



CCS Deployment – what will be required? Insights from Shell's CCS activities

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ZERO10 – Zero Emission Conference
Oslo, November 22-23, 2010



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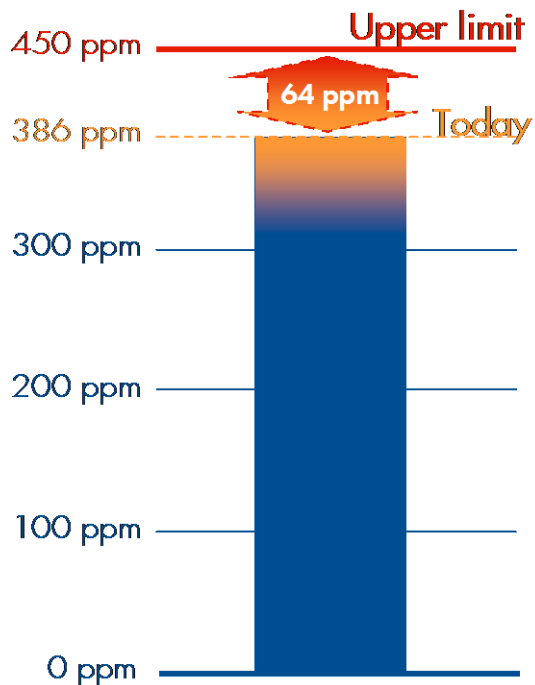
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THE ENERGY AND CO₂ CHALLENGE

ALL CO₂ REDUCTION PATHWAYS WILL BE REQUIRED

CO₂ CONCENTRATION IN ATMOSPHERE

Science warns of a 450 ppm upper limit



Emissions are rising at over 2 ppm per year

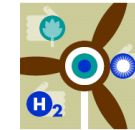
MEETING DEMAND WITH LESS CO₂

The world will need ALL options it has



Energy efficiency

AND



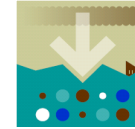
Renewables

AND



Nuclear

AND



CO₂ Capture and Storage

AND



Forestry

All five pathways are essential and will be needed **at scale** to meet energy demand this century and to limit CO₂ emissions.

SHELL'S RESPONSES TO THE CO₂ CHALLENGE

1. Natural Gas

2. Biofuels

3. Carbon Capture and Storage (CCS)

4. Energy efficiency



Perdido, USA



Biofuels, Brazil (Sugar cane for proposed Cosan joint venture)



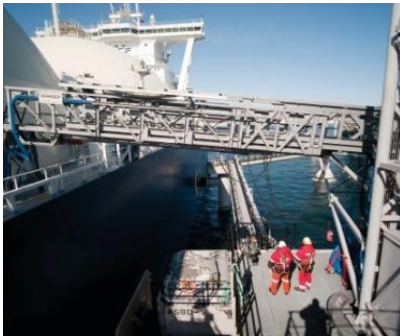
Carbon Capture Research, Mongstad, Norway



SEPC, Singapore (part of the global energy efficiency programme)

NATURAL GAS FOR ELECTRICITY

- Power generation emits one third of the world's CO₂
- More power from natural gas would make the biggest contribution, at the lowest cost, to emission targets this decade
- A modern gas plant emits 50% less CO₂ than a modern coal plant
- By 2012 over half of Shell's energy output will be natural gas



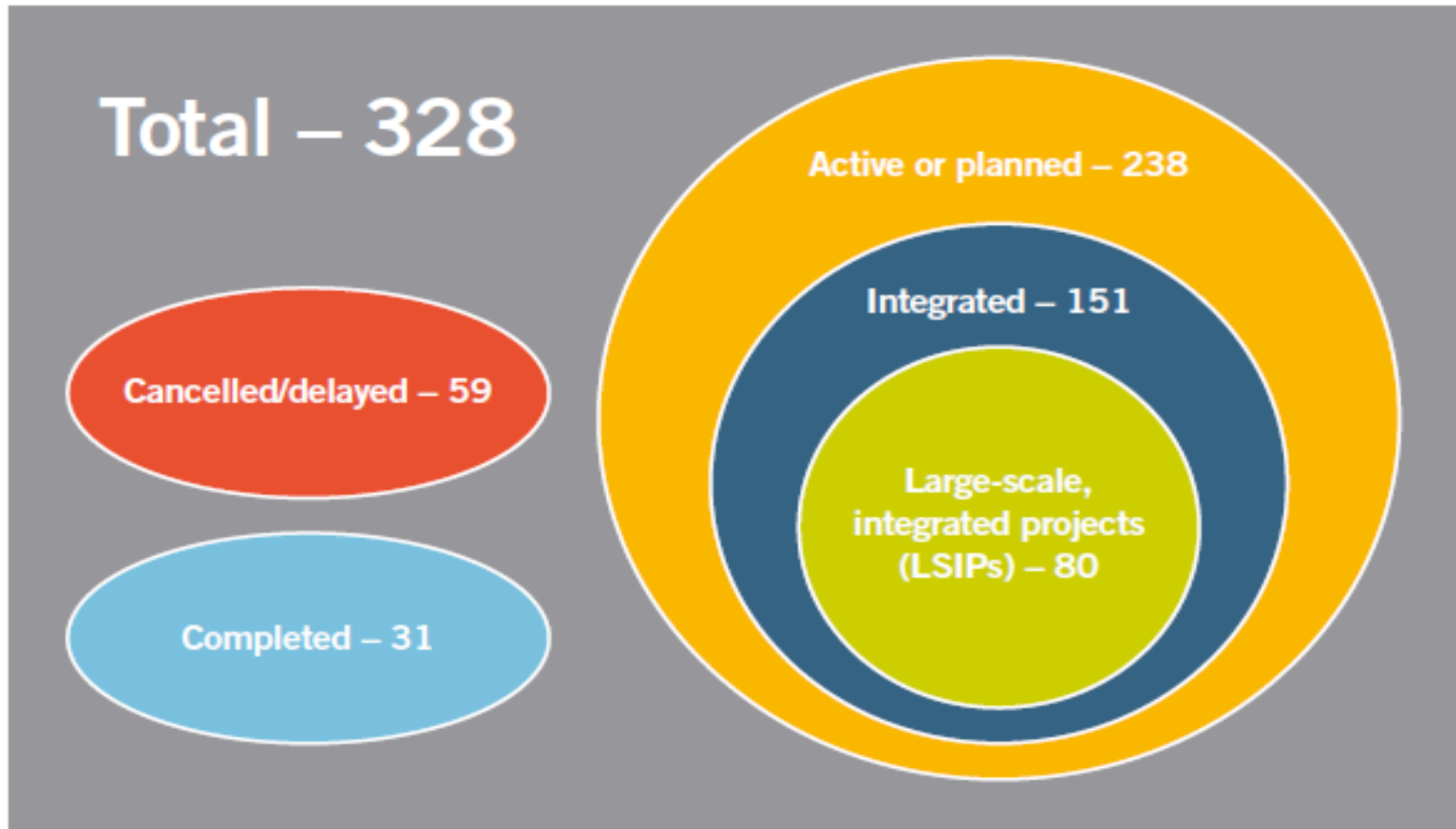
THE CCS OPPORTUNITY

- CCS could account for 19% of the CO₂ reductions needed by 2050
- Without CCS the cost of meeting CO₂ emissions targets could be 70% higher
- Government support is essential in the demonstration phase
- Full scale deployment will rely on a strong CO₂ market price

“The next decade is a key “make or break” period for CCS; governments, industry and public stakeholders must act rapidly to demonstrate CCS at scale around the world in a variety of settings.” (International Energy Agency)



CCS GLOBAL ACTIVITY – RECENT PROJECT SURVEY (APRIL 2010)



Source: Global CCS Institute Projects Update

SHELL'S CCS ACTIVITIES

- Shell is involved in a number of demonstration projects with industry partners to help advance the technologies and understanding of CCS.

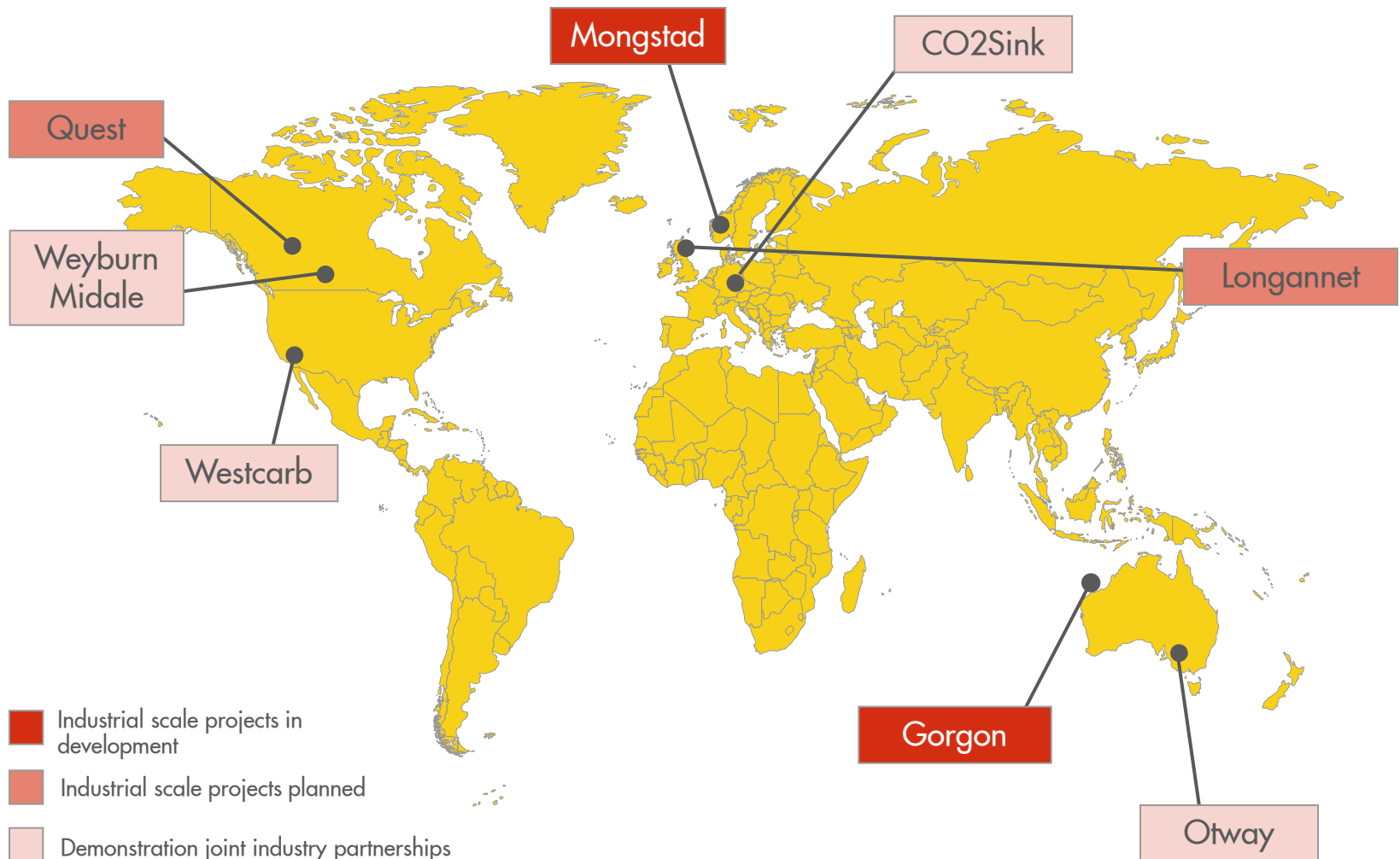
These include:

- CCS demonstration project in Mongstad, Norway, which is expected to capture up to 100,000 tonnes of CO₂ a year from 2011.
- The Gorgon liquefied natural gas project in Australia will capture up to 4 million tonnes of CO₂ a year.
- The Quest project in Canada will capture and store over 1 million tonnes of CO₂ a year from oil sands.

Technology Centre Mongstad (TCM), Norway



SHELL DEVELOPING CCS TECHNOLOGIES FOR THE FUTURE



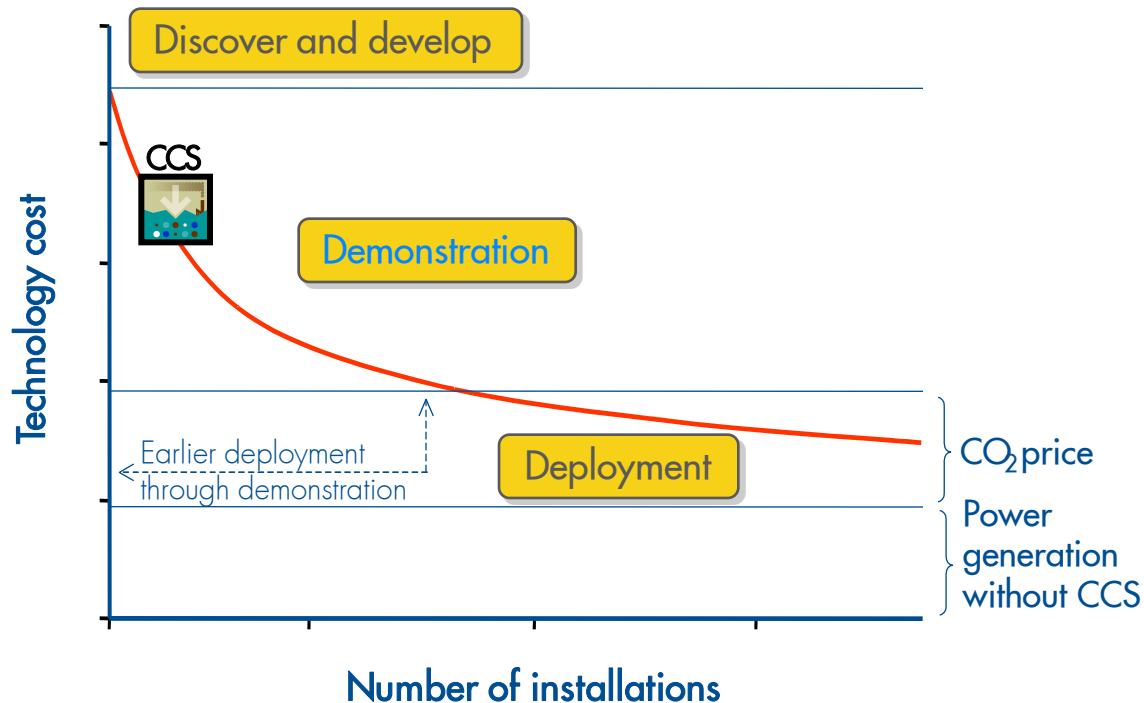
EARLY INSIGHTS FROM CCS PROJECTS

WHAT WILL HELP TO ACCELERATE DEPLOYMENT OF CCS

- Close commercial gap for frontier CCS projects; funding mechanisms
- Continue reduction of CCS costs (Capture, Transport, Storage)
- Adopt market mechanisms to achieve a credible/stable CO₂ price
- Enable deployment of CCS in emerging economies
- Address uncertainties on conditions for post-injection liability handover to governments
- Achieve Public awareness and support for CCS.
- Develop CO₂ transportation infrastructure plays
- Build on proven CO₂-EOR industry where possible
- Agree fit-for-purpose CCS standards, for example on MMV

BRIDGE COMMERCIAL GAP TO MARKET DRIVEN CCS

BRINGING CCS DOWN THE COST CURVE



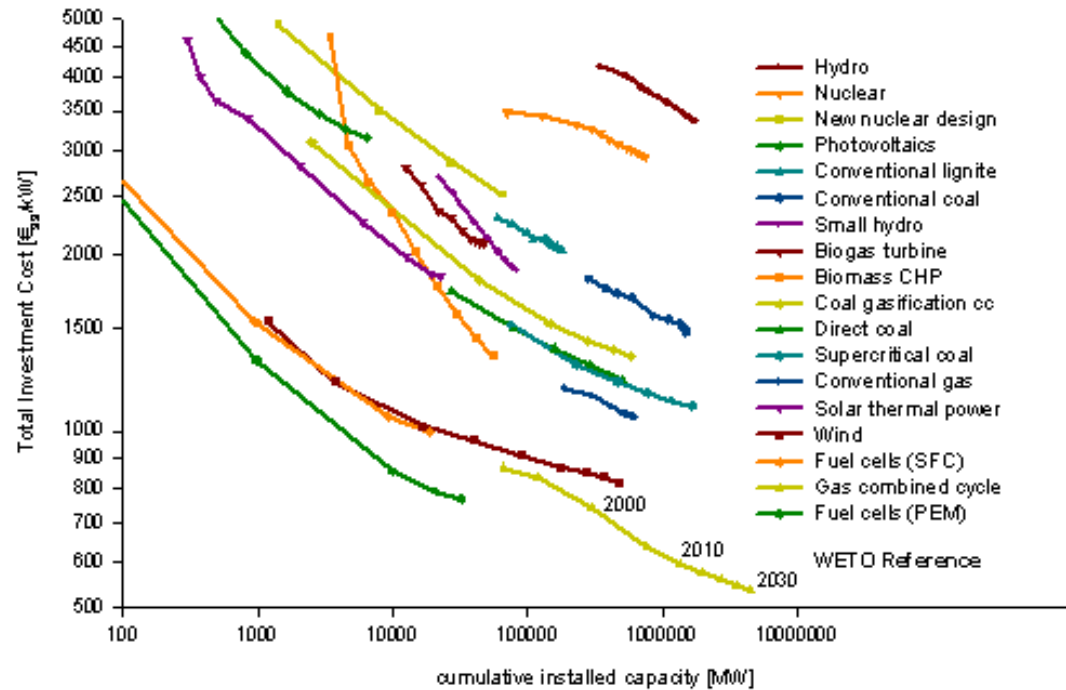
PHASES TO DEPLOYMENT

- **Discover and develop**
Need to refocus and rapidly expand research and development
- **Demonstration**
No early adopters and high start-up costs –this phase needs support
- **Deployment**
Typically driven by the CO₂ market

CCS is driven almost entirely by climate change considerations, therefore requires clear incentives linked to policy goals that gives price signals to the value of emissions avoided

COST REDUCTION

- CCS will realise its cost reduction experience curve by developing & deploying novel technologies, increasing efficiency, and achieving;
 - Repetition (global demo programme),
 - Standardisation,
 - Scale,
 - Competitive markets
- CCS will likely have modest learning rates as many elements are mature technologies.

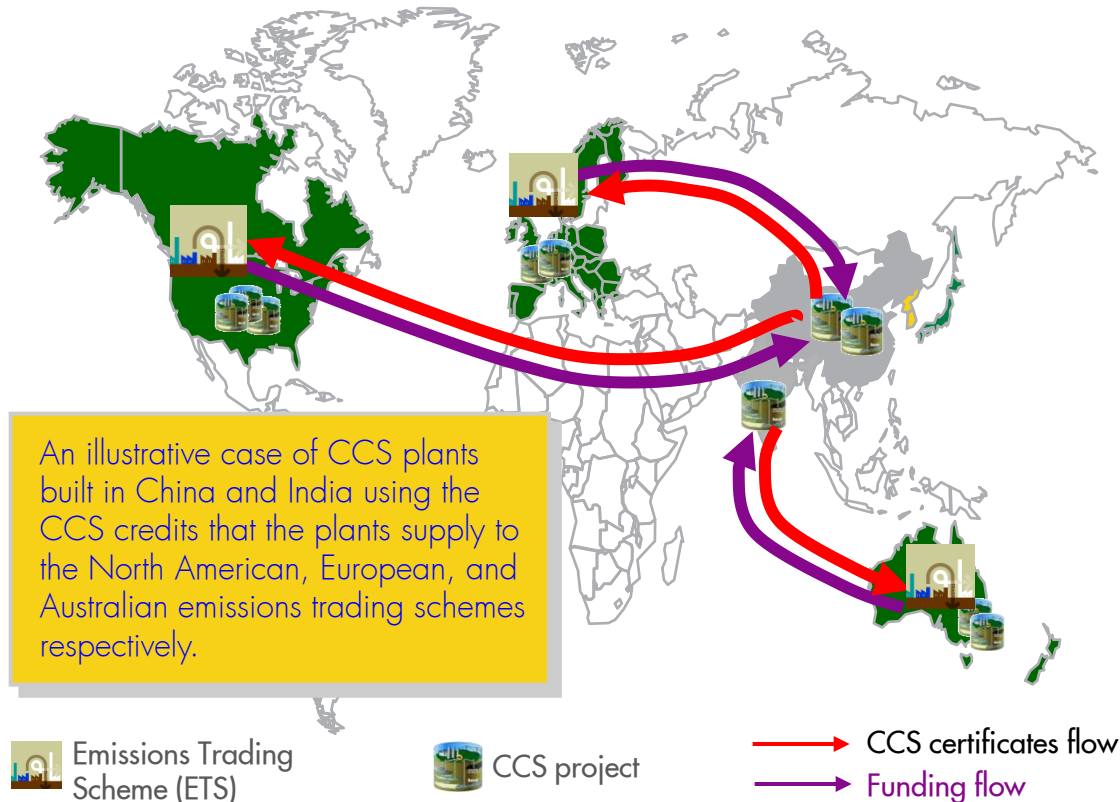


Historic Energy Sector Learning Curves

THE UNDERLYING NEED FOR A CO₂ MARKET

FUNDING CCS PROJECTS THROUGH EMISSIONS TRADING

Graphics are illustrative



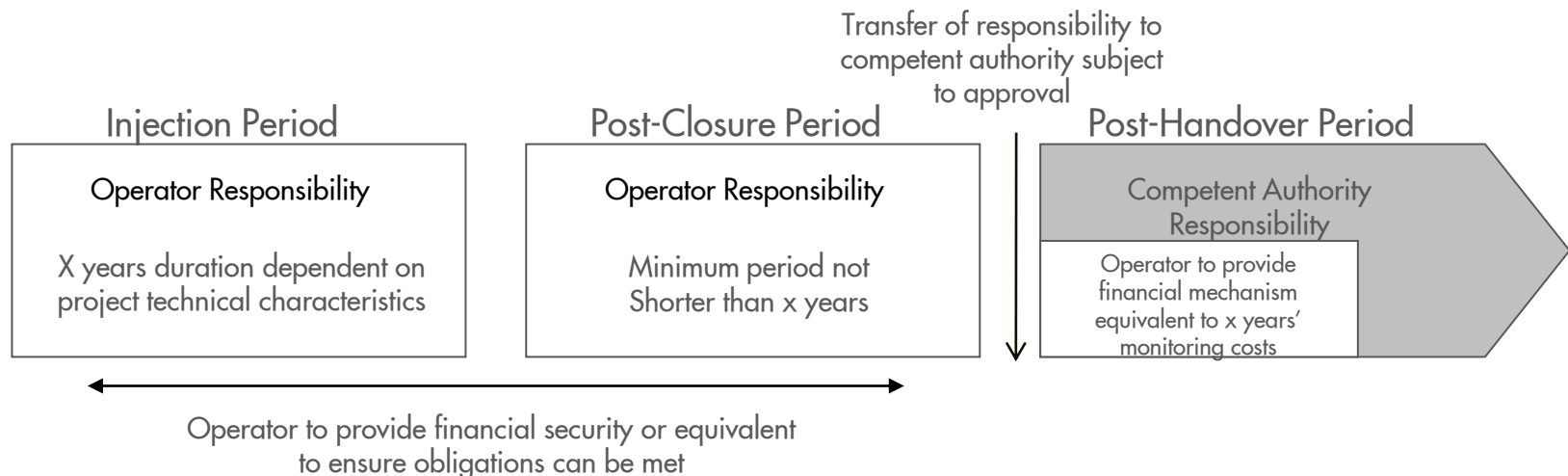
PHASES TO DEPLOYMENT

- **Initial funding**
Direct funding for initial CCS infrastructure will be needed, especially for first large scale demo projects in developing countries
- **CCS projects and ETS**
Establishment of Emissions Trading Schemes create demand for CO₂ reduction and price for CO₂ abated – this mechanism can be used to fund CCS projects including the ones in developing countries

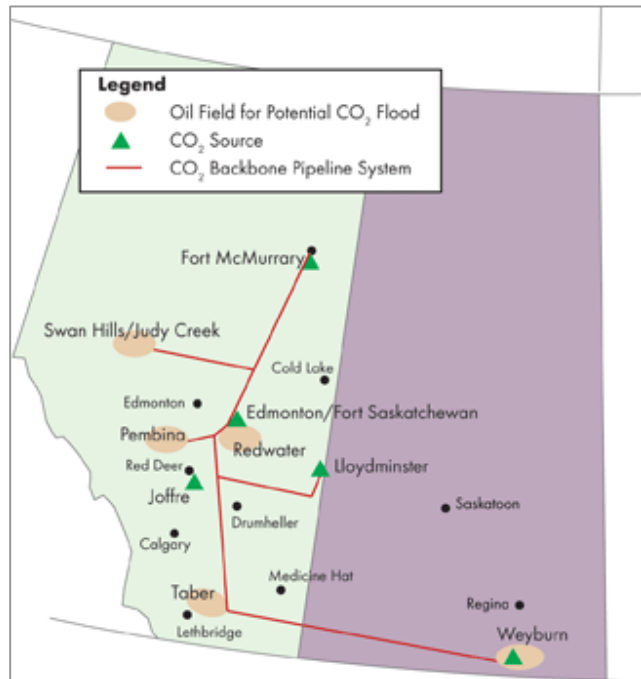
ADDRESS LONG-TERM LIABILITY

Long-term liability will need to be managed and security/funds identified for post-closure stewardship and/or cover unexpected post-closure remediation

- Companies don't last forever and cannot take perpetual liability.
- Governments best suited to provide long-term stewardship and are only guaranteed entity to exist if problems arise long-term
- Insurance will not offer perpetual terms and will not cover certain liability
- Performance standards are difficult to prove and can be unrelated to risk of concern
- The already relatively small CCS risks decrease rapidly after post-injection and closure criteria will be set by government regulators.

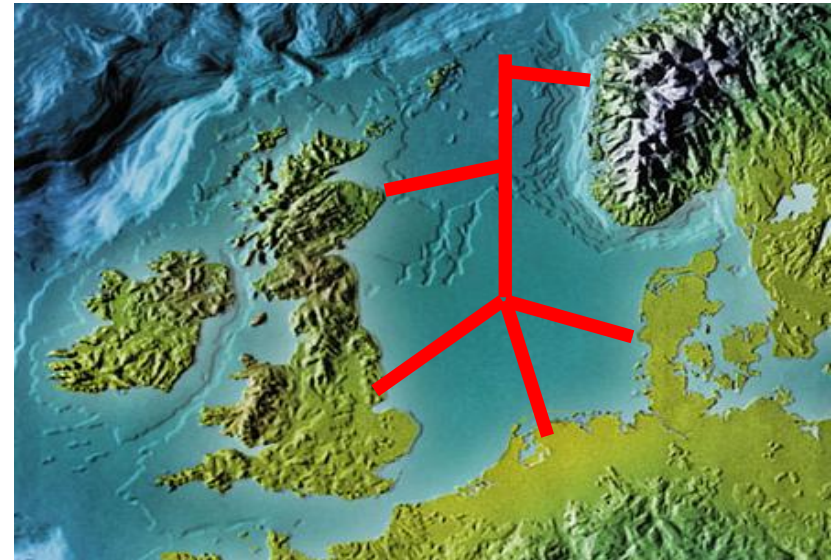


CO₂ TRANSPORTATION INFRASTRUCTURE DEVELOPMENT



Proposed Alberta Backbone CO₂ Pipeline Schematic – National Energy Board Canada

- CO₂ Transportation infrastructure plays are being developed to optimise multiple source & sink connections and achieve economy of scale



Original North Sea Infrastructure Project (CENS)

CO₂-EOR – TAKING A GAME WE KNOW INTO THE FUTURE

- Proven Technology
 - 30+ years experience
- Difference for the Future:
 - CO₂ from industry
 - CCS support/integration
- Next Wave
 - Cost reductions
 - Recovery improvements
 - Maximise CO₂ sequestration
 - Source to sink infrastructure



European Energy Forum



CO₂-EOR Operations Texas, USA

ADDRESS PUBLIC AWARENESS AND SUPPORT FOR CCS



Public perception of CCS is a potential barrier to the implementation as a CC mitigation technology.

Active public engagement is key to building public understanding

- Public awareness is generally low, the role of CCS is not understood.
- Concerns amongst local communities about project safety – what if there is a leak?
- Environmental and health concerns
- Rationale for CCS versus other options, e.g. Renewables

Demonstration projects have a key role to demonstrate safe & responsible operations

CCS DEPLOYMENT - GOVERNMENT & INDUSTRY ACTIONS

INDUSTRY CAN:

- ✓ Research a wide array of potential technology
- ✓ Develop technology to advance the innovation
- ✓ Demonstrate and deploy technology to roll the technology out from lab-scale into eventual commercial scale, step-up the learning curve, and bring costs down as early as possible
- ✓ Project implementation – competently manage and integrate different aspects of the project

GOVERNMENTS SHOULD:

- ✓ Create an international framework including a mechanism recognising CCS, and a new tradable Carbon Storage Unit, verifying stored CO₂
- ✓ Create funds or allowances to support commercial scale demonstration projects
- ✓ A group of countries agreeing to implement, as a satellite endorsed by the international framework
- ✓ Create regulatory frameworks resolving liability, technical and legal issues

