

Global Review of Large-Scale CO₂ Storage Projects*

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Abstract

After three years of monitoring and reporting annual global progress in carbon capture and sequestration (CCS) by the Global CCS Institute, trends are emerging relating to CCS storage. There has been a levelling in the number of large-scale integrated projects (LSIP's) in the asset lifecycle "pipeline", reducing from 85 to 77 to 74 as of the time of writing.

Eight operating integrated projects existed as of late 2011, with two more projects scheduled to start operating in 2012 and six having reached a final investment decision (FID). Another 11 projects responded that they would be ready for FID by late 2012. Of the operating projects, only the Century natural gas processing project commenced operation after 2008 and an estimated net 33 MT CO₂ is presently stored annually by all projects.

Storage assessment from screening to first injection is likely to be a rate determining step for many integrated projects. Early operating projects are being managed on whole or part by oil companies, which have many decades of experience in high risk environments and understanding the trade-offs between exploration investment and project success.

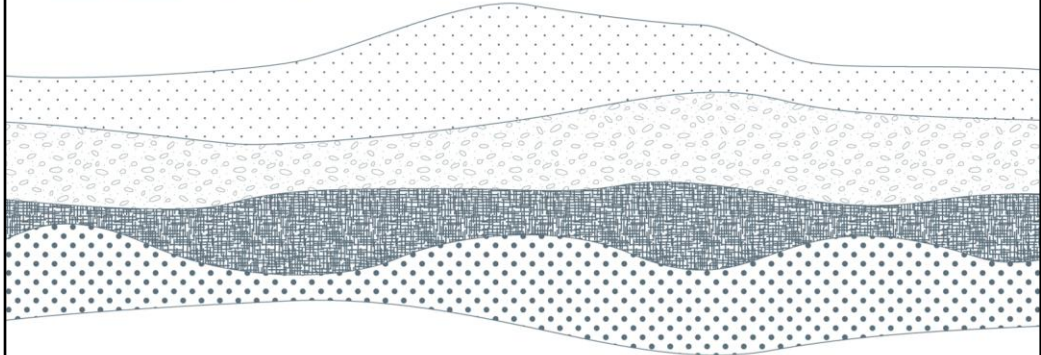
Funding profiles for storage assessment differ from that of the capture components, as significant funding for data acquisition is required early in the project, often when other project components are still at a desktop or early prefeasibility stage.

The recent period of austerity compounded with increased cost estimates and limited options for additional resourcing have seen several projects deferred. One area of exception is CO₂EOR where high oil prices plus some incentives for domestic production are creating widespread interest in CO₂EOR as a way of abating CO₂. CO₂EOR dominates the US CCS LSIPS, but there is growing interest in the Middle East, Europe, China, and producing Asian nations.

CO₂EOR can contribute to progressing CCS deployment as it provides a natural laboratory for CO₂ injection, but it is not universally applicable, for significant changes are required in operational practice as well as regulatory, legal, and infrastructure frameworks for substantial increases in CO₂ injection volume.



GLOBAL
CCS
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GLOBAL REVIEW OF LARGE-SCALE CO₂ STORAGE PROJECTS

Steve Whittaker, Global CCS Institute

AAPG Singapore

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Presenter's notes: On behalf of the Institute's Storage Team, acknowledgement is made to Ernie Perkins, Angeline Kneppers and Kathy Hill

STATUS OF GEOLOGICAL STORAGE

- Geological storage of CO₂ has been safely demonstrated in:
 - saline reservoirs for >15 years; and
 - oil and gas reservoirs for decades.
- Most perceived risk in CCS is associated with storage.
- Storage characterisation is expensive and lengthy, requiring:
 - large early investment; and
 - must begin with initial concept of CCS project.
- Interest in CO₂ enhanced oil recovery (EOR) as CCS is increasing globally.

GLOBAL DISTRIBUTION OF CCS

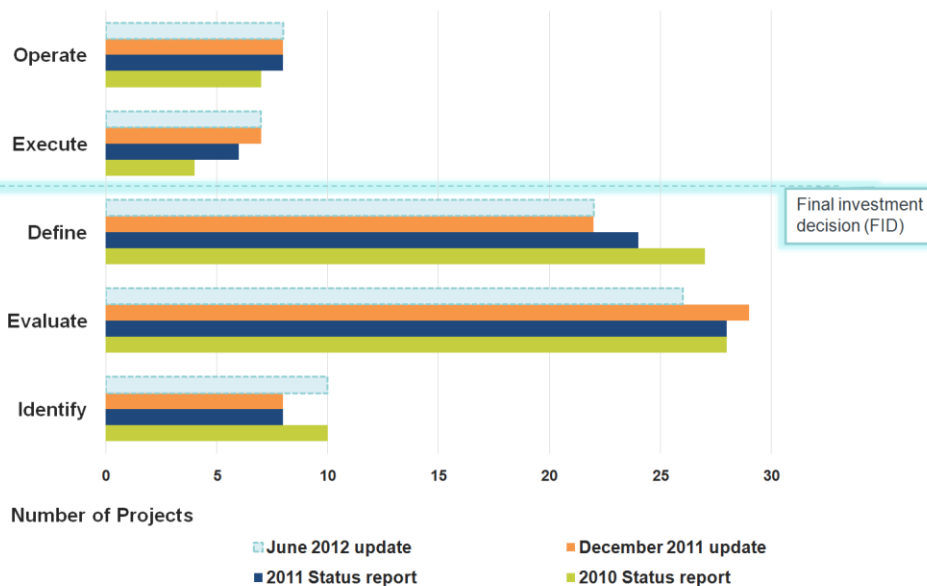
Large-scale integrated projects (LSIP)



LSIP Criteria

- ≥ 0.8 Mtpa CO_2 for coal-based power plants
- ≥ 0.4 Mtpa for industrial plants
- Anthropogenic CO_2
- Monitoring of injected CO_2

LIFECYCLE STATUS OF CCS

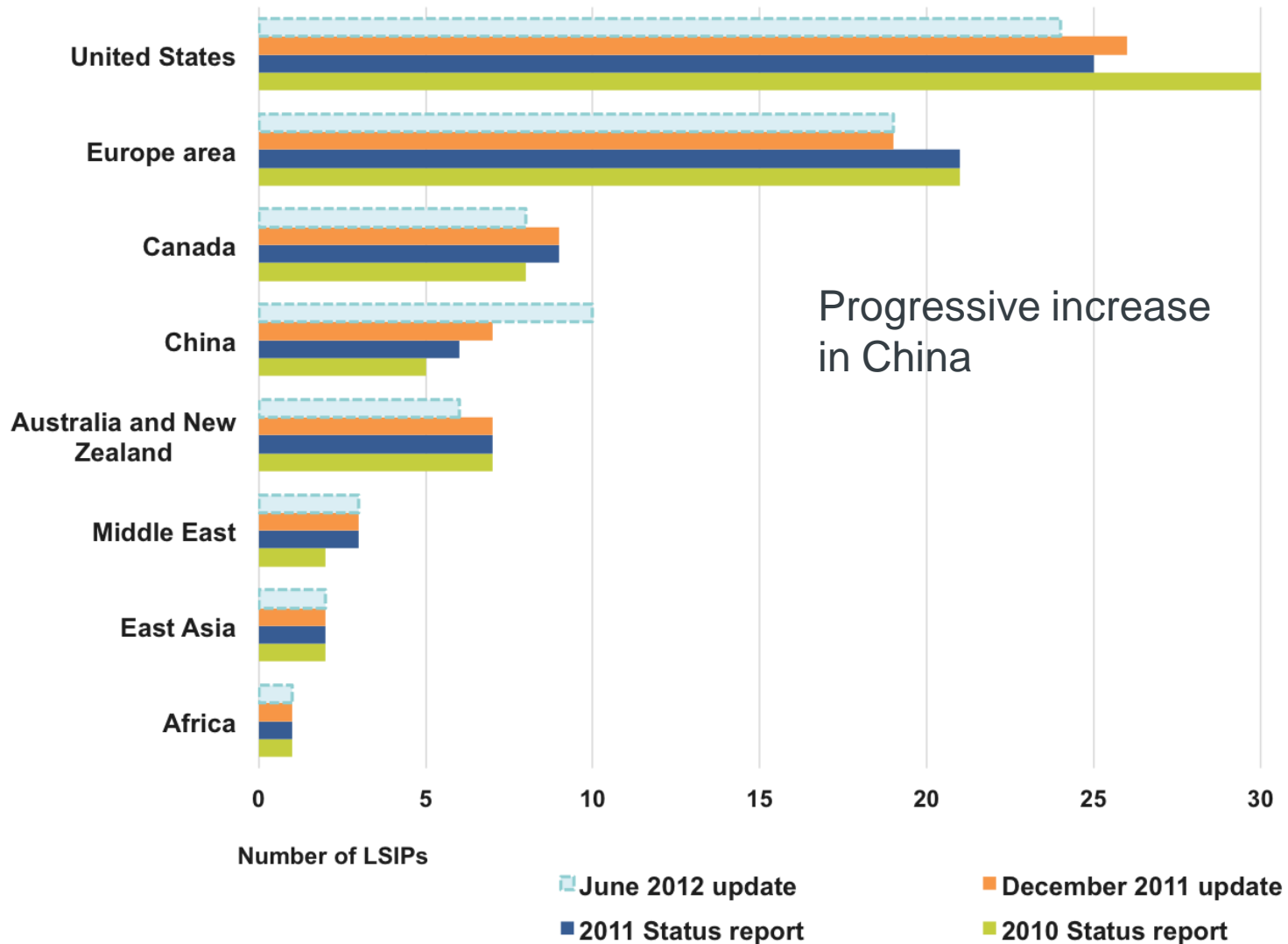


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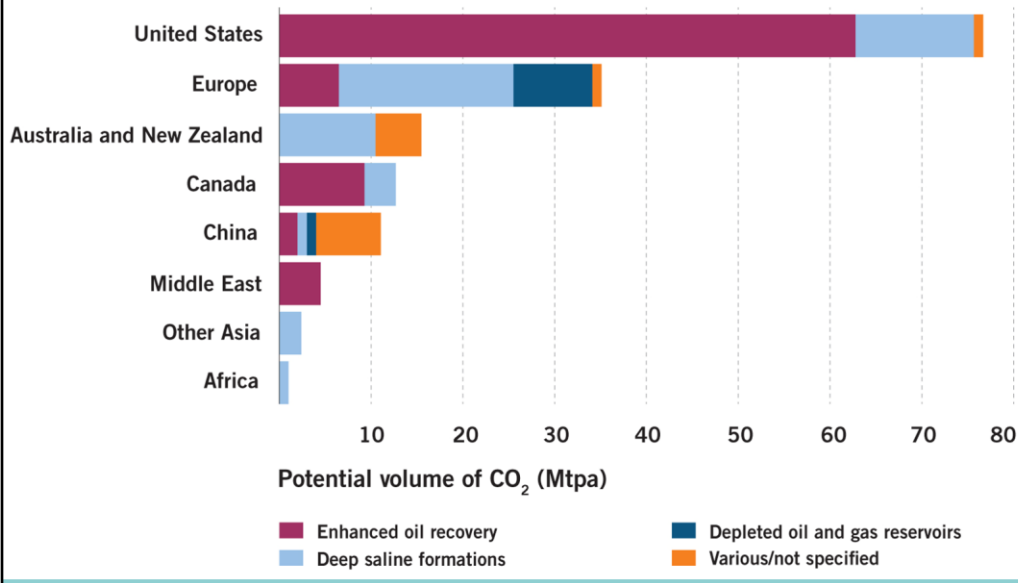
Presenter's notes: Steady progress of projects reaching construction

- 2 projects in Execute in 2009; 4 in 2010; 6 as per our 2011 survey, updated to 7 projects at the end of 2011 with Air Products entering construction in Texas
- Total number of LSIPs stands at **73, down by one project** since the release of the 2011 Status report: 7 projects were removed from the Institute's LSIP listing:
- Two in Europe: Longannet, Jämschwalde and Peel Energy; Two in the US: Sweeny Gasification and Good Spring IGCC – now NGCC without CCS; Project Pioneer in Canada; Coolimba in Australia.
- 6 projects were added to our LSIP listing: Four in China: Datang Daqing and Datang Dongying, Shanxi International Energy Group CCUS Project, Jilin Oil Field; One in the US: NRG Energy Parish; One in the UK: Caledonia Clean Energy Project.

REGIONAL STATUS OF CCS



REGIONAL BIAS TOWARDS STORAGE SELECTION INCLUDING IDENTITY OF OPERATIONAL STAGES



Presenter's notes: While EOR is an important step on the demonstration path, CO₂ monitoring and accounting requirements will also have to be stringent to ensure that CO₂ is permanently stored. Current assessments on EOR and depleted oil and gas fields capacity strongly suggest that deep saline formations will provide the bulk of storage potential in the long term.

19% reduction=8.17 billion tonnes annually=8170 Sleipners or 3400 large projects

Utsira Sand has an estimated pore-space volume of about 6 x 10¹¹ m³. If only 1% of this were utilised for CO₂ storage, that stores 50 years emissions from around 20 coal-fired plants.

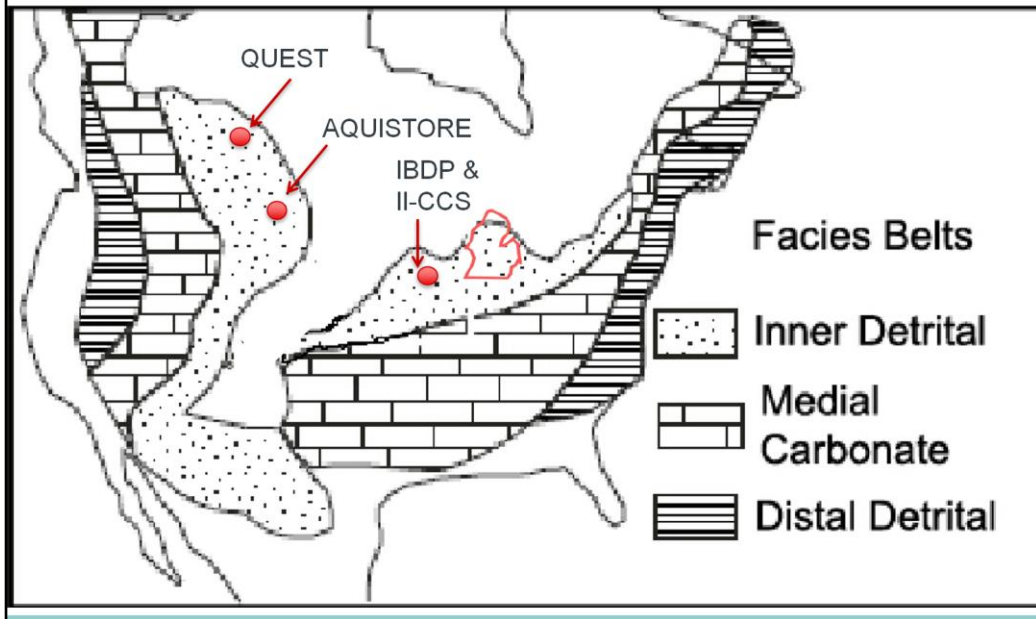
In storage there is a large reliance, especially in the US, on EOR. EOR can provide immediate assistance to the demonstration of CCS because:

- the sites are already geologically understood;
- it provides additional revenue; and
- it requires less time for development than greenfield exploration;

Policymakers need to factor these lead times into their assessment of a project's progress, and projects that have not yet commenced active storage assessment may be challenged to achieve operation before 2020.

LOWER CAMBRIAN STRATA NORTH AMERICA

SALINE RESERVOIR STORAGE IN SHEET SANDSTONES



FACTORS IN CCS DEPLOYMENT

STOPPERS

- Long-term investment environment.
- Third party and long-term liability.
- Public perception.

DELAYERS

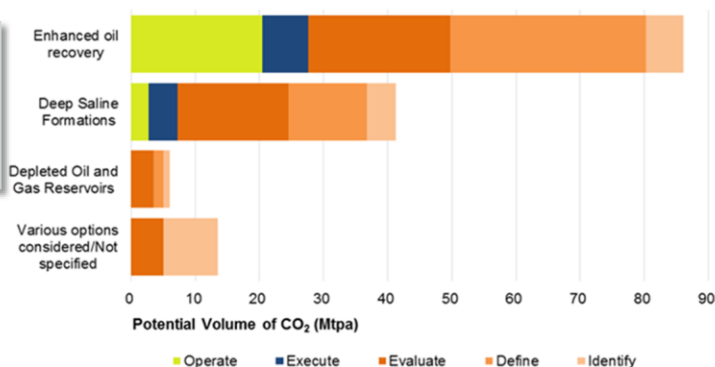
- Timelines for large-scale development.
- Uncertainty in government approvals.
- Developing regulatory frameworks.

ENABLERS

- Use of CO₂ for EOR (CCS in US).
- Sharing of infrastructure – hubs and networks.
- Government funding – demos.
- Storage capacity atlases.
- Informed politicians, public and stakeholders.
- International collaboration on all above issues.
- Efficient sharing of knowledge.

ROLE OF CO₂ EOR IN CCS AS AN ENABLER

Existing geologic storage of anthropogenic CO₂ is mainly by EOR.

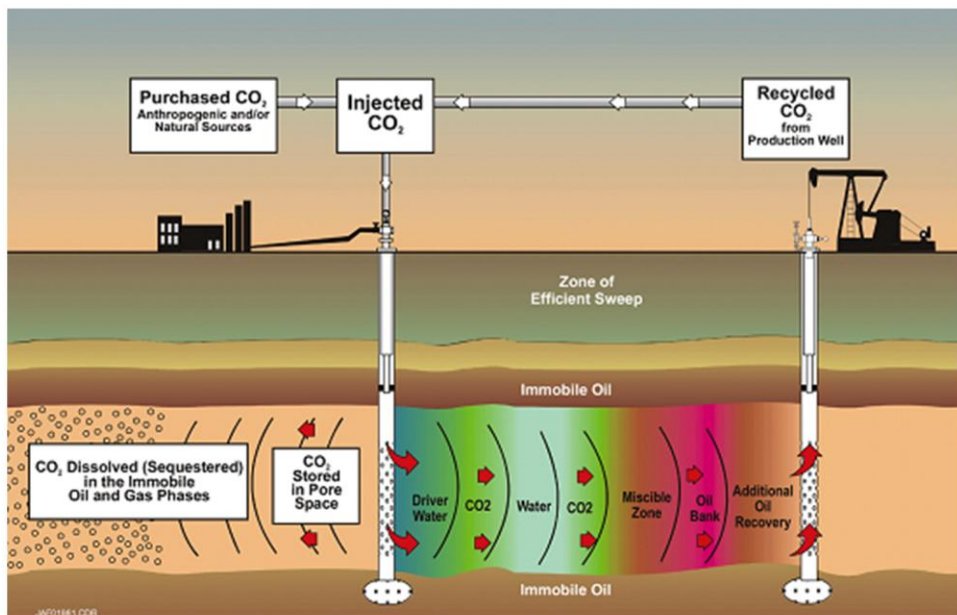


- Important commercial driver.
- Supports CCS demonstration activity.

However

- Must demonstrate permanence of storage – measurement, monitoring, and verification (MMV).
- Regulations and policy needed to transition CO₂ EOR to CCS.

CO₂ EOR AND ASSOCIATED STORAGE



CCS IN DEVELOPING COUNTRIES

- Non-OECD emissions projected to increase 86 percent by 2035.
- According to the International Energy Agency (IEA), 50-60 percent of CCS needs to occur in non-OECD countries.
- Preparing for CCS yields benefits over ‘wait and see’ approach by allowing:
 - access to future funds;
 - enabling Clean Development Mechanism (CDM) projects; and
 - developing commercial propositions.
- Preparatory work includes:
 - screening geological opportunities; and
 - developing policy settings.
- There are now more than 10 LSIPs in Asia.

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Presenter’s notes: It is important that companies and government continue to work together to maintain the current momentum. There are many demonstration projects being planned in non-OECD countries, particularly China which has 10, but not all of these projects will come to fruition. With the significant, but manageable, challenges associated with CCS, many developing countries are taking a “wait and see” approach. While there are some aspects of CCS that can be “transferred” from developed to developing countries, some aspects need to be tested domestically; this mitigates against a “wait and see” approach. Countries should start undertaking the pre-investment, enabling demonstration activities now (many of which will need to address country-specific requirements), in order to be in a position to benefit from emission reductions from CCS in the coming decades.

CCS in the CDM—may be number one factor to provide financial support to CCS projects in developing countries, although CER prices may not be sufficient to enhance the CCS business case. Only based on CO₂ that is permanently stored, “Additionality” and “Permanence” will be difficult to demonstrate with EOR. Only paid when project is in operational phase so does not help with the capital.

15 projects:

China – 10 large scale projects in planning, many smaller projects, including some in operation

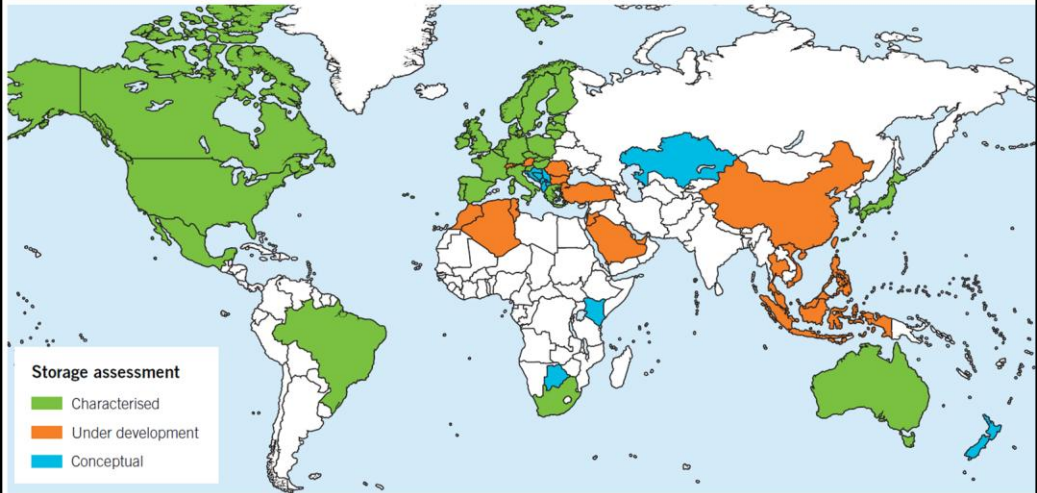
Middle East (UAE) – 3 projects in planning

Korea – 2 projects in planning

WHAT IS HAPPENING IN ASIA?

- **China:** seven large-scale projects in planning, many smaller projects, including some in operation.
- **Middle East (UAE):** three projects in planning.
- **Korea:** two projects in planning.
- **South East Asia:** scoping studies, many in very early planning.
- **India:** very early stages.

GLOBAL CAPACITY ASSESSMENTS



GEOLOGICAL STORAGE CHALLENGES

System Scale

- Large regions to characterise and monitor over long-time frames.

Trapping

- Capacity estimations.
- Residual trapping efficiency.
- Kinetics of geochemical trapping.

Reservoir management

- Pressure management.
- Geomechanical effects on wells, reservoirs and seals.
- Mitigation and remediation techniques.

Performance assessment

- Ongoing monitoring and remediation plans.
- Address public's safety concerns.
- Storage verification.

LESSONS FROM EXISTING PROJECTS

No technical barriers to implementing CO₂ storage.

R&D ongoing – need more data from large operational projects.

Subsurface uncertainties drive site-specific data acquisition.

Time and data required for site assessment should not be underestimated.

CO₂ disposal requires same attitude, approach and capability as a major **petroleum development**.

Significant financial investment will be required prior to FID.

Presenter's notes: Not "more R&D is needed" to increase confidence before CCS technology can be moved forward but "more R&D is needed" while large-scale projects progress and feed R&D with data.

PROGRESS IS BEING MADE...

- CCS projects are operating today in a number of industries and countries:
 - often where capture is part of the industrial process, and where well explored storage locations exist; and
 - are often based on EOR, which provides a value on CO₂ (business case).
- More projects are entering construction and operation (Shell's Quest project achieved FID on 5 September 2012).
- Two large-scale power station CCS projects are under construction.

...BUT A NUMBER OF CHALLENGES REMAIN

Overall number of projects static and development behind targets.

High profile cancellations, many pointing to lack of adequate policy support. Policy support is vital!

Continuing issues with public acceptance, despite proven nature of individual components.

More effort is needed to foster storage deployment globally, particularly in non-OECD countries.

The Global CCS Institute works collaboratively to build and share expertise on CCS

Annual Global Status of CCS – released October 2012

- **SHARE KNOWLEDGE**
- **ACCELERATE DEPLOYMENT**
- **ENSURE ROLE OF CCS IN REDUCING GHG EMISSIONS**



Presenter's notes: Global CCS Institute continually tracks the worldwide status of large-scale integrated CCS projects (LSIPs) as part of one of its 3 main areas of activities. These projects involve all stages of the CCS chain (capture, transport and storage of carbon dioxide).



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