CAGS Technical Workshop

Canberra 18th – 22nd January 2010

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DEFINING STORAGE READY

Purpose of session
分组会议的目的

- Engage and elicit comments
- Consider issues raised in other presentations
- Identify what is reality now
  - Technically & commercially
  - Policy & regulatory & legal
- What is required for future
- Stimulate thoughts for Panel Session (afternoon)
  - “Are China and Australia Storage Ready?”

Who are CGSS ?

- CGSS = CO_2 Geological Storage Solutions
- CO_2 geological storage services firm
- Provide geoscience advice for geological storage of CO_2: Technical, Legal, Regulatory, Strategic
- Assist in deployment of geological storage at industrial scale: Regional Assessment, Prospect Exploration, Site Injection
- Combined 60 years experience in CO_2 storage
- Main Office in Canberra- with Associates and Alliances nationally (Perth, Melbourne, Adelaide, Brisbane) and Internationally

Storage Ready questions ?

*储存就绪*涉及到的疑问

- How do we define Storage Ready?
  - And implement Storage Ready?
- When is a geological storage site Storage Ready?
  - How much drilling and modelling required?
- Are there other technical issues to consider?
  - Monitoring, long term sustainability
- Are there stages of Storage Ready?
  - Milestones, levels of proof and certainty
- Are there advanced technologies that may affect Storage Ready?
- Or is it just a policy matter – not technical?

Is "Storage Ready" simply knowing / believing you have a *viable* and *nearby* sedimentary basin

"储存就绪"是否仅仅意味着知道和相信你已经有了一个可行的和近距离的沉积盆地？


How much detailed geological knowledge would qualify?
需要多少详细的地质知识你就够资格了？
•Extensive广泛的
•Thick深厚的
•Reservoirs储存层
•Seals密封
•Faults裂隙缺陷
•Migration Pathways
迁移路径

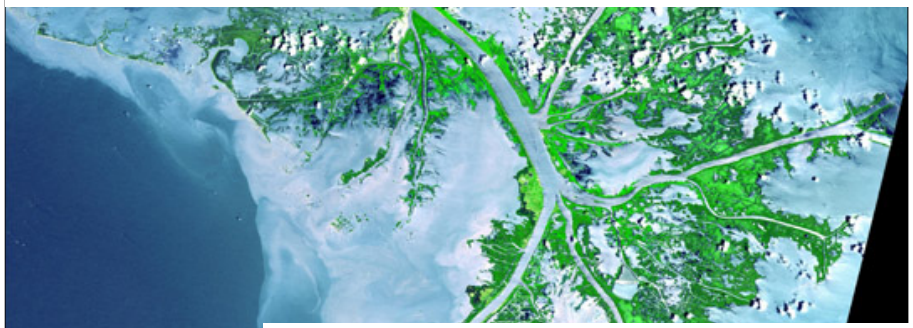
What data sets do you need to have?

你需要具有哪些数据库？

How much money will it cost to qualify?
需要花费多少资金来获取合格的资质

Are some geological solutions / sites going to be a lot better, more manageable, than others

存在一些地质解决方案和场所比其他的方案和场所更好和更易操控管理吗？



-and how do we predict in advance –

- 此外，我们如何提前预知呢？ -


How big is the challenge ?
面临的挑战有多大?
Are we ready & prepared?
我们真的就绪和准备好了吗?
Commercially & technically?
我说的是在经济和技术两方面上

Reservoir Pressure Build up: considerations

储存地层压力蓄积：需要考虑的方面

- Will impact across all aspects of geological storage
  - Technically
  - Legally
  - Regulatory
  - Commercially

Depositional Environments
沉积环境

- Understanding reservoir and seal heterogeneity will influence numerous outcomes
  - Technical
  - Commercial

- **…… this is just doing our homework properly – normal business practices**
- **– or is it**

It is not normal Power or Coal industry practices

但对电力或煤碳工业而言，它却不是业内的常规实践

How do we make the technology transfer happen

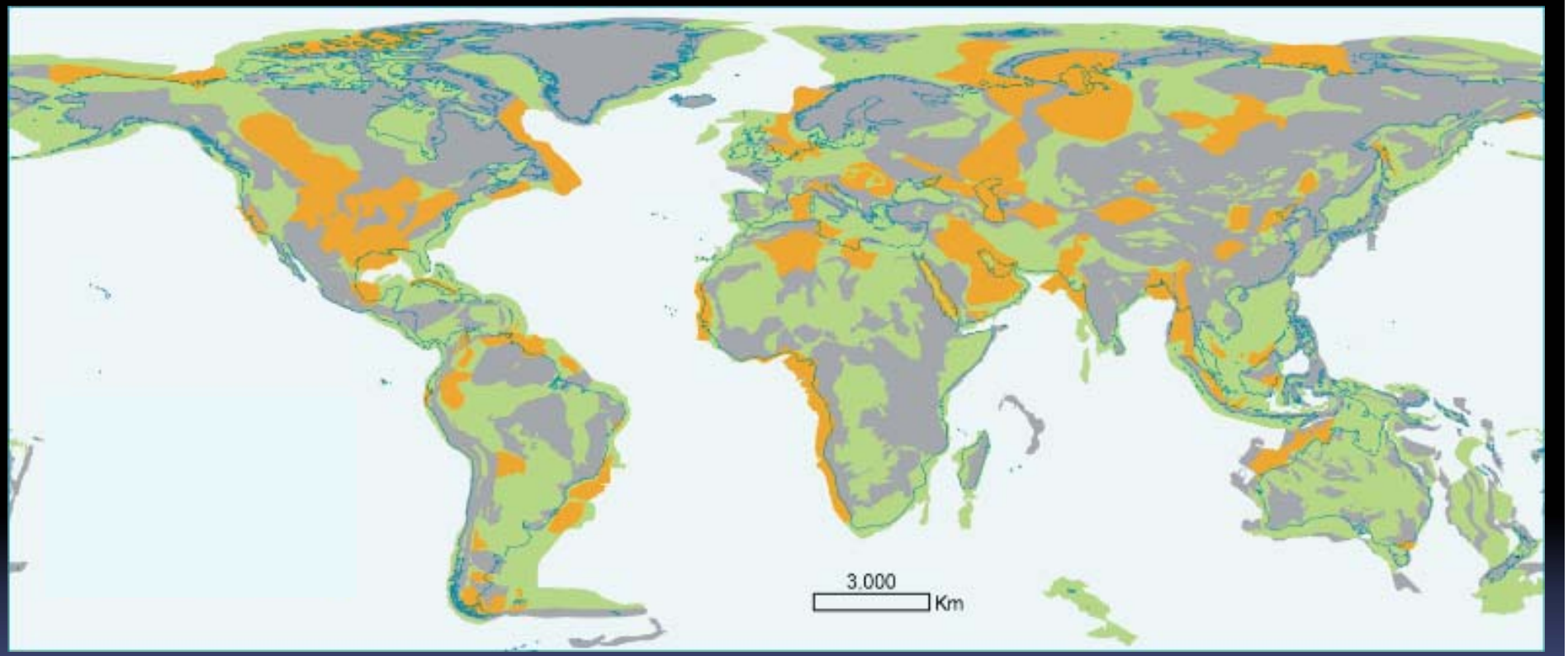
我们如何使技术转变发生？

Does it matter the level we are working at
我们工作所处的层次会影响它吗？

World, Country, Province (state), Basin, Site

世界、国家、省（州）、盆地、场地

World Map of CO_2 Storage Prospectivity
CO2存储远景预测的世界地图



Highly Prospective高预期前景

Prospective – High to Low预期前景-高至低

Non-Prospective无预期前景

•From Bradshaw & Dance 2004

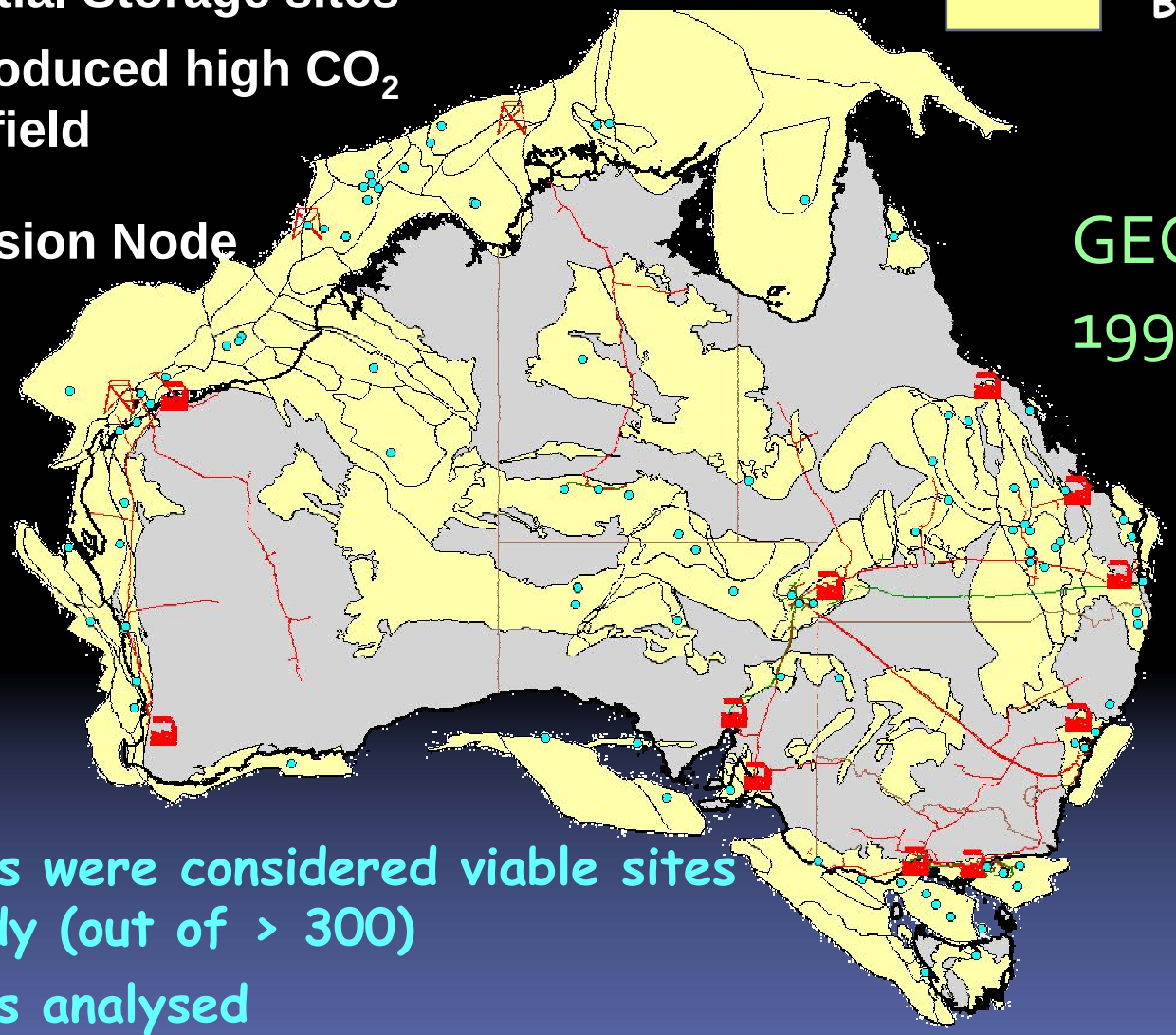
All Basins & Storage Sites examined

Potential Storage sites

Unproduced high CO_2 gas field

Emission Node

Basins Studied



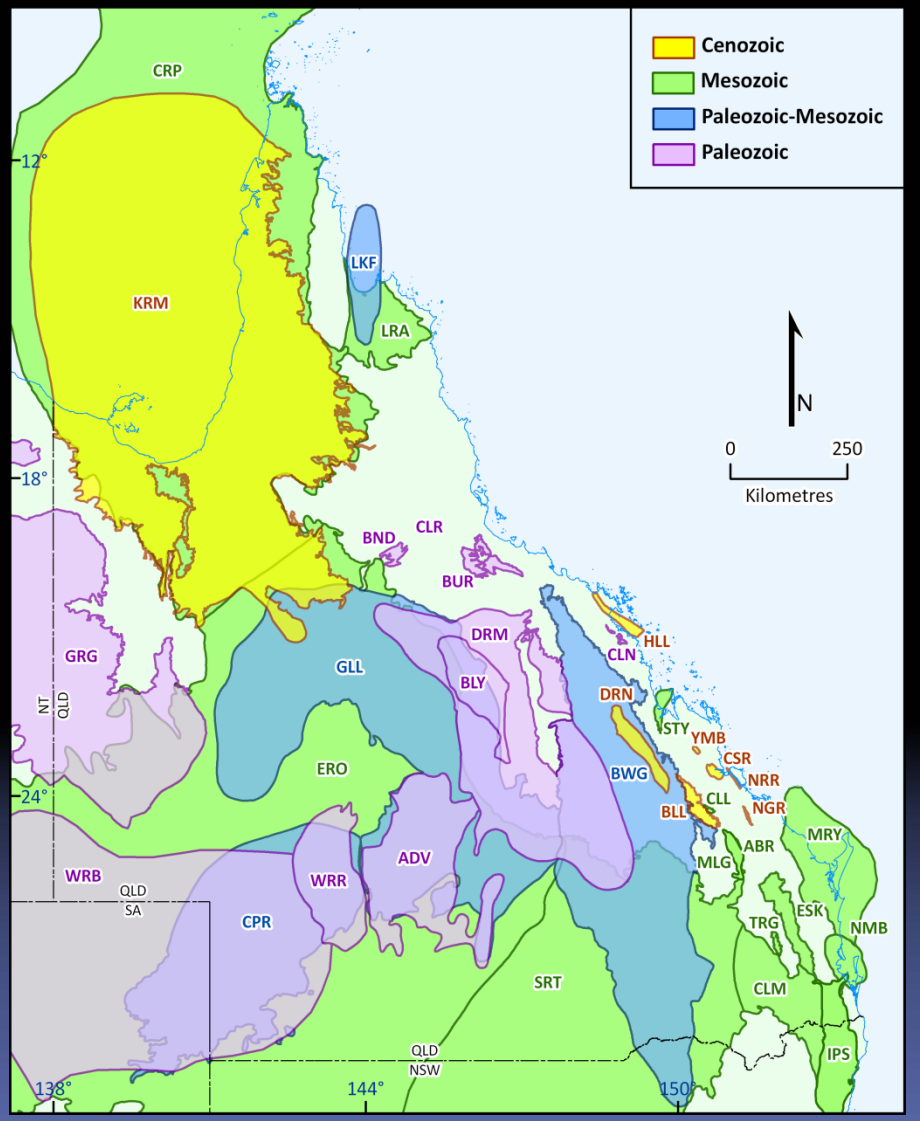
GEODISC
1999 to 2003

* 48 basins were considered viable sites for study (out of > 300)
* 102 sites analysed
* 65 proved viable Storage Sites
* 22 sites not viable; 15 regional basin overviews

•From Bradshaw et al 2003

Queensland CO_2 Storage Atlas
昆士兰州CO_2储存地图集

- Stage 1 of QDME Carbon Geostorage Initiative: **768 – 1,296** Mt storage capacity required for major emission nodes
- 36 Queensland basins assessed for geological storage prospectivity
- High-grade basins for more detailed studies & data acquisition to identify storage sites
- Geological assessment – excludes existing resources
- Product includes A3 hardcopy atlas and GIS (ArcGIS and MapInfo formats)



Assessed sedimentary basins classified by age

•From Bradshaw et al 2009

What is geological storage prospectivity?

什么是地质储存前景？

- "Prospectivity is a qualitative assessment of the likelihood that a suitable storage location is present in a given area based on the available information.
- By nature, it will change over time and with new information.
- Estimates of prospectivity are developed by examining data (if possible), examining existing knowledge, applying established conceptual models and, ideally, generating new conceptual models or applying an analogue from a neighbouring basin or some other geologically similar setting.
- The concept of prospectivity is often used when it is too complex or technically impossible to assign numerical estimates to the extent of a resource."

World Map of CO_2 Storage Prospectivity

CO_2储存前景的世界地图

Remember : *("this is a geologists map")*

Like any Prospectivity map,
this is a map of where to begin to look for
CO_2 storage space

Not a map of where it actually is?

Now need real data with appropriate testing
(Dedicated CO2 wells, focussed seismic, aquifer tests)

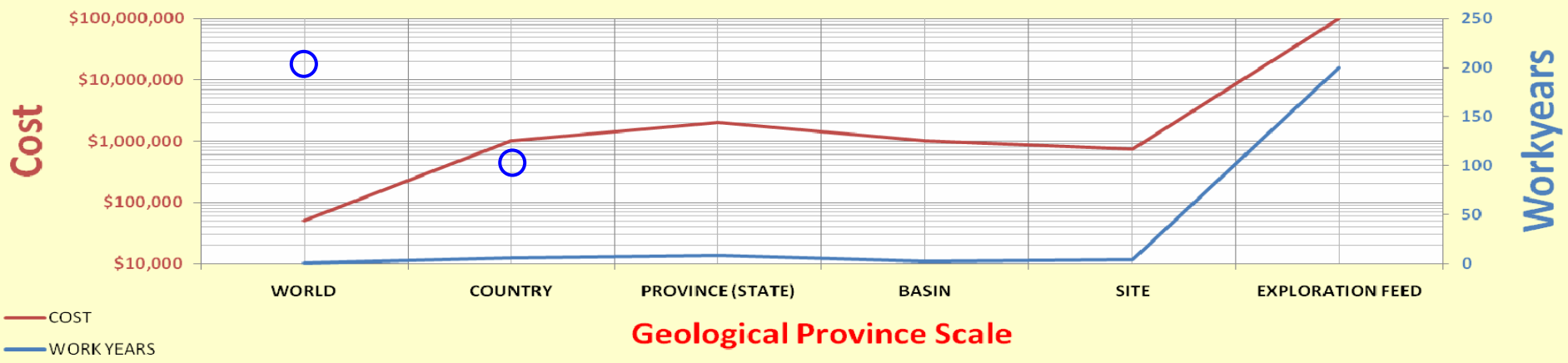
Do we need these in place to be "Storage Ready"

•From Bradshaw & Dance 2004

TIME & COSTS – SCREENING WORK

时间&成本—筛选工作

	WORLD	COUNTRY	PROVINCE (STATE)	BASIN	SITE	EXPLORATION FEED
WORK YEARS	0.5 (200)	6 (120)	8	2	4	100s
COST	$50K	$1 Mill	$2 Mill	$1 Mill	$0.75 Mill	$50 - $100 Mill
LEVEL	BASIN	BASIN	BASIN/PLAY	PLAY / SITE	PLAY / SITE (SCREENING)	SITE (RES/SEAL)
ORIGINATOR	GOV'T	GOV'T	GOV'T	GOV'T, IND	INDUSTRY	INDUSTRY
DURATION (YRS)	0.25	2	1	0.5	1	5



At what level are we storage ready

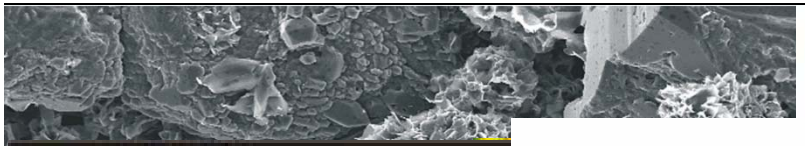
Data & knowledge？数据&知识？

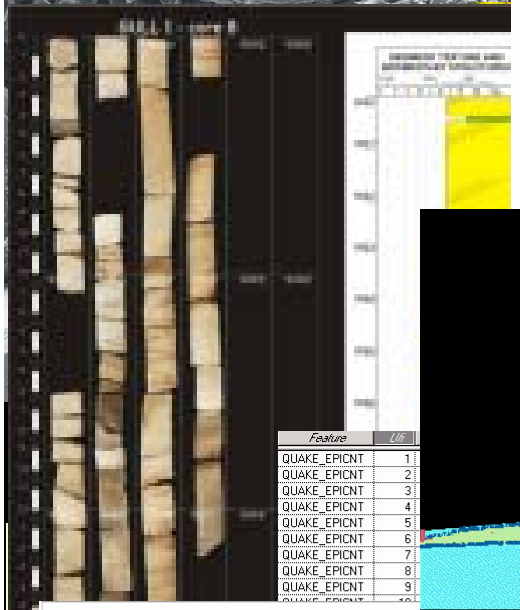
How much 多少

At what level of detail 细致到什么程度

What will regulators require 法规制定者需要什么

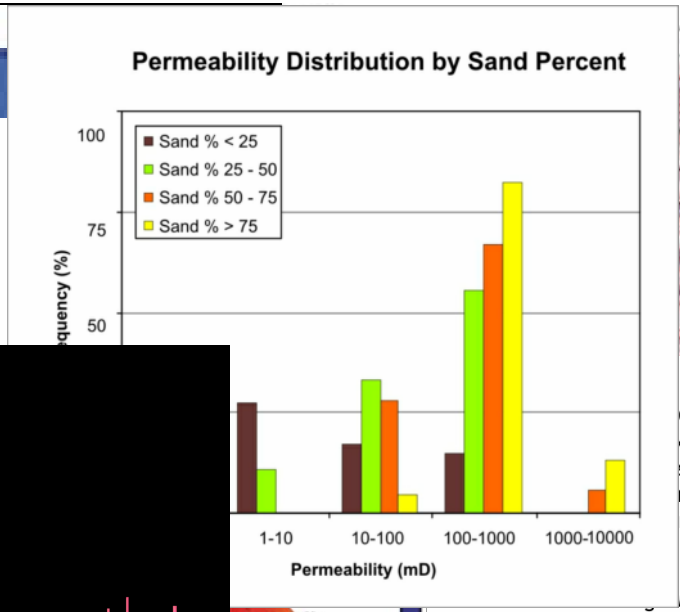
What levels of proof and certainty有何种水平的验证和确定性

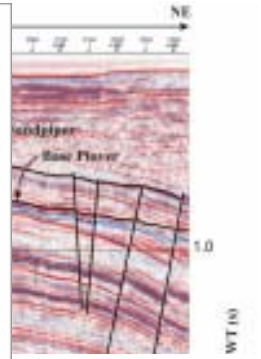




GEODISC Project 2

Site Specific Studies for Geological Storage of Carbon Dioxide





Feature	UI
QUAKE_EPICNT	1
QUAKE_EPICNT	2
QUAKE_EPICNT	3
QUAKE_EPICNT	4
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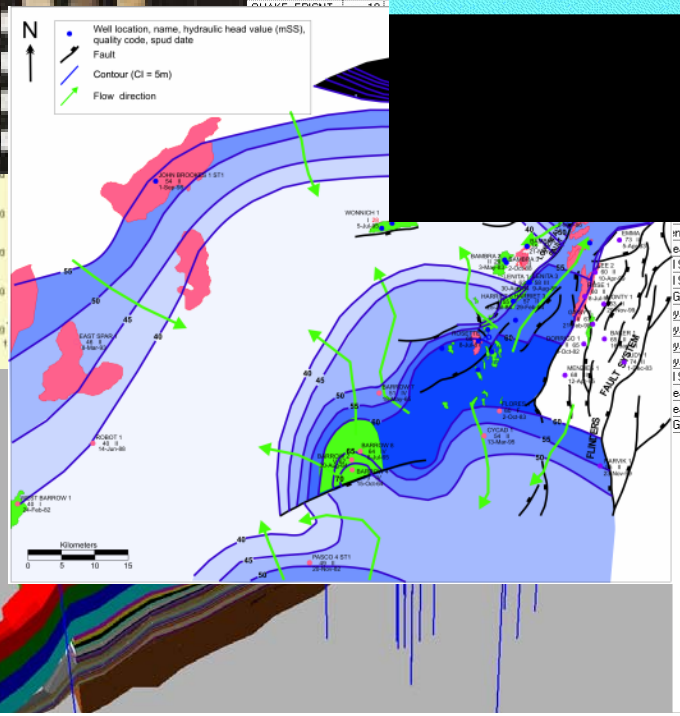
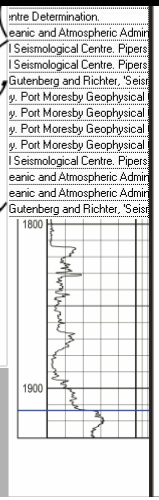
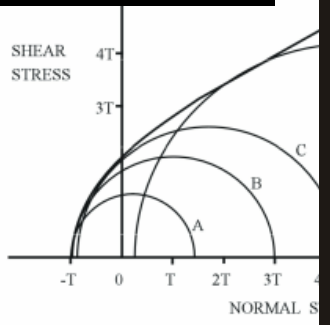
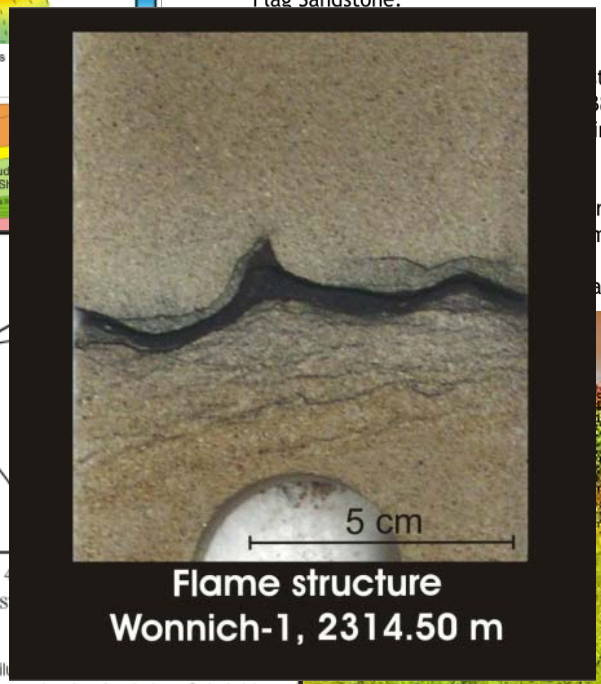
QUAKE_EPICNT	6
QUAKE_EPICNT	7
QUAKE_EPICNT	8
QUAKE_EPICNT	9







Mohr diagram with Mohr circles for different failu
fracturing; B: maximum stress difference for pure extension fracturing; C: hybrid extensional-shear failure. T denotes the tensile strength of the rock.
After Etheridge (1983).



SS.
horizontal scale.
nce boundary.
nsgressive surface.
mum flooding surface.
main Flag Sandstone

Muderong Shale regional seal or intraformational seals within the Flag Sandstone.

t2
8).
ne A -

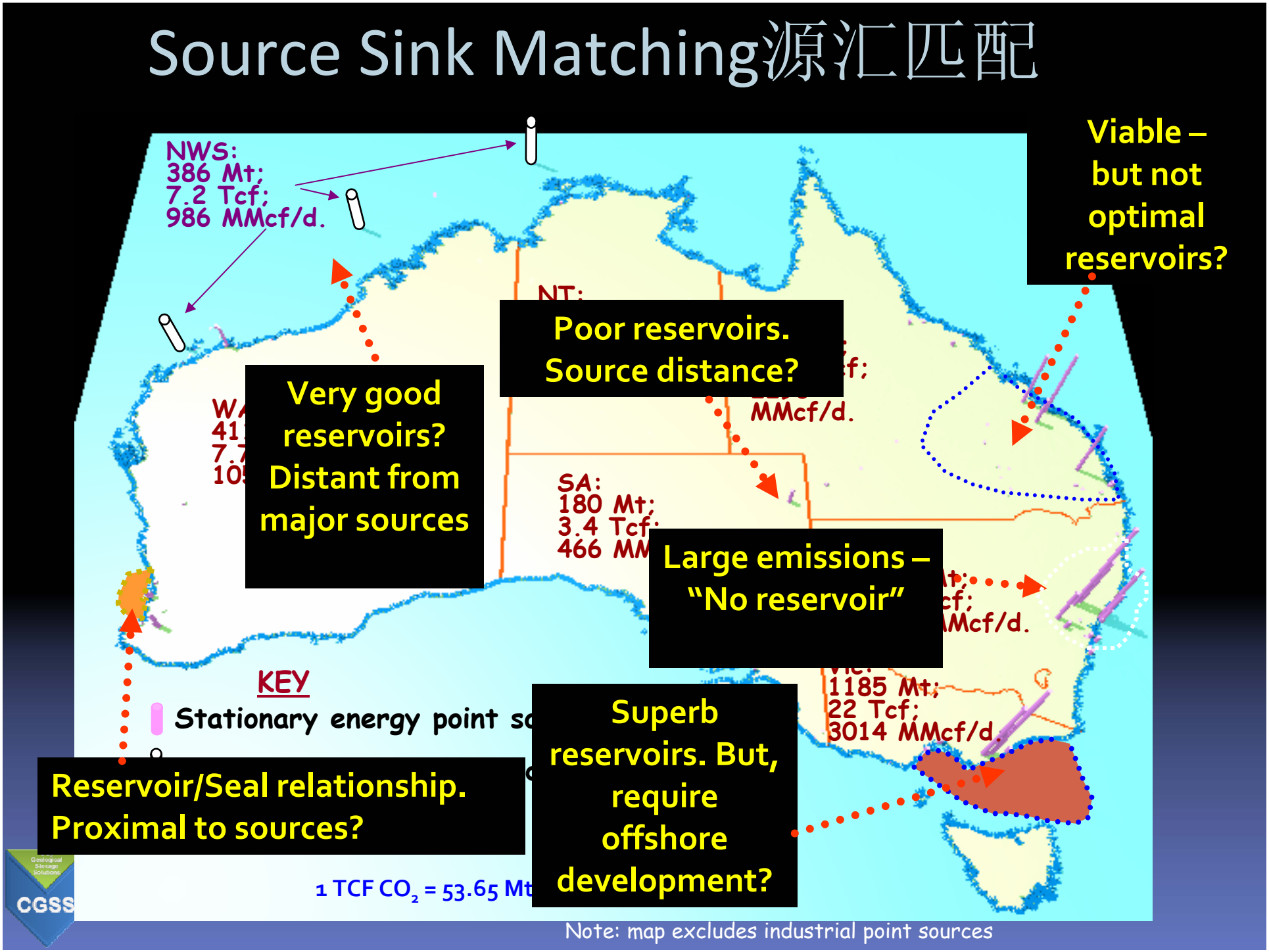
ract.
ms

act.

Are there fundamental conceptual issues?
有没有基础科学问题？

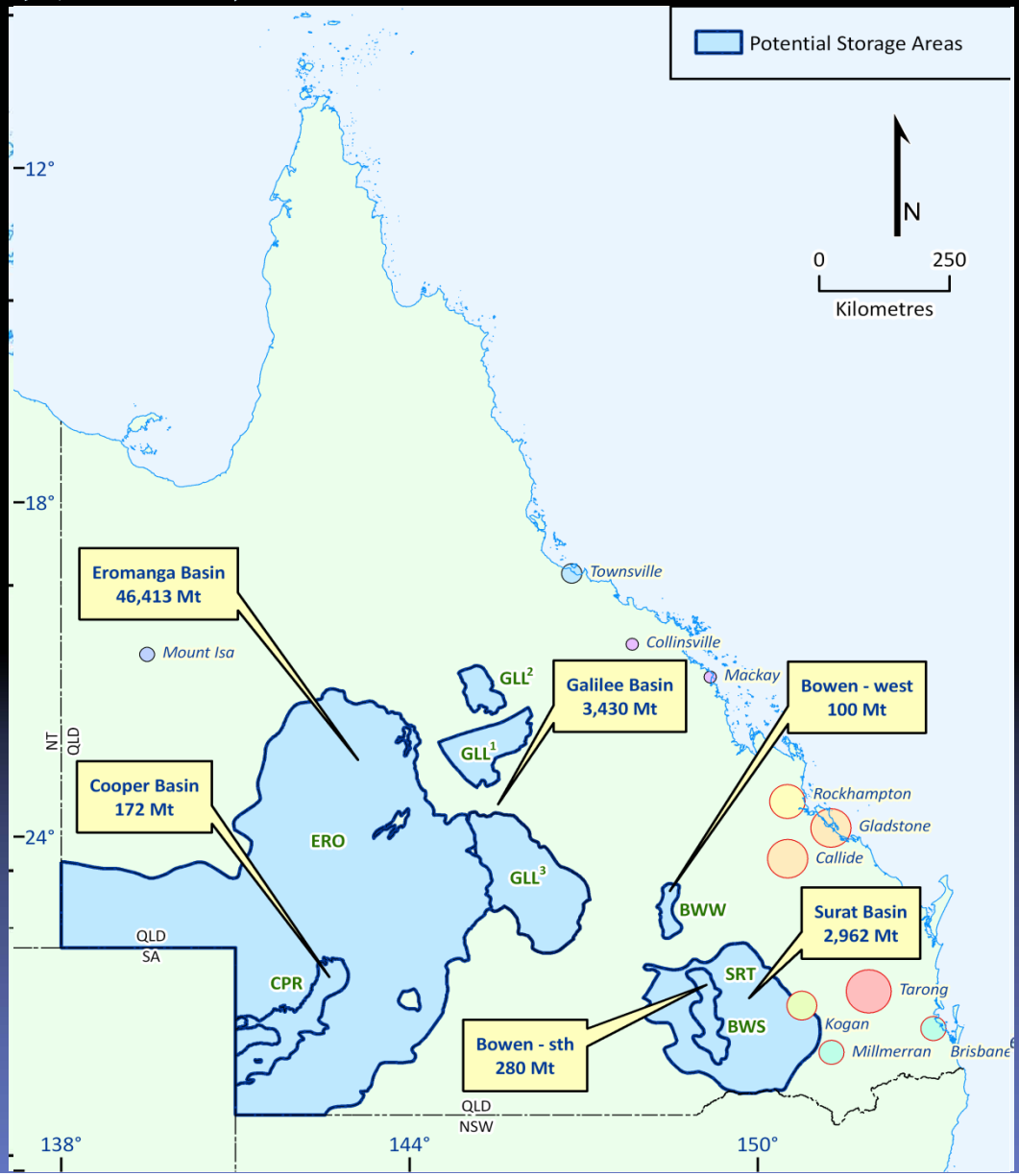
Will industry integration be an issue?
工业集成会存在问题吗？

Source Sink Matching源汇匹配



Note: map excludes industrial point sources

Source Sink Matching – Queensland
源汇匹配 – 昆士兰



Qld Emission Sources

High Prospectivity basins

Does the scale of the challenge affect the answer 挑战的存在会影响我们的响应吗？

Should we just get on and do it:

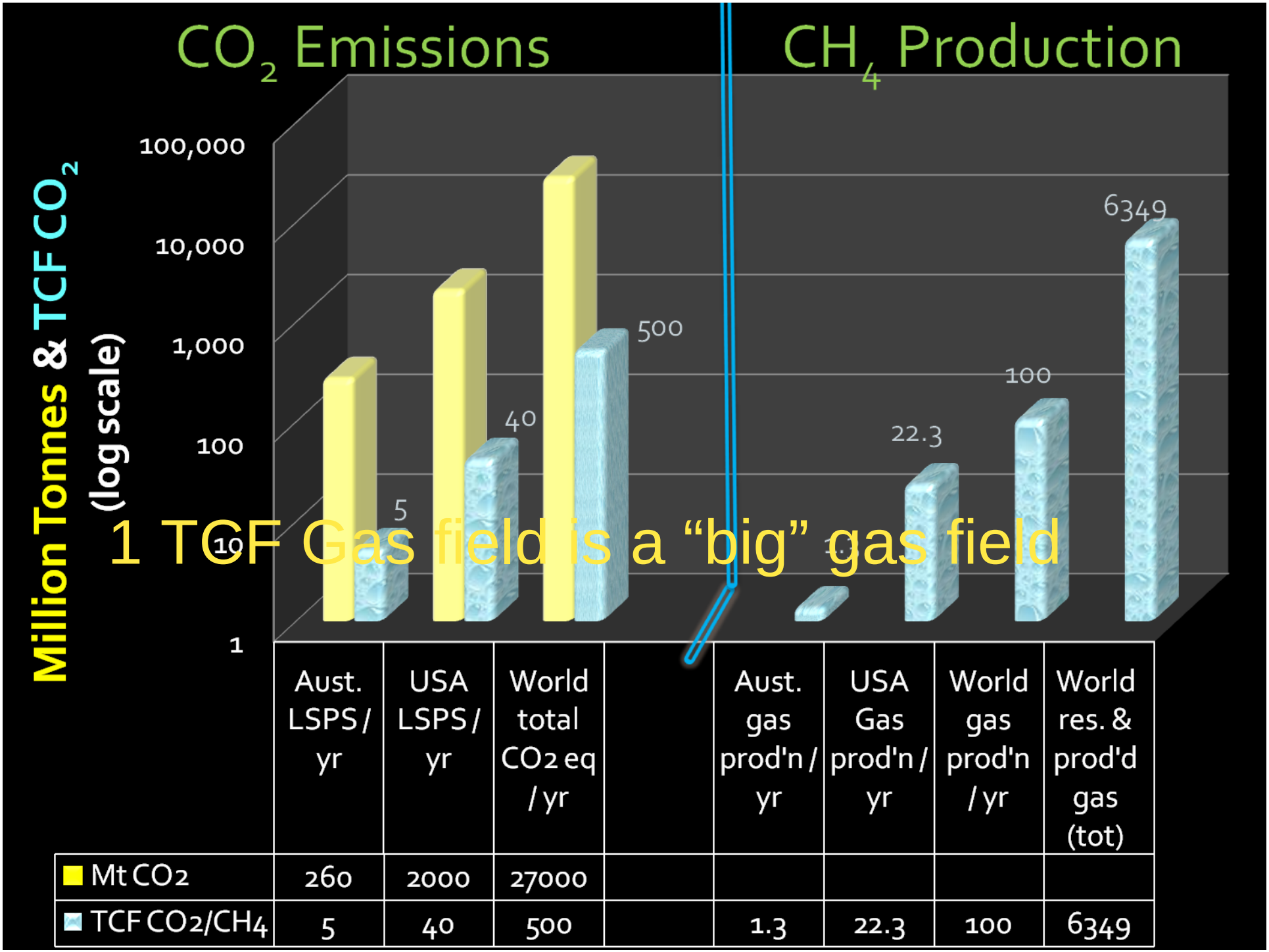
我们是否应该放手去干:

Less talk, more action

少说多做，行胜于言

More policy certainty for business model

为商业模式提供确定性更强的政策



	Aust. LSPS / yr	USA LSPS / yr	World total CO_2 eq / yr		Aust. gas prod'n / yr	USA Gas prod'n / yr	World gas prod'n / yr	World res. & prod'd gas (tot)
Mt CO_2	260	2000	27000					
TCF CO_2/CH_4	5	40	500		1.3	22.3	100	6349

Subsurface Certainty地下地质状况的确定性：Merrow (2003a, 2003b)

- Over 1000 exploration & production projects from the oil and gas industry
- Projects from $1 million to $3 billion were assessed
  - 1 in 8 were disasters
- For the megaprojects (>$1 billion)
  - Only 3 of the 14 assessed were described as successful in delivering as promised,

Subsurface Certainty地下地质状况的确定性：Merrow (2003a, 2003b)

- Half described as failures
  - delivering as promised on project management and business perspectives.
- Difficulties associated with
  - the facilities and
  - subsurface reservoir, and
  - working to deadlines rather than making decisions based on the timing of arrival of accurate information.

Subsurface Certainty地下地质状况的确定性：Bickel et al (2008)

- Whilst uncertainty quantification has improved over a 10 year period
  - this has not improved decision making in the oil and gas industry,
- The highest ranking of uncertainty in the investment decisions were
  - with subsurface considerations,
  - above other matters such as a volatile oil price
  - (82% of 494 respondents).

Time & Cost: Storage时间 & 成本: 储存

How much is required to find & develop storage sites

CGSS

Work Plan工作流程

1. Desk Top Compilation
   6 – 12 months
   - Identifying potential reservoir seal pairs, drainage cells, migration pathways and trapping mechanisms
2. Exploration Assessment
   1 – 3 years
   - Finding injectivity and containment
3. Development
   1 – 3 years
   - Validating and proving the extent and sustainability of injectivity, storage capacity and commerciality
4. Injection and Storage
   1- - 50 years
   - Operation of the site, with ongoing monitoring, data acquisition and assessment
5. Abandon Storage site
   subject to regulation
   - Meet regulatory requirements to allow release from site

Work Plan

Generic Work Plan For Geological Storage	
Phases	**Tasks**
Screening Study For Selected Area	High level assessment of potential areas to examine
Compile & load data from existing sources	Publications, Well and seismic, field data, etc
Desk Top Compilation	Map well (stratigraphy) and seismic surfaces,
	Prelimnary Assessment, Examine Prospects, Rock data (core & cuttings)
	Build Static Geological and Dynamic Reservoir model; iterative process
	Select sites for detailed assessment
Exploration Assessment	Public outreach (community engagement)
	Obtain new data, revisit desk top and compilation phases
	Select Storage Site
Development	Acquire New Data (Wells & Seismic)
	Develop Draft Injection and Storage Plan (with Regulator)
	Sub-surface Stakeholder Agreement & Collaboration
	Obtain Final Draft Plan Approval
	Acquire New Data - Wells & Seismic
Injection and Storage Activities	Maintain Monitoring, Measurement & Verification for Life of Project
	Maintain Entire Desk Top Compilation and Exploration Activities for Life of Project
Abandon Storage Site	Seek Regulator Permission to be Released from Storage Site

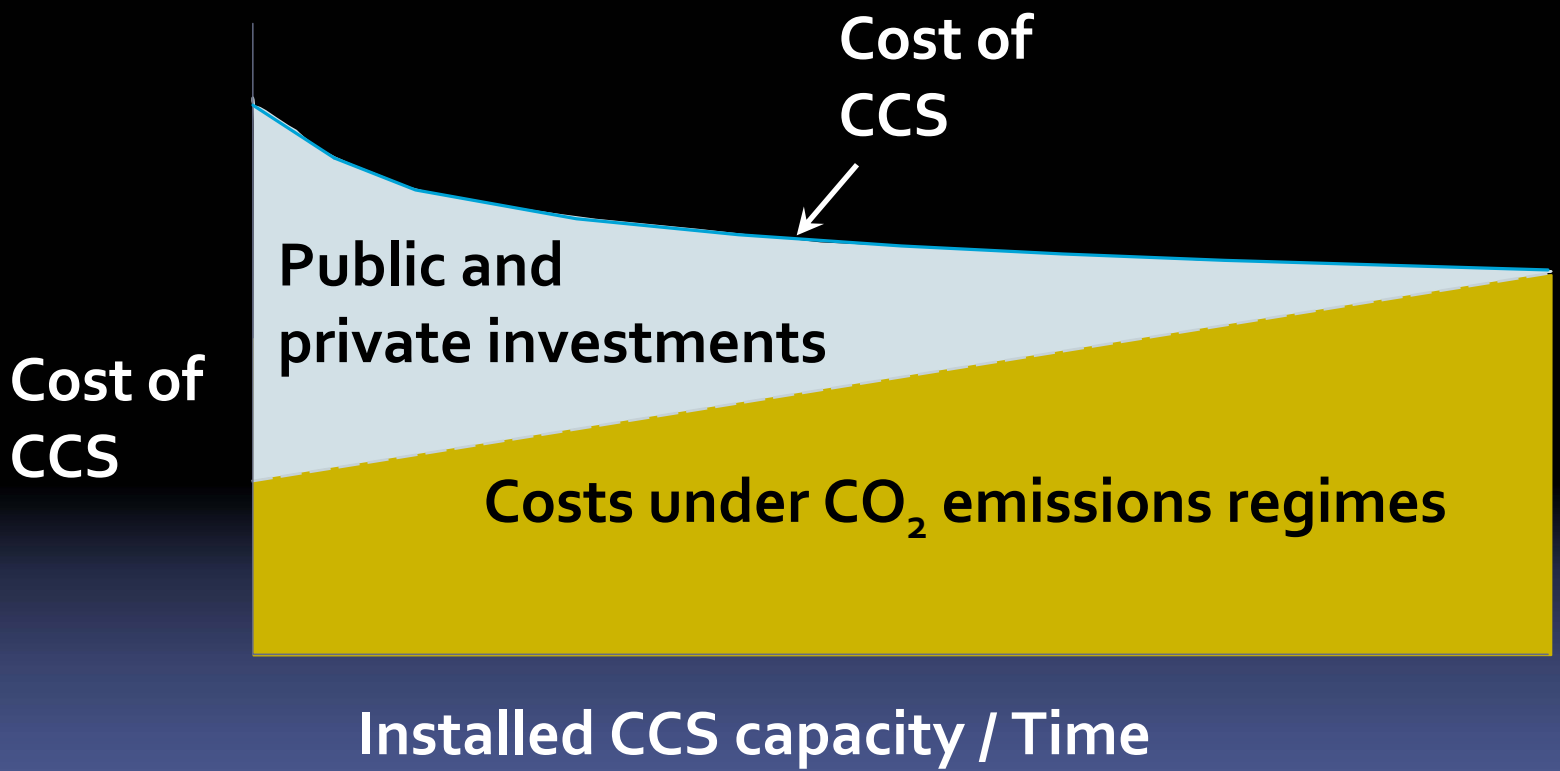
Time & Cost : Storage时间 & 成本 :储存

TASK	Time (Years)	Cost $mill (Onshore)	Cost $mill (Offshore)
FEED	1 – 2	5 – 10	5 – 30
Development	1 – 3	5 – 200	50 – 1500
TOTALS	**4 – 11**	**20 – 300**	**95 - 1830**

Plus add $2 – 3 + billion for Power Plant with Capture

Note: Estimate are for Australian conditions and in $AUS

Significant upfront investment required until CCS is commercially viable



DEFINITIONS定义

什么是“储存就绪”

是指辨识、验证和确保一个能够注入商业数量的 CO_2，并将其可持续地储藏在深层地下的地质储存地点，同时在注入期间和注入完成后的储存阶段保持地质结构和构造的完整性的过程和结果

但是：

- 但是没有描述证明一个封存地点可行需要开展的一系列过程，
- 没有详细分辨可能需要的确信度的不同等级，
- 没有表述清楚理解深层地下储层属性的概念性特性，
- 没有详细记录特定深层地下的地质特点对其能否被称作“储存就绪“的实际影响

What is Storage Ready?什么是“储存就绪”

The processes and outcomes from identifying, proving and securing a geological storage site that is capable of having commercial quantities of CO_2 injected and stored in the deep subsurface on a sustainable basis, whilst maintaining high geological integrity in the geological structures and formations both during and after the injection and storage period.

BUT :

- does not describe the processes involved proving a storage site,
- does not elaborate on levels of proof and certainty that may be required,
- does not express the conceptual nature of the understanding of the geological attributes of the deep subsurface, and
- does not document the actual impacts that the geological characteristics of the deep subsurface may have on a site being proven to be storage ready.

Technically

What if not storage ready如果没有储存就绪

- Delay the whole CCS Chain延误整个CCS项目的实施
- Wrongly locate power stations有可能会错误地规划建设电厂
- Build pipelines to sites that aren't sustainable导致所建管道提前废弃

- Would you build an LNG plant first ?你是否会在发现气田之前建立LNG冷冻厂吗？
  - Then explore for a gas field!!显然应该首先勘探天然气田!
- Without Storage Ready, does CCS exist at all如果没有储存就绪，CCS会存在吗？！

CGSS