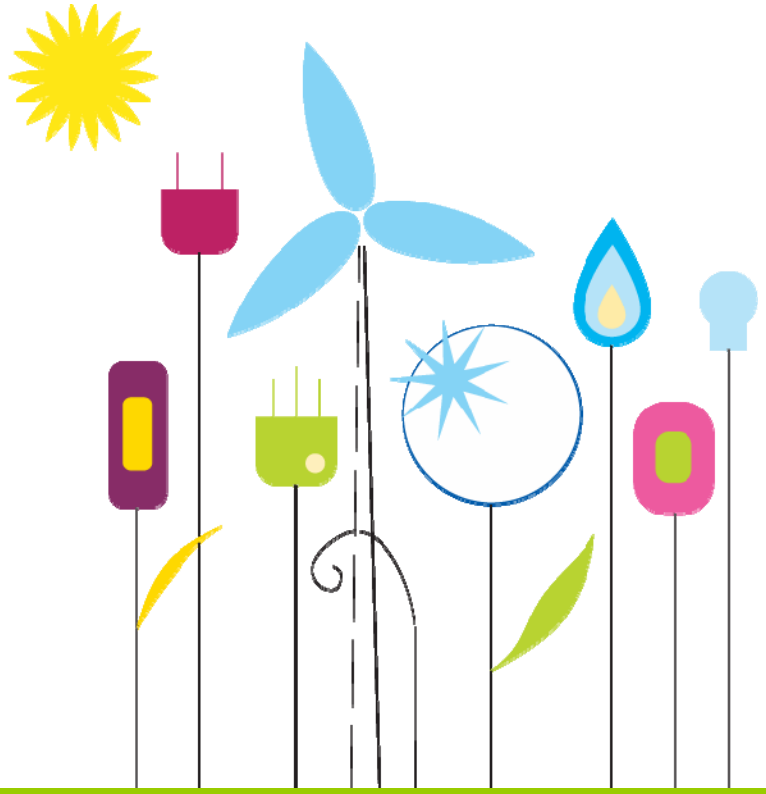


CCS in Europe and USA

Iain Wright
CO_2 Project Manager, BP Alternative Energy

CAS/ETIP IGCC Workshop

Beijing, May 23rd 2007

Agenda

- CO_2 Capture and geological Storage (CCS)
- BP's CCS projects:
  - In Salah (Algeria)
  - Peterhead hydrogen power (DF-1)
  - Carson hydrogen power (DF-2)
  - Kwinana hydrogen power (DF-3)
  - DF4, 5 etc……
- Summary

BP CCS Technology Program

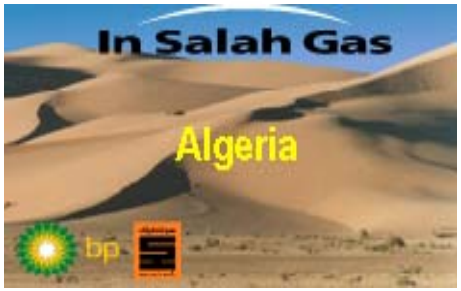
Research

Carbon Mitigation Initiative — CMI Carbon Mitigation Initiative Princeton University — PEI Princeton Environmental Institute

Industry / Academic Initiatives

CO_2 Capture Project

Technical Demonstrations



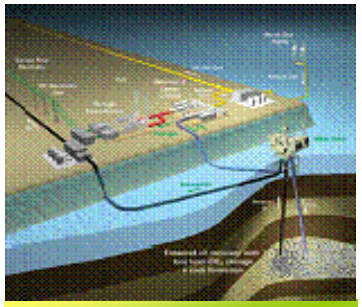
Source-sink matching
- CO2CRC, EUGeocapacity, Coach, US Regional partnerships

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

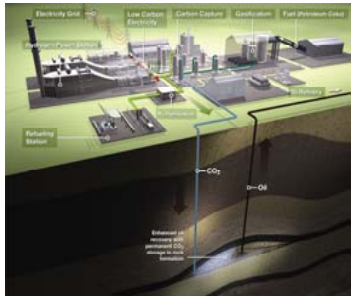
Assurance framework
- CO2CRC, CSLF, IMCO2, WRI

3rd Party Demonstrations
- Sleipner, Weyburn, CO2Remove

Industrial Scale Projects



DF1

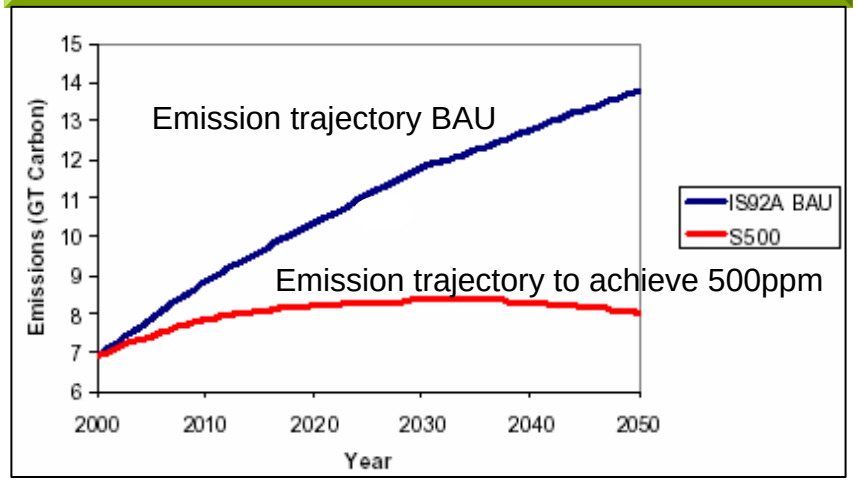


DF2

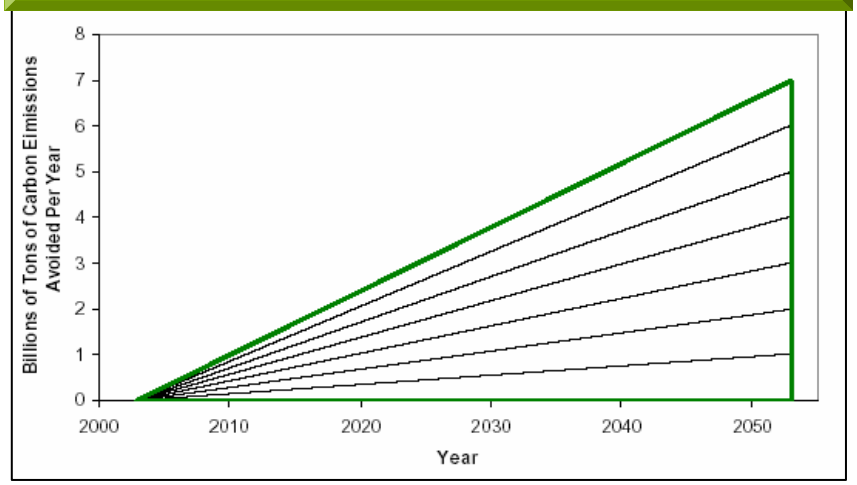
DF3, 4, 5 . . .

Technology Options for GHG Stabilization

The Stabilisation Wedge



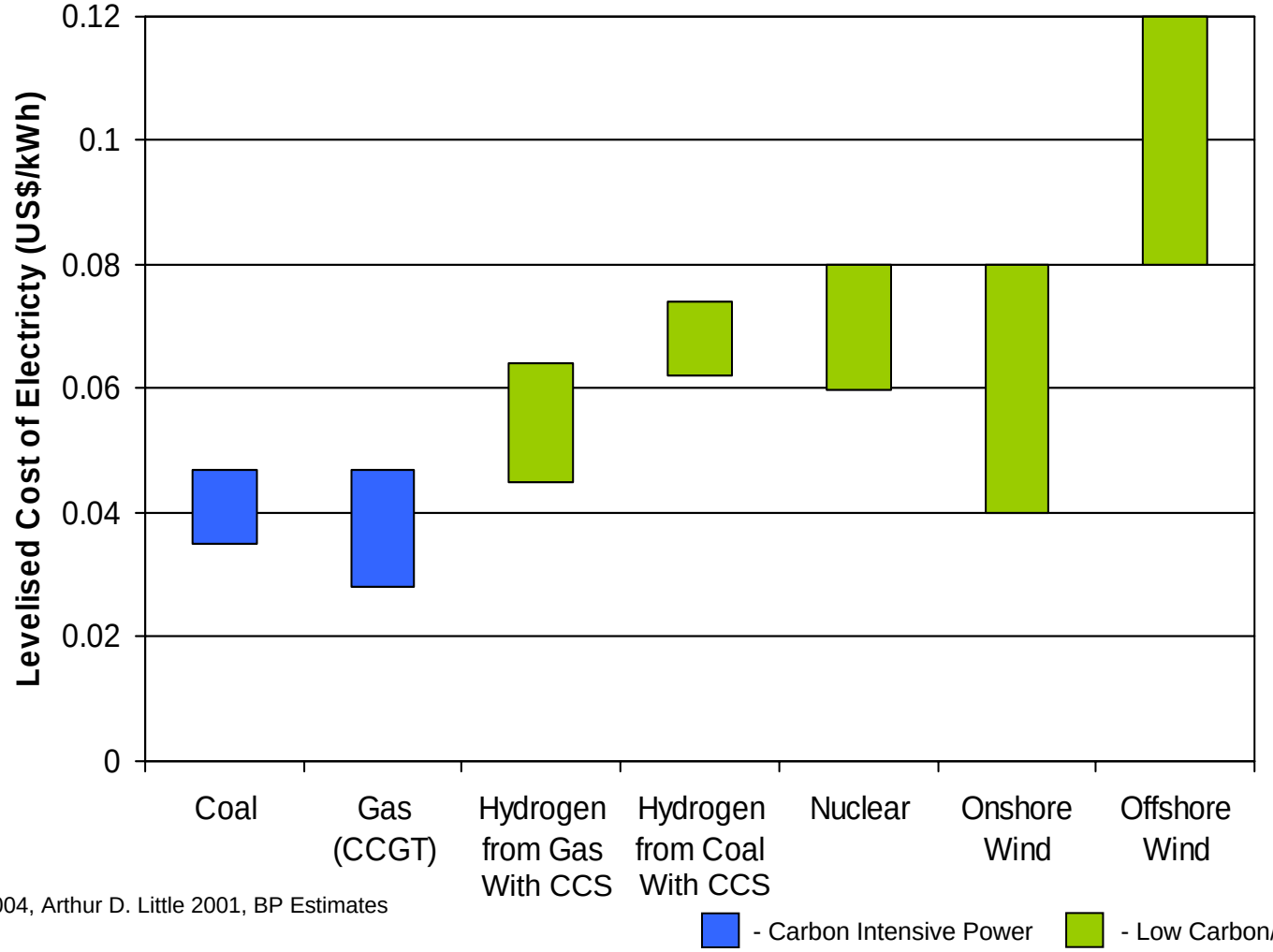
1 GtC Slices of the Stabilisation Wedge



Examples of Lower Carbon Slices	Scale for 1 GtC Reduction by 2050
Increased **energy efficiency** across the economy	'Emissions/$GDP' increased
Increased **energy efficiency** (e.g. vehicles only)	2 billion gasoline/diesel cars achieving 30mpg
Fuel switching natural gas displacing coal for power	1400GW fuelled by gas instead of coal
Solar PV or **wind** replaces coal for power	1000x scale up PV; 70x scale up for wind
Biofuels to replace petroleum based fuels	200×10^6 ha growing area (equals US agricultural land)
Carbon Capture and Geological Storage	CO_2 captured from 700 1 GW coal plants; storage = 3,500x In Salah/Sleipner
Carbon Free Hydrogen for Transport	1 billion H_2 carbon free cars. H_2 from fossil fuels with CO_2 capture & storage or from renewables or nuclear
Nuclear displaces coal for power	**700 1GW plants (2x current)**
Biosequestration in forests and soil	**Increase planted area and/or reduce deforestation**

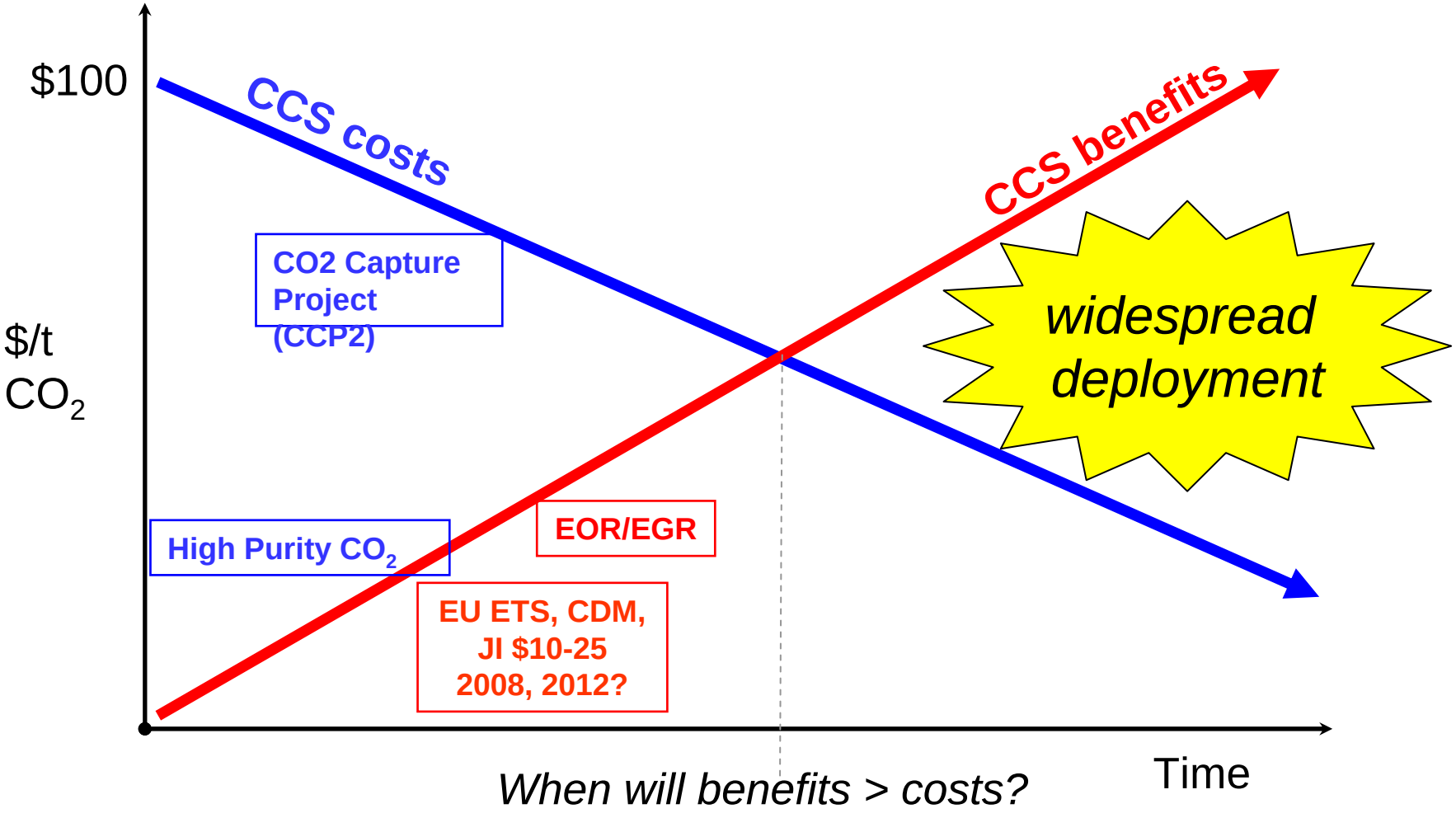
Green Power Costs ($/KWhr)

Carbon free hydrogen from natural gas is one of the lowest cost low carbon power generation options, broadly comparable with onshore wind costs



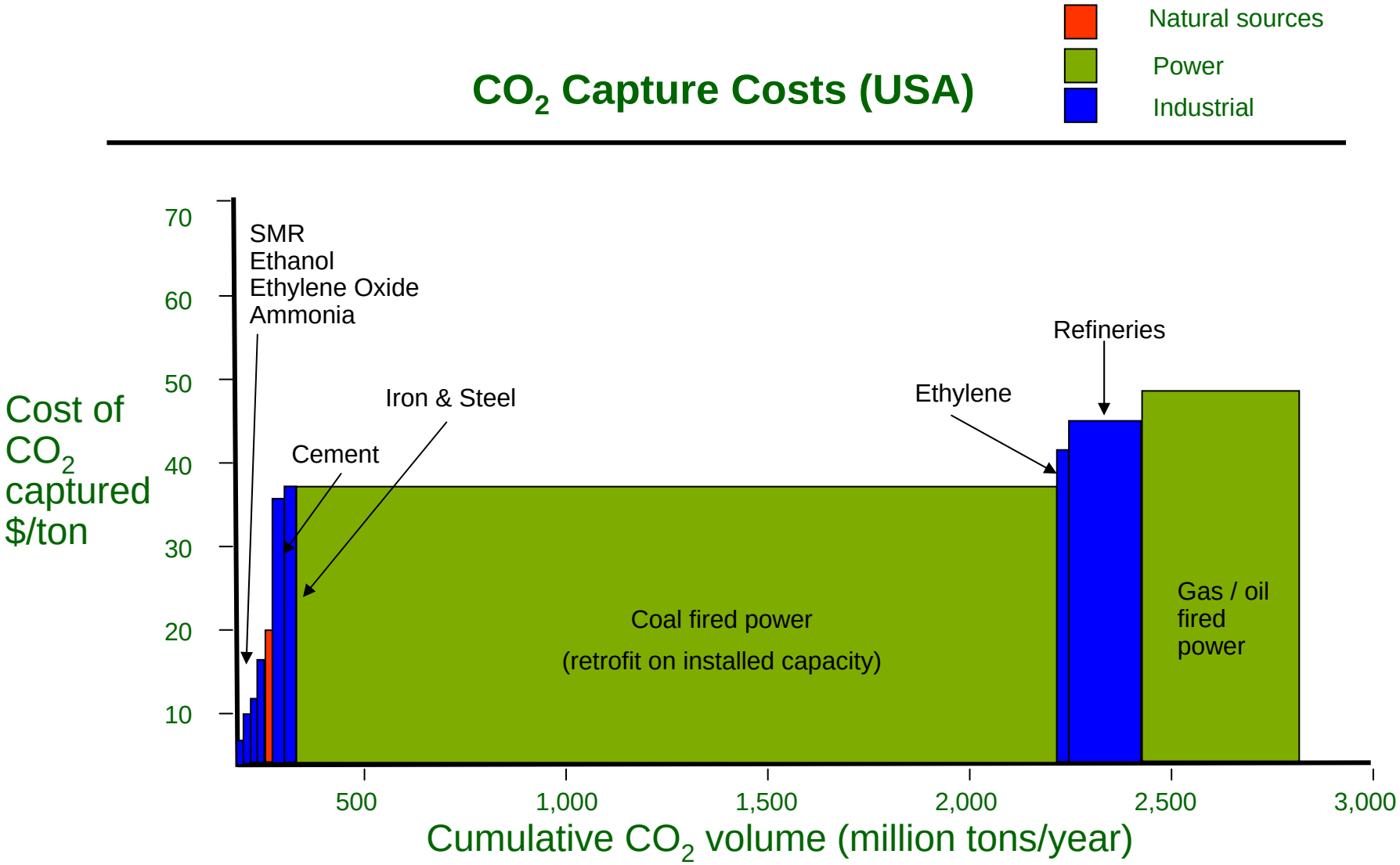
Sources: Navigant 2004, Arthur D. Little 2001, BP Estimates

When will CCS be Deployed?



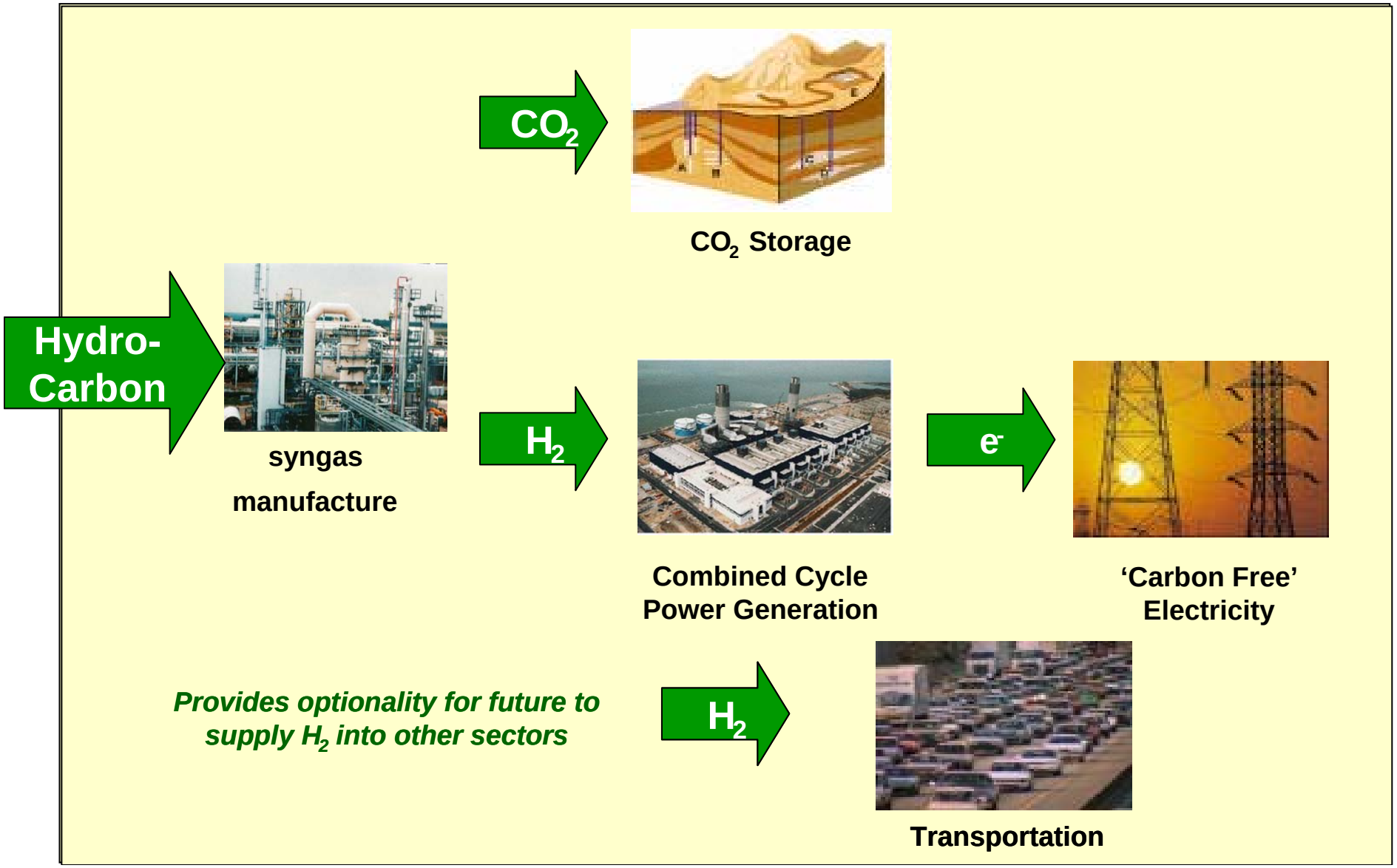
CCS Opportunities: Low-Hanging Fruit?

CO_2 Capture Costs (USA)

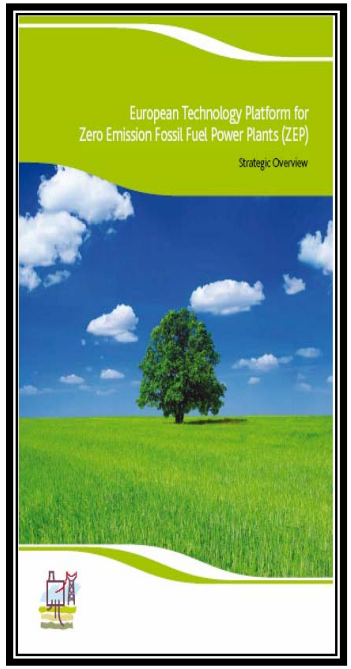


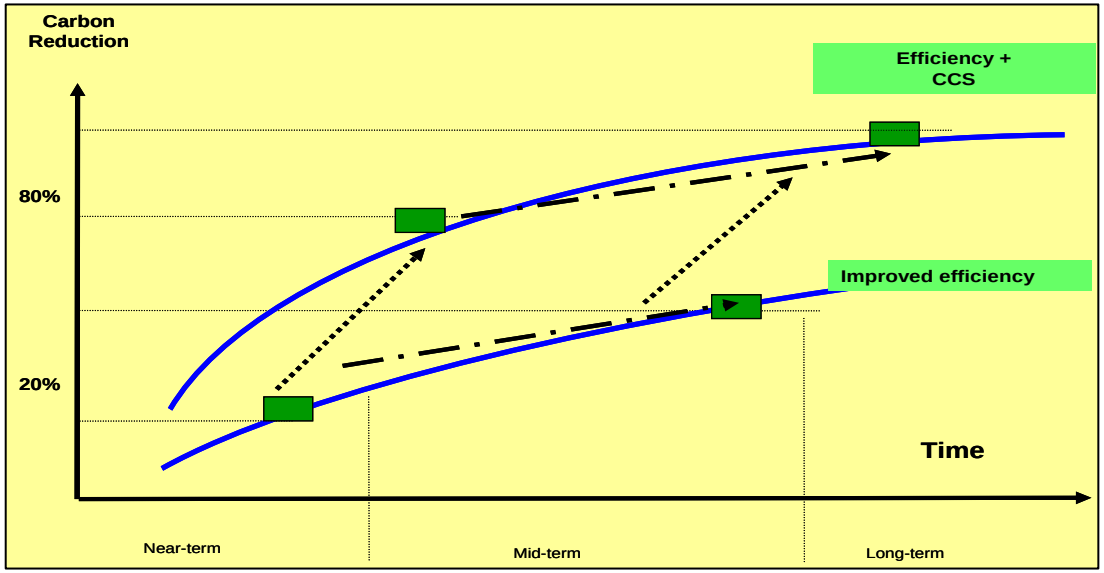
Source: IEA, Ecofys, BAH, BP team analysis

A Business Model for CCS Deployment



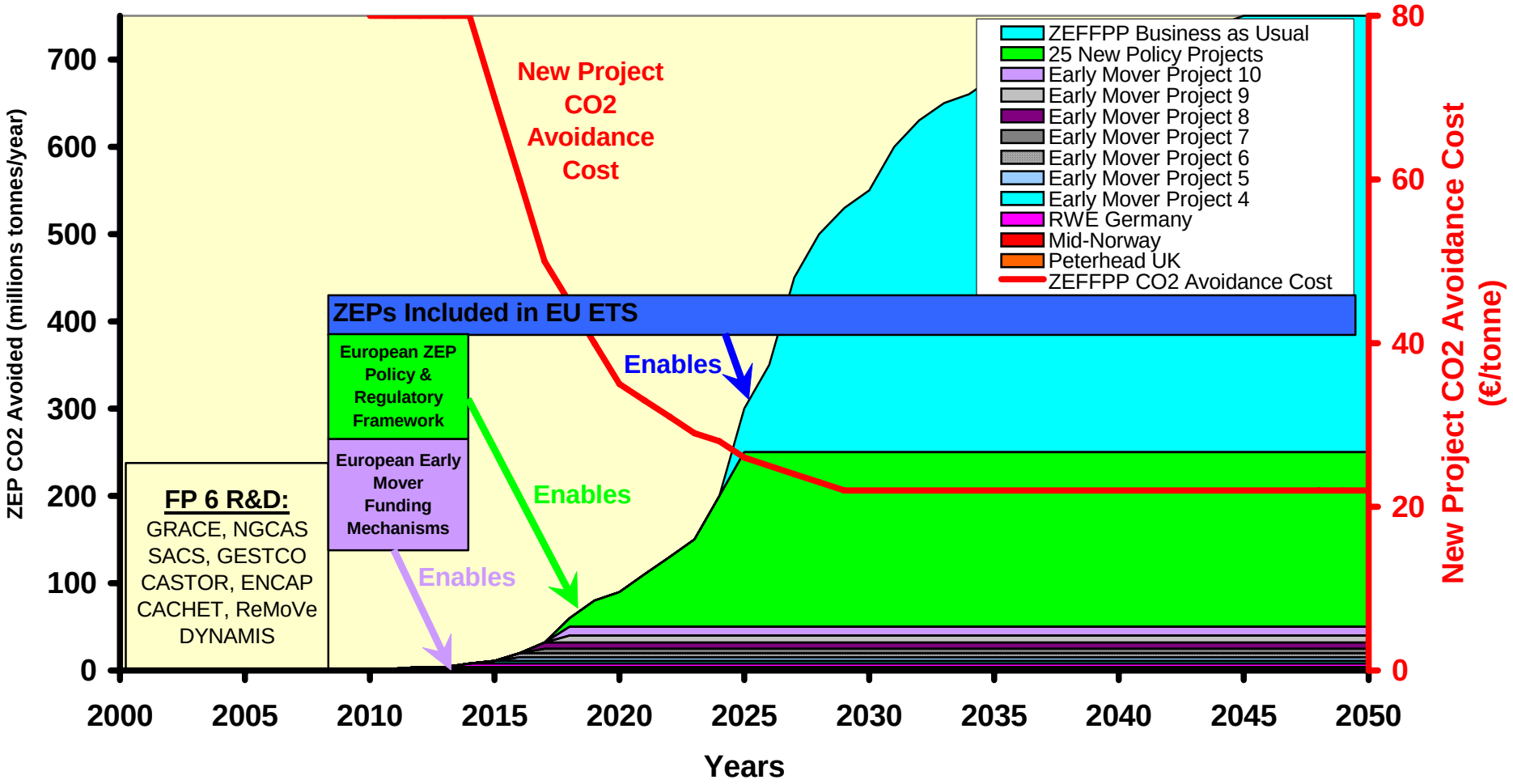
European Technology Platform ZEP





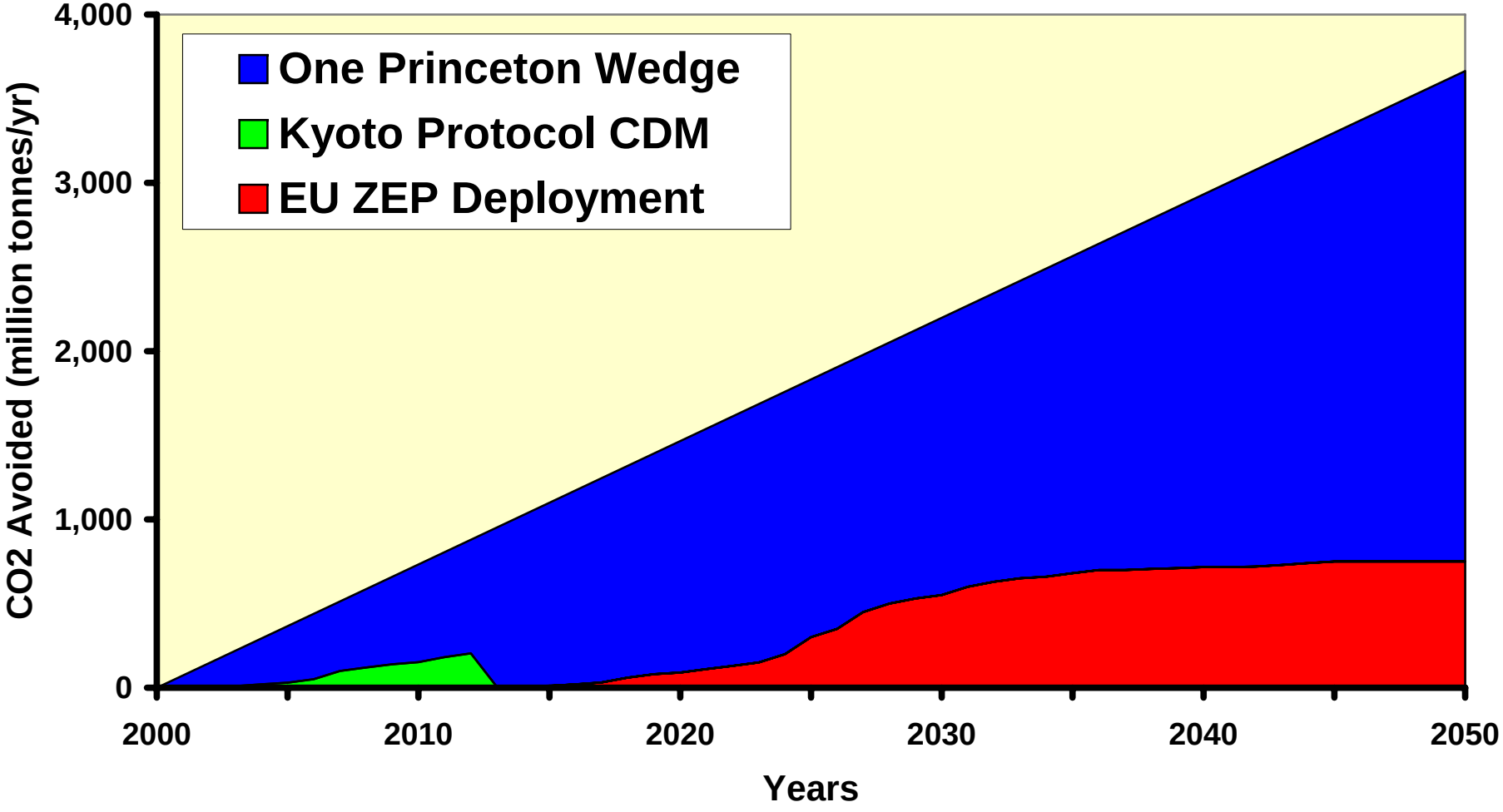
CCS Deployment Roadmap for Europe

EU ZEP Deployment Roadmap



EU CCS Deployment, CDM and One Wedge

CO2 Mitigation vs One Princeton Wedge

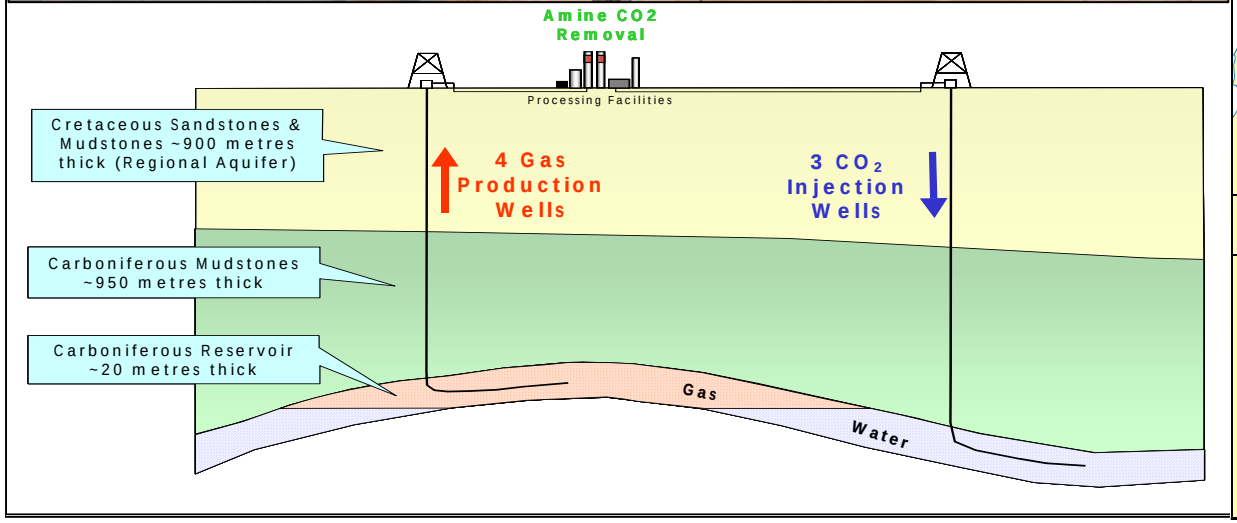


BP’s CCS Projects

BP’s CCS projects:

- In Salah (Algeria)
- Peterhead hydrogen power (DF-1)
- Carson hydrogen power (DF-2)
- DF-3, 4, 5……..

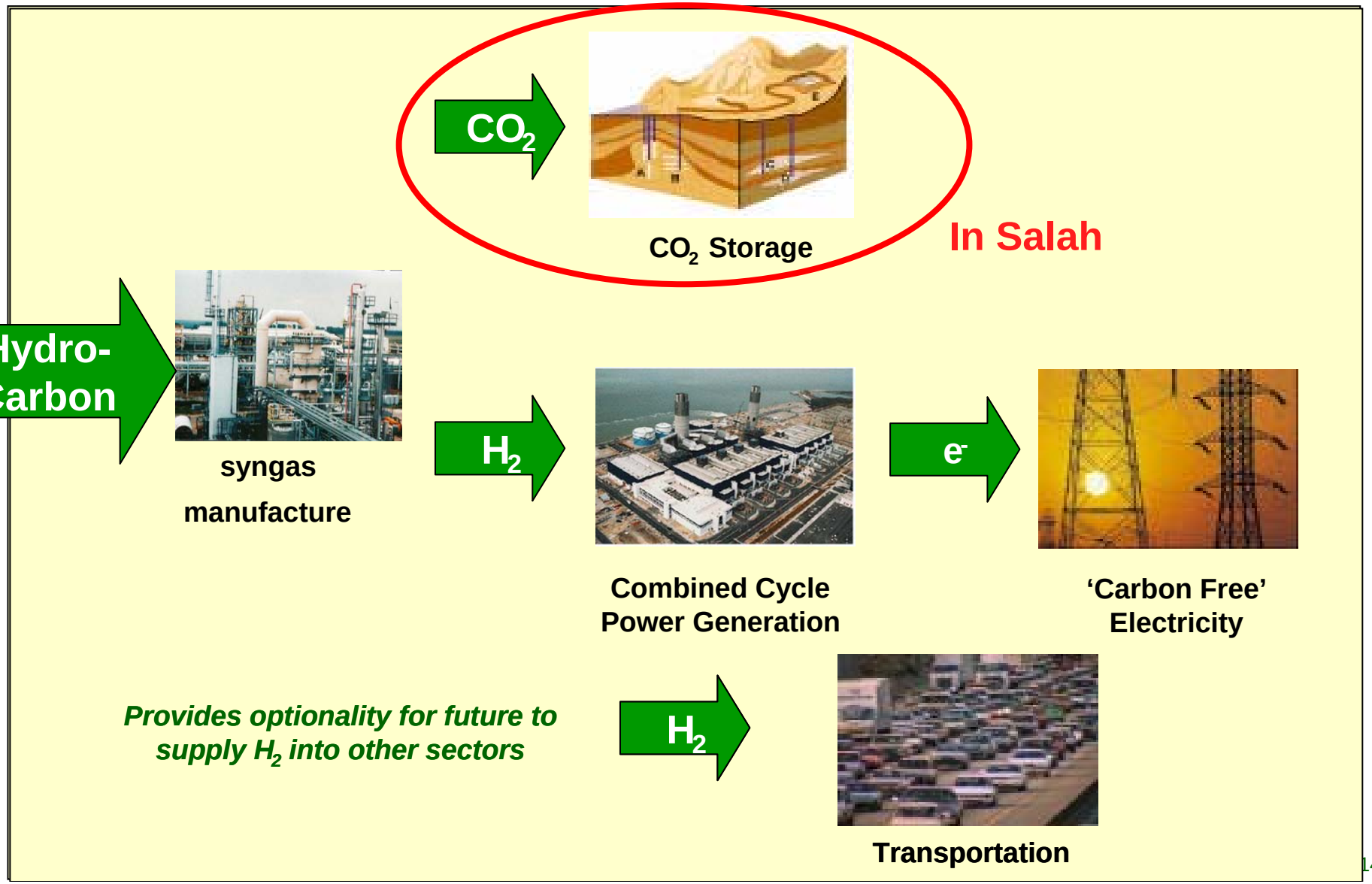
In Salah CO_2 Storage project, Algeria



Climate Change Milestones

- Industrial Scale Demonstration of CO_2 Geological Storage (Conventional Capture)
- Storage Formation is very similar to the North Sea (USA & China)
- Started Storage in August 2004
- 1mmtpa CO_2 Stored (17mm tonnes total)
- $100mm Incremental Cost for Storage No commercial benefit
- Test-bed for CO_2 Monitoring Technologies $30mm Research Project

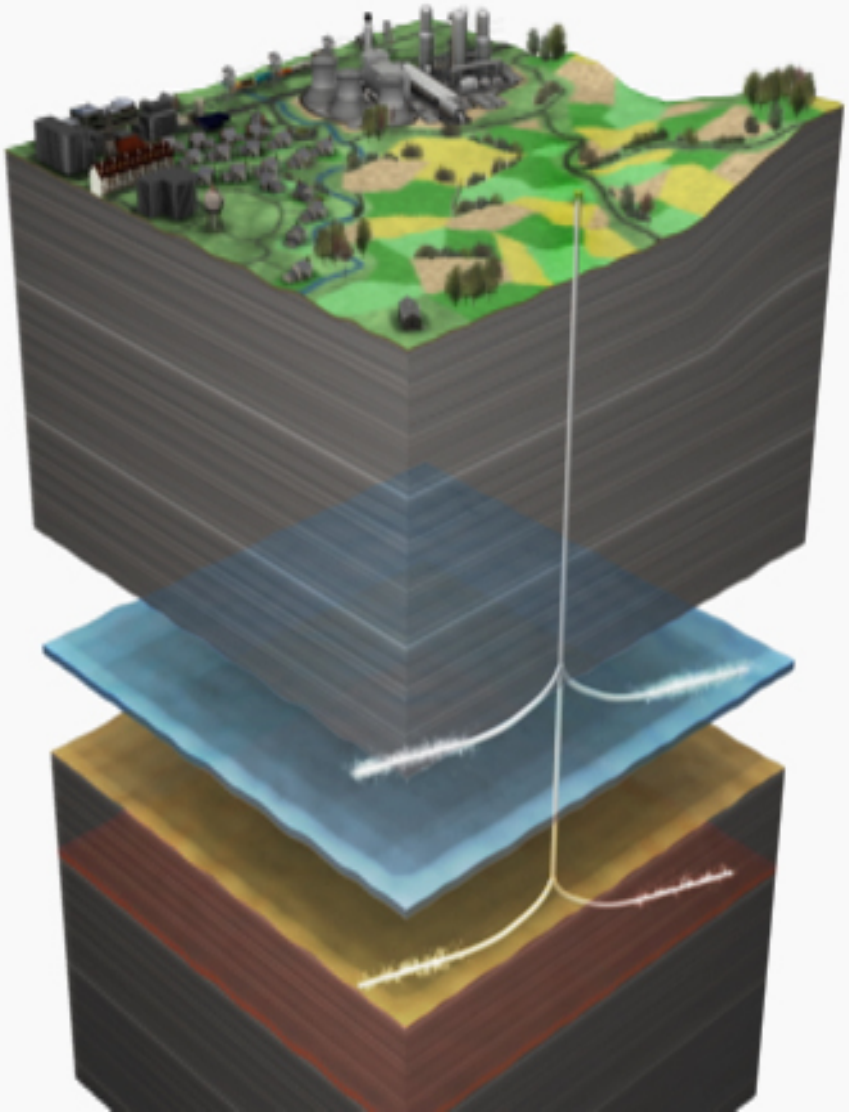
A Business Model for CCS Deployment



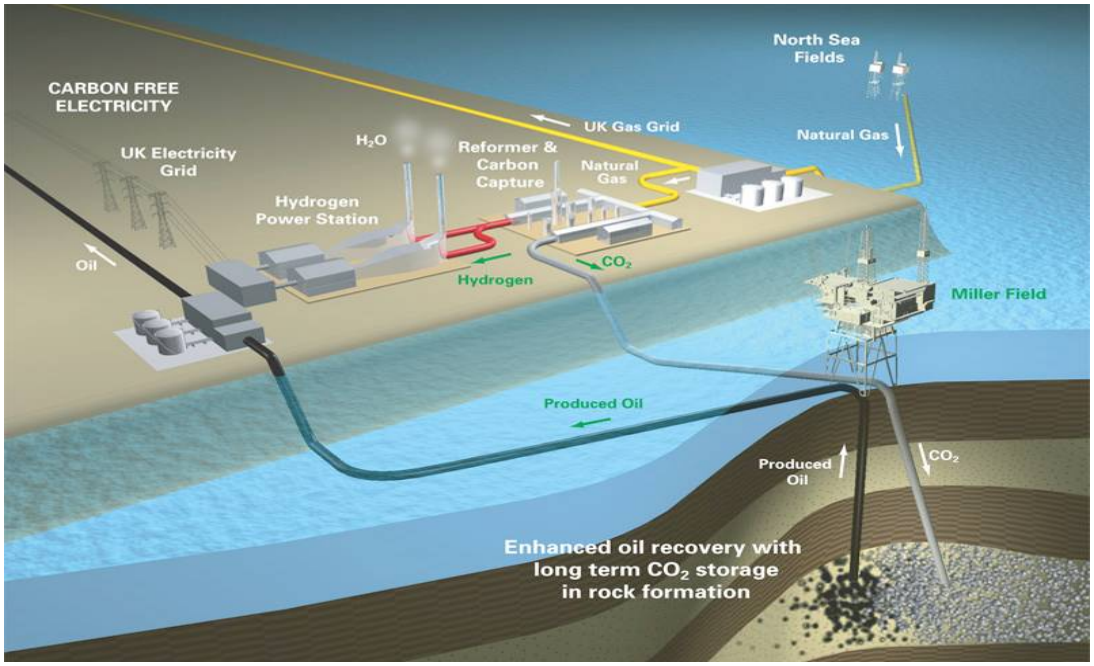
H2P Business Requirements

- Growing Power Market
- Advantaged fuel, infrastructure, geology
- Supporting Government Policy
- Regulatory Framework for CO_2 geological storage

Application of CCS to Power Generation



Peterhead Hydrogen Power Project, Scotland



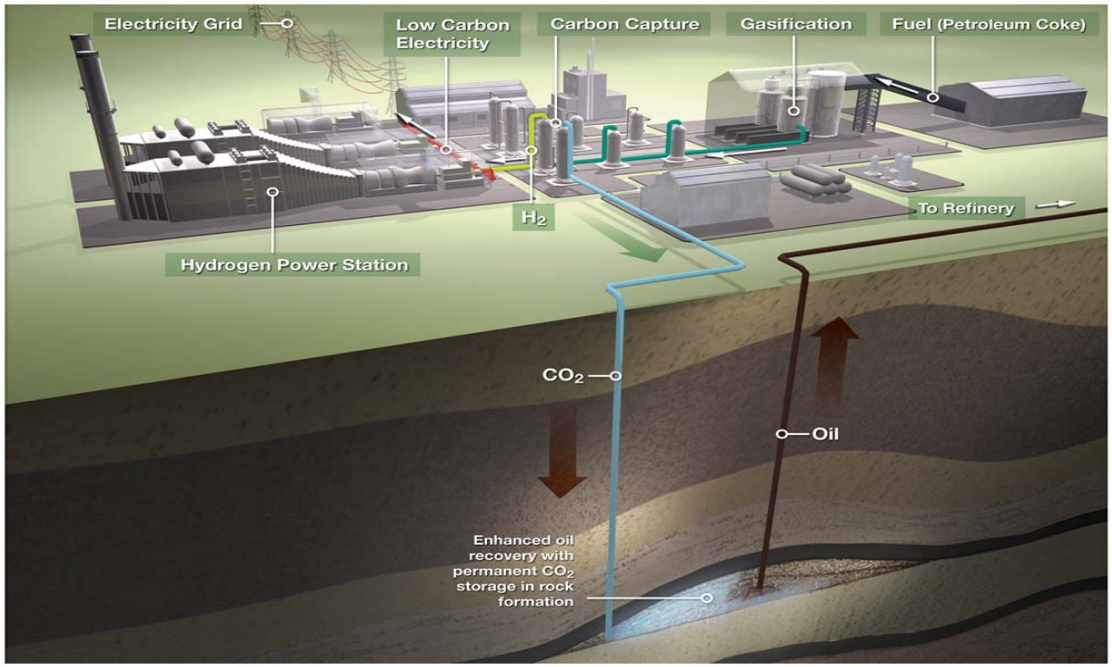
Project Milestones

- Europe's largest hydrogen-fired power generation facility
- First CO_2 EOR project in North Sea
- 1st CO_2 storage in an offshore oil field
- Uses Auto Thermal Reforming technology

Climate Change Milestones

- 475 MW of clean electricity - enough to power about 300,000 homes
- 1.8 mmtpa CO_2 captured and stored = 500,000 cars off the road
- Equivalent to the UK's entire installed wind farm capacity

Carson Hydrogen Power Project, California



Project Milestones

- World's largest hydrogen-fired power generation facility
- Uses gasification technology to gasify petcoke – a solid fuel generated as a byproduct of the refining process

Climate Change Milestones

- 500 MW of clean electricity ~ 325,000 Southern Californian homes
- 4 mmtpa CO_2 avoided
- Pipeline infrastructure to transport the CO_2 to an upstream buyer for EOR and permanent storage
- Lowest CO_2 emissions in the world for an IGCC plant.

BP DF Initiatives Complement Futuregen

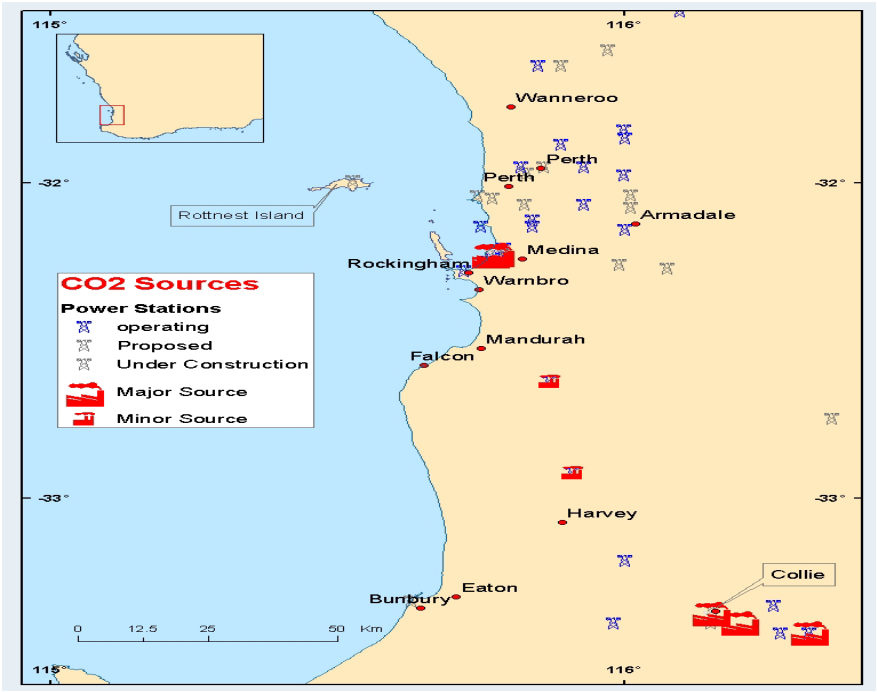
		In Salah	DF-1	DF-2	Futuregen
Start	**(Year)**	2004	2009	2011	2015?
Location		Africa	Scotland	California	USA **(China/India?)**
Fuel	**Type**	Gas Separation	Natural Gas	Pet-Coke	Coal (type?)
Technology	**Basis**	Amine	Steam Methane Reformer	Gasification	Gasification **(plug&play R&D)**
Power	**(MW)**	N/A	350	500	275
Plant	**Reliability**	R&D	Must Work	Must Work	R&D
CO2 Stored	**(mmtpa)**	1	1.3	4	1
Storage	**Formation**	Gas Field	Offshore EOR	Onshore EOR	Saline?
Investment		Industry	Industry	Industry	Govt/Industry 80/20
Purpose	**Primary** **Secondary**	Demonstrate Storage Test Monitoring Technology	Green Electricity at Scale Establish Policy Framework	Green Electricity at Scale Demonstrate H2 with CCS	Develop and Test Clean Coal Breakthrough Technology

Kwinana Hydrogen Power Project, Australia

RIO TINTO

bp

hydrogen energy



Project Milestones

- IGCC technology to gasify local coal
- Investment decision: 2011
- Onstream: 2015

Climate Change Milestones

- 500 MW of clean electricity: 15% of Western Australia's power demand
- 4 mmtpa CO_2 avoided
- CO2 storage in an offshore deep saline formation

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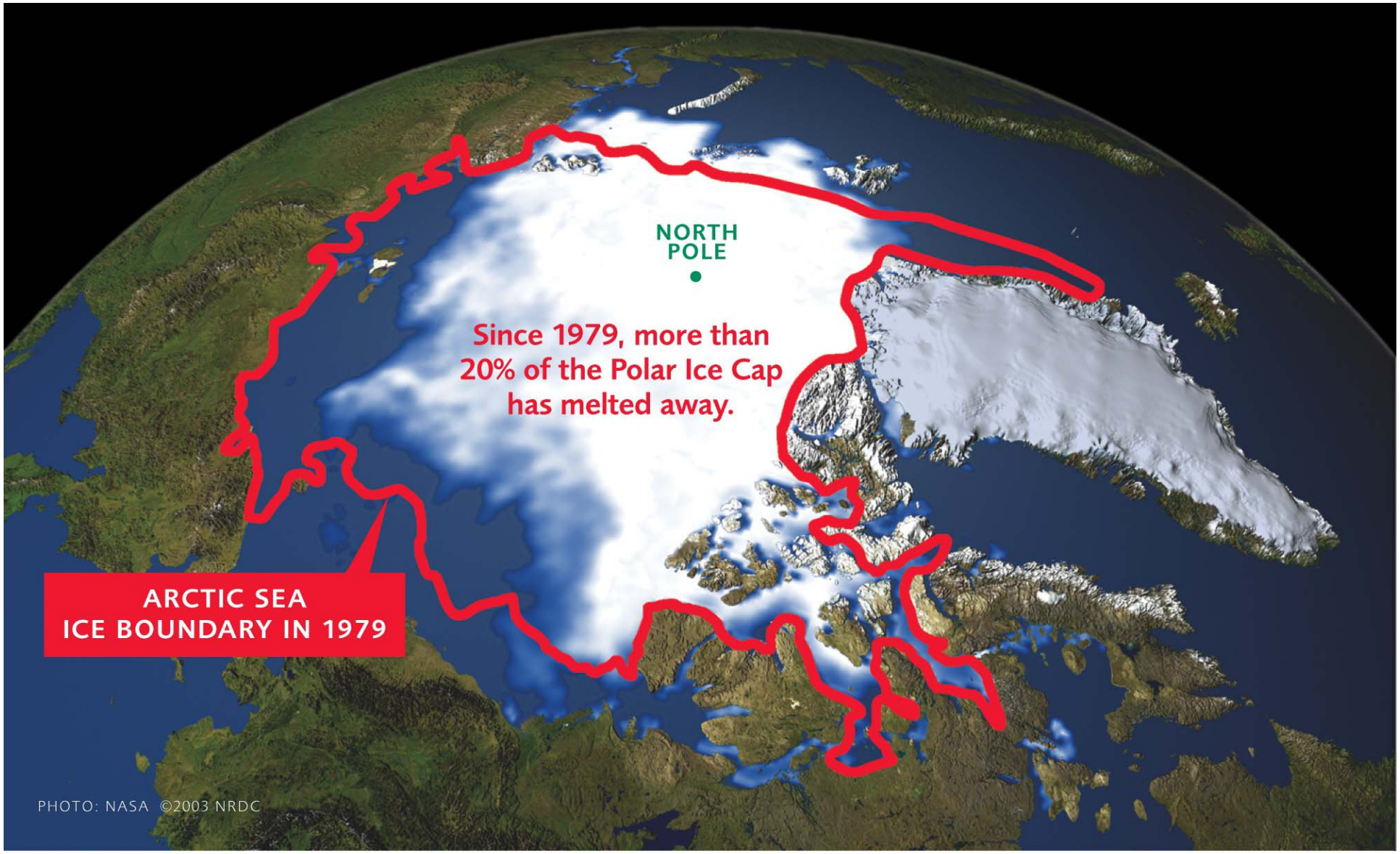
Summary

- **BP is Taking Big Steps Towards CCS Deployment**

- **What's required:**
  1. Growing Power Market
  2. Advantaged fuel, infrastructure, geology
  3. Supporting Government Policy
  4. Regulatory Framework for CO_2 geological storage

- **In Salah, Peterhead, Carson and Kwinana demonstrate viability in different settings**

- **BP is ready to invest in CCS projects in locations that meet the four requirements (above)**

Thank You. Questions?