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The China Australia Geological Storage of CO₂ (CAGS) Project: An example of bilateral cooperation and successful capacity building

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Abstract

The China Australia Geological Storage of CO₂ (CAGS) Project is a collaborative project that aims to accelerate the development and deployment of geological storage of carbon dioxide in China and Australia. There are four main programs under CAGS to build CCS capabilities in both countries: research projects, technical workshops, training schools, and scholarly exchanges. All have contributed in advancing CCS/CCUS knowledge and building capability in China and Australia. Now in its third phase and its 10th year, CAGS is regarded as a successful bilateral project, which has produced essential research for advancing CCUS in China, established a strong network for Australian and Chinese researchers and institutions, and contributed to advancing CCUS globally. The paper describes the history of the collaboration and impact of this successful bilateral project.

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1. Introduction

The China Australia Geological Storage of CO₂ (CAGS) project was established in 2008 through a Letter of Intention between the Australian and Chinese governments and is jointly managed by the Department of Industry,

Innovation and Science (DIIS) through Geoscience Australia and China's Ministry of Science and Technology (MOST) through the Administrative Centre for China's Agenda 21 (ACCA21). The project aims to help accelerate the development and deployment of geological storage of carbon dioxide in both China and Australia. CAGS is currently in its third phase and is celebrating its 10th year. It is considered by both the Australian and Chinese governments, participating organisations, and international observers to be a highly successful demonstration of bilateral cooperation and has been suggested as a model for other bilateral collaborations.

2. CAGS Phase 1

CAGS was established under the Asia-Pacific Partnership on Clean Development and Climate (APP), with funding of AU\$2.86m from the Australian Government Department of Resources, Energy and Tourism. The initial phase ran from 2009 to 2012 with more than 400 people from over 70 Chinese, Australian, and international organisations participating in activities, including research projects, professional workshops and CCS training schools [1]. In addition, Chinese researchers were given the opportunity to participate in a visiting scholarship program to Australia and to apply for funding to attend significant international CCS conferences.

CAGS1 achieved the following outcomes:

- Established a new framework and different model of co-operative research with China;
- Assisted with the establishment of a set of criteria for assessing potential geological storage sites in China;
- Provided recommendations for the development of regulations for CO₂ storage in China;
- Increased understanding of CO₂ interactions during enhanced oil recovery;
- Assisted the China Geological Survey in producing a Chinese geological storage atlas;
- Established the CAGS website that enabled distribution of training school and workshop materials and presentations (cagsinfo.net);
- Increased collaboration between Chinese organisations, particularly those under different ministries; and
- Built a strong Australia-China network and communications platform for future collaboration.



Fig. 1. CAGS1 Training School in Beijing, 2012

3. CAGS Phase 2

Built on the collaborative work of CAGS Phase 1, CAGS Phase 2 (CAGS2) was endorsed by the Australian and Chinese governments and was funded under Australia-China Joint Coordination Group on Clean Coal Technology (JCG) program. The Department of Industry and Science provided funding of AU\$1.39m to support the ongoing collaboration from 2012 to 2015.

CAGS2 continued to have impact on the research and development of geological storage in China [2,3]. CAGS has been a catalyst for attracting additional CCS funding for research activities, including the two projects funded under the China Clean Development Mechanism Fund. The targeted research projects have assisted CCUS advancement in China. For example, one of the research projects has assisted the Chinese Government's Ministry of Environmental Protection in its implementation of a national approach to environmental regulation of CCUS projects [4].

CAGS2 has established a network of key CCS/CCUS researchers in China and Australia, several of which contributed to the "storage section" of the 12th and 13th Five-Year plan for Scientific and Technological Development of CCUS in China.



Fig. 2. CAGS2 Chinese delegates visiting the CO₂CRC Otway CO₂ demonstration project in 2013

4. CAGS Phase 3

The nature of the capacity building activities changed over the course of the project. In CAGS3 (2016–2018), the focus in China changed from national level capacity building and supporting desktop/laboratory research projects in the earlier phases of CAGS to the targeted area of Xinjiang province in western China; a region undergoing rapid industrial growth [5]. This strategic area of China is home to a large coal chemical industry but is coming under increasing scrutiny for its rapid growth in carbon dioxide emissions. CCUS is considered to be a key technology by the provincial and Chinese governments to address these emissions. The region appears to be prospective for large scale implementation of CCUS: it has a ready supply of higher purity and comparatively inexpensive CO₂ from industrial emissions; basin capacity assessments suggest the Junggar Basin has large-scale storage potential; it is a low population region; the CO₂ could be used for enhanced oil recovery (EOR) or enhanced water recovery (EWR); and there is typically good co-location of sources and potential storage sites. However, CCUS knowledge and supporting research capacity in the province is limited in comparison to other regions. CAGS held the first English-Chinese bilingual CCUS workshop in Xinjiang in 2017, sponsored two large research projects (with Chinese co-funding) that supported pre-feasibility assessments for CCUS demonstration pilots, leveraged support for the establishment of the Xinjiang CCUS Engineering Research Centre at Xinjiang University, and organised a very successful training school for postgraduate university students with support from international geological storage experts (Fig. 3). These activities were undertaken to attract students and start the process of increasing CCUS research capacity in the province, which will ultimately contribute to the supporting research infrastructure for a CCUS industry in Xinjiang.

In Australia, there has also been a change in the nature of the capacity building activities. In the early stages of the CAGS project, Australia hosted virtually all scientific exchanges but this has changed in more recent times with increasing numbers of Australian researchers undertaking scientific exchanges in China. Presentations at the early workshops were mostly by Australian and international speakers but there is now a greater sharing of Chinese CCUS research and industry experience and knowledge. This is built on the substantial investment in CCUS research by the Chinese Government and industry, resulting in at least seven CCUS demonstration projects constructed or in development [6]. The evolution from CAGS1 to the current program reflects this growth in both knowledge of, and confidence in, CCUS among Chinese researchers. Indeed, one of the early programs in CAGS

supported top Chinese researchers to participate in international CCUS conferences in order to accelerate their exposure to international research and to encourage them to share their own. In June 2018, CAGS partnered with the international journal Applied Energy to hold ‘CCUS2018-Applied Energy Symposium and Forum 2018: Carbon capture, utilization and storage’ in Perth, Australia [7]. A large delegation of Chinese researchers, industry representatives and government officials attended the event. The open forum provided an opportunity for many Chinese researchers to deliver their first presentations in English to an international audience. The conference proceedings will also be published in an English language journal, again, a first for many of the delegates. The symposium provided a platform to showcase innovative Chinese research that is not widely disseminated beyond a Chinese domestic audience.



Fig. 3. Students having fun with CO₂: CAGS3 training school in Xinjiang (2017).

5. CAGS: celebrating 10 years of achievement

Through three phases and ten years, CAGS continues to build capacity in geological storage. This has been achieved through researcher exchanges, study tours, research project support, and facilitating access to leading international experts for sharing their knowledge at workshops and training schools. CAGS has been both an instrumental and enabling program in bringing together research, government and commercial organisations within China to collaboratively address CCUS. Although largely focused on CCUS in China, the program is a true collaboration and has benefited both countries. A summary of the impact and benefit of these different programs is described in Table 1.

The collaborative project has facilitated the individual exchange of some 30 researchers between the two countries, 2 study tours, and supported 15 training schools and workshops. The CAGS alumni now includes over 900 researchers, industry representatives and government officials. The project has had a measureable positive impact on advancing CCUS in China through its capacity building activities.

Table 1. Summary of impact of different capacity building activities

Category	Impact
Scientific exchanges (for Chinese researchers and hosts)	<p>Knowledge and cultural exchange</p> <p>Adopted and implemented techniques or approaches learnt in Australia (e.g. regulations, monitoring and modelling)</p> <p>Joint papers with Australian researchers in English language journals (can raise Chinese researchers' profile)</p> <p>Improved research capacity in Chinese organisations involved</p>
Scientific exchanges (for Australian researchers and hosts)	<p>Knowledge and cultural exchange</p> <p>Co-authorship on papers with Chinese researchers</p> <p>Provided long-term Chinese contacts for Australian researchers and opportunities to apply for joint research funding</p> <p>Led to further visits and exchanges between collaborating institutes</p> <p>Led to joint projects and funding for Australian institutes</p>
Research projects (in China)	<p>Expanded research teams and increased capacity to undertake more research</p> <p>Inspired junior researchers within the sponsored institution to undertake CCUS research</p> <p>Increased attendance of Chinese researchers at international conferences.</p> <p>Increased the potential for additional Chinese Central Government funding and upgrading of scientific equipment within Chinese institutes</p> <p>Led to reclassification of some Chinese laboratories or institutes to a National Level Facility, which in turn enables the institute to compete for project funding from a wider pool of Chinese funding mechanisms</p>
Workshops (in China, with bilingual interpretation)	<p>Provided Chinese researchers access to international experts and CCUS policy updates from other countries</p> <p>Provided learning experience for junior researchers, company or provincial government officers who have limited English skills and little opportunity to attend major international CCUS conferences</p> <p>Chinese workshop participants considered that their involvement led to an increased awareness and priority placed on CCUS within their organisations, which in some organisations, led to more funding and resources being allocated to CCUS research</p> <p>Provided a rare domestic networking opportunity for different Chinese government departments, companies and researchers in the CCUS field</p> <p>International participants gained insight to new CCUS project developments little known outside China</p>
Workshops (in Australia)	<p>Provided updates from Chinese academics on research activities</p> <p>Australian participants gained high level policy updates and insight to CCUS progress in China</p> <p>Established new relationships between Australia and Chinese researchers, government officers and industry representatives</p> <p>Australian researchers gained valuable information about the application of CCUS to EOR or EWR, which is not presently practised in Australia</p>
Training schools	<p>Inspired postgraduate students and junior scientists and engineers. Training schools have resulted in some students to undertake CCUS studies</p> <p>Increased awareness and technical knowledge of CCUS</p> <p>Provided networking opportunities for students to international experts</p> <p>International experts established wider Chinese networks and better appreciation of Chinese domestic concerns</p>

Study tours (in China)	<p>Cultural exchange</p> <p>Increased awareness and knowledge of facilities and Chinese technological developments and engineering for Australian delegates</p> <p>Enabled a better appreciation of the scale of the climate and air pollution challenge</p>
Study tours (in Australia)	<p>Cultural exchange</p> <p>Increased awareness and knowledge of advanced CCUS scientific research facilities for Chinese delegates</p> <p>Increased awareness of environmental monitoring requirements</p>

6. Next Steps

Building on a decade of success, both the Australian and Chinese governments and CAGS research community desire to continue to work together to continue to advance CCUS. The project structure and funding arrangements for a next phase of CAGS (CAGS Plus) is currently being explored by ACCA21 and Geoscience Australia. There are possible mutual benefits for both countries as we move towards implementing large-scale demonstration projects and full CCUS implementation projects. Australian projects can potentially attract Chinese investment and utilise Chinese technology (especially in capturing CO₂). China can continue to engage with Australian expertise in monitoring, hydrogeology and regulatory frameworks. There are opportunities to undertake research that is not possible in Australia but can be carried out in Chinese facilities (e.g. test measurement of emissions from a leaky CO₂ at a well research site or evaluating storage security above existing geological storage demonstration facilities). If funded, CAGS Plus will offer an opportunity to build on the existing network, transform CAGS into a CCUS knowledge and data sharing platform hub, and undertake joint Australian-Chinese research projects to address some of the knowledge and technology gaps facing both countries.

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