



A Decade of CCS Development: A Global Review

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Prior to RCSP



- In the beginning was Sleipner
 - 1 Mt/y Injection started in 1996 – continued to date for 17 years
 - First to demonstrate you could observe injected CO₂ with seismic monitoring
 - Demonstrated you can track fate of the CO₂ in the reservoir
 - First to calibrate reservoir models against seismic monitoring

Prior to RCSP



- Next in line was Weyburn
 - 1Mt/y CO₂ injection into a depleting oil field
 - First project to demonstrate seismic monitoring was suitable for deep shallow reservoirs
 - First to prove the benefits of doing a surface monitoring baseline
 - Kerr Incident

Commercial Application of CCS in Oil and Gas Sector



Sleipner
1Mt/y CO₂



Weyburn
2.5 Mt/y CO₂



In-Salah
1.2 Mt/y CO₂



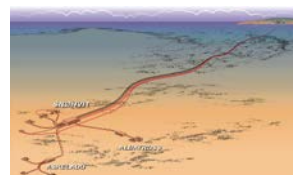
Snohvit
0.7Mt/y CO₂



Gorgon
3Mt/y CO₂

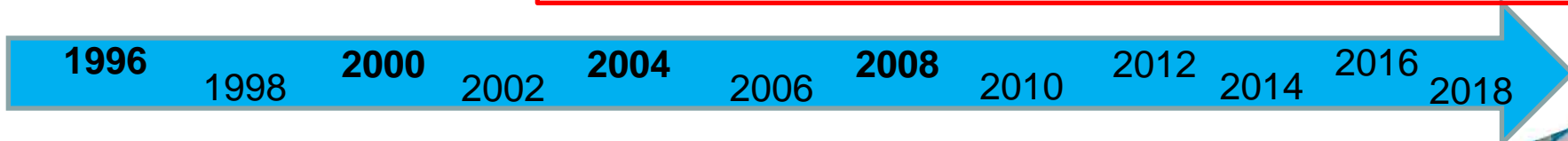


350km overland pipeline



160km sub sea pipeline

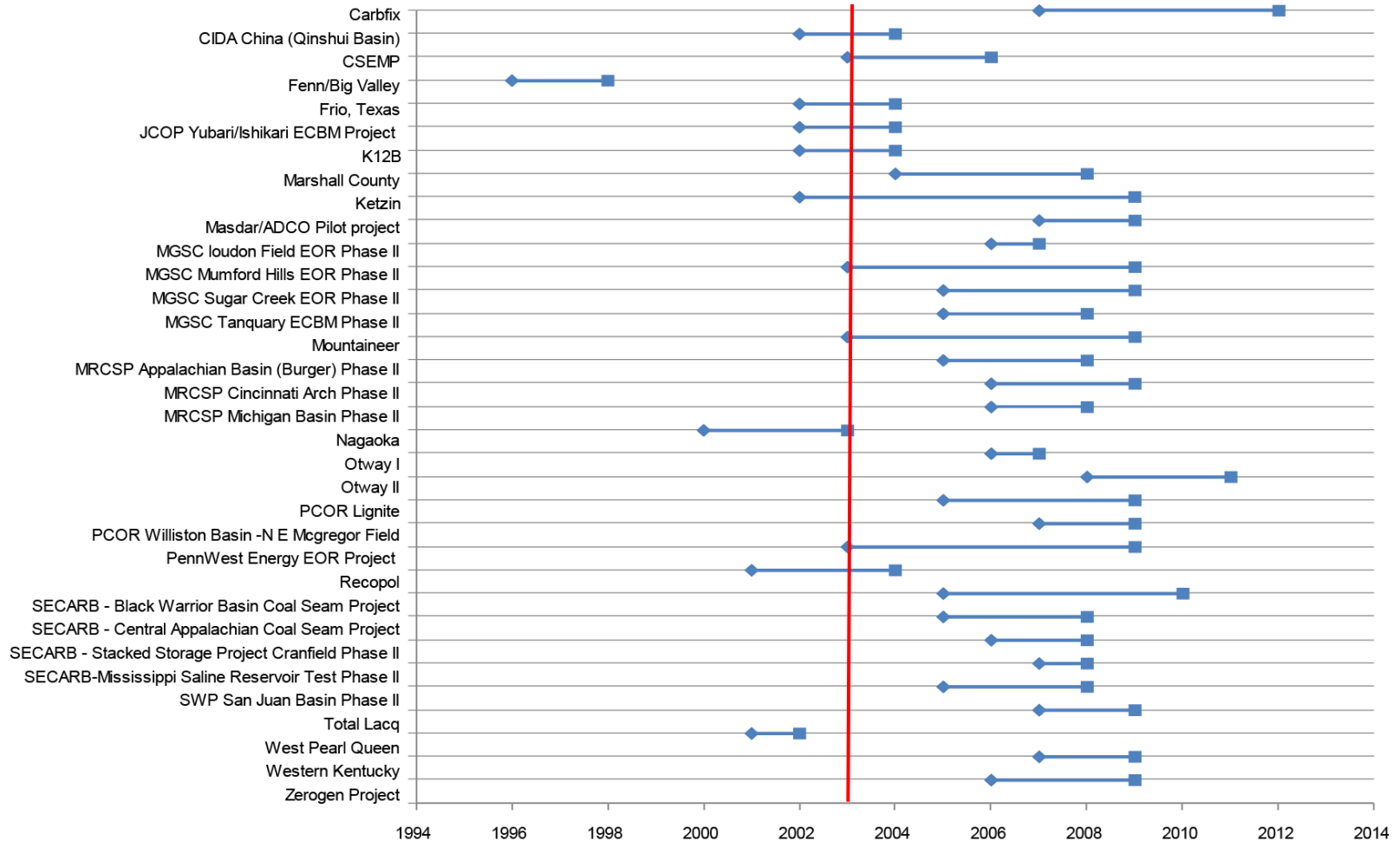
RCSP Time Window





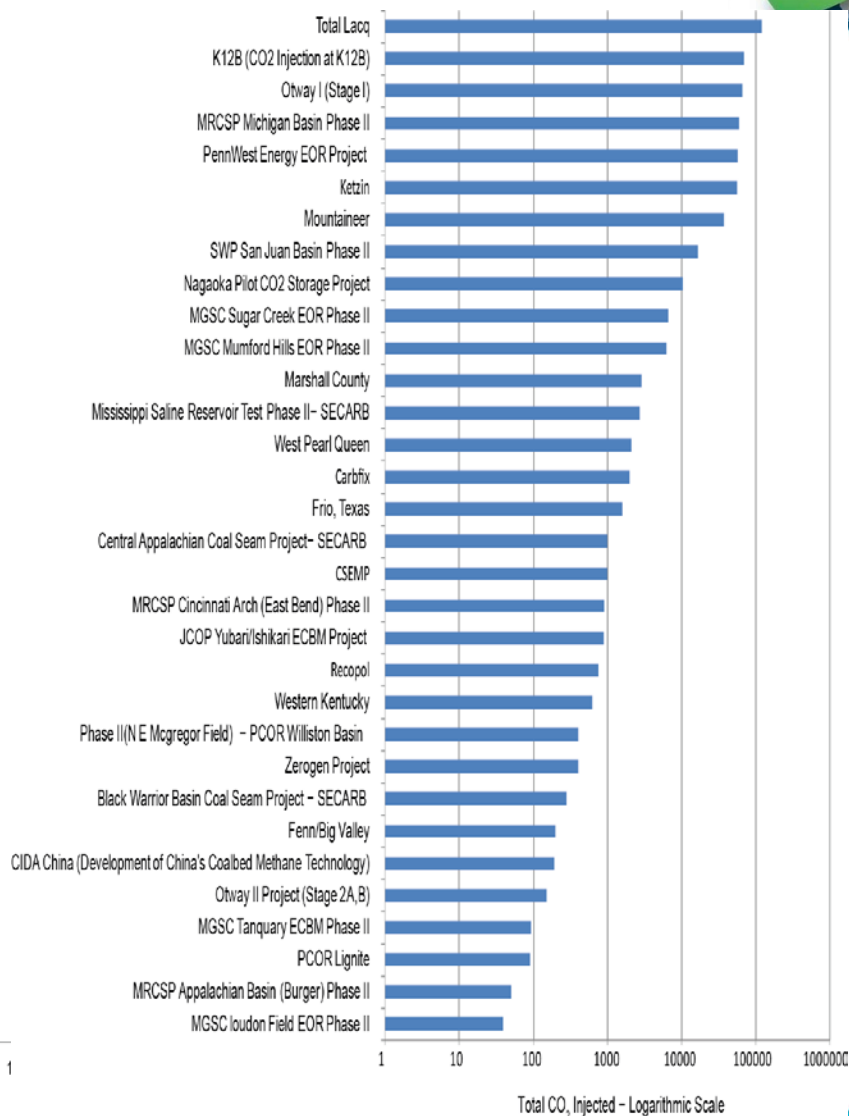
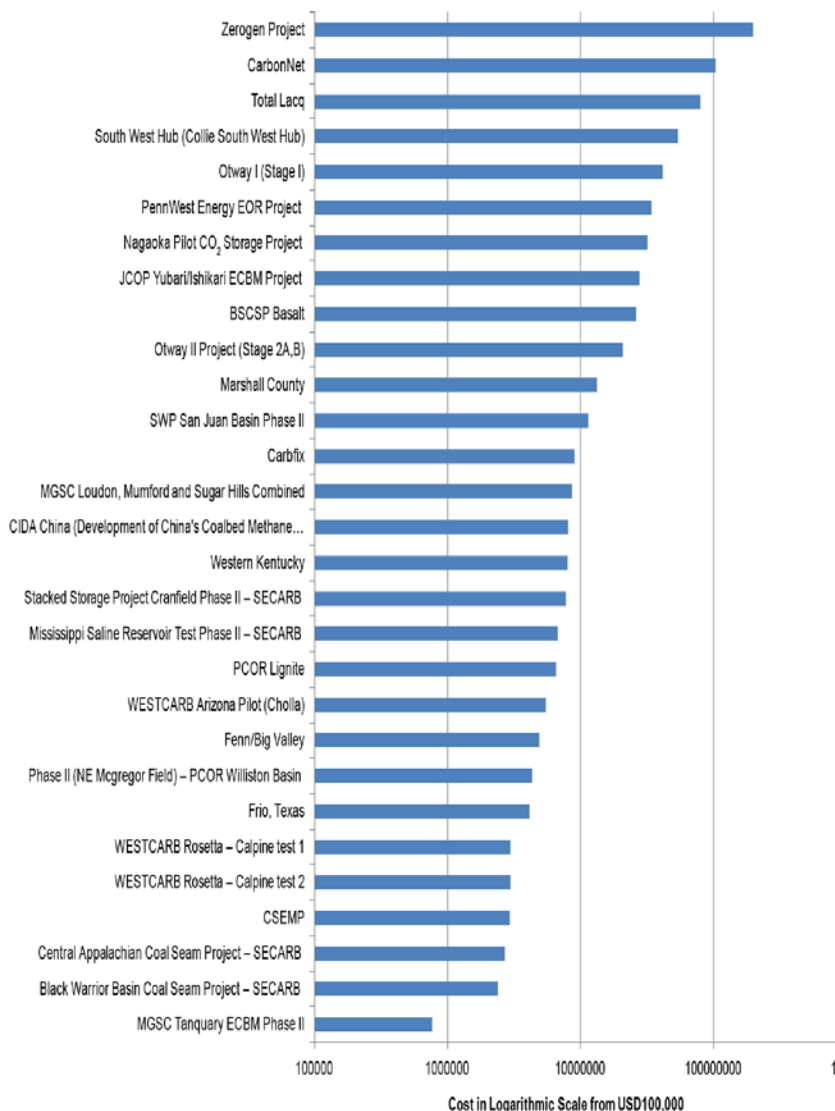
1 BSCSP Basalt	16 MGSC Sugar Creek EOR Phase II	31 SECARB - Stacked Storage Project Cranfield Phase II
2 Carbfix	17 MGSC Tanquary ECBM Phase II	32 SECARB - Mississippi Saline Reservoir Test Phase II
3 CarbonNet	18 Mountaineer	33 South West Hub (Collie South West Hub)
4 CIDA China	19 MRCSP Appalachian Basin (Burger) Phase II	34 Surat Basin CCS Project (Previously Wandoan)
5 CS Energy Callide Oxyfuel Project	20 MRCSP Cincinnati Arch (East Bend) Phase II	35 SWP San Juan Basin Phase II
6 CSEMP	21 MRCSP Michigan Basin Phase II	36 Teapot Dome, Wyoming
7 Fenn/Big Valley	22 Nagaoka Pilot CO2 Storage Project	37 Total Lacq
8 Frio, Texas	23 Otway I (Stage I)	38 West Pearl Queen
9 JCOP Yubari/Ishikari ECBM Project	24 Otway II Project (Stage 2A,B)	39 WESTCARB Arizona Pilot (Cholla)
10 K12B	25 PCOR Lignite	40 WESTCARB Northern California CO ₂ Reduction Project
11 Ketzin	26 PCOR Williston Basin -Phase II (NE Mcgregor Field)	41 WESTCARB Rosetta-Calpine test 1
12 Marshall County	27 PennWest Energy EOR Project	42 WESTCARB Rosetta-Calpine test 2
13 Masdar/ADCO Pilot project	28 Recopol	43 Western Kentucky
14 MGSC Ioudon Field EOR Phase II	29 SECARB - Black Warrior Basin Coal Seam Project	44 Zerogen Project
15 MGSC Mumfords Hills EOR Phase II	30 SECARB - Central Appalachian Coal Seam Project	

Project Lead Times



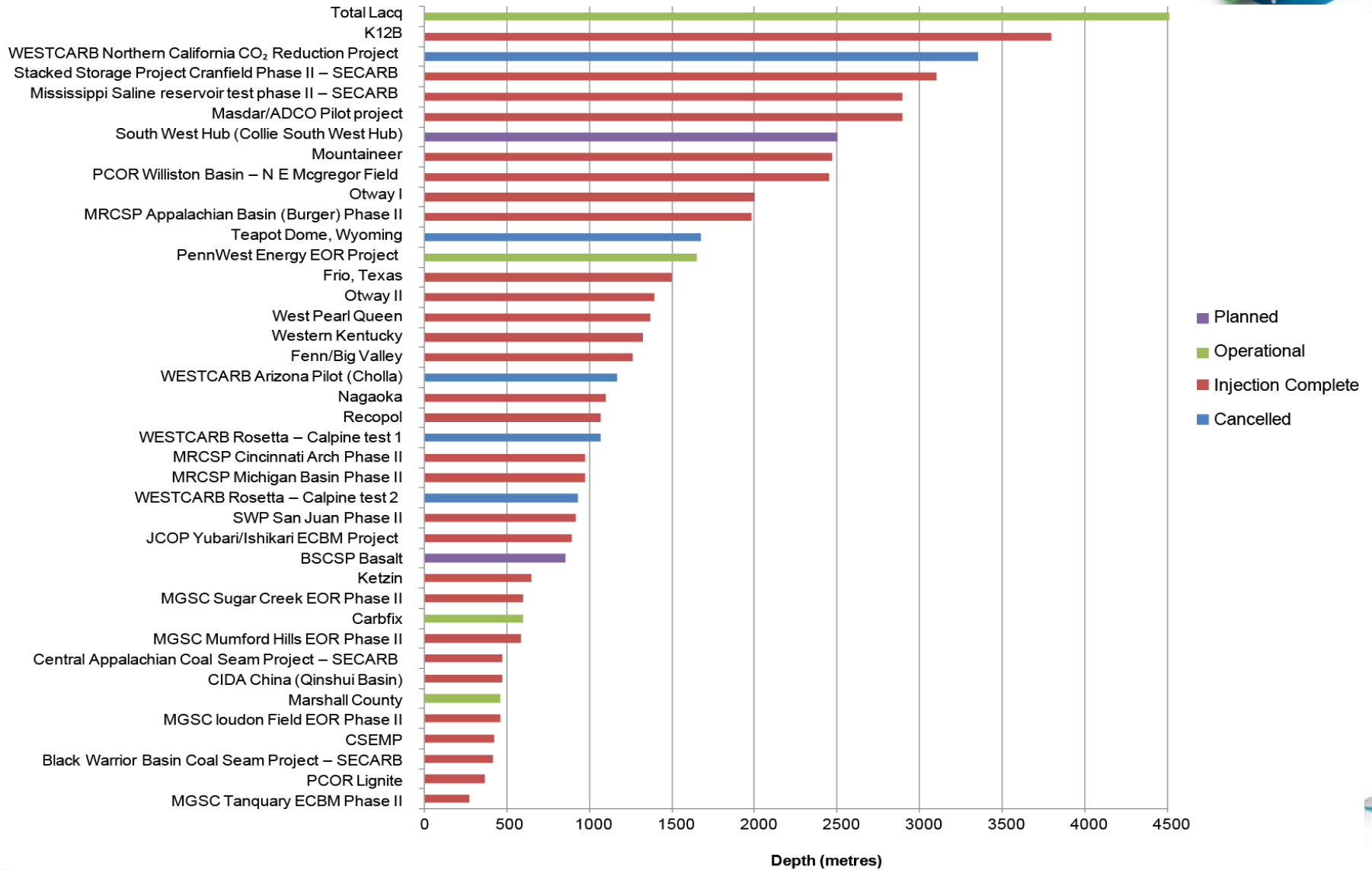
Indicative Costs

Indicative Depth





Indicative Depth



Small scale injections outside USA



- Coal seams – direct injection
 - RECOPOL/MOVECBM, Poland
 - JCOP ECBM Project, Japan
 - CIDA, China
- Coal seams – after drainage
 - Nothing outside USA
- Direct injections not successful – EU/Japan lost interest
- Basalt formations
 - CarbFix, Iceland
 - CO₂ dissolved in water prior to injection

Small scale injections outside USA

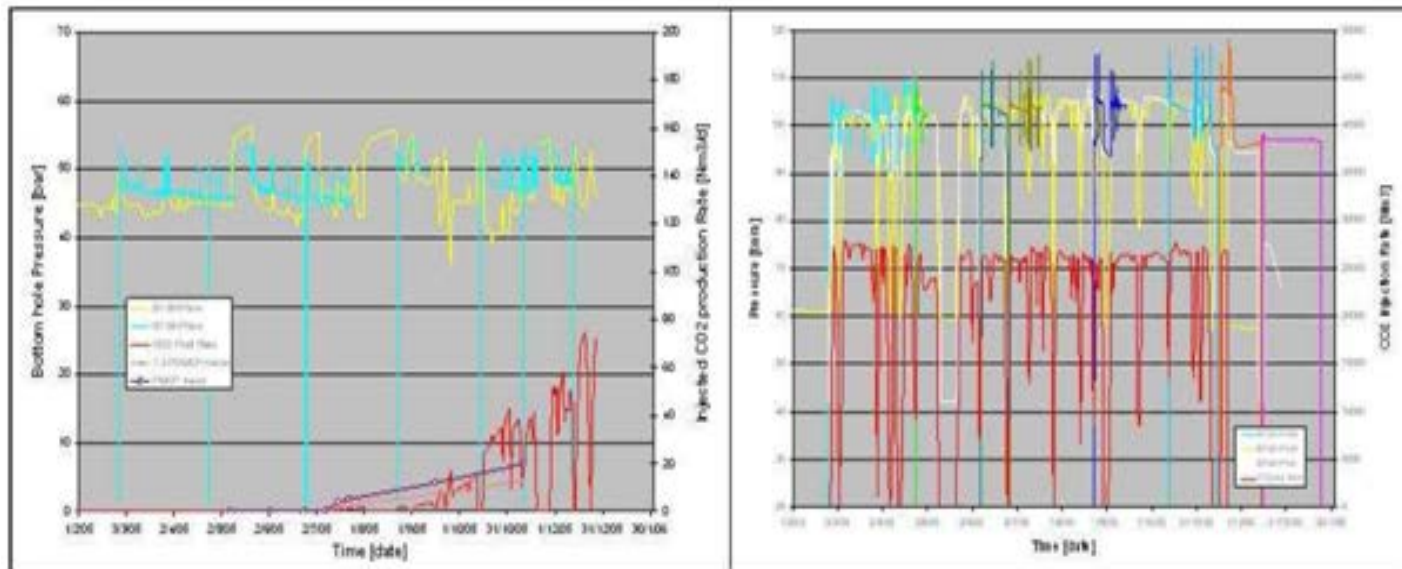


- Deep saline formations
 - Nagoka, Japan
 - Post closure monitoring underway
 - Lacq, France
 - Mustang, Israel
- Depleted gas fields
 - Ketzin, Germany
 - Post closure monitoring underway
 - Otway, Australia
 - K-12B Netherlands

Project Highlights



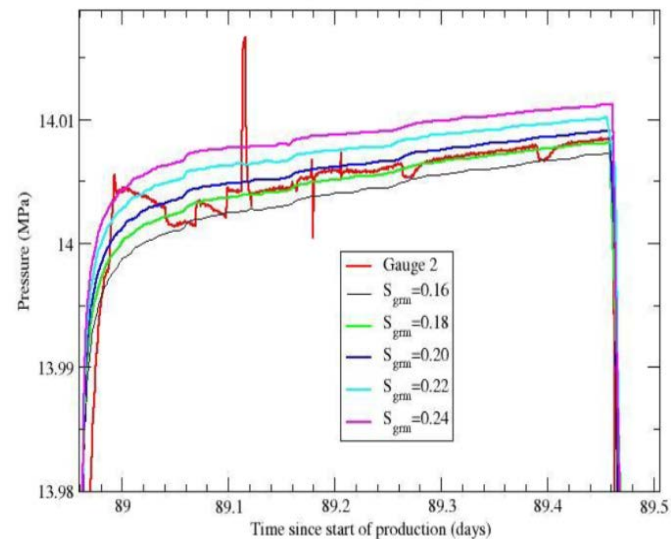
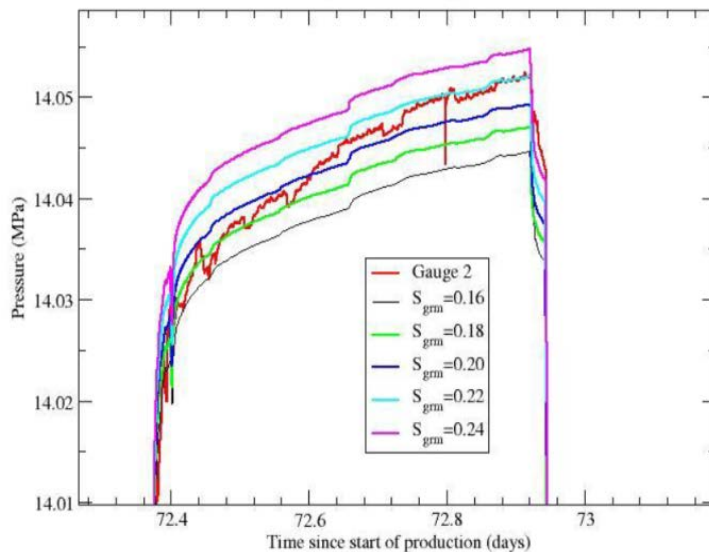
- K12-B
 - The reservoir model was calibrated to an approximately 17 year production history and could accurately predict the pressure response for 2 short-term CO₂ injection tests



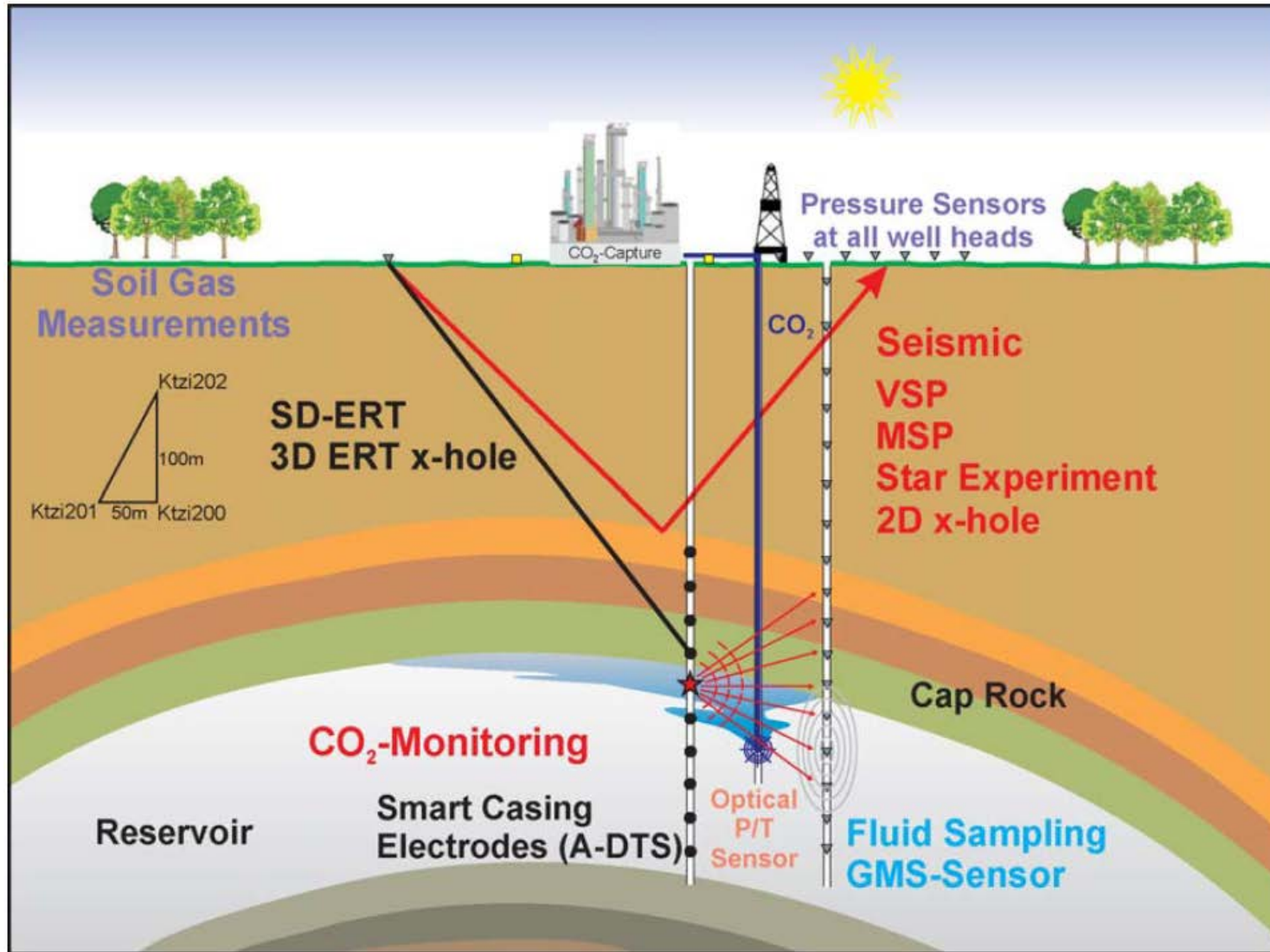
Otway



- Was the first to specifically determine the CO₂ residual saturation in a saline aquifer
- Using observed downhole pressures resulted in an average value of the CO₂ residual saturation between 15-19 %.



Ketzin



Examples of pilot successes



- K-12 B, The Netherlands
 - Monitoring and operational experience used to develop permit application for ROAD project to EC.
 - First Injection/Monitoring permit approved by EC.
- Nagoka, Japan
 - Monitoring during earthquake demonstrated that seismic activity does not impact storage security
 - Post closure monitoring demonstrated CO₂ dissolution in reservoir brine

Examples of pilot outcomes



- Weyburn, Canada
 - Demonstrated importance of baseline monitoring
 - Supposed leak from site was disproved based on baseline monitoring
 - New technique by University of Texas based on C isotope analysis showed baseline data not critical
- ZeroGen, Australia.
 - Need historical geological data before you commit to start drilling.

Public Awareness



- Pilots play a key role
 - Visitor centres at sites
 - Direct local dialogue
 - First hand experience of CO₂ storage site
 - Meet the scientists
 - Disseminate information a local level
 - Build public confidence
 - Lacq, France
 - Ketzin, Germany

A picture tells a 1000 words



Concluding Remarks



- CO₂ injection pilots are the key to global implementation of CCS.
 - Build science/knowledge base
 - Key to developing public confidence
 - Develop expertise for future larger scale implementation
- The number of CO₂ pilot projects outside the USA roughly number those in the RCSP
- The data we have to date comes to a large degree from non USA pilots
 - Weyburn, Sleipner, Ketzin, K12-B & Cranfield published in IJGGC
- Urge you when you have time to publish your work.
- RCSP results are the next step in building the knowledge base on CO₂ storage.

The next 10 years?




- New storage pilots in Taiwan, Israel, South Africa, UK and Switzerland
- New integrated demos in: UK (2), Norway, Netherlands?
- China, to take the lead on CCS development?
- South East Asia becomes a big CCS player?
- Middle East next centre for CO₂-EOR roll out



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TWO THOUSAND AND
FOURTEEN
AUSTIN, TX – USA

- 
- Call for papers
 - Deadline for abstracts
 - Registration opens
 - Authors notified
 - Early bird closes

27th September
2013

10th January 2014

7th March 2014

2nd May 2014

13th June 2014



Thank you, any Questions?

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