What Have We Learned?
Insights from the Workshop

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Context

- Fossil fuels dominate primary energy supply worldwide (and even more so in China and the USA) and coal dominates electricity generation in China, the USA, and worldwide.
- High growth of energy use and electricity generation is expected in China, the United States and the world in the rest of this century, and high fossil-fuel and coal-dependence are expected to continue.
- High prices and economic vulnerability associated with oil & natural gas motivate interest in coal gasification & liquefaction. Air pollution, acid precipitation, and climate change motivate interest in cleaner coal technologies, including CO_2 capture and sequestration (CCS).

Gov't-industry alliances for IGCC and co-production

- Gov't-industry alliances are working well in the USA (FutureGen) and Europe (and starting to work in China), bringing together the complementary skills and resources of the private & public sectors.
- International participation in such alliances is increasing and is very promising as a way to share insights, costs, & risks and to accelerate progress in all of the partner countries.

Status and prospects of IGCC and Co-Production

- Six IGCC demo plants are operating worldwide, 2 in the USA.
- IGCC offers similar efficiency to Ultra-Super-Critical Pulverized Coal (USCPC) plants. USCPC is cheaper, but IGCC offers better control of conventional pollutants, lower water demand, reduced solid waste, possibility of H_2 co-production, and lower cost to add CO_2 capture (to a new plant). USCPC can be made amenable to retrofit for CCS (IGCC cannot), but cost of retrofit itself would be high.
- Deployment of IGCC has been slow because of high cost, complexity similar to chemical plant, lack of CO_2 policy, and (until recently) cheap natural gas.
- China's goal is to have commercialized IGCC capacity by 2020 to convert coal to electricity & H_2 with near-zero emissions, plus synthetic oil and gas capacity to replace 50 million t/a of oil.
- A variety of pilot and demo projects around China with both corporate & gov't support are underway or planned pursuant to that goal. Chinese alliance for IGCC and co-production is intended to coordinate RD&D and provide platform for international cooperation.

Towards a research & deployment agenda on C capture

- Options for C capture in coal-burning power plants are (a) pre-combustion capture of the CO_2 in IGCC plants with shift reaction to H_2 and CO_2; and (b) post-combustion capture in PC power plants.
- With current technology, cost of electricity from IGCC with carbon capture appears to be less than from PC with carbon capture (comparing new plants built from outset to do this). Cost per ton of avoided CO_2 emission is likewise lower for IGCC with CCS.
- Further development of PC/post-combustion options conceivably could close the cost gap, and more R&D should be done to pursue this. Promising options include oxy-firing, chilled-ammonia absorption.
- Until CO_2 price or policy dictates CO_2 capture, most new plants will be PC. It's important that these be built in a way that allows later retrofit for CO_2 capture when price or regulation makes this attractive.
- Regulations specifying fraction of coal-electric-generation CO_2 to be sequestered could be considered to get started.
- Fischer-Tropsch coal-to-liquids technology lends itself to low-cost C capture (~\$10/tCO_2) and should not be deployed without this.

CO_2 storage and utilization technology

- Storage options are oceanic (large capacity but least understood), terrestrial (moderate capacity), and geologic (medium to large capacity).
- Best geologic options on current understanding are enhanced coal bed methane recovery (ECBM), enhanced oil recovery (EOR), depleted oil & gas fields, unmineable coal seams, and saline reservoirs. Largest capacity worldwide is in saline reservoirs.
- Enhanced recovery of oil & gas and enhanced coal-bed methane production bring economic benefits that offset sequestration costs, thus are particularly attractive for early implementation.
- More research is needed on all technical aspects of sequestration -- fundamental processes (e.g., pore behavior), leak rates & safety, storage capacities, and measurement-monitoring-verification -- as well as on policy aspects including permitting and liability.
- Unlike technology transfer, geology can't be transferred; thus geologic assessments of sequestration potential must be done for every region with large CO_2 sources. These assessments are large tasks and for most regions have barely begun.

Sweeping conclusions

- Interest has grown very rapidly in China and the USA (and in the UK and Australia) in advanced coal technologies that can reduce conventional pollutants & Hg from coal-electric power plants, can co-produce electricity & H_2, can produce liquid fuels from coal, and can capture & sequester a large part of the resulting CO_2.
- Research, development, & demonstrations on these technologies have been multiplying in all of our countries, but much more work will be needed to clarify the full potentials.
- CCS will not occur on the needed scale until strong policies make it attractive or require it.
- There are very large benefits to be obtained from public-private partnerships and from increased international cooperation on both the technical and the policy aspects of this challenge. Let us continue!

Thank you!