# CO2 storage potential and source-sink matching for Guangdong, southern China

#### 广东省陆海二氧化碳封存潜力和源汇匹配研究

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# Guangdong is among the most industrialized province in China

- Area 180 000 km<sup>2</sup>, residents 95 million;
- 2008 GDP ~357 b €, #1 in China, among which ~50% comes from industry;



图1 1978-2008年地区生产总值及其增长速度

#### Guangdong determined to go low carbon, but CCS was not considered

- Low-carbon economy has been included in the "Action Plan for Implementing the <Pearl River Delta reform & Development Plan (2008-2020)>" of the provincial Science and Technology Department.
- However, this is primarily focused on renewable energy development and energy efficiency improvement. CCS is not included.



# IGGC power plants are in planning, but CO2 storage was not considered



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# **Projects**

• **PACOS**: Preliminary Assessment of CO2 Storage Capacity in Guangdong and Offshore (2009)

Funded by: British Consulate-General Guangzhou

 GDCCSR: Guangdong CCS Readiness Study (2010-2013)

#### — Funded by:

#### **British Consulate-General Guangzhou Global CCS Institute**



## **Project implementers**

- South China Sea Institute of Oceanology, CAS, Di Zhou
- Guangzhou Institute of Energy Conservation, CAS, Dai-Qing Zhao
- Energy Research Institute, NDRC, Qiang Liu
- Institute of Rock and Soil Mechanics, CAS, Xiao-Chun Li
- LinksChina Investment Advisory Ltd, Shenzhen, Jia Li
- Edinburgh Univ., Dr. Jon Gibbins
- Cambridge Univ., Dr. Xi Liang



# **Target of GDCCSR**

To promote CCS and CCR in Guangdong through answering the questions of

- If Guangdong needs CCS in her road to low-carbon economy ?
- How can and how much the cost ?



# Task 2. Estimate storage capacity inland & offshore GD

- Estimate storage capacity inland GD
  - Sanshui Basin; Maoming Basin
- Estimate storage capacity offshore GD
  - Pearl River Mouth Basin, Qiongdongnan Basin, Yinggehai Basin, Beibuwan Basin
- Identify early opportunities and prospective areas





Basins inland Guangdong are small & with low storage capacity



- Large oil/gas-bearing sedimentary basins exist in northern South China Sea;
- This implies large capacity for CO2 storage in deep saline formations and depleted oil/gas fields.

#### Preliminary Assessment of CO2 Storage Capacity in Sanshui Basin and Pearl River Mouth Basin





# **The Sanshui Basin**



- A basin of 3400 km<sup>2</sup> in the Pearl River Delta
- Effective capacity very small (~20 Mtco<sub>2</sub>)
- Poor reservoirs: small, low porosity and permeability
  - Chances as test site for technical development



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# **The Pearl River Mouth Basin**

- Total area ~200,000 km2
- Maximum sediment thickness >14 km
- The largest basin in N. South China Sea
- Proximal to industrialized areas



#### **Structure and data points**



# Stratigraphic column

#### **Potential reservoir:**

- \* M. Miocene Zhujiang Fm.
- \* L. Miocene Hanjiang Fm.
- \* U. Oligocene Zhuhai Fm.

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#### **Isopach maps**



### **Isopach of** formations below 800m sub-seafloor

116'00'E

150 200 km

Isopach of Lower to Middle Miocene

Below 800 Meters From Seafloor



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Thickness (m)

5500-6000

4800-5500

4300-4800

3700-4300

3200-3700

2700-3200

2200-2700

1700-2200

1300-1700

1000-1300

600-1000

300-600

0-300

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#### **Contouring geothermal gradient based on well data**

#### **Capacity assessment for**

#### saline formations of the Pearl River Mouth Basin

Parameter		LM. Miocene	Paleogene	Total		
Volume below 800m $V(m^3)$		187000×109	164000×109			
Net/Gross ratio <i>R</i>		0.5	0.37			
Average porosity $\phi$		0.2 0.1				
$CO_2$ density $\rho_{CO_2}(t/m^3)$		Table 4	Table 4			
Effective capacity (t), >800 m	<i>E</i> =0.01	86×10 <sup>9</sup>	32×10 <sup>9</sup>	118×10 <sup>9</sup>		
	<i>E</i> =0.024	225×10 <sup>9</sup>	83×10 <sup>9</sup>	<b>308×10</b> <sup>9</sup>		
	<i>E</i> =0.04	345×10 <sup>9</sup>	128×10 <sup>9</sup>	473×10 <sup>9</sup>		
Effective capacity (t), 800~2500 m	<i>E</i> =0.01	71×10 <sup>9</sup>	10×10 <sup>9</sup>	81×10 <sup>9</sup>		
	<i>E</i> =0.024	184×10 <sup>9</sup>	26×10 <sup>9</sup>	210×10 <sup>9</sup>		
	<i>E</i> =0.04	284×10 <sup>9</sup>	40×10 <sup>9</sup>	324×10 <sup>9</sup>		



# Effective capacity in oil/gas fields of the Pearl River Mouth Basin

Parameter	Value
OOIP (t)	$0.9  imes 10^9$
Oil density (t/m³)	0.9
Recovery rate R <sub>f</sub>	0.5
Volume factor B <sub>f</sub>	1.03
$CO_2$ density $(t/m^3)$	0.566
Efficiency factor E	0.25
Capacity (t)	$0.06  imes 10^9$

Controlled storage capacity of 60 MtCO2





- Promising area 150~300 km from the Pearl River Delta;
- Promising reservoirs: Lower & Middle Miocene sandstones & limestones

If 10% of the effective storage capacity may be used, then the PRMB has the capacity to store <u>190 year emissions</u> (at 2006 level) from Guangdong.





# **3. Potential Storage Site**



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LF2G1

- Faulted dome, area ~160 km<sup>2</sup>
- ~200 km off Hongkong
- Two seal-aquifer assemblages
- Aquifer: delta front & shallow marine sandstone



China Au Data source: CNOOC 22 中澳二氧化碳地质封存





#### Two Aquifers

	Upper	Lower
Thickness (m)	73.5	120
Net/Gross	0.87	0.84
Porosity (%)	9~30	21~27
Permeability (mD)	80~700	80~700
Seal thickness (m)	>50	6 (??)

#### Potential capacity >300 Mt



中澳二氧化碳地质封存

Data source: CNOOC

Æ

de

(0)

SE

**T**40

1250

1500

1750

2000

2250

Shenzhen

### **Offshore storage vs. onshore**

Merits:

- Land saving;
- No damage to ground water;
- Low environmental impact;
- (for China) Good marine facies aquifers.

#### Defects:

• High cost of infrastructure, operation, and monitoring.



#### Maturity:

- The maturity of offshore CO2 storage is NOT lower than onshore storage.
- In the world, 3 out of 5 existing large CCS projects using offshore storage:
  - Sliepner, 1 MtCO2/yr since 1996;
  - Snøvit, 0.7 MtCO2/yr since 2008;
  - Gorgen, 3.4 MtCO2/yr to be started in 2014.

(Weyburn, 0.8 MtCO2/yr since 2000) (In Salah, 1.2 MtCO2/yr since 2004)





#### **Offshore CO2 storage is** crucial for SE China !

- Chinese offshore basins are of high prospectivity for CO2 storage !
- This matches nicely the large emission sources along the coastal SE China.
- Offshore storage is • perhaps the only hope for CCS in **Guangdong!**

age of CO<sub>2</sub>

#### Early opportunities for CO2 storage Offshore southern China !

- By utilizing existing data, platform and other facilities, the cost of CO2 injection may be greatly reduced.
- Early planning is the key !



