Large-scale CCS deployment requirements
Insights from Shell's activities

CO_2 Capture and Storage, Regional Awareness Raising Workshop
Middle-East Technical University,
13-14 June 2012, Ankara, Turkey

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WHY CCS WILL (NEED TO) HAPPEN …

- Significant rise in energy consumption expected
- Dominance of fossil fuels in the mix for decades
- World agreed to limit global warming to 2° C
- This requires almost full decarbonisation of power, and to less extent industry, by 2050
- CCS is only technology that can cut CO_2 emissions from large-scale fossil fuel use, without CCS the cost to halve emissions by 2050 will be 70% higher (IEA)
- Several nations develop emissions regulations and some lead in demonstration/deployment of CCS

Illustration of scale of ambition: European Commission roadmap to a competitive low carbon economy in 2050

Europe 2020 Strategy:

- 20% reduction in GHG emissions
- Increasing the share of renewables in the energy mix to 20%
- Achieving a 20% Energy Efficiency Target by 2020.

➢ Transition to a competitive low carbon economy means that the EU should prepare for reductions in its domestic* emissions by **80% by 2050** compared to 1990.

Example analysis of reductions required:

GHG reductions cf 1990	2030	2050
Power (CO_2)	-54% to -68%	-93% to -99%
Industry (CO_2)	-34% to -40%	-83% to -87%
Transport (CO_2)	+20% to -9%	-54% to -67%

http://ec.europa.eu/clima/policies/roadmap/index_en.htm

•Real internal reductions – no offsetting through carbon market

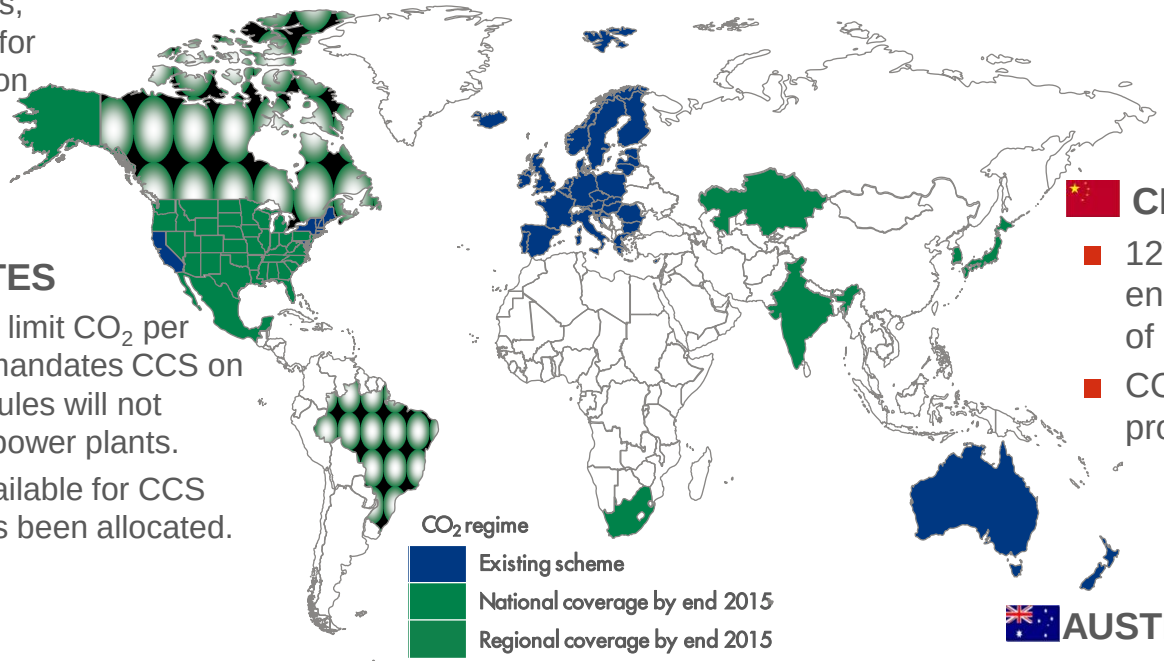
CCS funding is available and CO_2 policy is progressing but implied pricing is generally too low for sustainable CCS

EUROPE

- Ongoing discussion to improve EU-ETS after CO_2 prices dropped to €6/tCO_2. NER300 funding for CCS projects a.o.projected to be €3 bln
- UK re-launched £1 billion CCS competition and subsidies via Electricity Market Reform.
- Germany implements weak CCS directive; public acceptance issues linger

CANADA

- Federal proposals on approach to reduce GHG emissions from oil and gas sectors, including support for CCS demonstration and provisions to mandate CCS.



UNITED STATES

- EPA's proposal to limit CO_2 per MWh effectively mandates CCS on new coal plants; rules will not regulate existing power plants.
- Public funding available for CCS projects, most has been allocated.

CHINA

- 12th FYP focuses on energy efficiency, signals of regional ETSs.
- CCS R&D and demo projects ongoing

GLOBAL

- CCS in CDM approved; CERs not enough to encourage projects alone.

SOUTH AFRICA

- Exploring carbon tax from 2013 at ~ \$15/tCO_2
- Developing CCS demonstration project(s)

AUSTRALIA

- Passed “Clean Energy Future” to set a CO_2 price of ~\$23/ton in 2013.
- Public funding available for flagship CCS projects

SOURCE: Shell review

CCS PROJECTS IN OPERATION GLOBALLY

Global map of large-scale integrated projects

CAPTURE FACILITY
- Power generation
- Natural gas processing
- Coal to liquids
- Coal gasification
- Oil refining
- Fertiliser production
- Aluminium, steel, cement or paper
- Various

STORAGE TYPE
- △ Geological
- ○ Beneficial reuse
- □ Geological and/or beneficial reuse
- ☆ To be determined (TBD) or undisclosed

Active or planned large-scale integrated projects by capture facility, storage type and region. (Source GCCSI)

- There are eight large scale integrated CCS projects in operation globally today.
- Sleipner and Snøhvit (Norway) and In Salah (Algeria) projects involve CCS as the CO_2 content of the extracted natural gas is too high to sell the gas.
- 5 operating CO_2-EOR projects in N.America, using industrial CO_2;
  - Weyburn-Midale, Canada
  - Rangely project, Colorado
  - Enid fertiliser, Oklahoma
  - Salt Creek, Wyoming
  - Sharon Ridge, Texas
- The number of projects involving CO_2 from non-natural gas sources is rising.

SHELL'S RESPONSE TO THE CO_2 CHALLENGE

Supplying More Natural Gas

Supplying More Biofuels

Progressing CCS

Energy Efficiency In Our Operations

NATURAL GAS – FAST AND LOW-COST DECARBONISATION

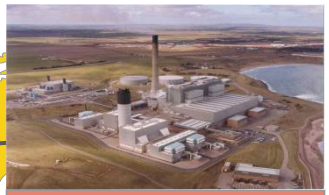
- One third of energy CO_2 emissions come from electricity generation
- Replacing coal-fired power with natural gas will cut greenhouse gas emissions now
- Together with carbon capture and storage (CCS), natural gas can play a significant role in the low CO_2 energy system beyond 2030
- Natural gas will complement the intermittency of renewables

CCS PROJECTS: PORTFOLIO APPROACH

Quest

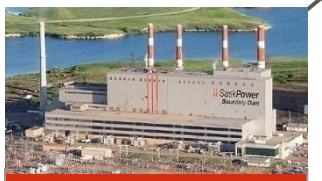
TCM

Weyburn Midale

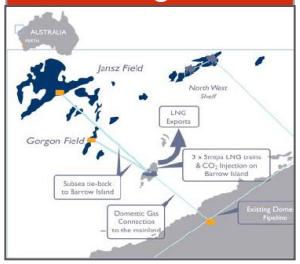


Peterhead

Aberthaw



Boundary Dam



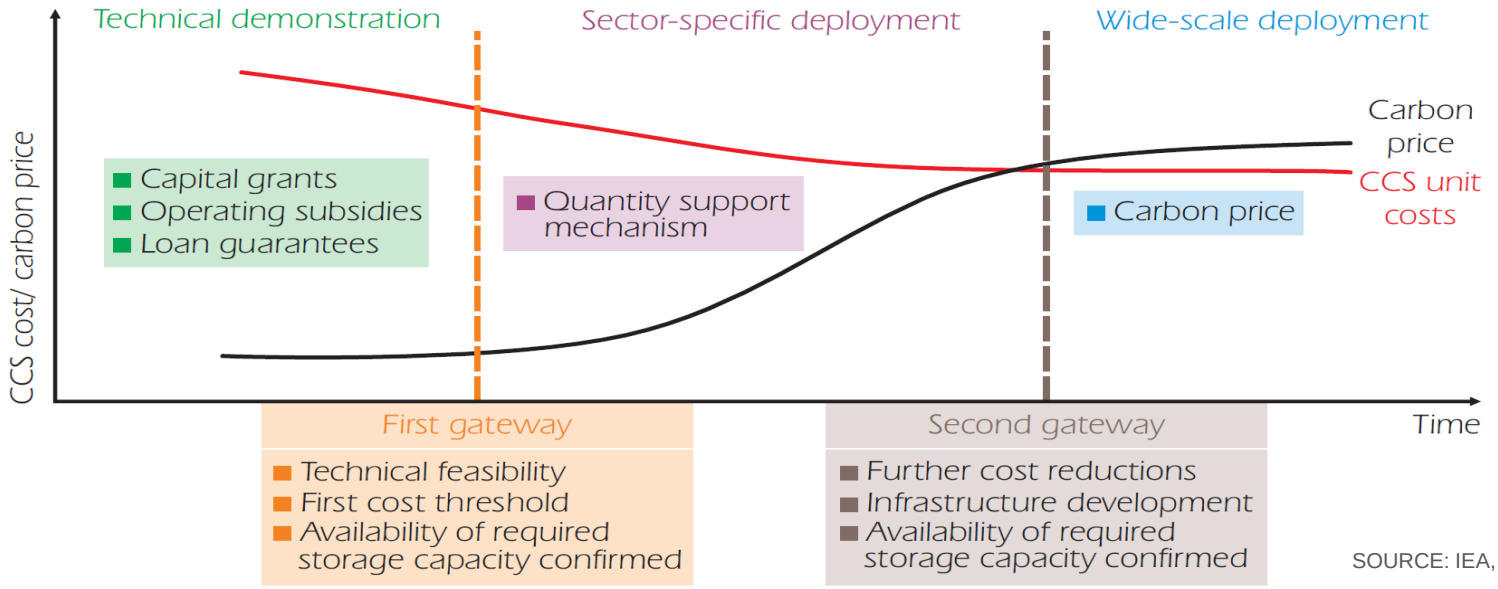
Gorgon

Otway

Shell involvement in CCS Projects;

- Industrial scale projects in operation
- Industrial scale projects in construction
- Industrial scale projects planned
- Demonstration projects, joint industry partnerships

ROAD TO COMMERCIAL DEPLOYMENT OF CCS



- Commercial gap to market driven CCS needs to be closed; higher price on CO_2, lower cost of CCS
- Two phases of demonstration expected to be required before commercial deployment 2030+
- Each phase will require its own support mechanisms

CCS IN THE CLEAN DEVELOPMENT MECHANISM

Issue: absence of market mechanisms and CO_2 price in emerging economies may limit CCS project opportunities

COP17/CMP7
UNITED NATIONS
CLIMATE CHANGE CONFERENCE 2011
DURBAN, SOUTH AFRICA

Recommendation

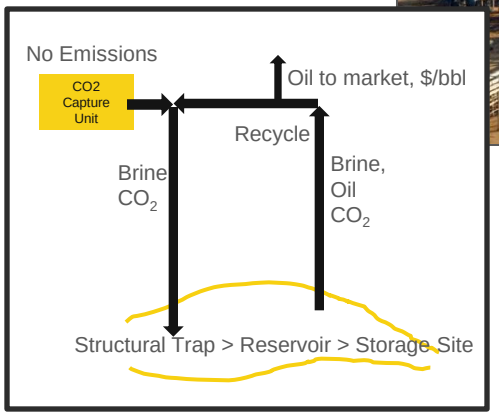
- Establishment of **Emissions Trading Schemes** which create demand for CO_2 reduction and a price for CO_2 to fund CCS projects, including in developing countries
- **Clean Development Mechanism (CDM)** is the principal offset mechanism that funds CO_2 reduction projects in emerging economies and developing countries
- The **Durban UNFCCC COP 17** delivered a number of outcomes including the adoption of procedures to allow CCS projects in the CDM
- Inclusion in the CDM ensures that CCS is recognised in future UNFCCC measures and policies

CO_2-EOR – TAKING A GAME WE KNOW INTO THE FUTURE

- Proven Technology
  - —30+ years experience
- Difference for the Future:
  - —CO_2 from industry
  - —CCS support/integration
- Next Wave
  - —Cost reductions
  - —Recovery improvements
  - —Maximise CO_2 sequestration
  - —Source to sink infrastructure
- CO_2 EOR = storage ; pursue where possible

European Energy Forum

CO_2-EOR Operations
Texas, USA



ADDRESS PUBLIC AWARENESS AND SUPPORT FOR CCS

Issue:
There is public concern about industrial developments in general, public awareness of CCS is generally low and it's role is not understood. There are concerns amongst local communities about the safety of CCS projects

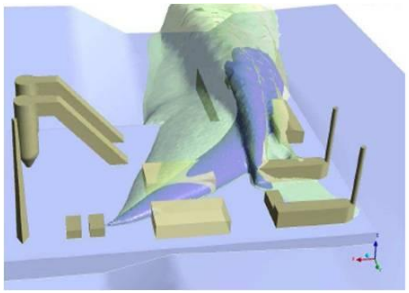
Recommendation

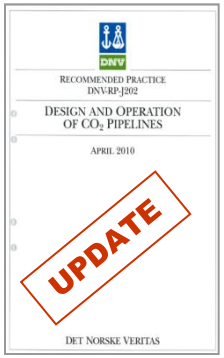
- Active engagement is key to building public understanding of the need for CCS
- Research shows governments need to communicate more about their energy choices and where CCS fits, before projects start.
- CCS projects have a key role to demonstrate safe and responsible CCS operations

ADDRESSING SAFETY STANDARDS & PUBLIC CONCERN

Shell CO_2 Release Project 2008 – 2011 – SpadeAdams

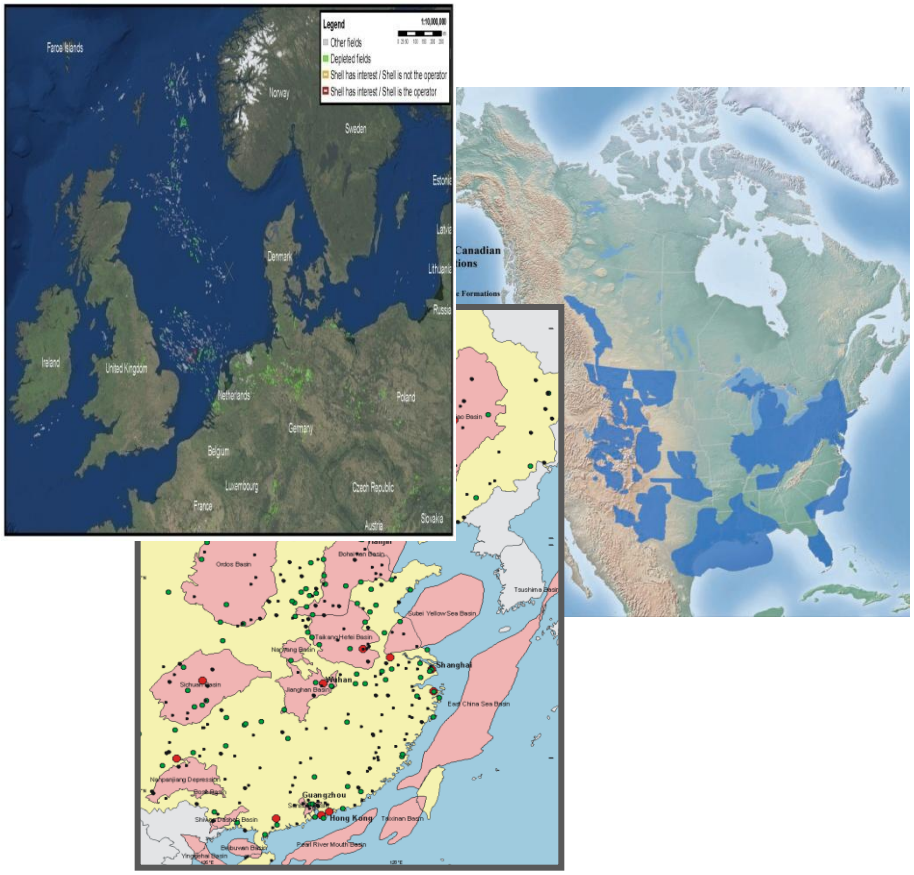
- Gathered data on the release and dispersion of dense phase CO_2 to evaluate and validate dispersion models
- Studied impact of releasing CO_2 in confined spaces
- Investigated emergency response systems (e.g. detection and water deluge)
- Obtained data to study CO_2 concentration, temperature and visible vapour cloud
- Provided informative demonstrations for stakeholders and input for future test programs and CO2PIPETRANS JIP



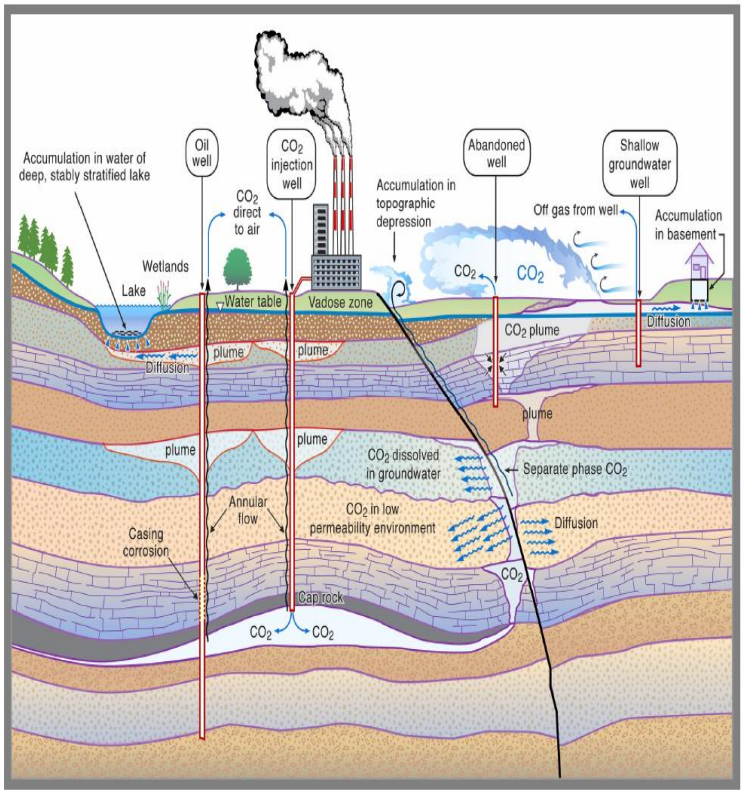


IDENTIFY THE STORAGE SPACE

- Sufficient data on depleted/abandoned oil & gas fields exists, initiatives are underway to provide useful data on suitable deep saline formations



- Detailed studies will be required to determine suitability of specific reservoirs for CO_2 storage; *capacity, injectivity, and containment*



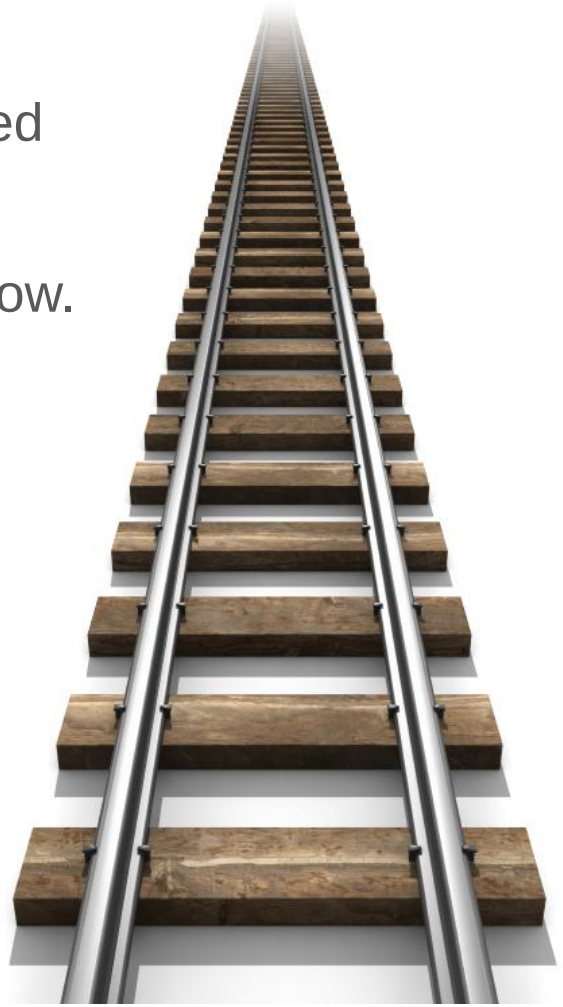
CCS DEPLOYMENT - STATE OF PLAY

- Deployment rates for large-scale integrated projects are off-pace
- We are not seeing the necessary rate of investment into full-scale demos
- The business case for deployment beyond demonstration is lacking

Global efforts ≠ significant emission reduction ambitions associated with CCS

DELIVERING CCS – 10 STEPS TO GET BACK ON TRACK

- More speed is required
- Demonstration projects need to be established quickly and properly funded.
- Infrastructure planning needs to take place now.
- Build on proven CO_2 -EOR industry.
- Agree fit-for-purpose CCS standards, for example on MMV.
- Enable deployment in emerging economies.
- Continue reduction of CCS costs.
- Continue to address public concerns.



SUPPORTIVE POLICIES ENABLE PROGRESS

- Policies to reduce CO_2 emissions should be outcome based
- Support needed to push CCS through the demonstration phase
- Policies that support a robust CO_2 price will drive a faster and smoother transition to a low carbon economy
- Action required now for infrastructure planning and the management of liabilities.
- Closer links between governments can accelerate progress