



Trondheim 30 May 2008 / Jens Hetland

## **COACH SUMMER SCHOOL ON CCS IN CHINA**

*Topical approach, learning goals and lectures –  
15-21 September 2008*

COACH Project

Location: Hangzhou, China, hosted by the Zhejiang University

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 CO<sub>2</sub> capture and permanent geological storage (CCS) - including the use of CO<sub>2</sub> 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 SUMMER SCHOOL**

The purpose of this *COACH Summer 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 CO<sub>2</sub> eventually is to be stored safely for thousands of years.

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 CO<sub>2</sub> – 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 Summer 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 CO<sub>2</sub> 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 pursue 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 Summer 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 Summer 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 CO<sub>2</sub>.

### 3. CURRICULUM:

The *COACH Summer 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 CO<sub>2</sub> separation techniques (physical/chemical absorption, adsorption, membrane techniques etc.)
- CO<sub>2</sub> conditioning and specifications thereof;
- Transfer of energy (and carriers) including the transport of CO<sub>2</sub>;
- 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 Summer School on CCS in China* will be open during one concentrated week – Monday to Sunday – in September 2008. 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 Summer School on CCS in China* will be English. This implies that all lectures will be delivered in the English language.

#### 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.

### 3.3 Selection and grants

Students eligible to attend the *COACH Summer School on CCS in China* will be selected upon qualifications that must be duly documented in the application.

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.

#### 3.3.1 Due date and application

The due date for submitting the application is by 30 June 2008. The application letter should include a CV and recommendations from a mentor or supervisor (if any). The forms will be sent electronically to Bodil Saetherskar,

e-mail: [bodil.j.satherskar@sintef.no](mailto: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 Summer School on CCS in China - application

## 4. SCHEDULE

<b>Monday</b>	
09:00- 9:15	<b>Welcome and introduction</b> <i>Francois Kalaydjian, IFP</i>
09:15-10:00	<b>Setting the scene; Global trends and growing concerns - Flash-light session on power generation and challenges of the future</b> <i>Tore Torp, StatoilHydro &amp; Jens Hetland, SINTEF Energy Research &amp; Xu Shisen, TPRI</i>
10:00-10:30	<b>Coffee/tea break discussion</b>
10:30-13:00	<b>Joint colloquium</b> 6-8 groups Facilitators: <i>Tore Torp, StatoilHydro &amp; Francois Kalaydjian, IFP</i> <i>Jens Hetland, SINTEF Energy Research</i>
13:00-14:00	<b>Lunch break</b>
14:00-15:00	<b>Joint colloquium (continued)</b> 6-8 groups
15:00-15:30	<b>Coffee/tea break discussion</b>
15:30-17:15	<b>Reporting and discussion on how to adjust or adapt, resolve and act with regards to GHG emissions</b> Presented by one spokesperson per group
17:15-17:30	<b>Concluding day 1</b> <i>Tore Torp, StatoilHydro</i>

<b>Tuesday</b>	
09:00-10:00	<p><b>Survey of advanced power cycles in the context of clean coal (1)</b> Jens Hetland, SINTEF Energy Research &amp; Professor Li Zheng, Tsinghua University &amp; NN, TPRI</p>
	<p><b>Site selection criteria</b> Ceri Vincent, BGS &amp; Tore Torp, StatoilHydro &amp; Professor Li Mingyuan, China University of Petroleum</p>
10:00-10:30	<b>Coffee/tea break</b>
10:30-11:15	<p><b>Survey of advanced power cycles in the context of clean coal (2)</b> Jens Hetland, SINTEF Energy Research &amp; Professor Li Zheng, Tsinghua University &amp; Dr. Xu Shisen, TPRI</p>
	<p><b>Screening and capacity estimates of regional basins. Sedimentary basins - Aquifers (1)</b> Ceri Vincent, BGS &amp; Francois Kalaydjian, IFP &amp; Tore Torp, StatoilHydro</p>
11:15-13:00	<p><b>Simple CO2 calculations of emissions with reference to world standards in power generation</b> Jens Hetland, SINTEF Energy Research &amp; Augustin Guillemont, Air Liquide &amp; Dr. Xu Shisen, GreenGen</p>
	<p><b>Screening and capacity estimates of regional basins. Sedimentary basins - Aquifers (2)</b> Ceri Vincent, BGS &amp; Francois Kalaydjian, IFP &amp; Tore Torp, StatoilHydro</p>
13:00-14:00	<b>Lunch break</b>
14:00-15:00	<p><b>Main principles for CCS. Details on post combustion capture</b> Professor Menxiang Fang, Zhejiang University &amp; Jens Hetland, SINTEF Energy Research &amp; Augustin Guillemont, Air Liquide</p>
	<p><b>Capacity estimates discussion including options for EOR / ECBM</b> Professor Li Mingyan, China University of Petroleum &amp; Francois Kalaydjian, IFP &amp; Ceri Vincent, BGS</p>
15:00-15:30	<b>Coffee/tea break discussion</b>
15:30-17:30	<p><b>Exercise 1: On post combustion capture - colloquium</b> Facilitators: Jens Hetland, SINTEF Energy Research &amp; Augustin Guillemont, Air Liquide &amp; Professor Menxiang Fang, Zhejiang University</p>
	<p><b>Exercise 1: On capacity estimates (Case story) - colloquium</b> Facilitators: Ceri Vincent, BGS &amp; Francois Kalaydjian, IFP &amp; Professor Li Mingyan, China University of Petroleum</p>
<b>Wednesday</b>	
09:00-09:45	<p><b>Summarising the previous day</b> Student report/presentation - one per group</p>
	<p><b>Summarising the previous day</b> Student report/presentation - one per group</p>
09:45-10:30	<p><b>Principles of pre-combustion capture</b> Professor Li Zheng, Tsinghua University &amp; Jens Hetland, SINTEF Energy Research, &amp; Dr. Xu Shisen, TPRI</p>
	<p><b>Mapping (Case story) - Geophysical background</b> Ceri Vincent, BGS &amp; Professor Li Mingyuan, China University of Petroleum</p>
10:30-11:15	<b>Coffee/tea break discussion</b>
11:15-13:00	<p><b>Yields and options with polygeneration</b> Professor Li Zheng, Tsinghua University &amp; Jens Hetland, SINTEF Energy Research &amp; NN, GreenGen</p>
	<p><b>New seismic data - Well data - Implication of well data. Reservoir geometry (static model)</b> Peter Frykman, GEUS &amp; Carsten Moller Nielsen, GEUS &amp; Professor Li Mingyan, China University of Petroleum &amp; Tore Torp, StatoilHydro</p>
13:00-14:00	
14:00-15:00	<p><b>Exercise 2: On pre-combustion capture and polygeneration</b> Facilitators: Professor Li Zheng, Tsinghua University &amp; Dr. Xu Shisen, TPRI &amp; Jens Hetland, SINTEF Energy Research</p>
	<p><b>Exercise 2: Site selection &amp; characterisation methods</b> Facilitators: Peter Frykman, GEUS &amp; Carsten Moller Nielsen, GEUS &amp; Professor Li Mingyan, China University of Petroleum &amp; Tore Torp, StatoilHydro</p>
15:00-15:30	<b>Coffee/tea break discussion</b>
15:30-17:30	<b>Colloquium work in groups</b>
	<b>Colloquium work in groups</b>
<b>Thursday</b>	
09:00-09:45	<p><b>Summarising the previous day</b> Student report/presentation - one per group</p>
	<p><b>Summarising the previous day</b> Student report/presentation - one per group</p>
09:45-10:30	<p><b>Principles of oxy combustion</b> Professor Menxiang Fang, Zhejiang University &amp; Jens Hetland, SINTEF Energy Research &amp; NN</p>
	<p><b>Geochemistry fluid/rock</b> Francois Kalaydjian, IFP &amp; Professor Li Mingyan, China University of Petroleum &amp; NN</p>
10:30-11:15	<b>Coffee/tea break discussion</b>
11:15-13:00	<p><b>Emerging techniques; Chemical looping combustion and near zero emission system'</b> Professor Hongguang Jin / Lin Gao, Institute of Engineering Thermophysics, Chinese Academy of Sciences &amp; Professor Zhongyang Luo, Zhejiang University &amp; NN</p>
	<p><b>Dynamic behavior and risk elements. Physical parameters</b> Peter Frykman, GEUS &amp; Carsten Moller Nielsen, GEUS &amp; Francois Kalaydjian, IFP &amp; Professor Li Mingyan, China University of Petroleum &amp; Tore Torp, StatoilHydro</p>
13:00-14:00	<b>Lunch break</b>
14:00-15:00	<p><b>Exercise 3 relating to oxy combustion and emerging techniques</b> Facilitators: Professor Hongguang Jin/Lin Gao, Institute of Engineering Thermophysics, Chinese Academy of Sciences &amp; Jens Hetland, SINTEF Energy Research &amp; Professor Zhongyang Luo, Zhejiang University</p>
	<p><b>Exercise 3: Developing the reservoir model</b> Facilitators: Peter Frykman, GEUS &amp; Carsten Moller Nielsen, GEUS &amp; Francois Kalaydjian, IFP &amp; Professor Li Mingyan, China University of Petroleum &amp; Tore Torp, StatoilHydro</p>
15:00-15:30	<b>Coffee/tea break discussion</b>
15:30-17:30	<b>Colloquium work</b>
	<b>Colloquium work</b>

<b>Friday</b>	
Excursion to a neighbouring power facility and an area of particular interest for geological storage (if appropriate)	
'No further work this day	
<b>Saturday</b>	
09:00-09:45	<p><b>Summarising the last colloquium work</b> Student report/presentation - one per group</p> <p><b>CO2 handling with emphasis on pre-conditioning, compression and pumping for export of liquid CO2</b> Augustin Guillemont, Air Liquide &amp; Jens Hetland, SINTEF Energy Research &amp; NN</p>
09:45-10:30	<p><b>Summarising the last colloquium work</b> Student report/presentation - one per group</p> <p><b>Case story from European CCS projects relating to the oil and gas industry:</b> • Example (1) from Sleipner and Snøhvit fields - the practical approach Tore Torp, StatoilHydro</p>
10:30-11:15	<b>Coffee/tea break discussion</b>
11:15-13:00	<p><b>CO2 transport by tank and pipes including the impacts of impurities</b> Augustin Guillemont, Air Liquide &amp; Tore Torp, StatoilHydro &amp; Jens Hetland, SINTEF Energy Research</p> <p>• Example (2) from Northern European pilot injection project. Peter Frykman, GEUS Carsten Moller Nielsen, GEUS</p>
13:00-14:00	<b>Lunch break</b>
14:00-15:00	<b>Industrial actions in China and Europe - status report on CCS</b> Professor Menxiang Fang / Professor Luo Zhongyang, Zhejiang University & NN
15:00-15:30	<b>Coffee/tea break discussion</b>
15:30-17:30	<b>Common social event to be organised by the students (surprise sessions)</b>
<b>Sunday</b>	
09:00-09:45	<b>Policy issues</b> Tore Torp, StatoilHydro & Professor Jin Hongguang, Institute of Engineering Thermophysics, Chinese Academy of Sciences
09:45-10:30	<b>Societal aspects pertaining to CCS</b> Francois Kalaydjian, IFP & Jens Hetland, SINTEF Energy Research & NN
10:30-11:00	<b>Coffee/tea break discussion</b>
11:00-11:45	<b>Public concerns and public acceptance</b> Francois Kalaydjian, IFP & Professor Li Mingyan, China University of Petroleum
11:45-13:00	<b>Policy recommendations and road mapping</b> Tore Torp, StatoilHydro & Professor Li Mingyan, China University of Petroleum
13:00-14:00	<b>Lunch break</b>
14:00-15:00	<b>Summarising and concluding the Summer School on CCS in China</b> Jens Hetland, SINTEF Energy Research & Francois Kalaydjian, IFP