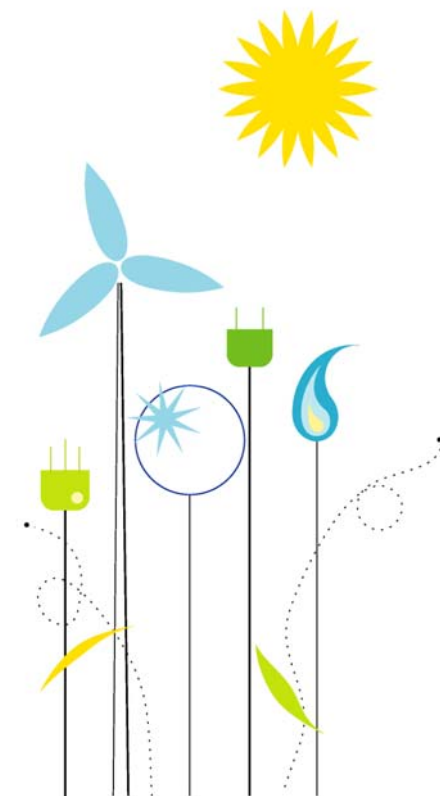


## CO<sub>2</sub> Capture and Sequestration: Views from Industry

Gardiner Hill  
Director Technology

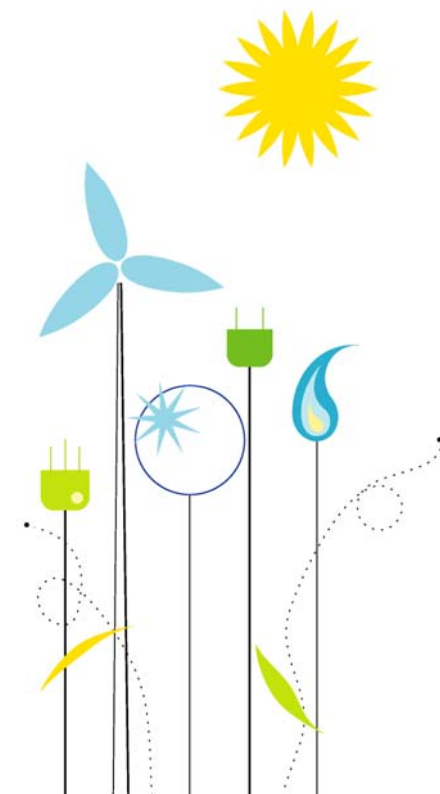
Bloomberg National Headquarters, NYC, 5<sup>th</sup> March 2009



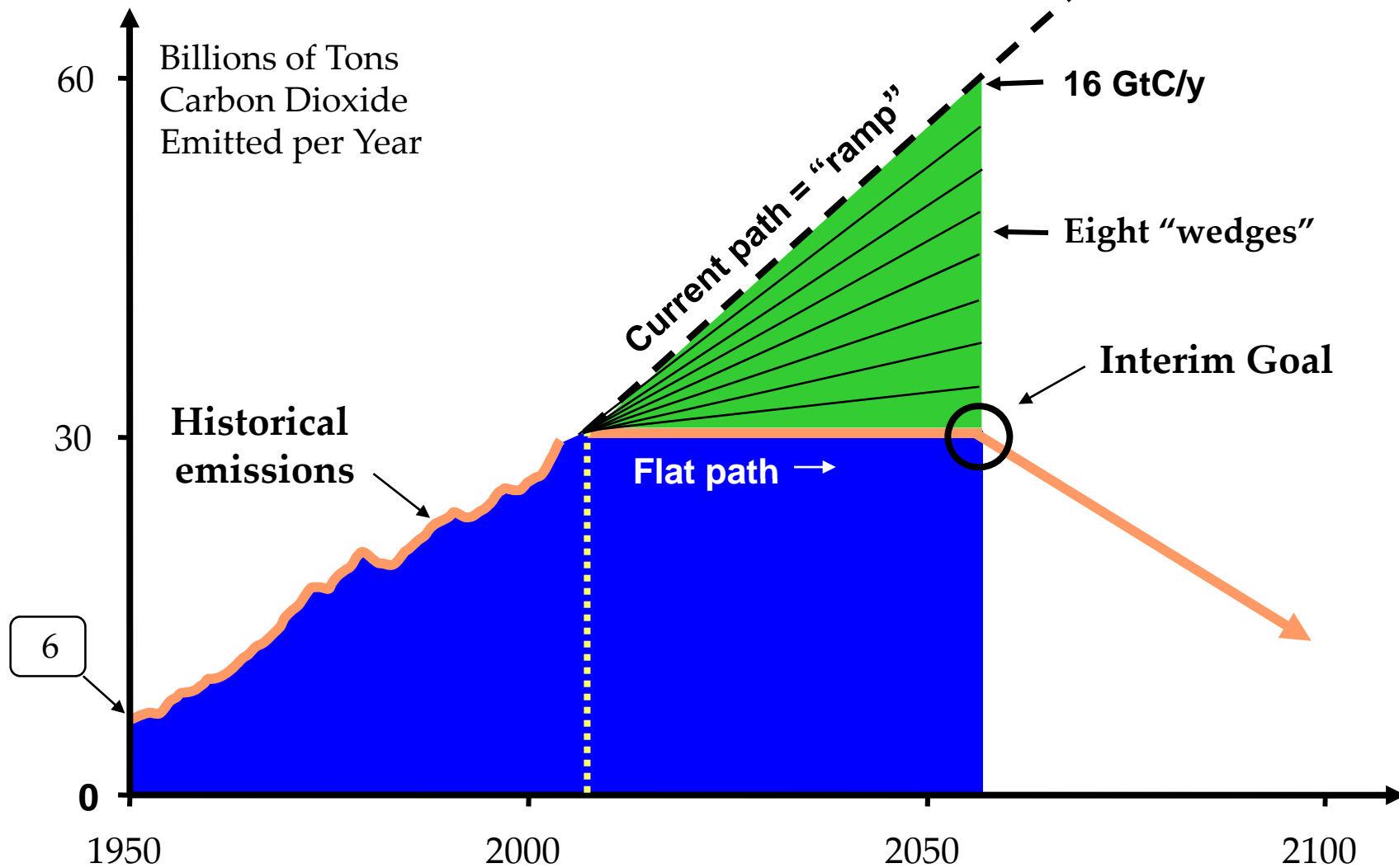


# Overview

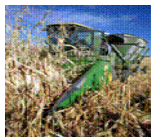
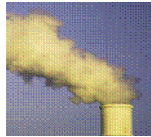
- *Context from an Energy Company perspective*
- *CO<sub>2</sub> Capture and Geological Storage*
- *What is BP doing?*
- *Sustainable deployment of CCS*



# Solutions to Climate Change: Stabilization Wedges



# BP Wedges in a stabilisation triangle



Wedges	Detail	Feasibility
 Efficiency	Double fuel efficiency of 2 billion cars from 30 to 60 mpg	There are 600 million cars in the world today, Projection is 2 billion by 2054. <b>1 wedge * Double the average fuel efficiency of the fleet.</b>
 Fuel Switching	Replace 1400 coal electric plants with natural gas-powered facilities (Adding an amount in 2054 almost equal to today's world gas usage)	<b>1 wedge * bringing one Alaska pipeline on line every year for 50 years; or</b> <b>1 wedge * 50 large LNG tankers docking and discharging every day</b>
 Carbon capture and storage	Capture AND store emissions from 800 coal electric plants	<b>1 wedge * 3500 In Salah developments (each need to last through to 2054)</b>
 Nuclear	Add double the current global nuclear capacity to replace coal-based electricity	400 nuclear plants today, <b>1 wedge * adding 700 more in the next 50 years</b>
 Wind	Increase wind electricity capacity by 50 times relative to today, for a total of 2 million large windmills	<b>1 wedge * windmills on an area approx 4 times that of UK</b>
 Solar	Use 40,000 square kms of solar panels to produce hydrogen for fuel cell cars	<b>1 wedge * solar panels covering area 230 times the area of London (1/12 size of UK)</b>
 Natural sinks	Eliminate tropical deforestation AND create new plantations on non-forested land to quintuple current plantation area	<b>1 wedge * new plantations with a total area 25 times that of the UK</b>

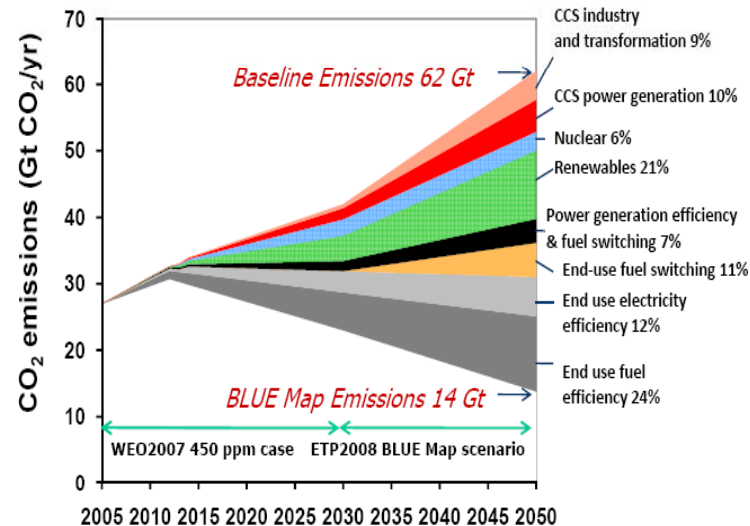
# CO<sub>2</sub> emission targets cannot be achieved *without* CCS



- Rising energy demand cannot be met by Renewables alone
- CO<sub>2</sub> emission targets cannot be met by Renewables & energy efficiency alone
- CCS can make a significant contribution to reducing CO<sub>2</sub> emissions by 2030 (& beyond);
  - €60bn more without CCS
  - Carbon price 46% higher



## A New Energy Revolution: Cutting Energy Related CO<sub>2</sub> Emissions



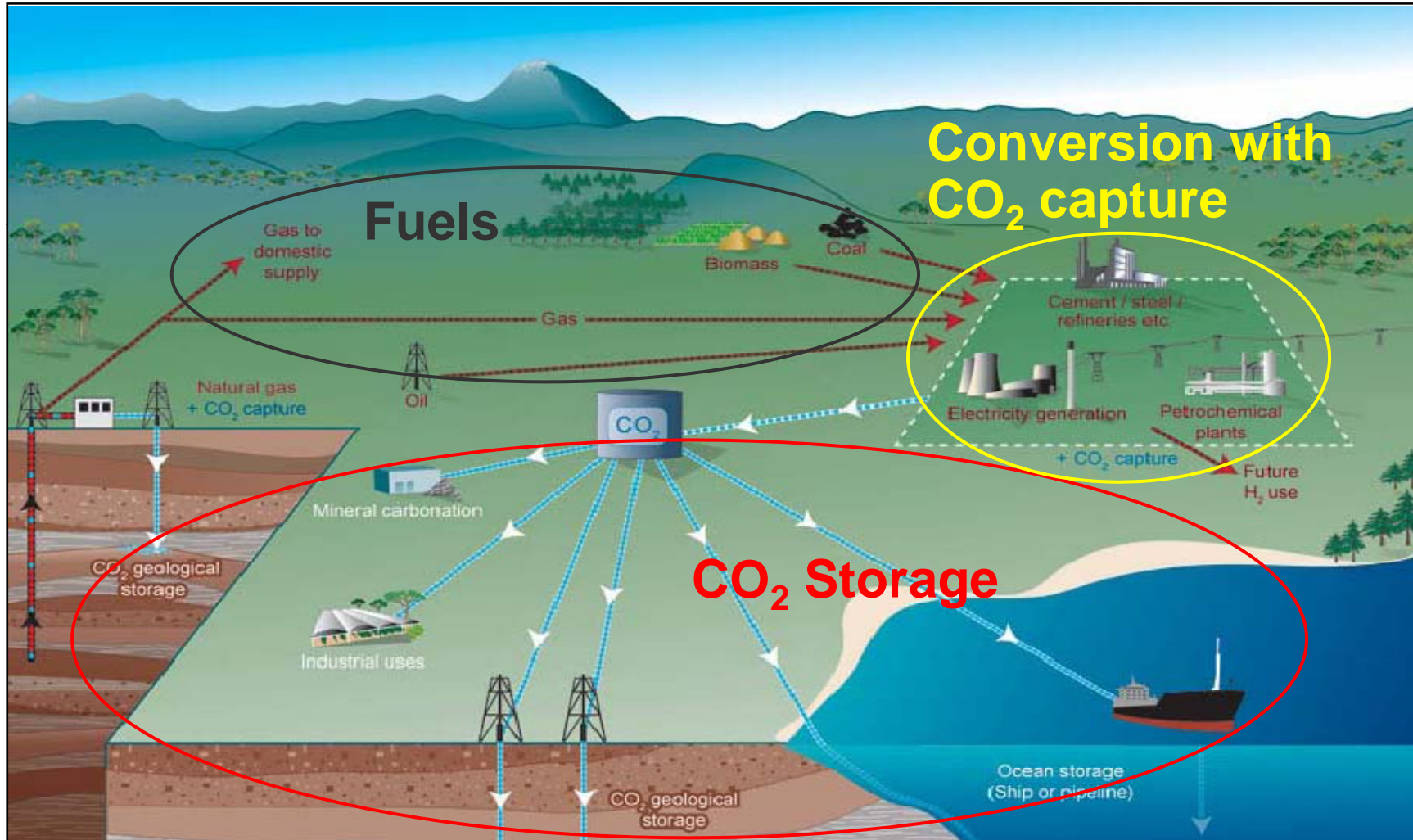
In support of the G8 Plan of Action

© OECD/IEA - 2008

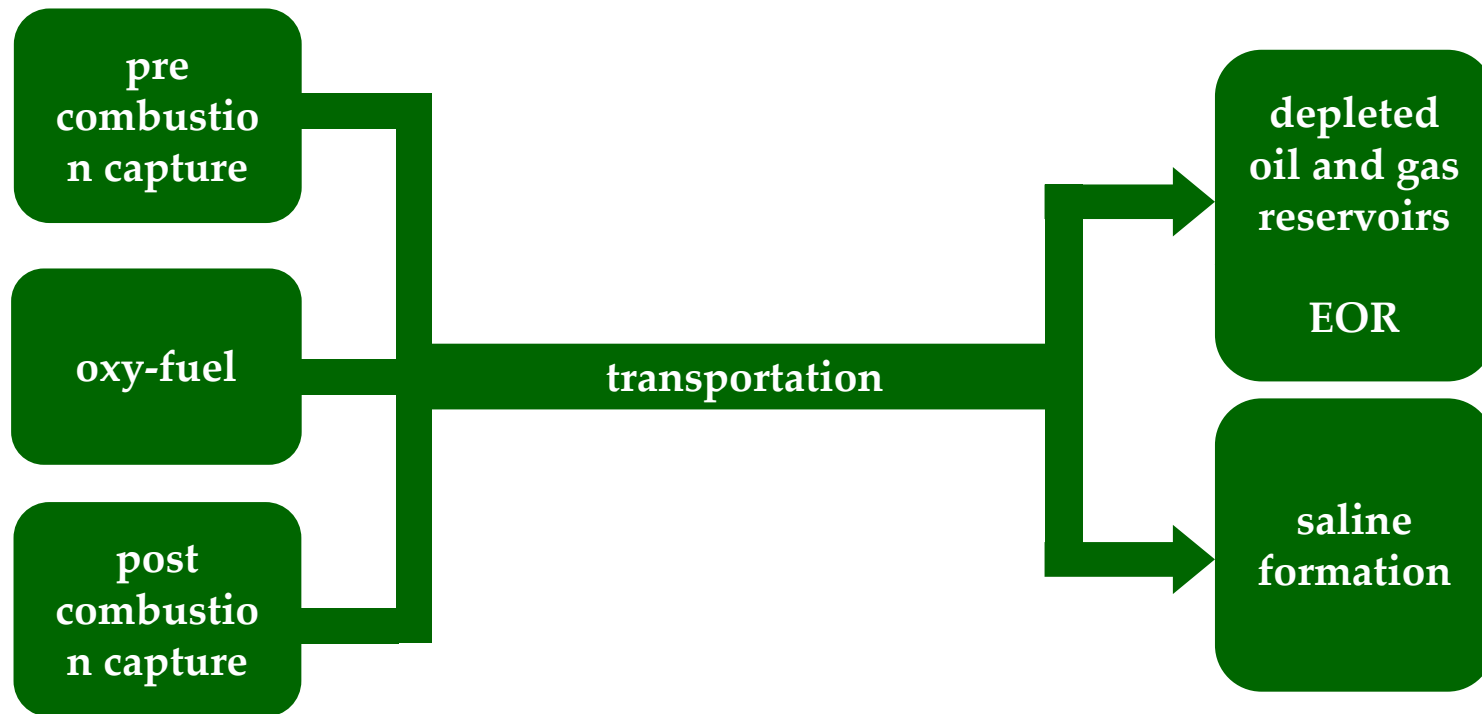
IEA Energy Technology Perspectives, June 2008

*CCS is a key solution for combating climate change  
..... a critical element within a portfolio of solutions*

# CO<sub>2</sub> capture and storage system



# What is carbon capture and storage?



...competitive but complex projects



# State of play of CO<sub>2</sub> capture & storage



**CO<sub>2</sub> Capture & Storage is ready for deployment now and is suited to large stationary point sources of CO<sub>2</sub> from power generation, industry and H<sub>2</sub> production.**

## CO<sub>2</sub> Capture

- √ Post-Combustion
- Pre-Combustion
- Oxyfuels
- \$60-100+/Tonne CO<sub>2</sub>

## High Purity Sources

- Already separated
- Hi Concentration
- √ Amines, Membranes, H<sub>2</sub>
- \$2-10/t CO<sub>2</sub>



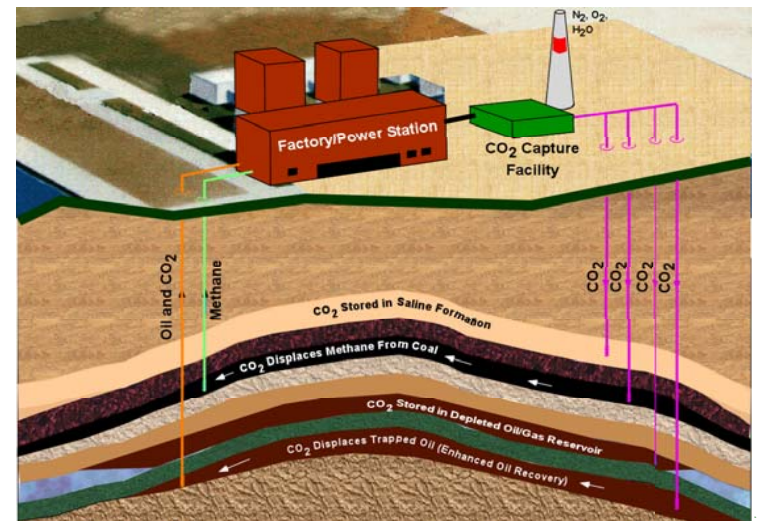
## Transport

- √ Pipelines
- Ships
- \$ Depends distance



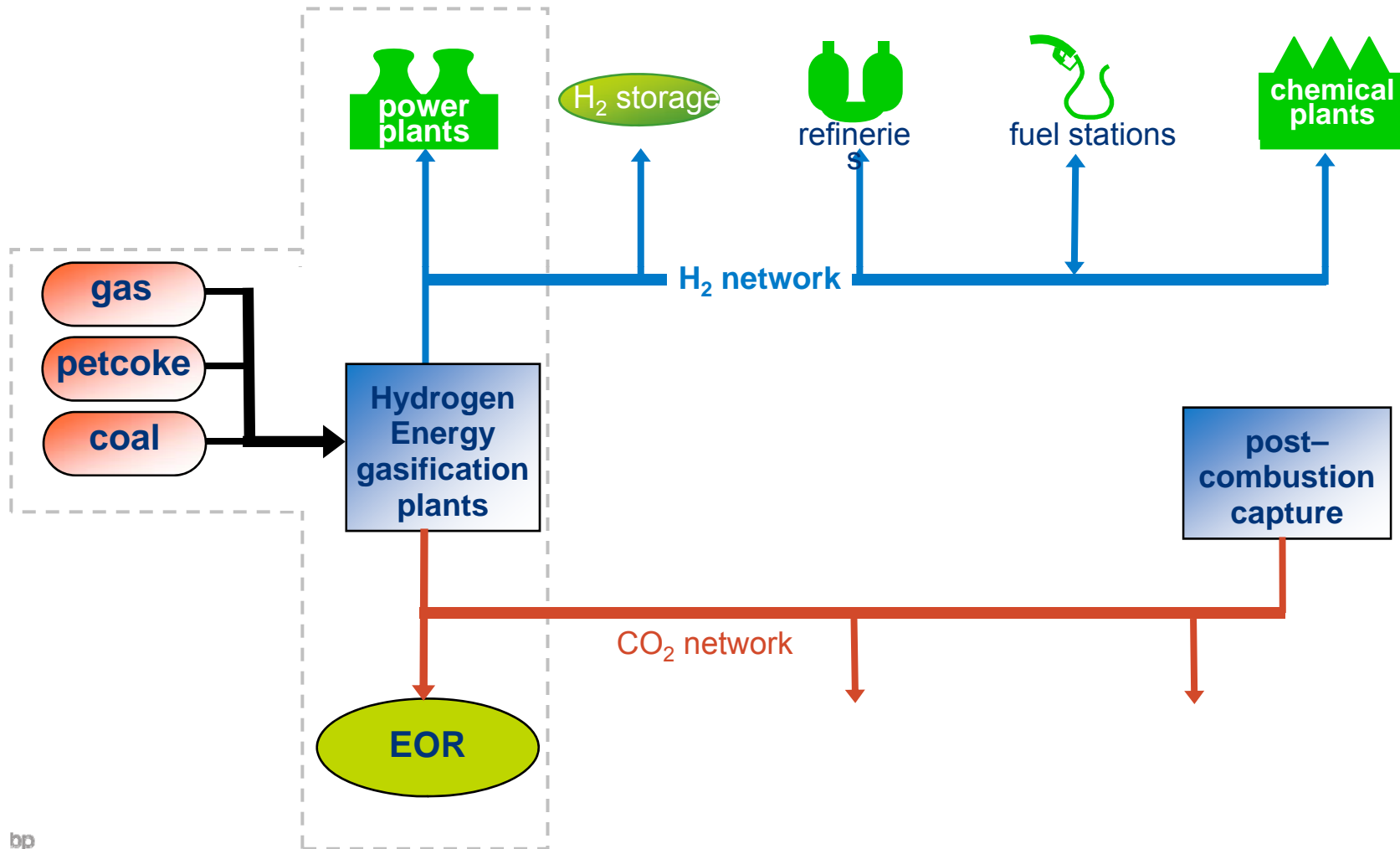
## Geological Storage

- √ Enhanced Oil Recovery
- √ Saline Aquifer Formations
- √ Depleted Oil/Gas Reservoirs
- Enhanced Coal Bed Methane
- \$4-20/t CO<sub>2</sub>





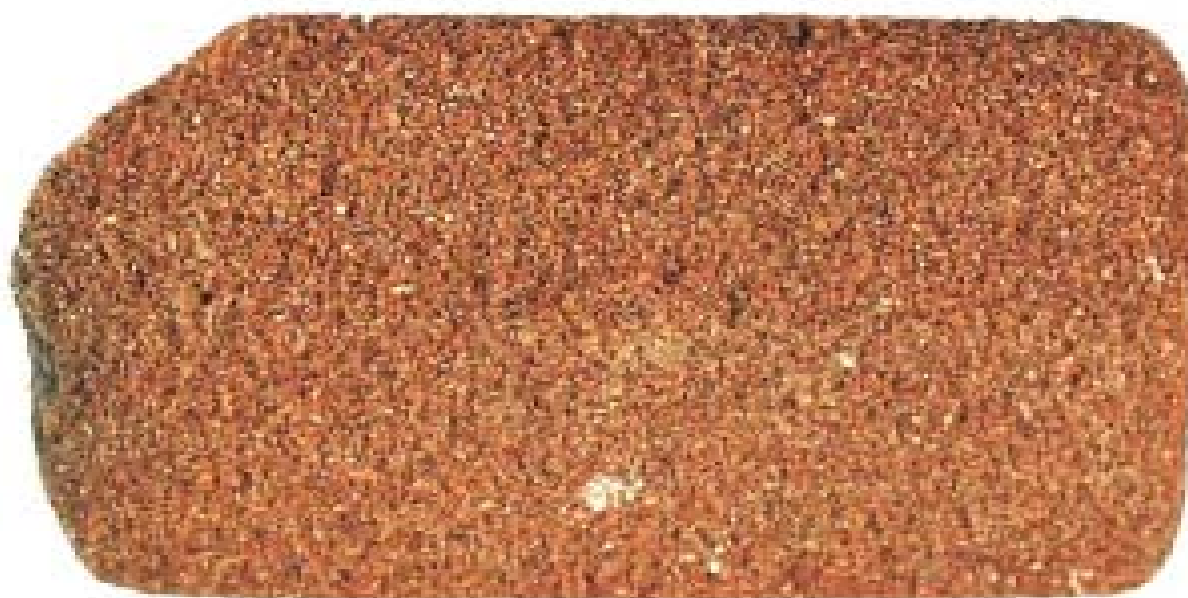
# Hydrogen Energy - a fuel supplier



**RioTinto**

A joint venture between  
BP Alternative Energy and Rio Tinto

CO<sub>2</sub> is stored in rock



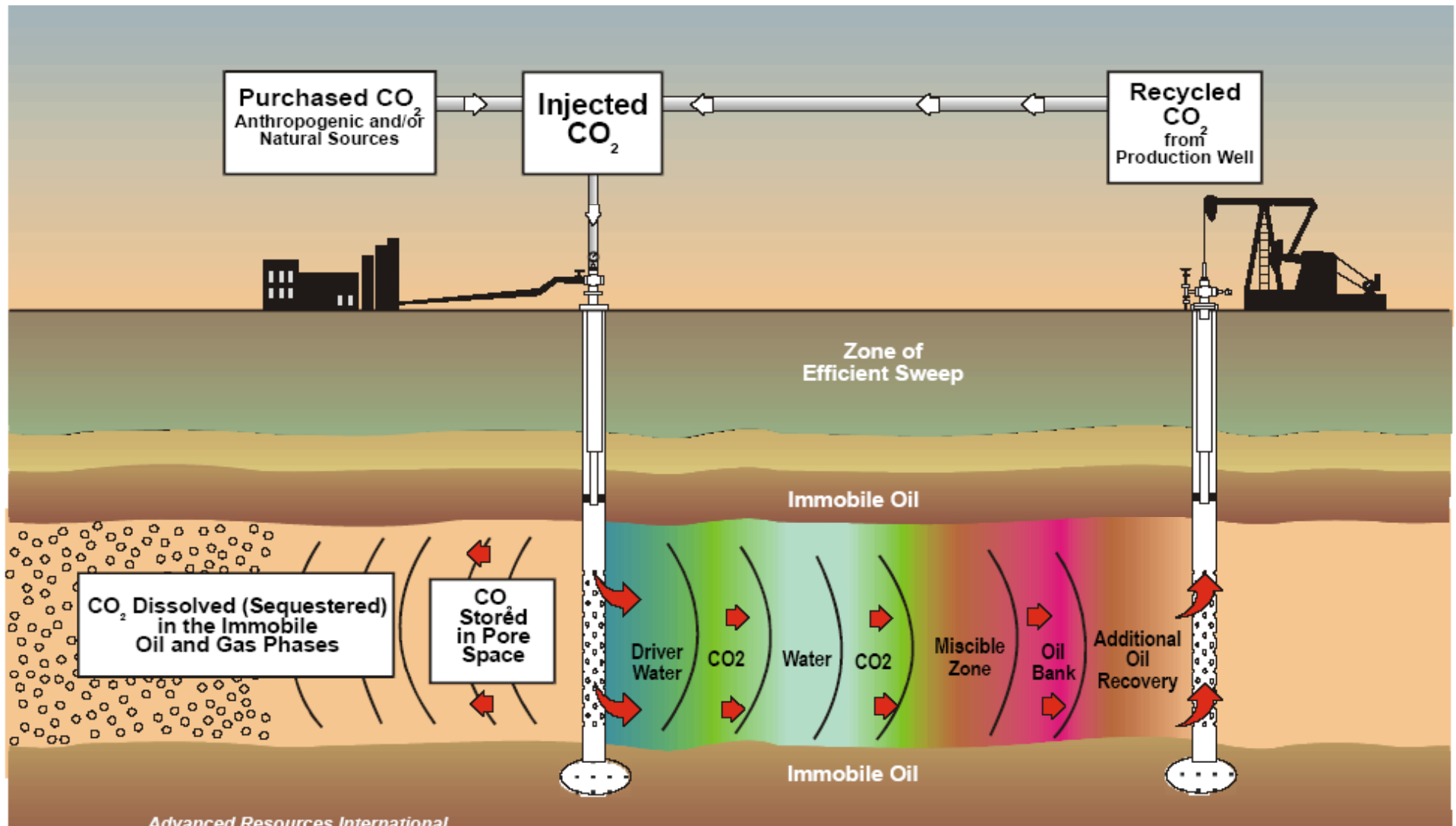
0 1 2 cm

CO<sub>2</sub> would be retained within the pore-spaces of the rock, deep underground

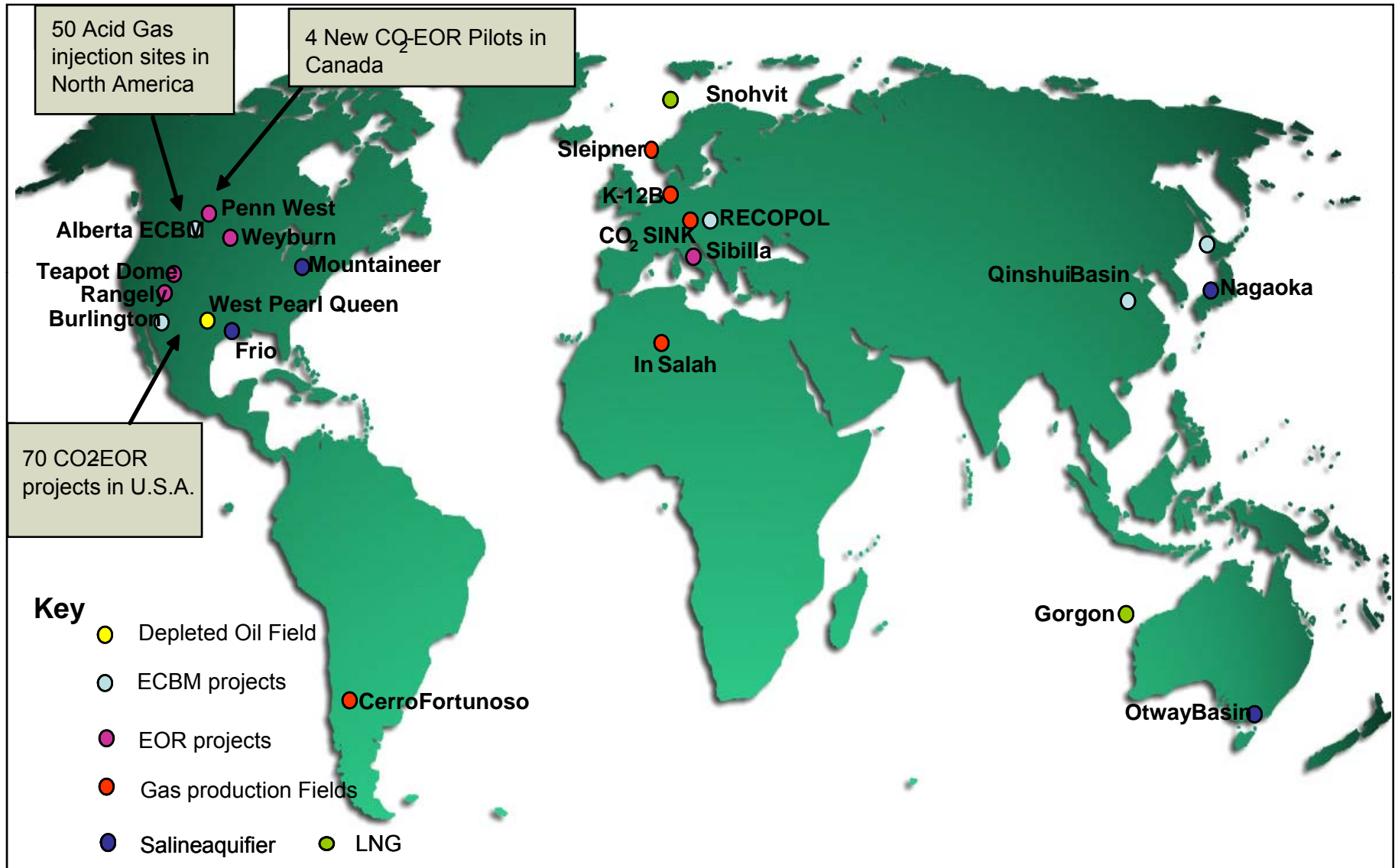
# CO<sub>2</sub> storage via EOR



..... Getting CO<sub>2</sub> Storage started



# CO<sub>2</sub> Injection and Storage Activities



# What is BP doing?- BP CCS technology program



Research



Industry / Academic Initiatives



**Source-sink matching**  
CO2CRC, EUGeocapacity, Coach, US Regional partnerships

**Public policy support**  
CSLF, ECCP, EU-ZEPP

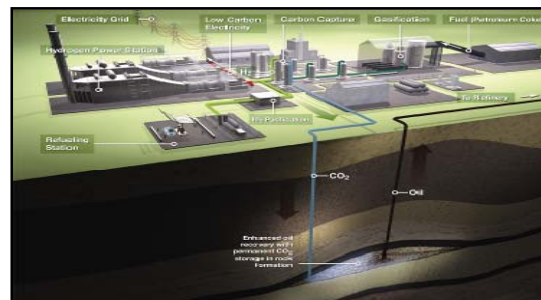
**Assurance framework**  
CO2CRC, CSLF, IMCO2, WRI

**3rd Party Demonstrations**  
Sleipner, Weyburn, CO2Remove, Ottway Basin

Technical Demonstrations



Industrial Scale Projects



California H2P



Abu Dhabi H2P



# CO<sub>2</sub> Capture Project (CCP)



## CO<sub>2</sub> Capture Project

### Cooperating for a Better Environment

The world will have to reduce **GreenHouse Gas** emissions before it stops using fossil fuels.

CO<sub>2</sub> capture and geological storage removes the carbon from fossil fuels and can provide a significant cost-effective GreenHouse Gas reduction option for the world.

The **CO<sub>2</sub> Capture Project** is an international initiative funded by eight of the world's leading energy companies and three governments.

#### Project Goals

- Conduct research, development and pilot testing to reduce the cost of CO<sub>2</sub> capture from large, fixed sources.
- Demonstrate that the geological storage of CO<sub>2</sub> is secure and can represent a viable GreenHouse Gas mitigation technique.
- Establish an extended network for CO<sub>2</sub> storage demonstrations to share learning.



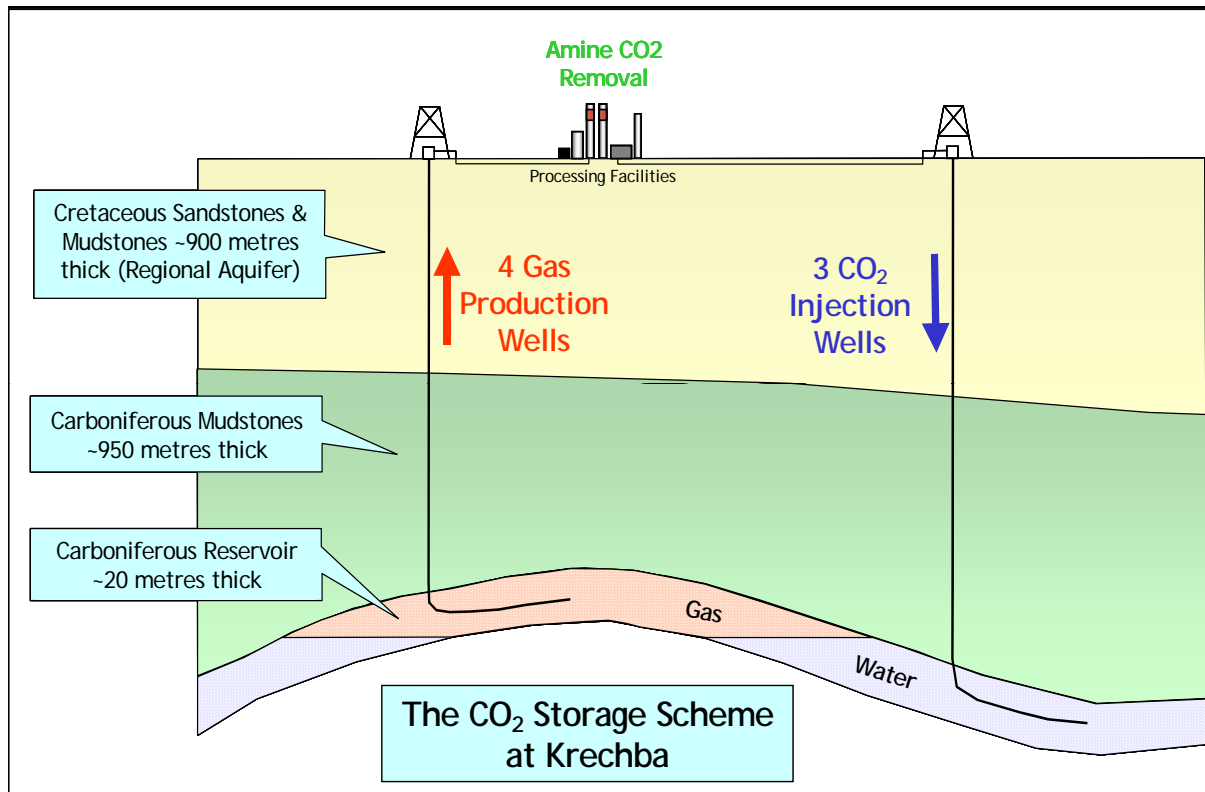
CO<sub>2</sub> Capture Project

CO<sub>2</sub> Capture Project



[www.co2captureproject.org](http://www.co2captureproject.org)





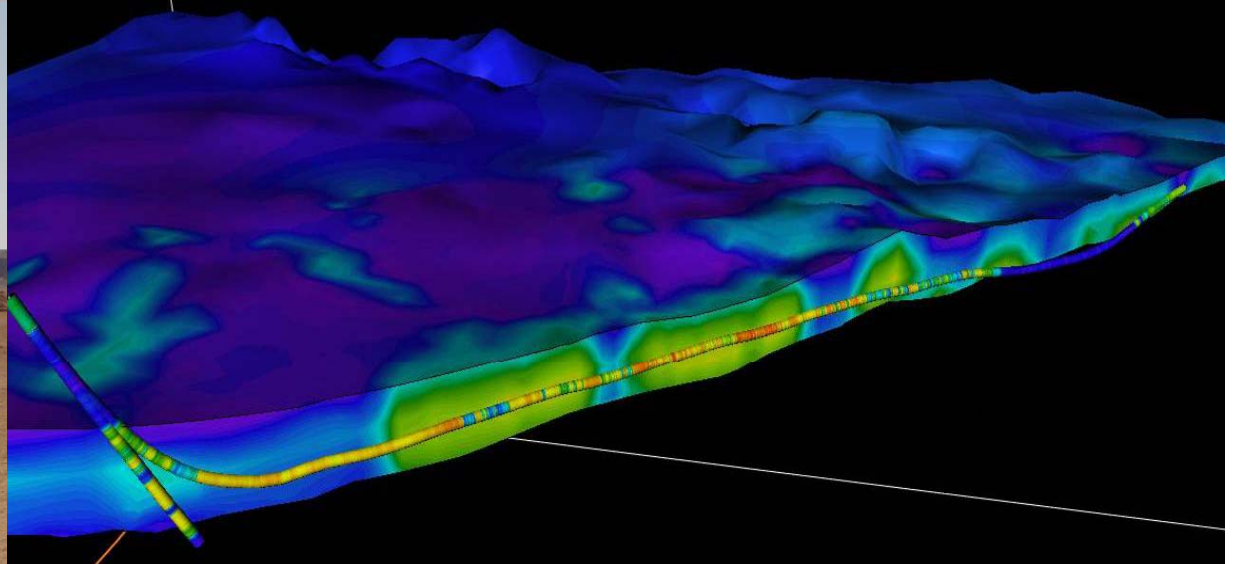
## Climate Change Milestones

- Industrial Scale Demonstration of CO<sub>2</sub> Geological Storage (Conventional Capture)
- Storage Formation is very similar to the North Sea (USA & China)
- Started Storage in August 2004
- 1mmtpa CO<sub>2</sub> Stored (17mm tonnes total)
- \$100mm Incremental Cost for Storage, No commercial benefit
- Test-bed for CO<sub>2</sub> Monitoring Technologies \$30mm Research Project

# CO<sub>2</sub> storage infrastructure



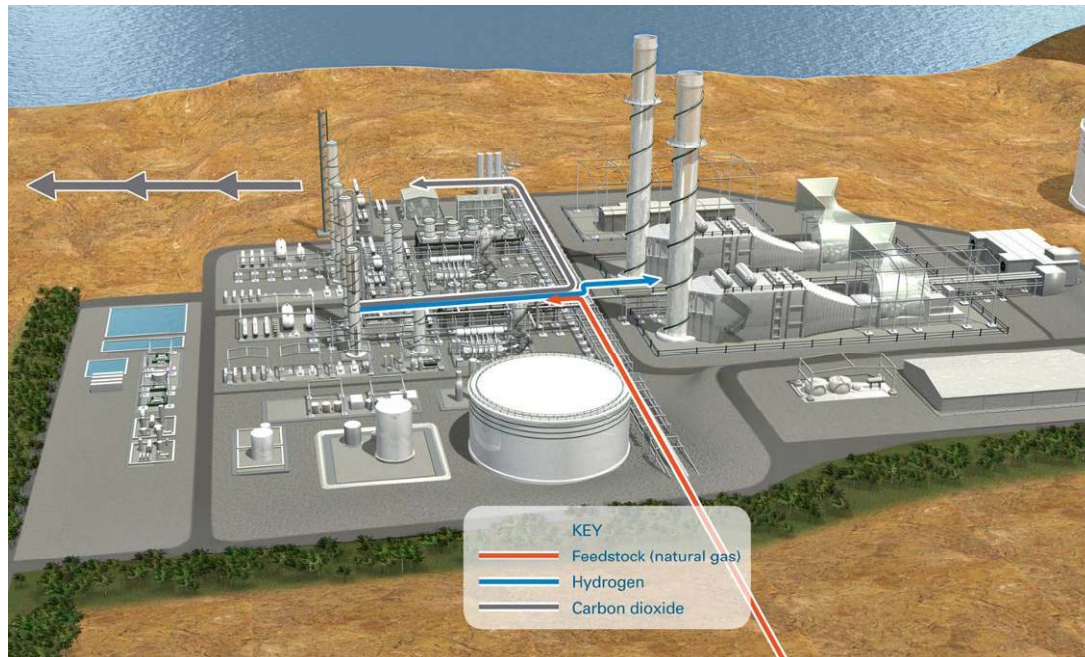
50mmscf/d CO<sub>2</sub>  
(1mmtpa)  
Compression  
Transportation  
Injection  
Storage





# Hydrogen Power Project, Abu Dhabi

MASDAR  
ABU DHABI FUTURE ENERGY COMPANY  
مصدر  
شركة أبوظبي لطاقة المستقبل



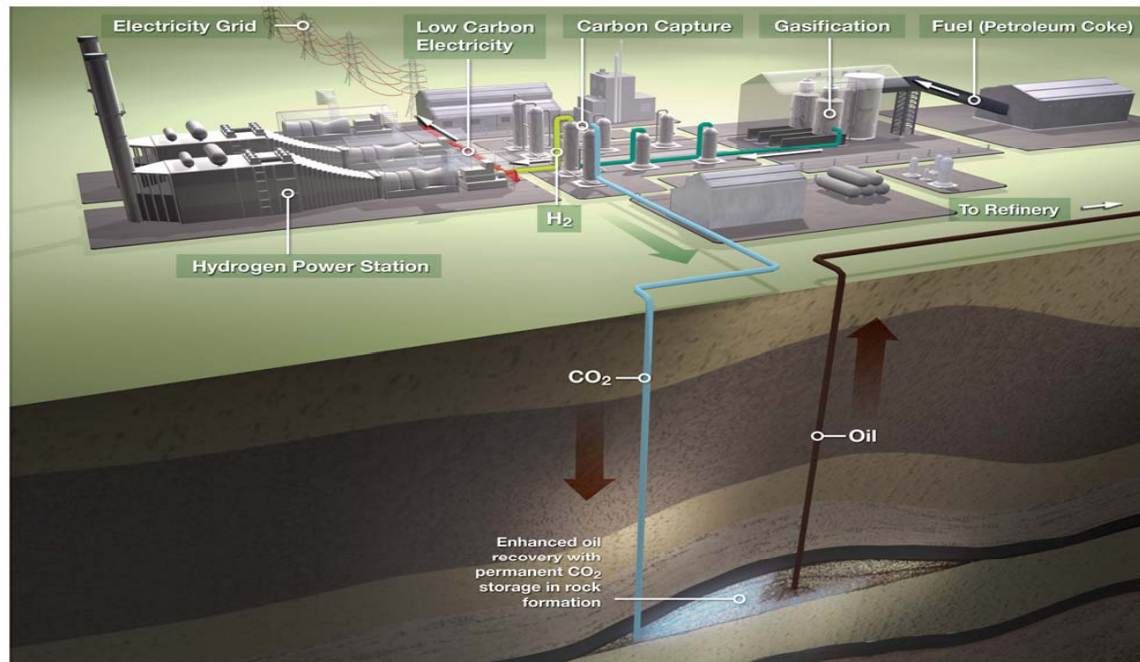
## Project

- Expected to be the world's first power plant powered by hydrogen derived from natural gas
- Delivered CO<sub>2</sub> could replace natural gas for Enhanced Oil Recovery
- Project Sanction Milestone 2010 & commissioning in 2013

## Climate Change Milestones

- 400 MW of low-carbon electricity = 5% of Abu Dhabi's capacity
- 1.7 mmtpa CO<sub>2</sub> captured = decarbonizing Abu Dhabi's transport sector
- CO<sub>2</sub> will be used for Enhanced Oil Recovery (EOR) and ultimately stored
- Secure geological storage of CO<sub>2</sub>

# Hydrogen Energy California Project



## Project

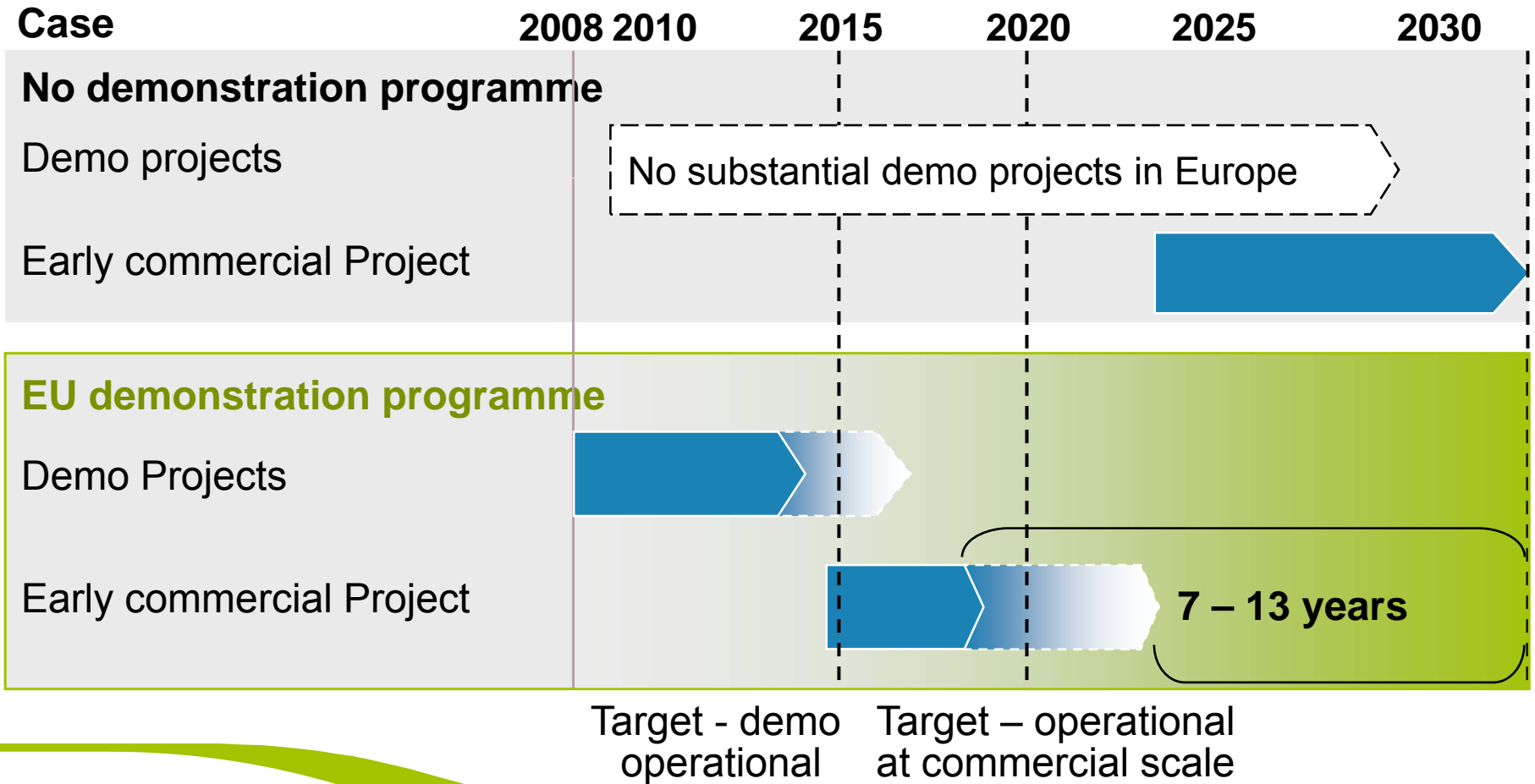
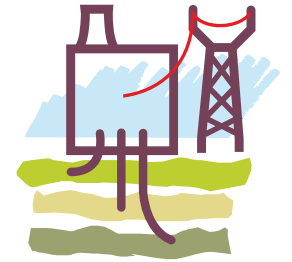
- Uses gasification technology to convert solid fuels into hydrogen for low carbon power generation with carbon capture and storage.
- Project Sanction Milestone 2011 & potential start-up in 2014

## Climate Change Milestones

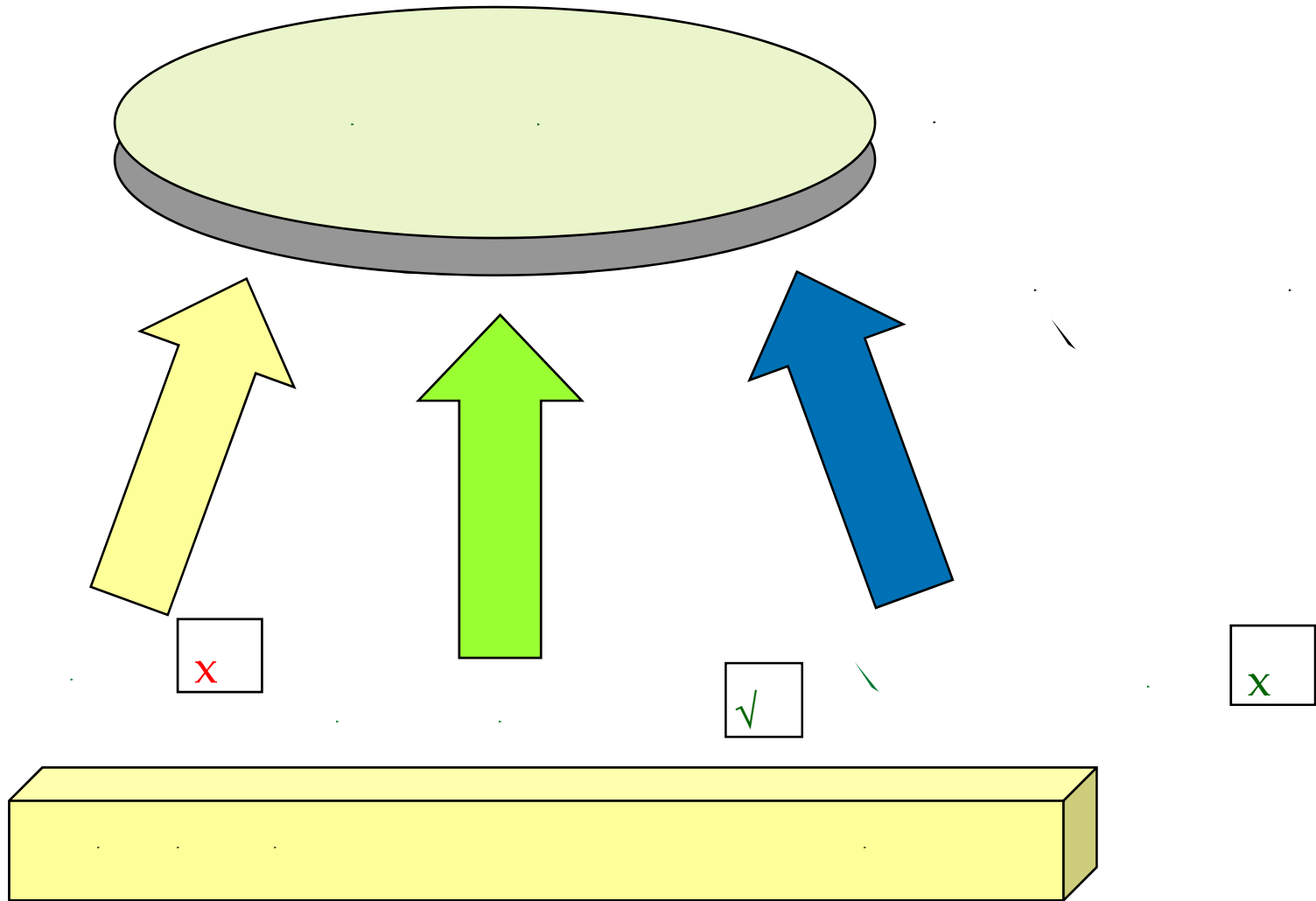
- 250 MW of hydrogen-generated electricity - enough to power 150,000 California homes
- Capture 2 million tpa of CO<sub>2</sub> for enhanced oil recovery (EOR) and long term storage in Kern County, California
- Lowest CO<sub>2</sub> emissions in the world for an IGCC plant due to 90% capture

# An EU Demonstration Programme Gives CCS a ~10 Year Head-Start

**Objective:**  
Enable commercial availability  
of CCS by 2020



# Sustainable Deployment of CCS





# Early Projects Require Funding to Fill the Economic Gap

- CCS not currently economically viable. Public contribution necessary for some portion
- Expectation is  $n^{\text{th}}$  plant costs will be highly cost competitive with other low carbon sources of energy

