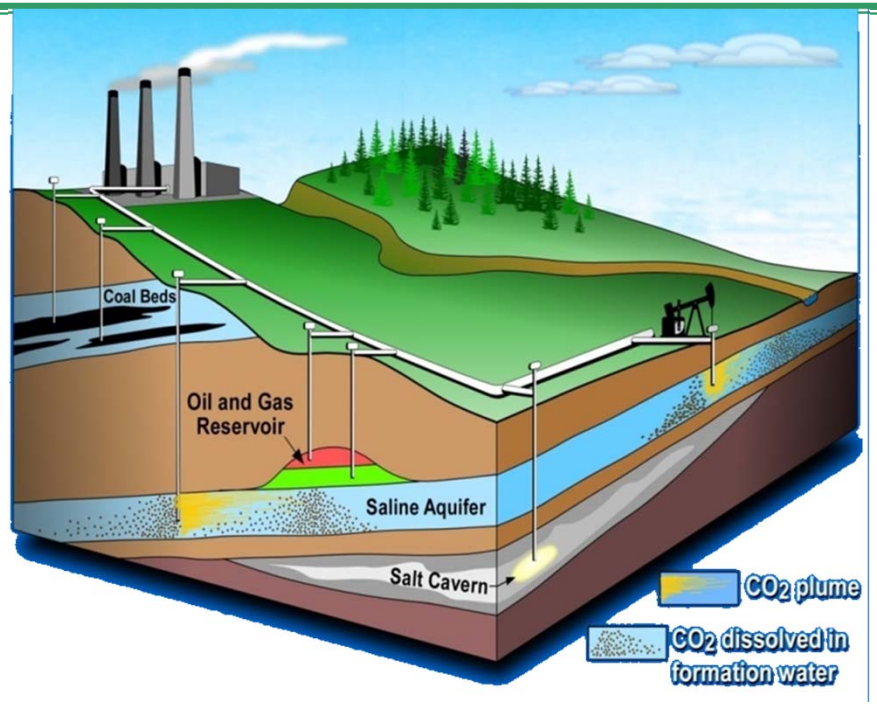
Orientation of ACTC

To create a new cost-competitive CCUS industry in the 2020s.



Pilots and demonstrations are key to the global implementation of CCS at the moment. The orientation of ACTC these years in CCUS is correct, which is consistent with the status of the development of CCUS and with the expectation and requirements from the governments.

CERC-ACTC Members

US team

China team

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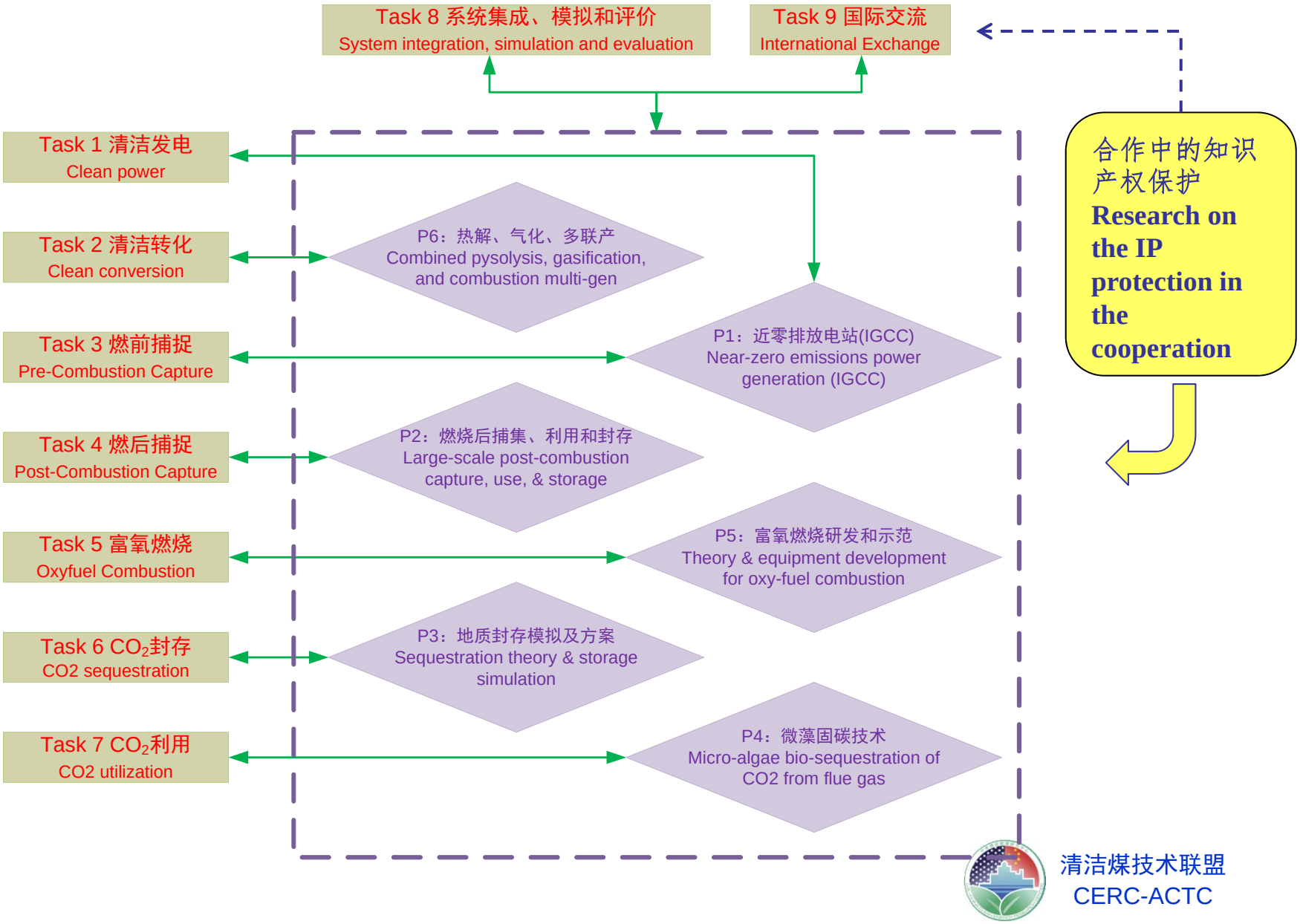
Projects and Tasks



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Virtual collaboration to Success

- Collaboration between the Chinese and US teams has been carried out since the foundation of the CERC-ACTC.
- Different forms of communication and exchanges between the two sides are involved, such as visiting, personal joint meeting, video meeting or audio meeting.

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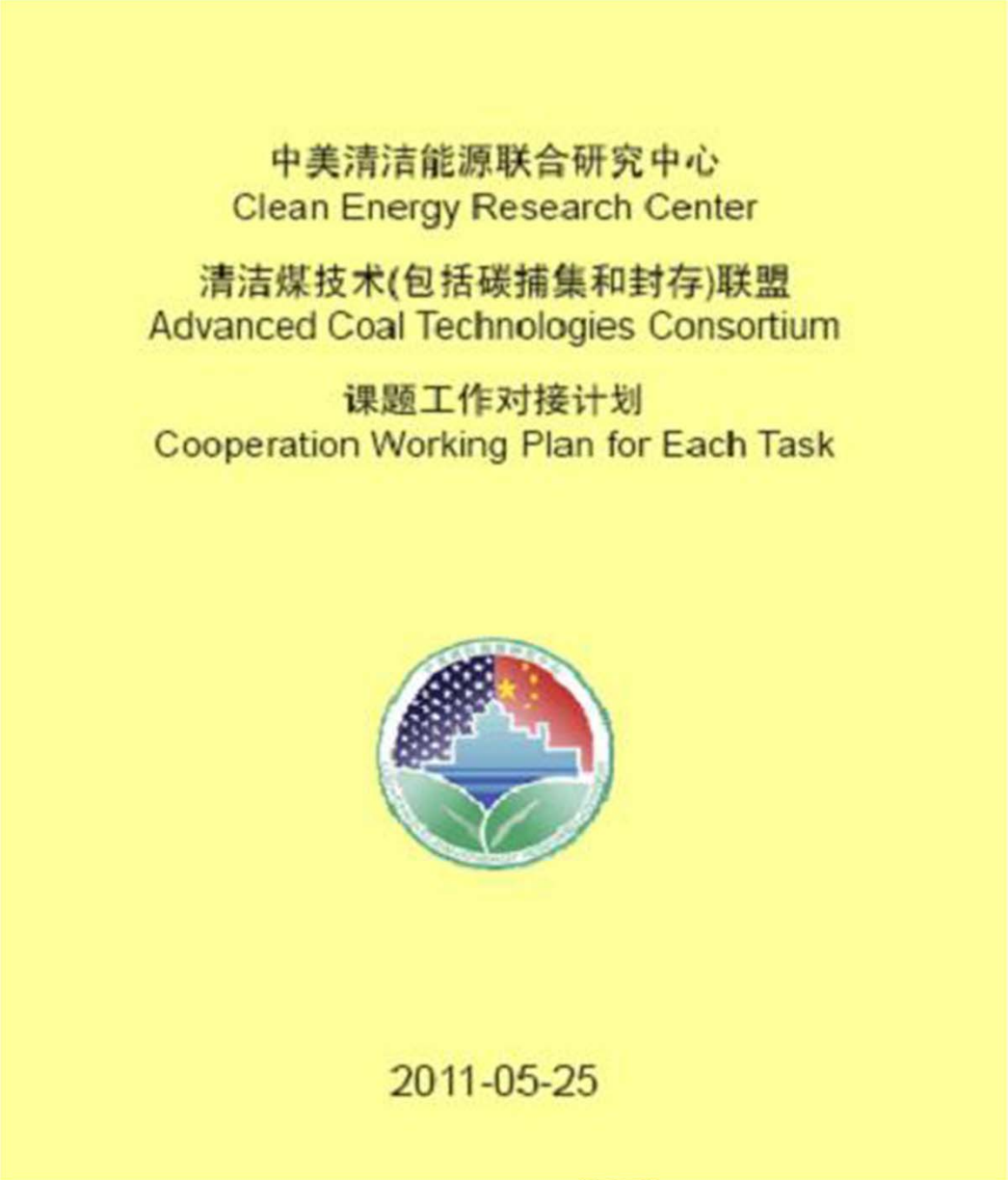
Progresses

- Collaboration plan (10 points) was established at the early stage of CERC
- The collaboration proceeds well over ACTC according to the plan.


中美清洁能源联合研究中心
Clean Energy Research Center

清洁煤技术(包括碳捕集和封存)联盟
Advanced Coal Technologies Consortium

课题工作对接计划
Cooperation Working Plan for Each Task

2011-05-25

Generation& Conversion

Research on issue related to super 700℃ USC boiler

Staged Coal conversion poly-generation system

- Migration and transformation mechanisms of mineral during coal combustion process.
- Coal conversion poly-generation technology combined pyrolysis, gasification and combustion is verified on 1MWt pilot plant and may be demonstrated in industry.

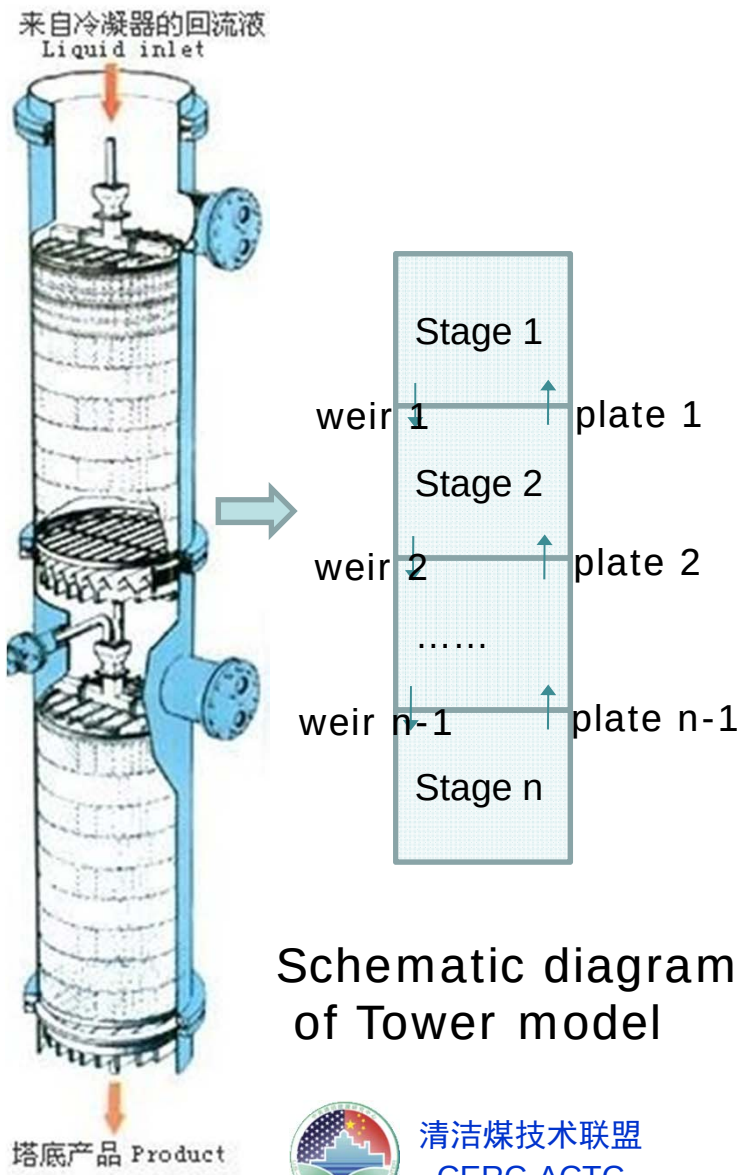
Effect of slagging and fouling behavior on heating surface

Torch of pyrolysis gas

1MWt coal stage conversion pilot plant

System Integration

- Dynamic modelling of CO_2 absorption process using aqueous MEA solution and dynamic behavior study (by Tsinghua, LLNL, Huaneng, Duke Energy)
- Performances analysis of a coal-fired power plant retrofitted with post-combustion CO_2 capture, including adding throttle valve, sliding pressure operation, and adding back-pressure turbines
- Application of advanced technologies in an IGCC system and a potential study
- Modelling of functional units of an IGCC system and system simulation
- Life-cycle analysis of coal to synthetic natural gas



Schematic diagram of Tower model

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Pre-Combustion Capture

Highlights

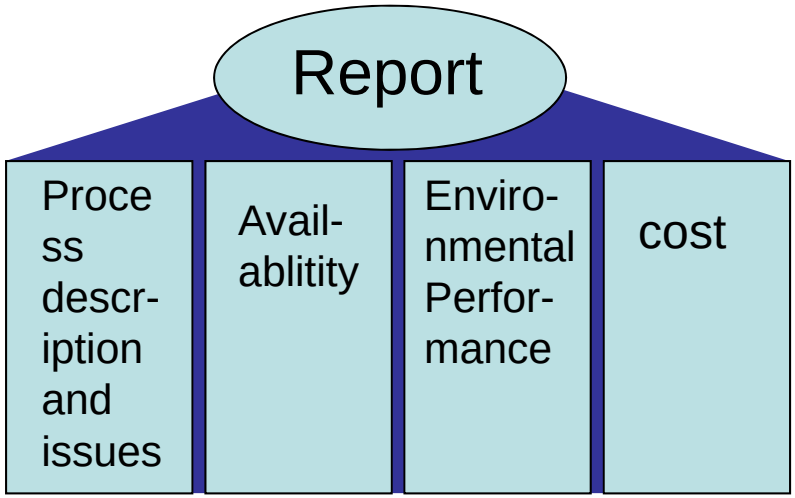
Collaboration Between CHNG and Duke Energy on IGCC

Share the operational knowledge gained from starting up and operation

Study and demonstrate the technologies of CO_2 capture, use and storage based on IGCC system and set up the test platform.

Explore the intersection of the energy strategy and interest of IGCC + CCS technology of the two countries, achieve mutual benefit and win-win situation.

Edwardsport IGCC



GREENGEN IGCC

Pre-Combustion Capture

Highlights

The first 250MW IGCC power plant in China started commercial operation on 6th November 2012

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Post-Combustion CO_2 Capture

Highlights

Duke cooperate with Huaneng and LLNL to implement a two-stage, post-combustion CCS project in Owensville, Indiana.

Duke Energy proposes to utilize unit 3 at its Gibson Station facility for this PCC project.

Gibson Power Plant

Stage I

Stage II

Shidongkou Carbon Capture Demonstration

Oxyfuel Combustion

Highlights

Data Share between HUST and B&W

- **True collaboration via open information exchange**
  - **Early creation of data exchange mechanism**
  - **MOU between HUST and B&W signed in June 2012**
- **Monthly teleconference and regular visits**
- **Cooperation extends to outside CERC**

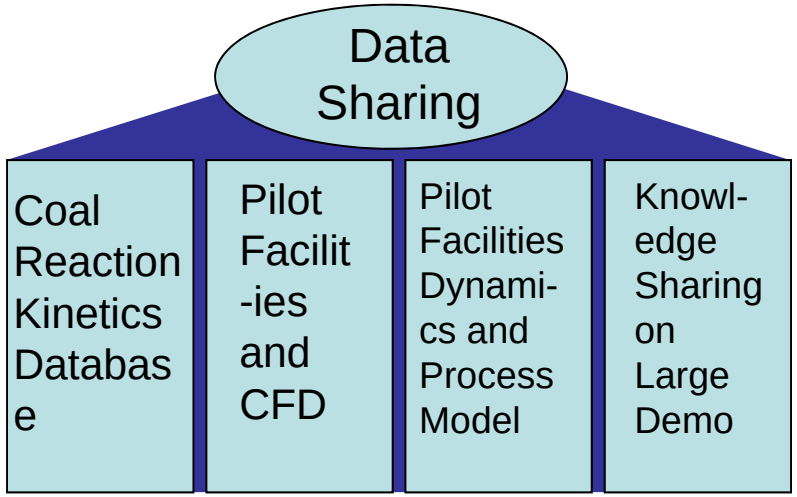
Technical Paper

Char Burnout of U.S. and Chinese Coals Under Oxy-Combustion Conditions

B&W babcock & wilcox power generation group

3 Joint paper
1 B&W Technical Paper

3 MW FCS

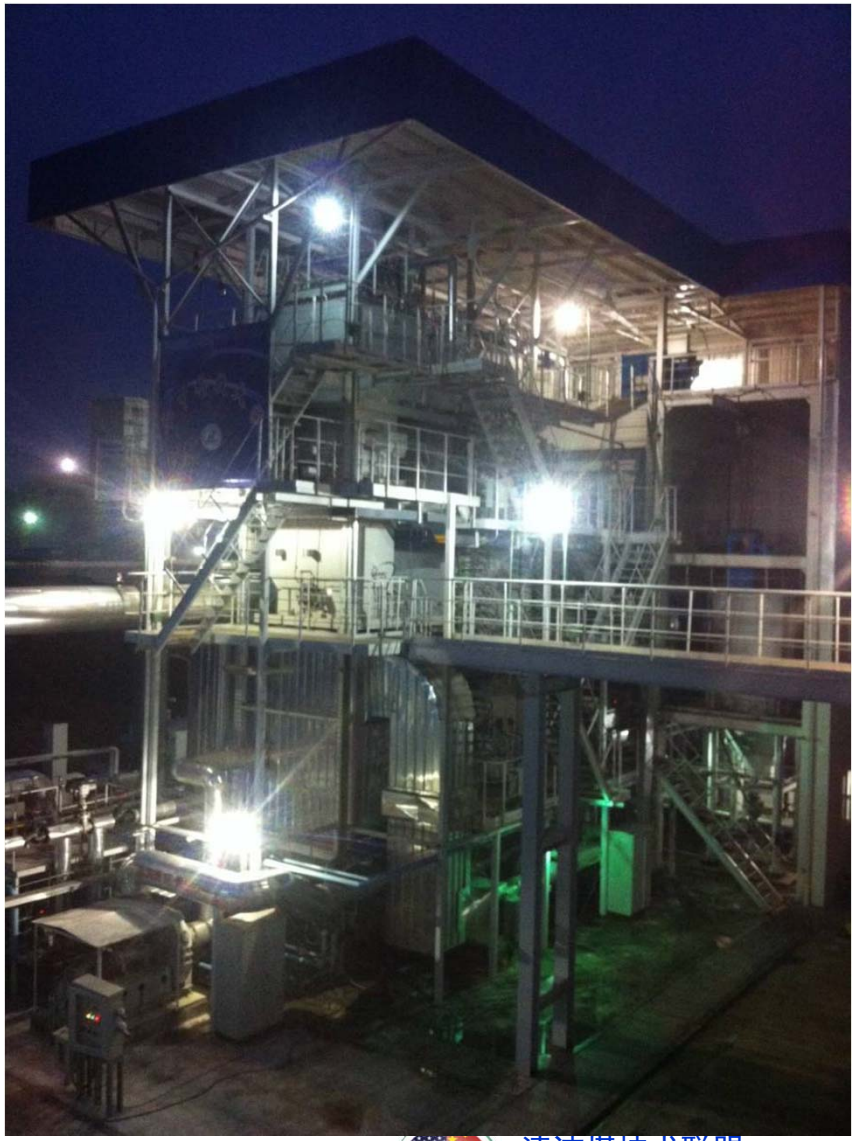


1.8MW SBS

Commission and Benchmark plan on 3MW FCS

Highlights

- ❖ **Stage I: air combustion commission (2012.1~2012.2)**
  - Burner work well
  - Heat transfer as design
  - PA, SA > 250C
- ❖ **Stage II: oxy-combustion commission (2012.3~2012.10)**
  - Switch from air to oxy-fuel
  - Oxygen injection safe at 300C
  - CO_2 ~80%dry,vol
  - Burner work well
- ❖ **Stage III: benchmark of air combustion (2012.11)**
  - Burnout ratio > 95%
  - Get the detailed data of air combustion
- ❖ **Stage IV: benchmark of oxy-combustion (2012.12-2013.6)**
  - Long-time and stable operation
  - Obtain the characteristic and control method of heat transfer and emission



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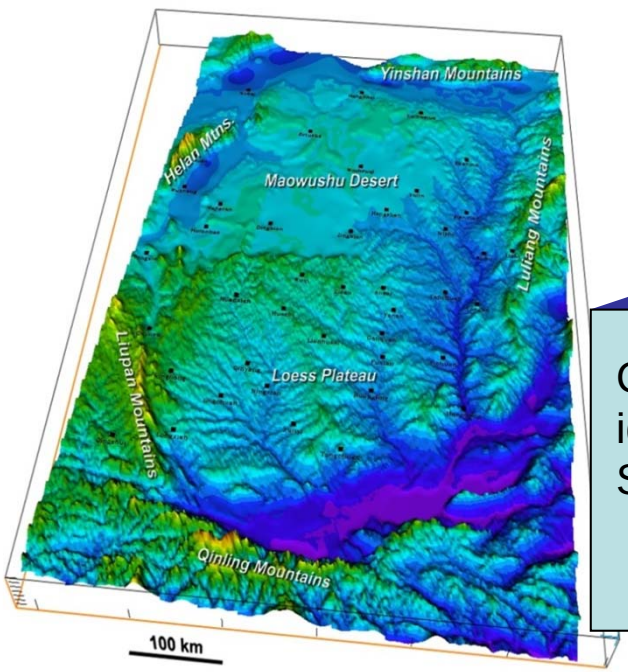
EOR & Storage

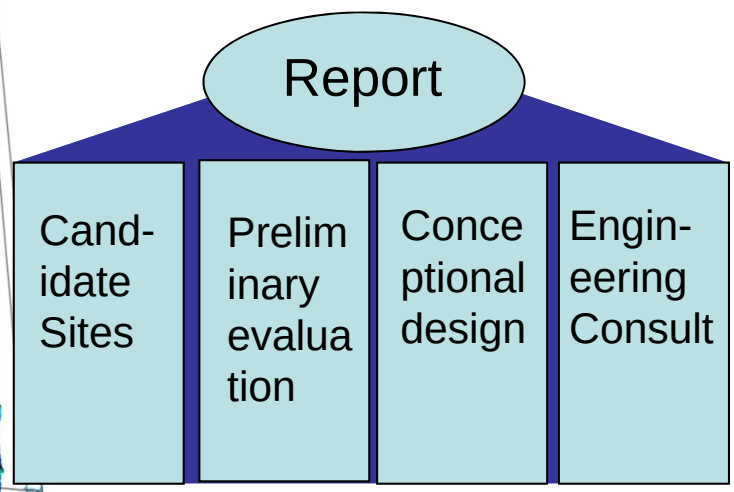
Highlights

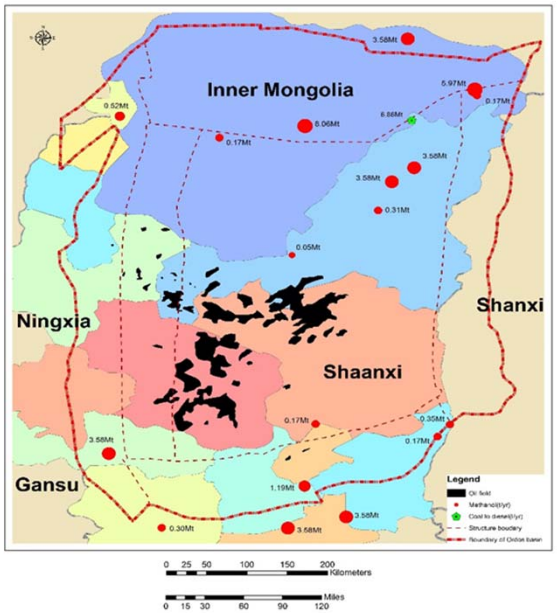
Site suitability and priority evaluations by the site screening methodology.

Ordos Basin collaboration on CO_2 storage between Yanchang Oil, University of Wyoming, and Northwest U.-Xian.

Ordos Basin, China





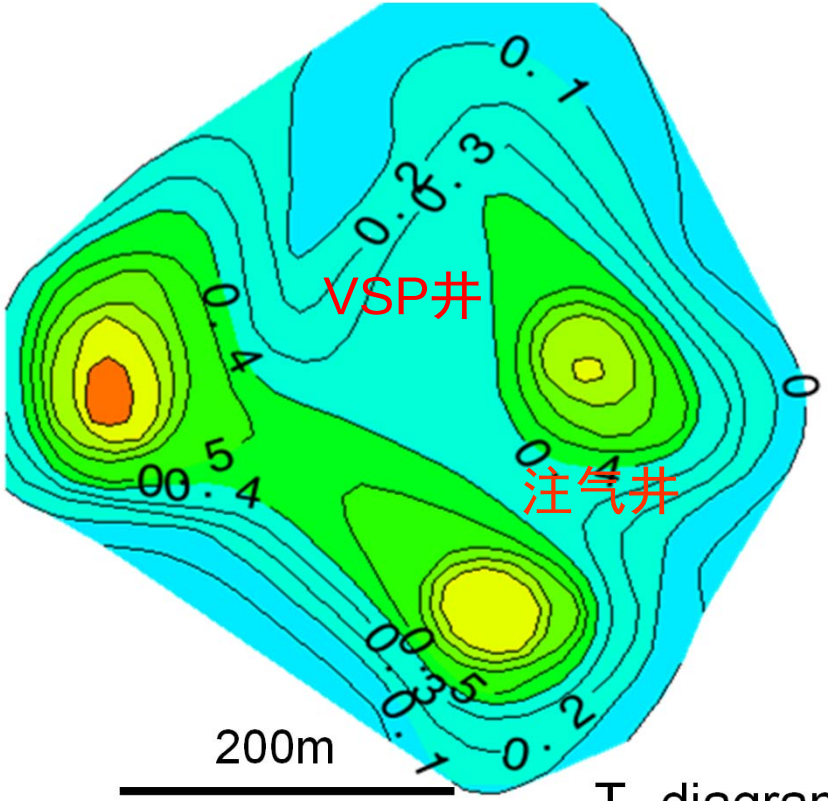


CO_2 storage

Highlights

Collaboration on pre-FEED, determine the concept design of deep aquifer CO_2 storage demonstration project.

Break through the technologies for large scale CO_2 storage in low permeability continental facies formations; the injection capability of single well can reach 1 millions ton per year;



T_0 diagram unit: ms

EOR

Highlights

CO_2-EOR pilot test region: Conduct CO_2 injection test in 2 wells (Shaanxi Yanchang Petroleum and UWy)

Surface infrastructure

Shaanxi Yanchang Petroleum CO2-EOR test

CO_2 Utilization

Highlights

CO_2 Utilization with Microalgae - A Sustainable Approach

Microalgae has advantages including a high growth rate, low land requirement, impressive high oil productivity (about 90 times that of soybeans), high carbon mitigation capacity (about 5-8 times of equivalent forest biomass), and a broad product portfolio, among others.

Duke Energy's Microalgae Project at East Bend Power Plant

Growth System Optimization in China

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Progress

Highlights

2011: Set up methods for microalgal strain improvement and develop pilot-scale cultivation systems.

2012: Obtain potential microalgae mutants showing fast growth and stress tolerance by mutagenesis. Optimize microalgae harvesting methods to reduce the cost.

2013:Selection of algae mutants with high oil yield and stress tolerance. Optimization of microalgae cultivation methods to increase biomass production

2014: Optimize wet algal oil extraction methods; process cost reduction; develop reliable cost estimate for microalgal CO2 capture and recycle.

2015: Continue process scale-up and integration of unit operations for CO2 recycle using algae; finalize cost estimates.

Intellectual Property

Highlights

1. TMP provides for protection of background IP, agreement on rights, and provides means for resolution of disputes; [1]

2. The "Technology Management Plans", with government endorsements, are "groundbreaking"; [2]

3. It provides a channel of interest sharing and disputes solution for IP management in Sino-US collaborative research. [3]

1,2 Quoted from CERC Co-chair Dr. Robert C. Marlay's Address at the Opening of 2nd CERC Workshop on Intellectual Property, February 26, 2013.

3 CERC Mid-term Evaluation Report.

TMP was originally produced by ACTC. The final TMP document of ACTC was taken as the common file for the three consortia in CERC.

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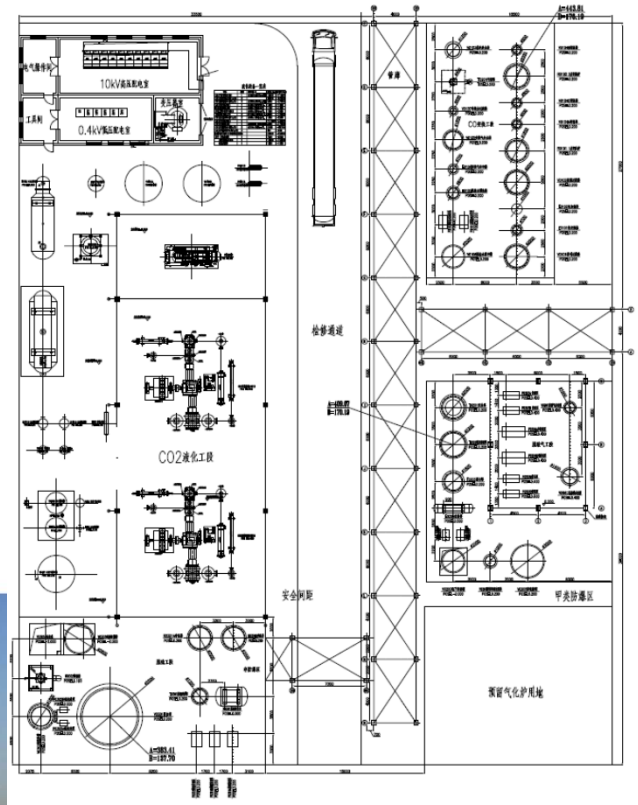
IGCC+CO_2 Capture in Huaneng

- Based on the operation of IGCC, Huaneng is starting a 30 MW precombustion CO_2 capture project for syngas cleanup.

30MW_{th} pre-combustion CO_2 capture system layout



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35MW$_{th}$ & 200 MWe oxyfuel demonstration

HUST leads the 35MW oxy demo project in Yingcheng and the 200MWe oxy plant pre-feasibility study in Shenmu.

Shenhua Group has invested more than 12 million US$ in the FEED study of this project.

Yanchang CO_2-EOR Demo.

- Yanchang Cooperated with University of Wyoming in CO_2-EOR project in Ordos Basin.
- A 100 kt/y CO_2-EOR demonstration project is planned by Shenhua Group, Yanchang, and Petroleum Association and will be scaled up gradually.

Shenhua CO2 capture facility

Collaboration

CO_2-EOR in Yanchang Co.

Shenhua

Yanchang

中美CERC

University of Wyoming Collaborates with China in CO2-EOR.

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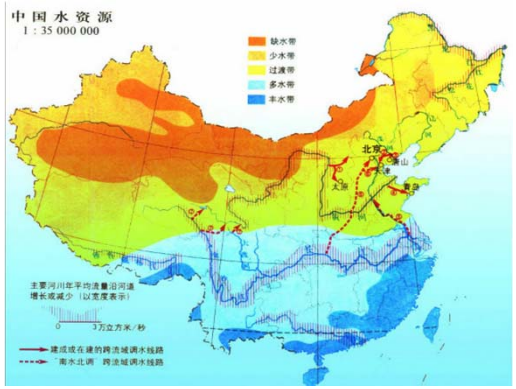
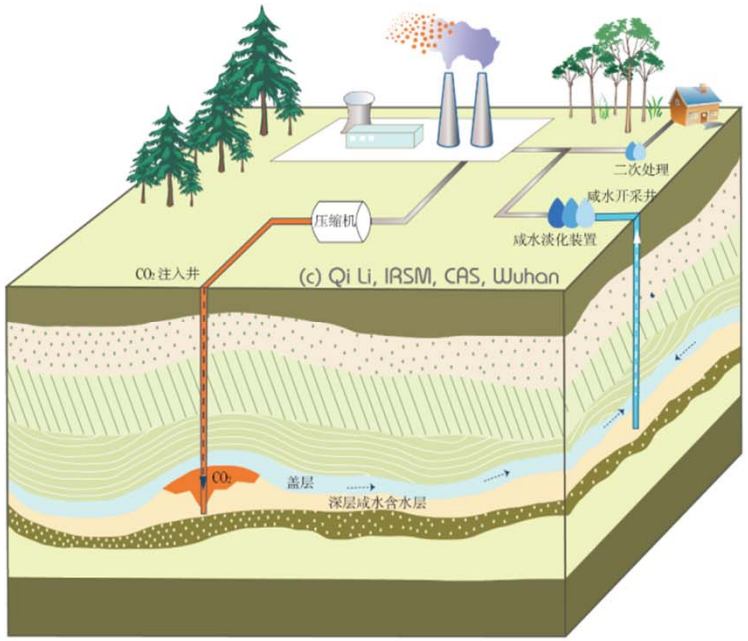
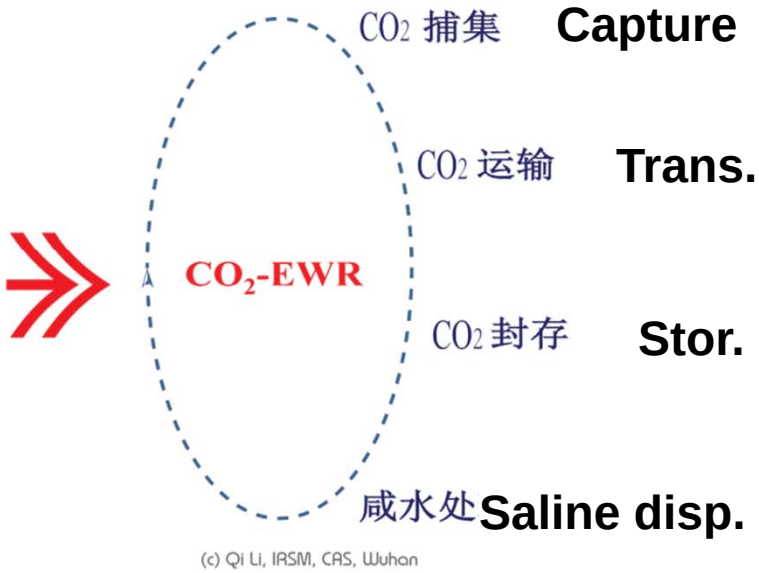
Water source utilization in west China







The novel CO_2-EWR CCUS technology takes the advantage of the rich deep saline aquifer resource to mitigate the pressure of water source shortage and high CO_2 emission, which has large potential of utilization.

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Proposals for Next 5 Years

Principles

- Demonstration projects; scale
- Deepening collaboration; data sharing
- Project extension; built on successes
- Realizable; payback; economics
- Interrelated; thematic

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Proposals for Next 5 Years

- ❖ Enhanced Water Recovery: Formation management using brine withdrawal, while storing CO_2. Recovery of potable water for agriculture, livestock, human consumption, industrial uses.
- ❖ Grid stability: Increased deployment of renewable energy adds intermittency function to grid operation; cyclic operations of large coal-fired power plants.
- ❖ Pressurized Oxy-combustion: Thermodynamic benefits to oxy-combustion at 7-12 bar; staged combustion eliminates recirculation; at sufficient scale to confirm kinetics and combustion control.
- ❖ Participation by industry: Shorter term research with reasonable payback; collaboration and cooperation in data sharing from large demonstration projects.

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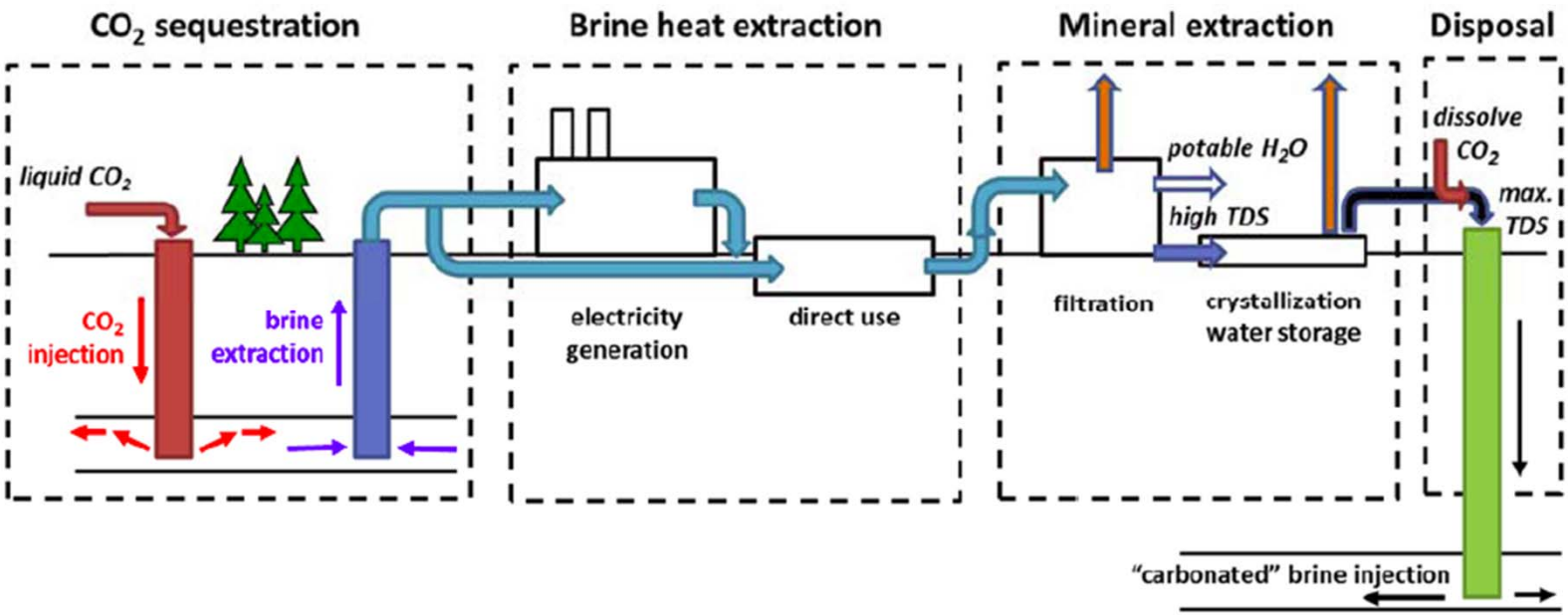
Example Collaboration on EWR

- Huaneng (on behalf of China ACTC) and WVU (on behalf of U.S. ACTC) sign an MOU to collaborate on a EWR project.



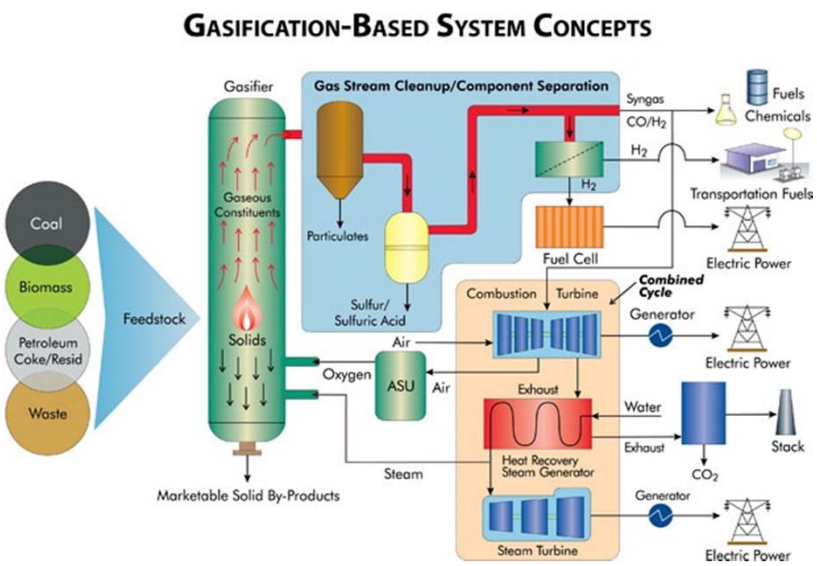
Example Collaboration on Large Demo Projects

IGCC+CO_2 Capture in Huaneng

- Based on the Tianjin IGCC, Huaneng is building a 100 kt/yr CO_2 capture project for EOR.

- TECP is developing IGCC+CCS technology, which will be the first clean coal generation project. The CO_2 capture rate is 90% with 3Mt/a capacity. CO_2 will be used for EOR in Permian basin.

SUMMIT POWER



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Thank you for your attention