



Hangzhou 23 April 2009 / Jens Hetland

COACH AUTUMN SCHOOL ON CCS IN CHINA

*Topical approach, learning goals and lectures –
12-18 October 2009*



COACH is a Sino-European research project aimed at creating a strong and durable cooperation between China and Europe. Responding to the fast growing energy demand of China, COACH will prepare the ground for new energy technology options that employ CO₂ capture and permanent geological storage (CCS) - including the use of CO₂ for enhanced oil or gas recovery. As such, COACH addresses topics of great importance to future generations in justifying the harnessing of indigenous coal as a compatible option within the growing environmental constraints.

A crucial action of COACH is to identify and rank candidate capture technologies that constitute the best options for China on a short-term basis. This implies conceptual studies and assessment of how related processing technologies are capable of reducing the environmental impact of greenhouse gases, and how they may affect the overall primary energy demand, as well as the capital and operational expenses.

1. CHALLENGE

The climate change issue is coined one of the most severe concerns of our time, and has brought leading nations into ambitious ventures in order to reduce their greenhouse gas emissions. The challenge is to provide enough electric power under a sustainable framework.

However, as so far no technology has been identified as being capable of providing very large quantities of power - on demand – at acceptable cost, fossil fuels are prone to remain the prevalent primary energy source in the foreseeable future. But, in response to the climate change issue, the problem of carbon dioxide emissions that results from the harnessing of fossil fuels must be urgently resolved. In this endeavour it is expected that emerging CCS techniques will become part of the solution.

2. PURPOSE OF THE AUTUMN SCHOOL

The purpose of this *COACH Autumn School on CCS in China* is to offer an arena for knowledge-sharing and learning about near zero-emission power generation from a group of professionals, researchers and scientists involved in international CCS programmes. In this manner understanding and learning will be conveyed of aspects relating to the electric power supply chain from source to demand – including the sink where the CO₂ eventually is to be stored safely for thousands of years.

The *COACH Autumn School of CCS in China* is a replica of a similar COACH event that took place in Hangzhou, China, in April 2009.

In order to be deemed successful knowledge on primary fuel sources and conversion technology will be conveyed. On this background capture techniques and advanced power cycles with options for co-production of chemicals and synthetic fuels will be covered, as well as the isolation and pre-treatment of the carbon dioxide. Furthermore, the linkage to the challenge of identifying, mapping and completing geological storage sites for the CO₂ – either in aquifers, or for the purpose of enhanced oil and gas recovery, will be addressed.

2.1 Objective:

The overall objective of this *COACH Autumn School on CCS in China* is to communicate knowledge and understanding of advanced emerging power cycles and systems that include CCS and geological storage aspects of CO₂ that is required in order to meet the growing demand for near zero emission

electric power generation in the near-to-medium term (say 2015-2020). In this pursuit special emphasis will be placed on the Chinese context.

2.2 Learning targets:

A suitable learning target would comprise several qualities like attitudes, skills and knowledge, as indicated below:

2.2.1 Attitudes;

Implying that each and every student that attends this *COACH Autumn School on CCS in China* is prone to take ownership to the following expressions:

“CCS is

- *topically interesting;*
- *necessary and useful in my future carrier;*
- *enabling me to understand and resolve numerous problems and concerns relating to the climate change issue and the issue of security of energy supply;*
- *representing an important part of the knowledge base that is required to supply modern societies with sufficient electric power and derived fuels within a sustainable framework;*
- *enabling me to read more about CCS and related techniques on my own, and make (by myself) independent and critical assessment of related technical and societal issues.”*

2.2.2 Skills;

Implying that this *COACH Autumn School on CCS in China* shall enable the student to:

- Apply principles, methods and physiochemical approaches on relevant problems;
- Assess alternative techniques and CCS concepts;
- Make appropriate calculations and recommendations

2.2.3 Knowledge;

Implying that the student shall become capable of understanding:

- The basis of thermodynamics pertaining to CCS and make use of this understanding;
- terms and development trends;

- the main elements of prevalent capture concepts;
- the limits to the theoretically possible with relevance to CCS;
- optional (and viable) conversion technologies and advanced gas separation techniques (chemical and physical absorption, adsorption, membranes etc.).
- most relevant aspects concerning the complexity of securing the storage (and use) of the captured CO₂.

3. CURRICULUM:

The *COACH Autumn School on CCS in China* shall provide the theoretical and practical knowledge on CCS and power cycles based on recent international research and development work. Vital elements are:

- Fuels and their properties, including analysis and pre-treatment;
- Energy conversion processes (gasification, reactors, combined cycle power generation; heat exchangers, steam extraction and usage)
- Acid gas removal and CO₂ separation techniques (physical/chemical absorption, adsorption, membrane techniques etc.)
- CO₂ conditioning and specifications thereof;
- Transfer of energy (and carriers) including the transport of CO₂;
- Chemicals and related processes;
- Auxiliary systems.
- Geological storage aspects; identification and mapping of sites, safety aspects, injection and monitoring.

The thematic approach will be lectures, exercises, colloquia, study groups and a common plant visit. Most lectures will be covered by compendia, articles and/or other material that will be made available to the students during the course.

The *COACH Autumn School on CCS in China* will be open during one concentrated week – Monday to Sunday – in October 2009. Key lecturers will be available throughout the entire week, and - as appropriate - take active part in discussions, and otherwise be available upon students' request.

3.1 Language

The official language of the *COACH Autumn School on CCS in China* will be English. This implies that all lectures will be delivered in the English language. It is also expected that the Chinese and European students will spend time together and socialise outside the formal part of the course using

the English language as a platform for communication. This is regarded as a part of networking activities and capacity building.

3.2 Target group

The target group is basically post-graduate students (PhD and PostDoc), academics and professionals from China and Europe working on energy supply systems and related topics, as well as geologists and geophysicists. To some extent also master students may be accepted.

3.3 Application, selection and grants

Students eligible to attend the *COACH Autumn School on CCS in China* will be selected upon qualifications that must be documented in a letter of application (LoA). The LoA should contain name (family name and given names), date and place of birth, citizenship, occupation, and a brief CV. Furthermore, the student should justify his/her interest in CCS and experience (if any) – or otherwise relate the relevance to other topics of his/her studies.

The attendance will be free of charge. However, in order to receive the *COACH Studies Diploma* students have to attend the classroom sessions, and take active part in resolving of all exercises.

Direct expenses for travel and subsistence will be carried by the COACH project. It is required, however, that economy class/lowest fares are chosen. European student may apply for a one month visa in due time.

3.3.1 Due date and application

The due date for submitting the application is **30 June 2009**. This will give the European students the required time to apply for visa and order economy-class air tickets.

Preferably the letter of application should include recommendations from a mentor or supervisor (if any). The application must be sent electronically to Ms Bodil J. Saetherskar via

e-mail: bodil.j.satherskar@sintef.no,

and must be received no later than 16 pm Central European time on the due date. Please mark the subject field: COACH Autumn School on CCS in China - application

4. SCHEDULE

COACH - Autumn School on CCS in China

Venue: China University of Petroleum, Beijing, China

Time: Monday 12 to Sunday 18 October 2009

Programme

Sunday, 11 Oct	
09:00 - 22:00	Registration
18:00 - 21:00	Dinner
Monday, 12 Oct	
Plenum sessions	
09:00 - 09:15	Welcome address and introduction NN
09:15 - 10:00	Setting the scene; Global trends and growing concerns - Flash-light session on power generation, GHG emissions and challenges of the future & Prof. Li Zheng, Tsinghua University Jens Hetland, SINTEF Energy Research
10:00 - 10:30	Coffee/tea break discussion
10:30 - 11:00	Financial issues linked with the reduction of greenhouse gas emissions Damien Navizet & Olivier Grandvoinet, Agence Francaise de Developpement (AFD)
11:00 - 13:00	Joint colloquium 6-8 groups Facilitators: Mengxiang Fang, Zhejiang University & Nicolas Maurand, IFP & Peter Frykman, GEUS & Prof. Li Zheng & Jens Hetland, SINTEF Energy Research & Damien Navizet & Olivier Grandvoinet, Agence Francaise de Developpement (AFD)
13:00 - 14:00	Lunch break (Zhi Jin Ting, 4th Floor)
14:00 - 16:00	Joint colloquium (continued) 6-8 groups
16:00 - 16:30	Coffee/tea break discussion
16:30 - 17:00	Reporting and discussion on how to adjust or adapt, resolve and act with regards to GHG emissions Presented by one spokesperson per group
17:00 - 17:15	Concluding day 1 Li Zheng, Tsinghua University & Jens Hetland, SINTEF Energy Research
18:00 - 20:00	Reception
Tuesday, 13 Oct	
Capture	Storage
09:00 - 10:00	Survey of advanced power cycles in the context of clean coal (1) Professor Li Zheng, Tsinghua University & Jens Hetland, SINTEF Energy Research
10:00 - 10:30	Site selection criteria Ceri Vincent, BGS & Professor Bo Peng, China University of Petroleum
Coffee/tea break	
10:30 - 11:45	Survey of advanced power cycles in the context of clean coal (2) Professor Li Zheng, Tsinghua University & Jens Hetland, SINTEF Energy Research
11:45 - 13:00	Screening and capacity estimates of regional basins. Sedimentary basins - Aquifers (1) Ceri Vincent, BGS & Nicolas Maurand, IFP
13:00 - 14:00	Simple CO2 calculations of emissions with reference to world standards in power generation Prof. Li Zheng, Tsinghua University & Jens Hetland, SINTEF Energy Research & Hanne Kvamsdal, SINTEF
14:00 - 15:00	Screening and capacity estimates of regional basins. Sedimentary basins - Aquifers and oilfields (2) Ceri Vincent, BGS & Nicolas Maurand, IFP & Bo Peng CUP Beijing
Lunch break	
14:00 - 15:00	Main principles for CCS. Details on post combustion capture Professor Menxiang Fang, Zhejiang University & Prof Li Zheng & Hanne Kvamsdal, SINTEF
15:00 - 15:30	Capacity estimates discussion including options for EOR / ECBM Professor Bo Peng, China University of Petroleum Nicolas Maurand, IFP & Ceri Vincent, BGS
Coffee/tea break discussion	
15:30 - 16:30	Exercise 1: On post combustion capture - colloquium Facilitators: Prof Li Zheng, Tsinghua University & Hanne Kvamsdal, SINTEF & Professor Menxiang Fang, Zhejiang University
16:30 - 18:00	Exercise 1: On capacity estimates (Case story) - colloquium Facilitators: Ceri Vincent, BGS & Nicolas Maurand, IFP
16:30 - 18:00	Colloquium (students work on their own on resolving the problems of the exercise)
18:00 - 20:00	Colloquium (students work on their own)
Dinner	

Wed, 14 Oct		Capture	Storage
09:00 - 09:45		Summarising the previous day Student report/presentation - one per group	Summarising the previous day Student report/presentation - one per group
09:45 - 10:30		Principles of pre-combustion capture and polygeneration <i>Xu Shisen, TPRI & Jens Hetland, SINTEF Energy Research, & Hanne Kvamsdal, SINTEF</i>	Mapping (Case story) - Geophysical background. Assessment of CO2 storage in oil-bearing reservoirs and CO2/EOR <i>Ceri Vincent, BGS & Professor Bo Peng, China University of Petroleum</i>
10:30 - 11:00	Coffee/tea break discussion		
11:00 - 13:00		Cost assessment of pre-combustion capture (European cases) <i>Hanne Kvamsdal, SINTEF</i> and Large-scale production of oxygen and gas purification <i>Marie-Khuny Khy, Air Liquide</i>	New seismic data - Well data - Implication of well data. Reservoir geometry (static model) <i>Peter Frykman, GEUS & Niels Erik Poulsen, GEUS & Professor Bo Peng, China University of Petroleum</i>
13:00 - 14:00	Lunch break		
14:00 - 15:00		Exercise 2: On pre-combustion capture and polygeneration Facilitators: <i>Xu Shisen, TPRI & Gao Lin, IET-CAS & Hanne Kvamsdal, SINTEF & Jens Hetland, SINTEF Energy Research</i>	Exercise 2: Site selection & characterisation methods Facilitators: <i>Peter Frykman, GEUS & Niels Erik Poulsen, GEUS & Professor Bo Peng, China University of Petroleum</i>
15:00 - 15:30	Coffee/tea break discussion		
15:30 - 17:30	Colloquium work in groups		Colloquium work in groups
17:30 - 20:00	Dinner		
Thur, 15 Oct			
		Capture (No1 Meeting Room, 2nd Floor)	Storage (No2 Meeting Room, 1st Floor)
09:00 - 09:45		Summarising the previous day Student report/presentation - one per group	Summarising the previous day Student report/presentation - one per group
09:45 - 10:30		Yields and options with polygeneration concepts using CCS <i>Gao Lin, Institute of Engineering Thermophysics, Chinese Academy of Sciences</i>	Geochemistry fluid/rock <i>Professor Bo Peng, China University of Petroleum & NN</i>
10:30 - 11:00	Coffee/tea break discussion		
11:00 - 13:00		Oxy combustion <i>Professor Menxiang Fang, Zhejiang University & Jens Hetland, SINTEF Energy Research</i> and Emerging techniques; Chemical looping combustion and near zero emission system' CCS technical routes suitable for China <i>Professor Hongguang Jin, Institute of Engineering Thermophysics, Chinese Academy of Sciences (IET-CAS) & Lin Gao, IET-CAS & Professor Zhongqiang Luo, Zhejiang University</i>	Dynamic behavior and risk elements. Physical parameters. <i>Peter Frykman, GEUS & Niels Erik Poulsen, GEUS & Nicolas Maurand, IFP</i>
13:00 - 14:00	Lunch break		
14:00 - 15:00		Exercise 3 relating to oxy combustion and emerging techniques Facilitators: <i>Professor Hongguang Jin/Lin Gao, Institute of Engineering Thermophysics, Chinese Academy of Sciences & Professor Mengxiang Fang, Zhejiang University</i>	Exercise 3: Developing the reservoir model Facilitators: <i>Peter Frykman, GEUS & Niels Erik Poulsen, GEUS & Nicolas Maurand, IFP & Professor Bo Peng, China University of Petroleum</i>
15:00 - 15:30	Coffee/tea break discussion		
15:30 - 17:30	Colloquium work		Colloquium work
17:30 - 20:00	Dinner		

Friday, Fri 16 Oct		Common event	
09:00 - 12:00	Plant visit		
12:00 - 13:00			
13:00 - 14:00	Lunch break (Shao Ye Fu Restaurant)		
14:00 - 18:00			
19:00 - 22:00	Common social event to be organised by the students Surprise sessions		
Saturday, 17 Oct		Capture	Storage
09:00 - 09:45	Summarising the last colloquium work Student report/presentation - one per group	Summarising the last colloquium work Student report/presentation - one per group	
09:45 - 10:30	The water-balance issue pertaining to power generation with CCS Hanne Kvamsdal, SINTEF & Jens Hetland, SINTEF Energy Research &	Case story from European CCS projects relating to the oil and gas industry: • Example (1) from Sleipner and Snøhvit fields - the practical approach Szczepan Polak, NTNU & Peter Frykman, GEUS	
10:30 - 11:00	Coffee/tea break discussion		
11:00 - 13:00	Principles for benchmarking of CCS technologies Hanne Kvamsdal, SINTEF and Example of CO2 transport by tank and pipes including the impacts of impurities Mengxiang Fang, Zhejiang University & Jens Hetland, SINTEF Energy Research	• Example (2) from Northern European pilot injection project. Peter Frykman, GEUS Niels Erik Poulsen, GEUS	
13:00 - 14:00	Lunch break		
14:00 - 15:00	Industrial actions in China and Europe - status report on CCS Gao Lin, IET- CAS & Professor Mengxiang Fang, Zhejiang University & Jens Hetland, SINTEF		
15:00 - 15:30	Coffee/tea break discussion		
15:30 - 19:00	No further activity planned this day		
19:00 - 22:00	Banquette		
Sunday, 18 Oct		Plenary	
09:00 - 09:45	Policy issues: What can China do next? Jens Hetland		
09:45 - 10:30	Broad discussion on CCS bringing up other topics than technical Four students to raise the issue based on the first colloquium on Monday		
10:30 - 11:00	Coffee/tea break discussion		
11:00 - 11:45	'Financing processes relating to infrastructures, the power sector and the implementation of CCS. Paul de la Guerivière, Agence Francaise de Developpement (AFD)		
11:45 - 12:30	'The importance of pursuing greener energy technologies. On order of magnitudes with regards to CCS costs, and what difficulties may result from financing large-scale CCS projects Olivier Grandvoinet, Agence Francaise Developpement (AFD)		
12:30 - 13:00	Summarising and concluding the Summer School on CCS in China Prof. NN China University of Petroleum & Peter Frykman, GEUS & Jens Hetland, SINTEF Energy Research & Student representative of China & Student representative of Europe		
13:00 - 14:00	Lunch break		
End			