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Getting Ready for Carbon Capture and Storage in China

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Content

- Chinese key stakeholders' views on CCS
- Value and financial issues of Capture Ready investment in China
- Overview of current CCS activities in China

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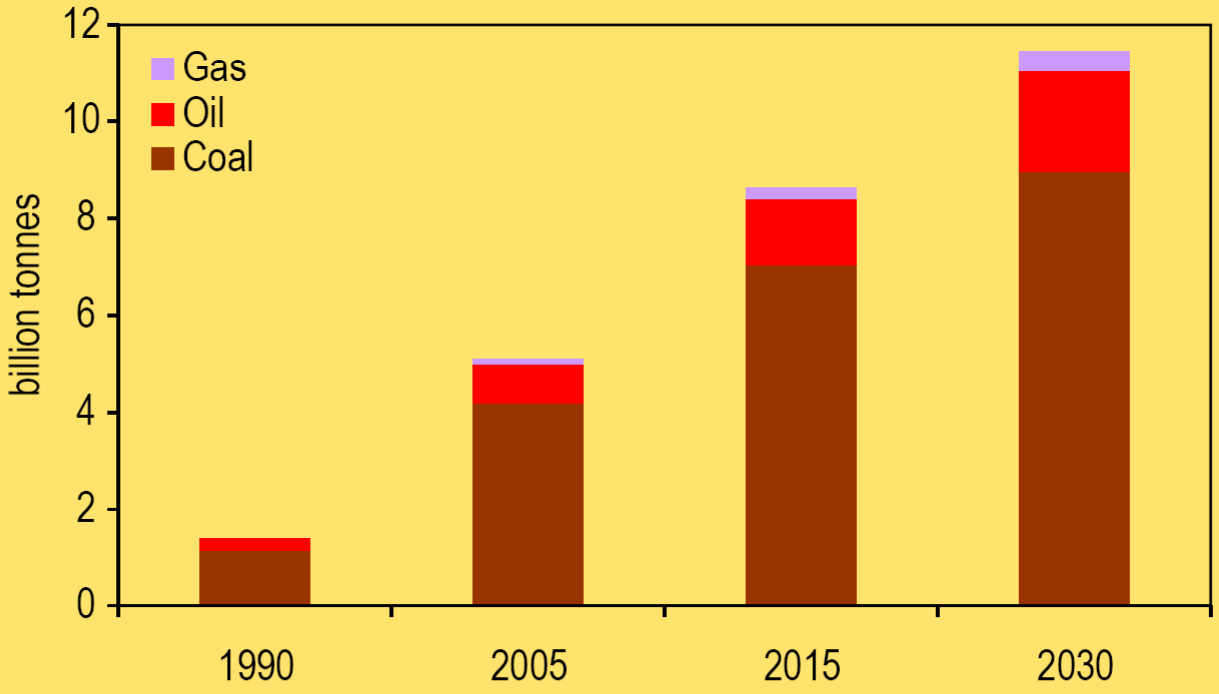
INTERNATIONAL ENERGY AGENCY

WORLD ENERGY OUTLOOK 2007

China and India Insights

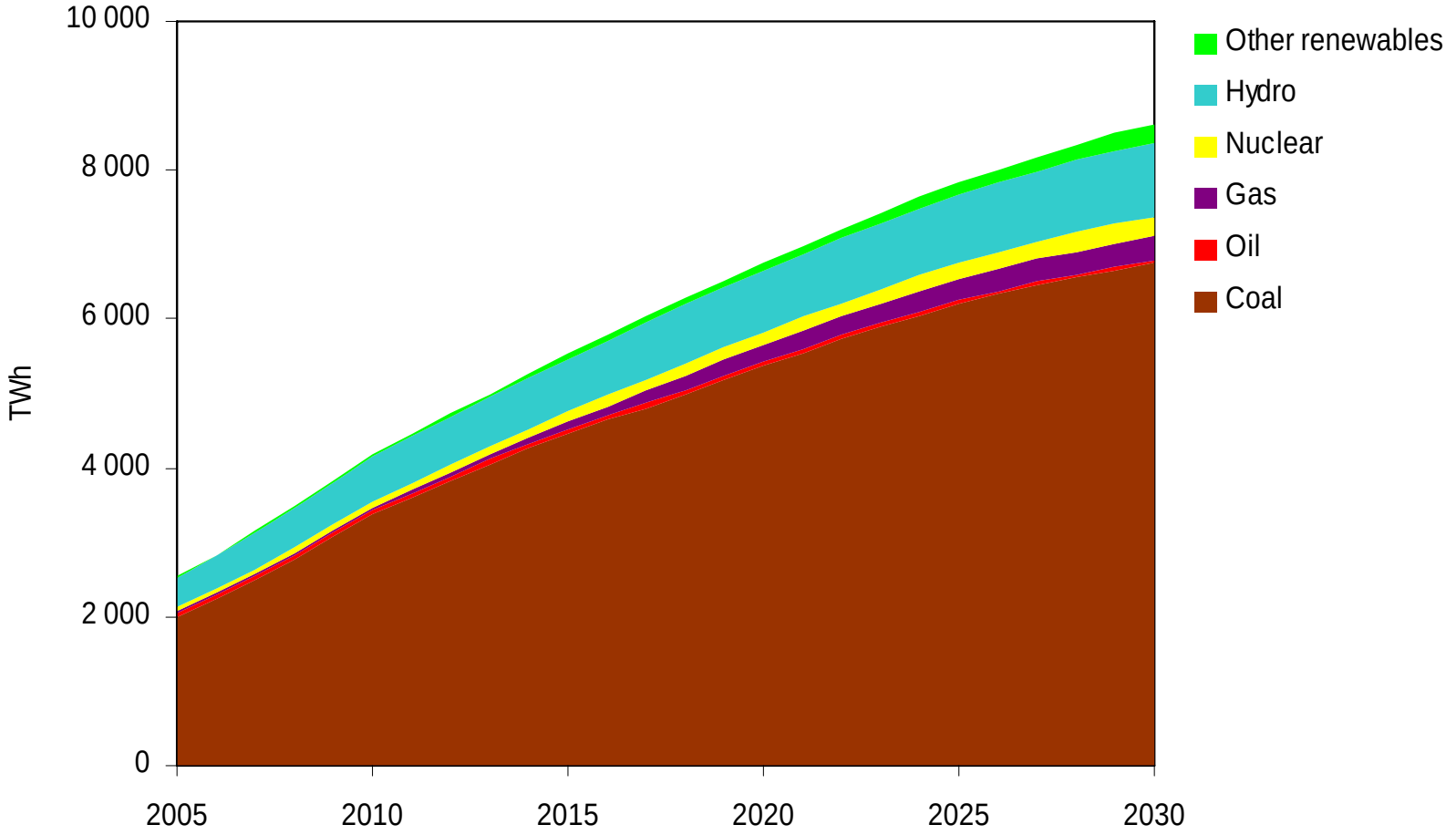
Nobuo Tanaka
Executive Director
International Energy Agency
Beijing, 9 November 2007

China's Energy-Related CO_2 emissions



Emissions soar from 5 Gt in 2005 to 11 Gt in 2030, though they remain below current OECD levels in per-capita terms

The Forecast of Electricity Generation in China



Source: IEA, 2007

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Analysis of Key Stakeholder Opinions on CCS in China

- Collaborate with Chinese institutions (CASS, CCII, SCUT) with minimal prior involvement with CCS issues
- Design Chinese-language questionnaire using mixed questionnaire (both open-ended and close-ended questions)
- Focus on Beijing (both national and regional), Wuhan and Pearl River Delta Regions
- Interview over 130 pre-selected key stakeholders in autumn 2006

Source: Reiner et al, 2007

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CASS (Beijing, Wuhan)

Cambridge, CCII (National)

SCUT (Pearl River Delta)

Source: Reiner et al, 2007

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Perceptions on Climate Change, Policies, Technologies

77% identified Climate Change as a serious problem for China

47% perceived current policies could lower emissions in 20 years

91% believed technologies were important in reducing emissions

Source: Reiner et al, 2007

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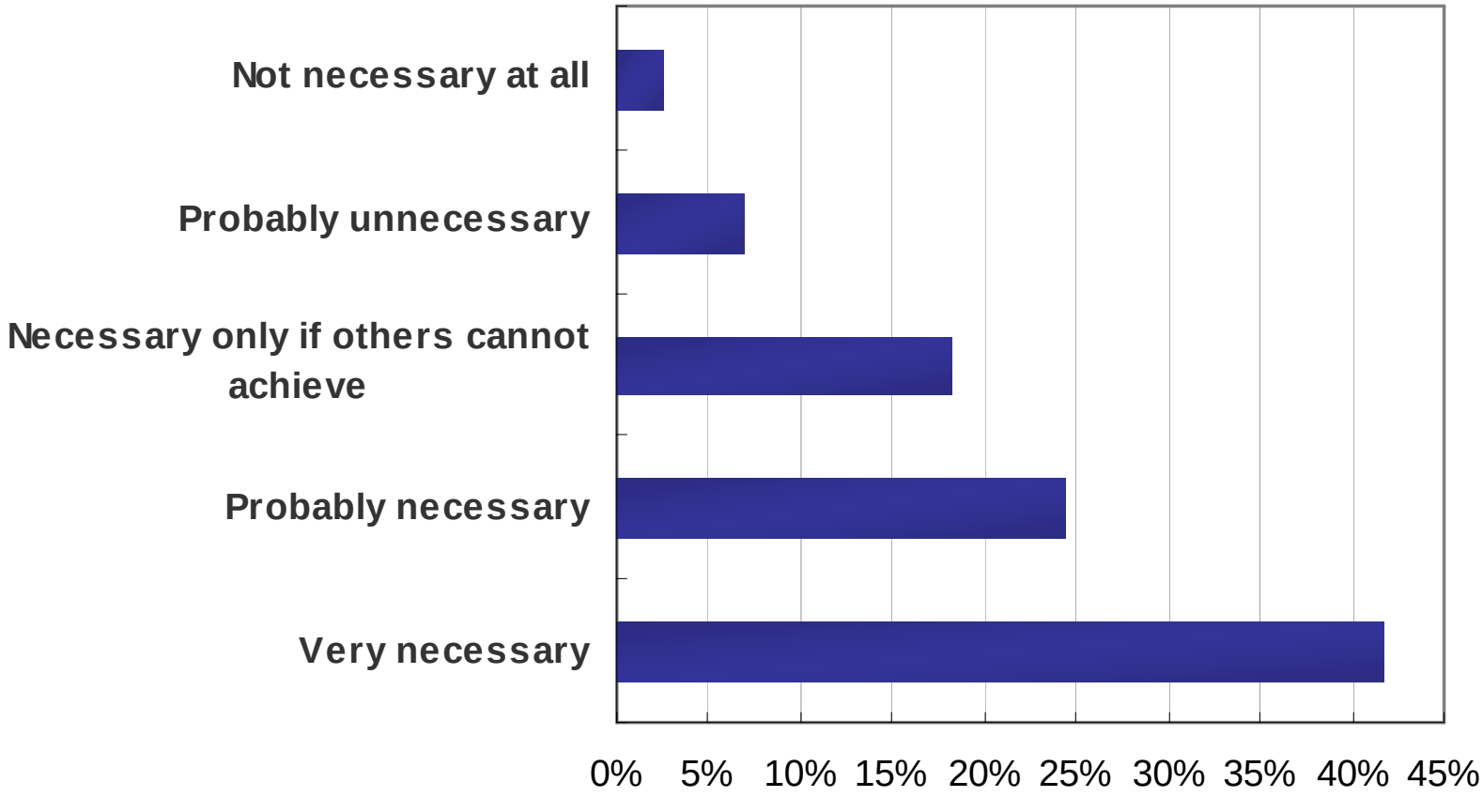
Necessity of CCS for Large GHG Emissions Reductions



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Source: Reiner et al, 2007

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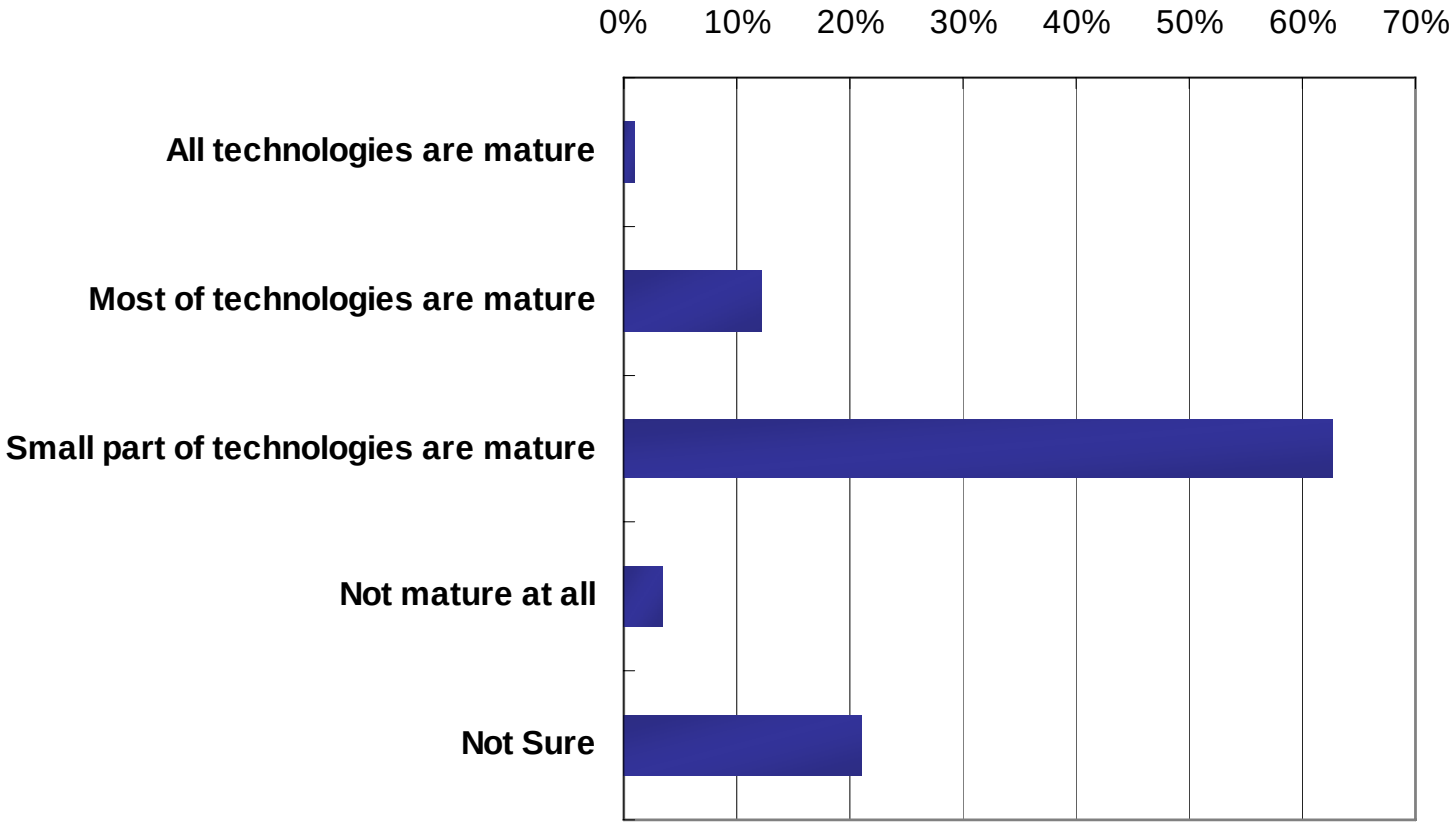
Views on Status of CCS Technologies



Source: Reiner et al, 2007

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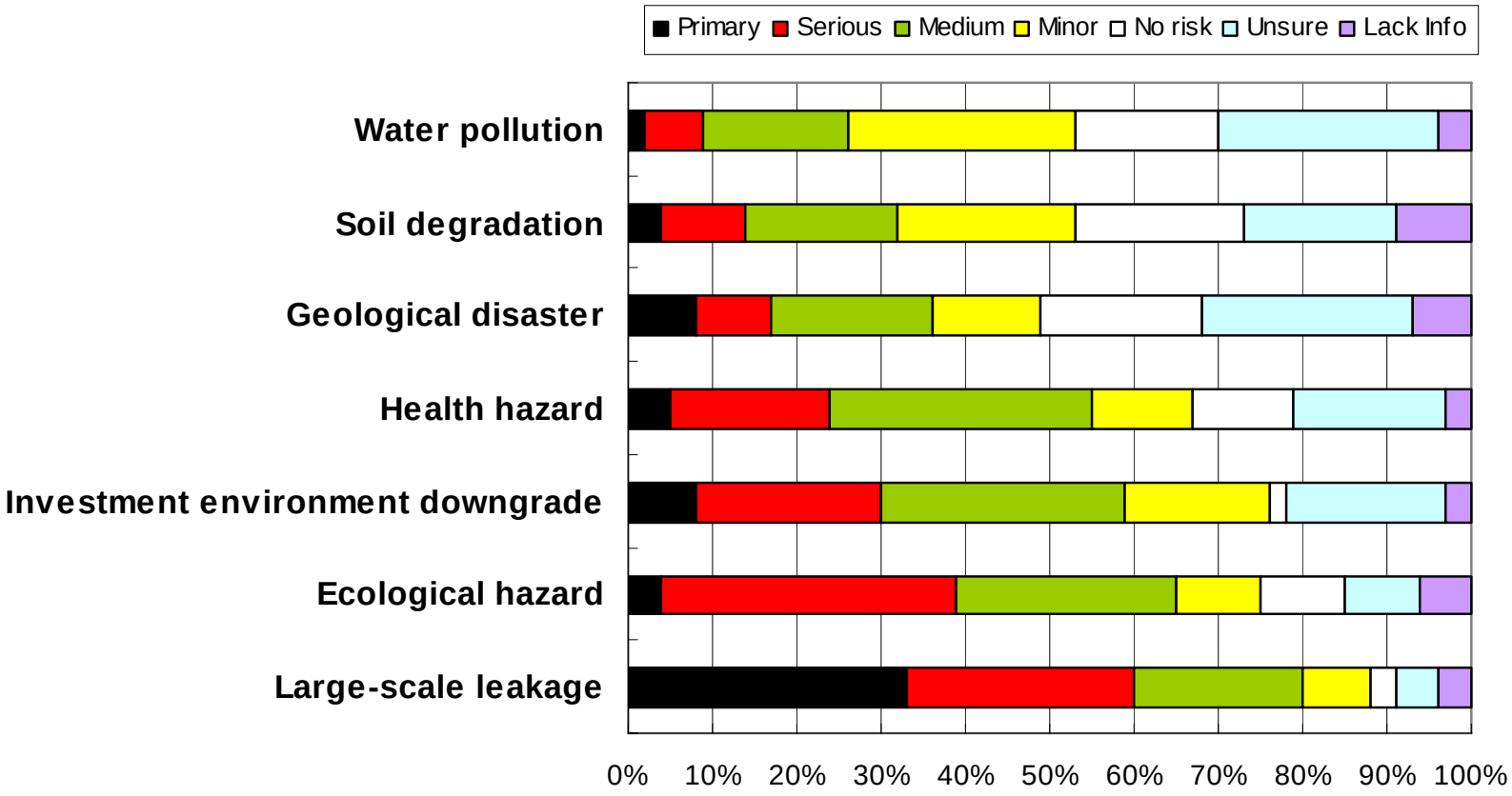
Perceptions of Potential Risk Factors



Source: Reiner et al, 2007

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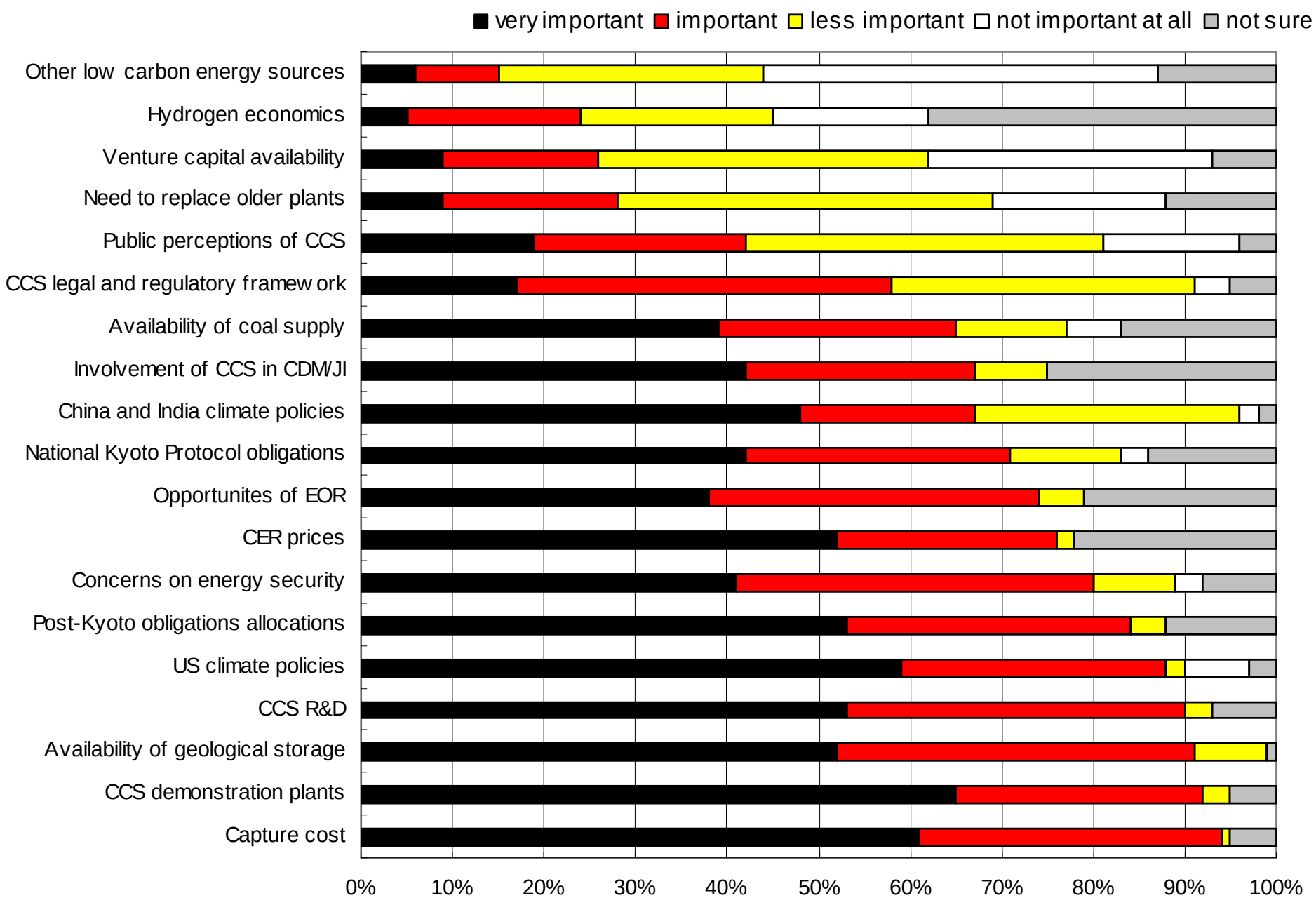
Importance of issues to the Development of CCS



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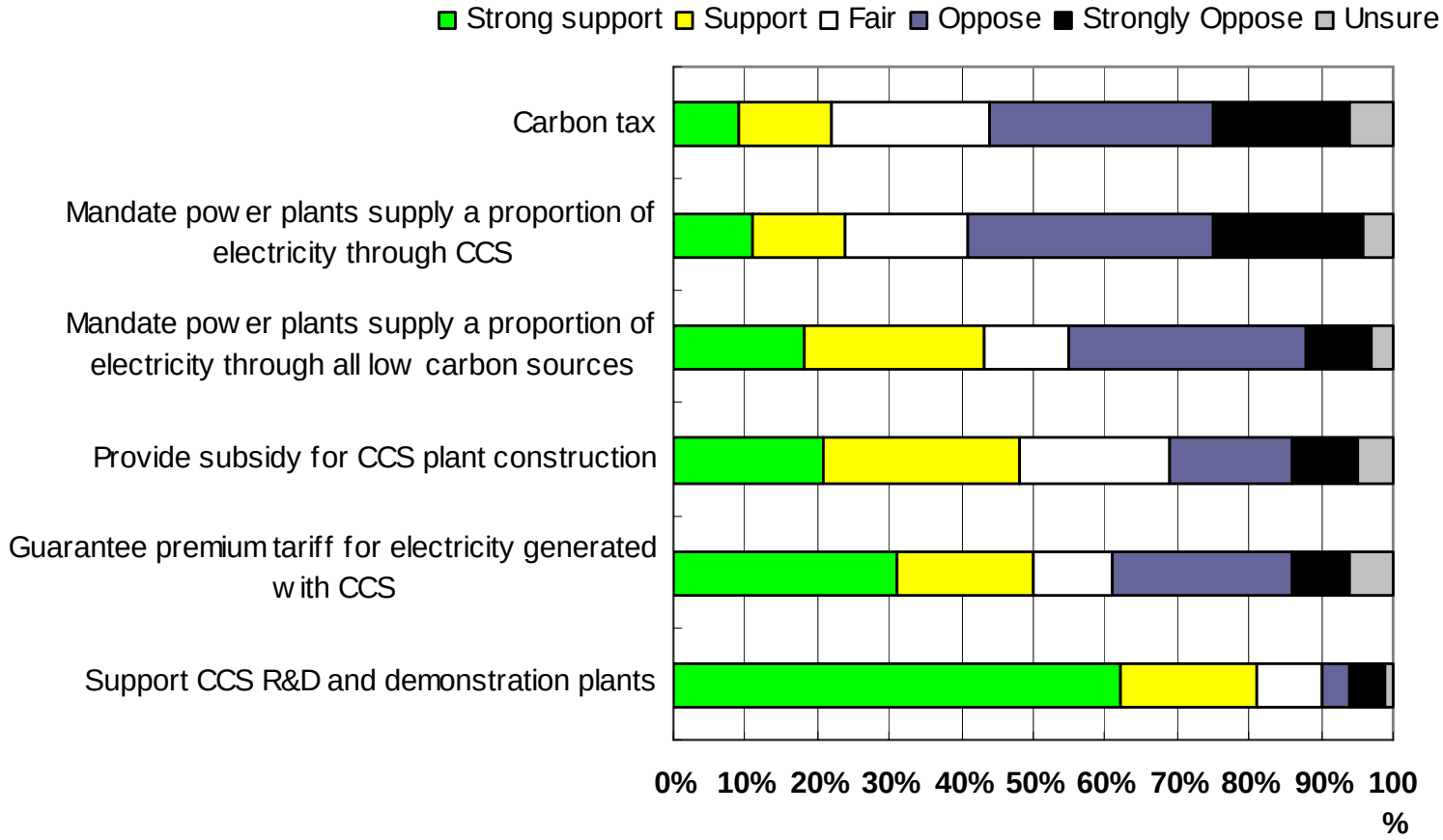
Views on Potential Mechanisms to Promote CCS



Source: Reiner et al, 2007

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Comparisons of Key Stakeholders Opinions – EU and China

	*EU**	*China*[#]
Needs of CCS for CO_2 Deep Cut Globally	**82%** necessary or probably	**66%** necessary or probably
Support for R&D and demonstration	**89%** like it a lot or somewhat	**81%** strong support or support
Views of CCS upon Energy Security	**Mostly increasing**	**Overwhelmingly reducing**

***Source: Shackley et al, 2007**

[#]Source: Reiner et al, 2007

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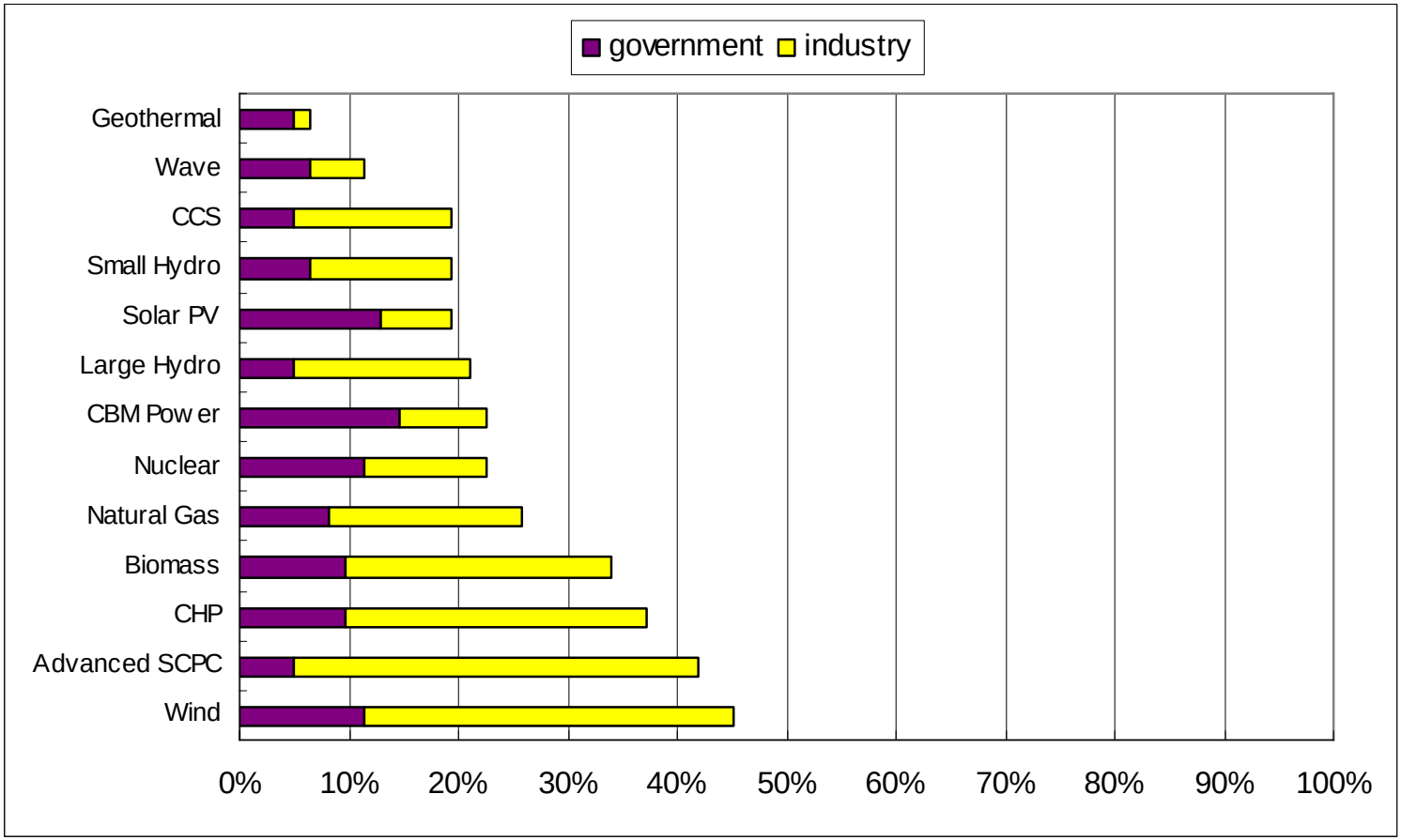
Attractiveness of CCS vs. Alternatives – 2007 survey of 62 Chinese stakeholders



Financing Lower Carbon Electricity in China - *Liang X, Reiner D, Neuhoff K, Cheng C*

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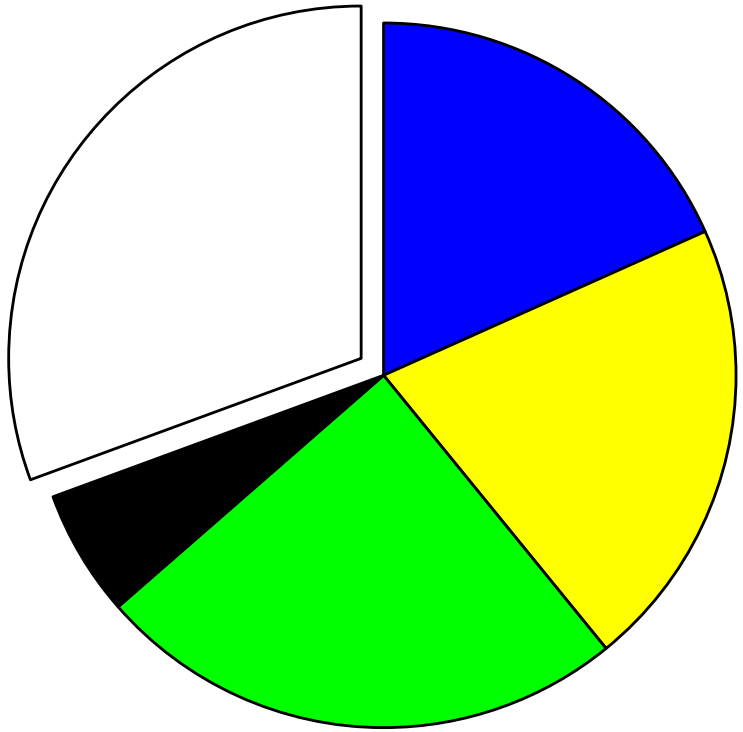
Opinions on Potential Capture Ready Support Scheme



Source: Reiner et al, 2007

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IEA Capture Ready Requirements

- A clearly identified strategy by which a credible capture technology can be fitted to the plant
- Space available both within and around the plant to permit the capture technology to be fitted
- A credible route for captured CO2 to be removed from site and sent to storage

Source: IEA, 2007

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Tllbury 2x800 MW Capture Ready Photo Montage

Source: Gibbins 2008, quoted from Hotchkiss, 2007

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TIlbury 2x800 MW Capture Ready Photo Montage

Source: Gibbins 2008, quoted from Hotchkiss, 2007

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Views on Capture Ready Investment by nine senior financial officials in Chinese power companies

- Policy Risk
- Uncertain about the technical impact of Capture Ready design
- Rising fuel cost impairs the value of Capture Ready
- **<u>High ability but low willingness</u> to pay for Capture Ready**

Source: Reiner et al, 2007

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In China, Capture Ready was viewed as crucial but hampered by a lack of incentives and policy support

- No current mechanism for generating carbon credits – CCS not currently allowed in CDM
- No domestic policy support to-date – focus restricted to R&D
- 'snake-bike effect' – industry reluctant based on experience with FGD-ready in 1990s

Source: Reiner et al, 2007

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If new plants have a low probability of retrofitting to CCS in future, selling the option of capturing CO_2 in the future to investors can generate additional income and has potential environmental benefit. The option is called Capture Option.

Source: Liang et al, 2006

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Capture Option Rationales

- Financing Capture Ready Investment
- Optimizing Capture Ready Decisions
- Invest in CCS without Linking to Power Plant Investment
- Additional Cash Infusion to Power Firms
- Political Leverage
- Academic and Research benefit

Source: Liang et al, 2006

Pricing Capture Ready and Capture Option

- Construct a comprehensive cash flow model
- Backward deduction methodology
- Use Monte-Carlo simulation to estimate outcomes in various scenarios
- Assume a plant built in 2010 and starting operation in 2012
- Consider inflation, tax, load factor, Chinese power despatch policy
- Performance and some cost data is obtained from Chinese firms and public domain
- Estimate fuel and carbon (CER) price based on historical information, adjusted by current market opinions

Source: Liang et al, 2006

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Scenarios Assumptions Briefing

	HO	*LO*	*HP*	*LP*
Construction Cycle	3 years	3 years	2 years	3 years
Capacity Load before Capture	Low	High	High	Low
Capacity Load after Capture	High	Low	High	Low
Transport, Monitor, Storage Cost	0.6	16.3	0.6	16.3
Basic Inflation	1.5%	4.5%	4.5%	1.5%
Carbon Prices Growth	8%	4.5%	4.5%	8%
Capture Ready Benefit	High	Low	High	Low

HO: High Option value scenario; LO: Low option value scenario;

HP: High project value scenario; LP: Low project value scenario;

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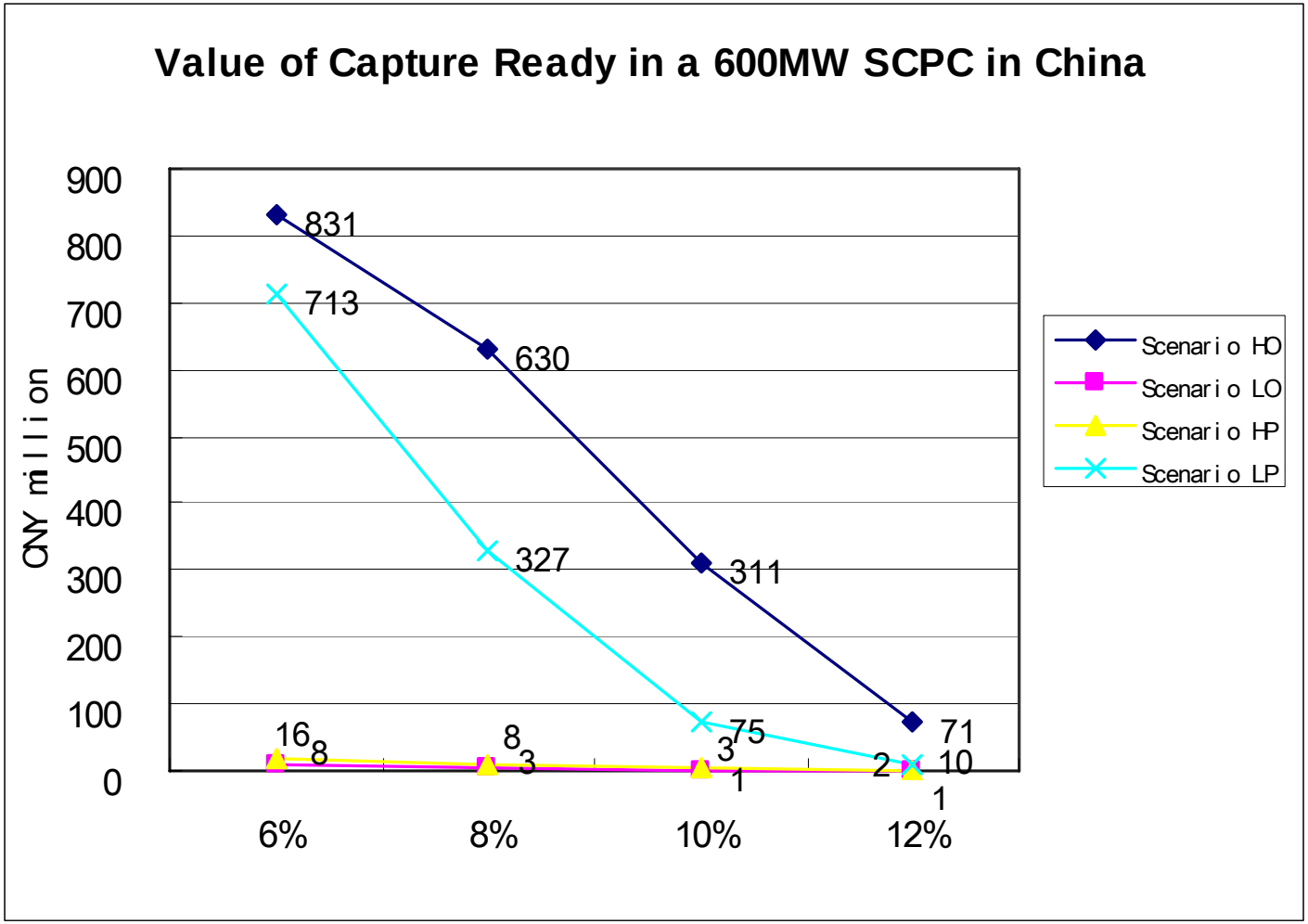

Financing Capture Ready Coal Fired Power Plants in China by Issuing Capture Options:
Liang X, Reiner D, Gibbins J, Li J

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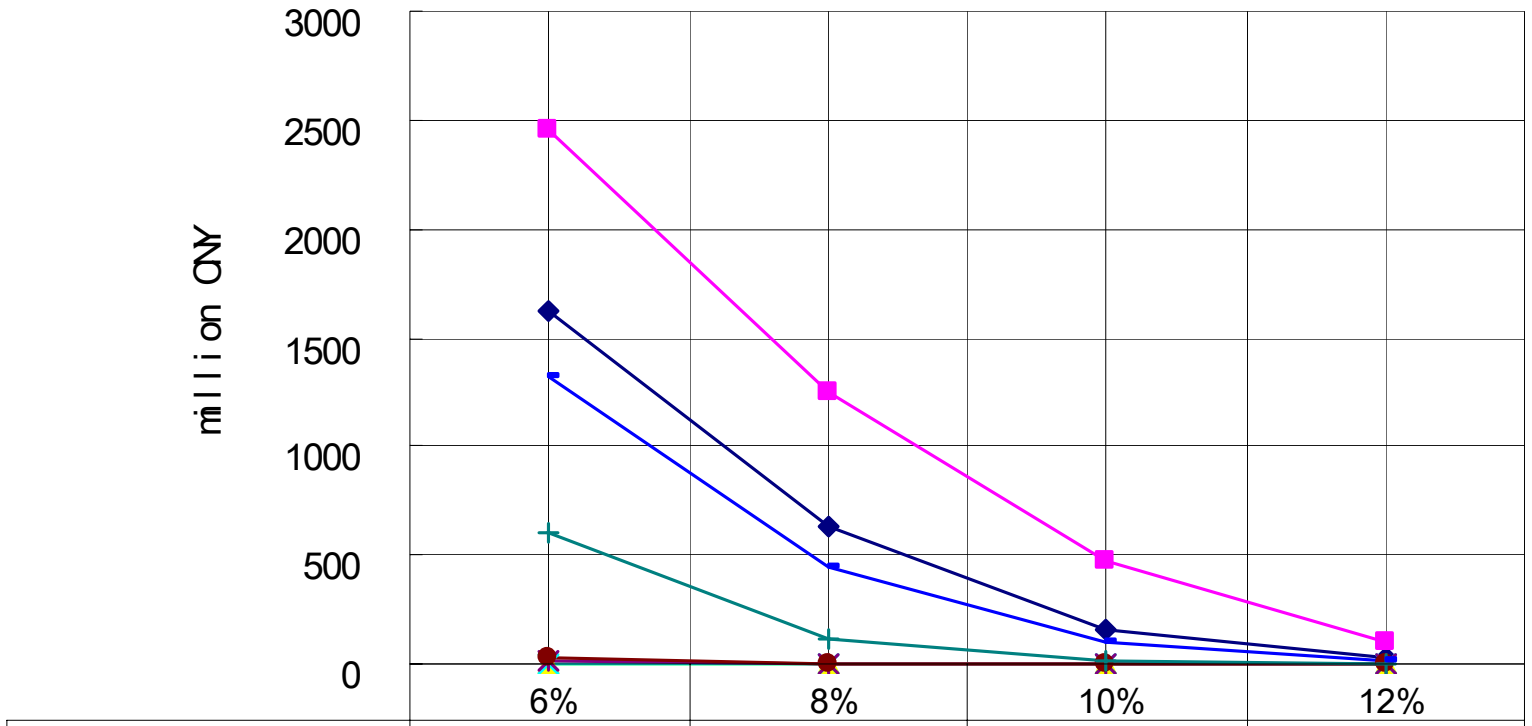
Value of Capture Option under different scenarios



	6%	8%	10%	12%
Scenario HO_nCR	1625	627	153	22
Scenario HO_CR	2451	1255	471	97
Scenario LO_nCR	3	1	1	0
Scenario LO_CR	7	2	1	0
Scenario HP_nCR	10	2	2	0
Scenario HP_CR	25	7	5	2
Scenario LP_nCR	609	113	16	0
Scenario LP_CR	1326	439	99	11

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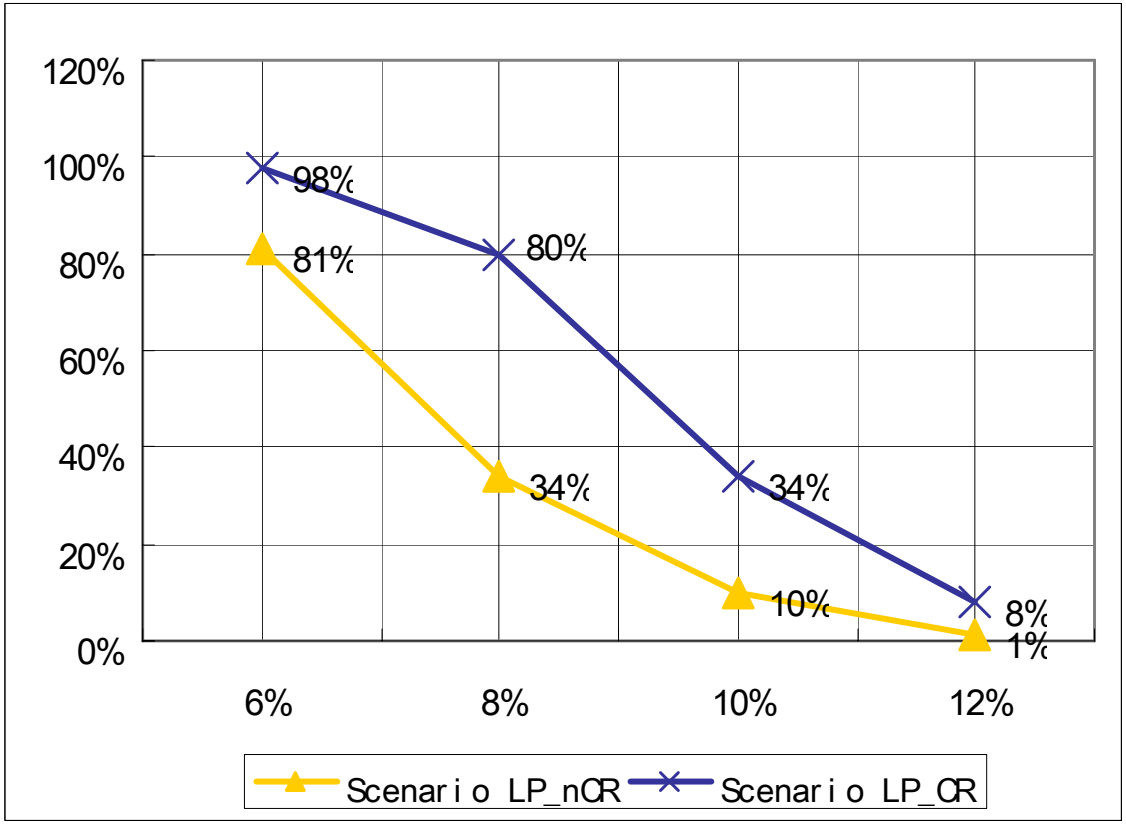
Cumulative Retrofitting Probabilities



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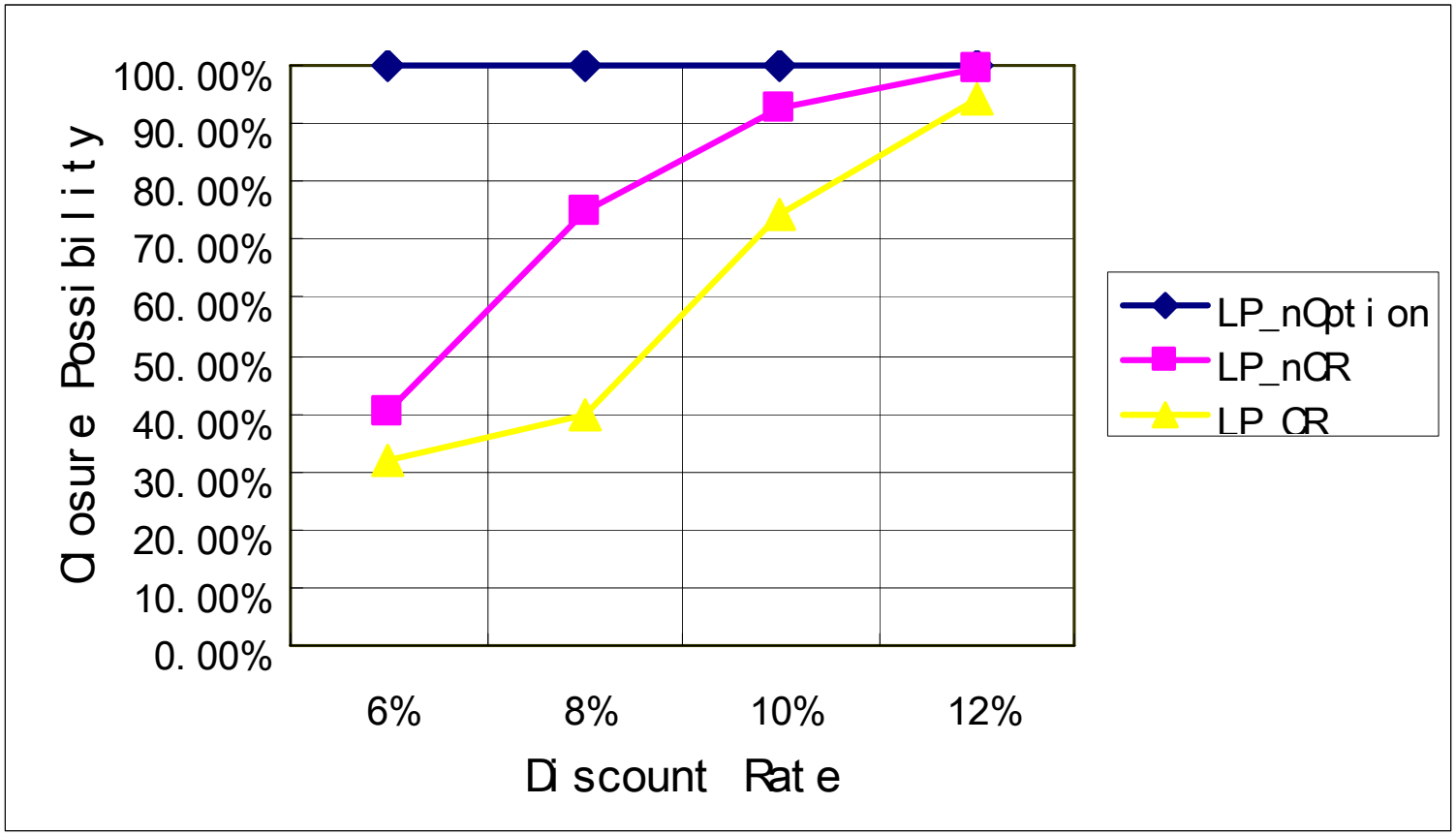
Probability of Closure in High Carbon Price and high fuel cost Scenario



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The retrofitting option is a valuable 'asset', while Capture Ready is an important investment opportunity.

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Limitations and Scope for Future Work

- Stakeholder Weighting & Bias – impossible to assign a weight to each stakeholder or correct for missing stakeholder bias
- Risk of Incorrect Input Assumptions
- Should fit the model with scenarios of climate policies, carbon prices and technology learning curves
- Have not yet considered various scenarios of Chinese electricity market reform, which may have significant impact on the results
- Should improve decision functions based on more realistic behavioural patterns and frameworks

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Overview of CCS Activities in China

- GREENGEN program led by China Huaneng Group (CHNG)
- A few enhanced oil recovery (EOR) and enhanced coal bed methane (ECBM) projects
- CCS was integrated into *National Medium and Long Term Science and Technology Development Plan towards 2020*
- China-EU-UK Near Zero Emissions Coal (NZEC) Demonstration Initiative
- COACH (CCS cooperation Action within China-EU)
- STRACO (EU FP7)
- China – Australia Huaneng CSIRO Post-combustion Capture Demo
- UK-China CAPPCCO project – Focus on Capture Ready

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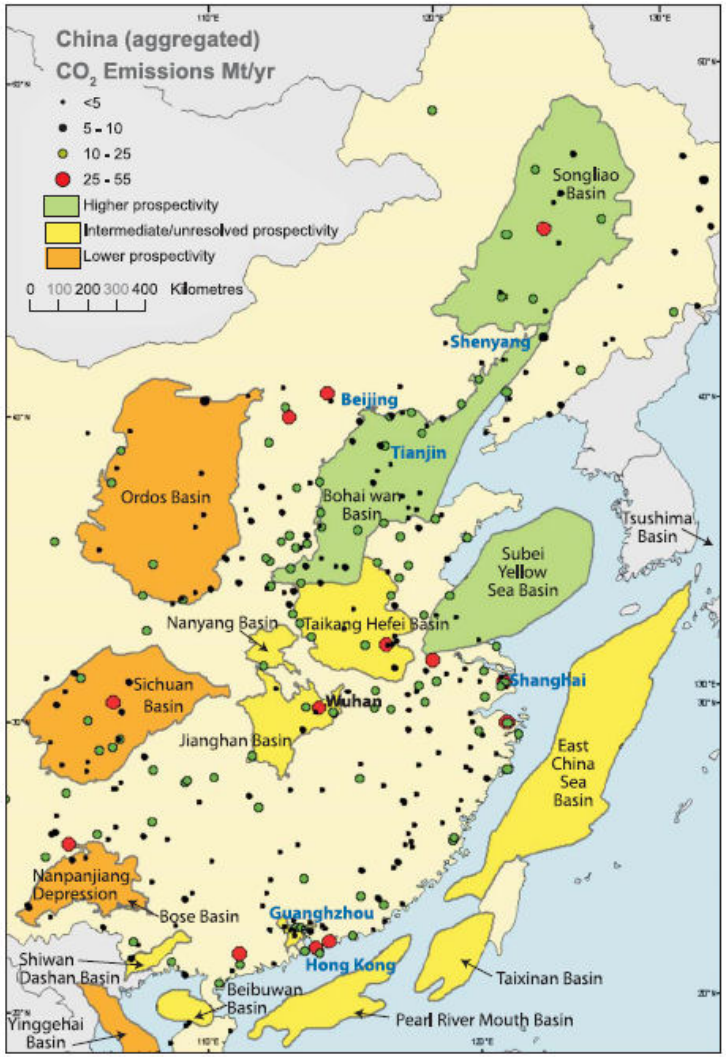
CO_2 storage prospectivity of selected sedimentary basins in China and SE Asia

- Oil Fields including enhanced recovery
- Enhanced Coal Bed Methane
- Saline Aquifers

Capacities of oil and gas fields and coal beds are limited relative to emissions, so saline aquifers are the main prospect for large-scale CO_2 storage in China.



Source: APEC, 2005

Conclusions

- Most Chinese key stakeholders believe CCS necessary to mitigate greenhouse gas emissions but over two thirds perceive CCS technologies as fairly risky and only partially mature. Energy penalty and security is a main concern.

- Analysis suggests that in absence of subsidies or mandates, new plants that currently do not have retrofitting plans to CCS, issue Capture Options to finance and optimize Capture Ready

- China is developing a number of its own CCS research (and potentially commercial) projects as well as being actively involved in international collaborations

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Comments and feedbacks welcome

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