



Accelerating the Adoption of Second and Third Generation Carbon Capture Technologies - Focus on Mechanisms

Context for Advancing 2nd and 3rd Generation Carbon Capture Technologies

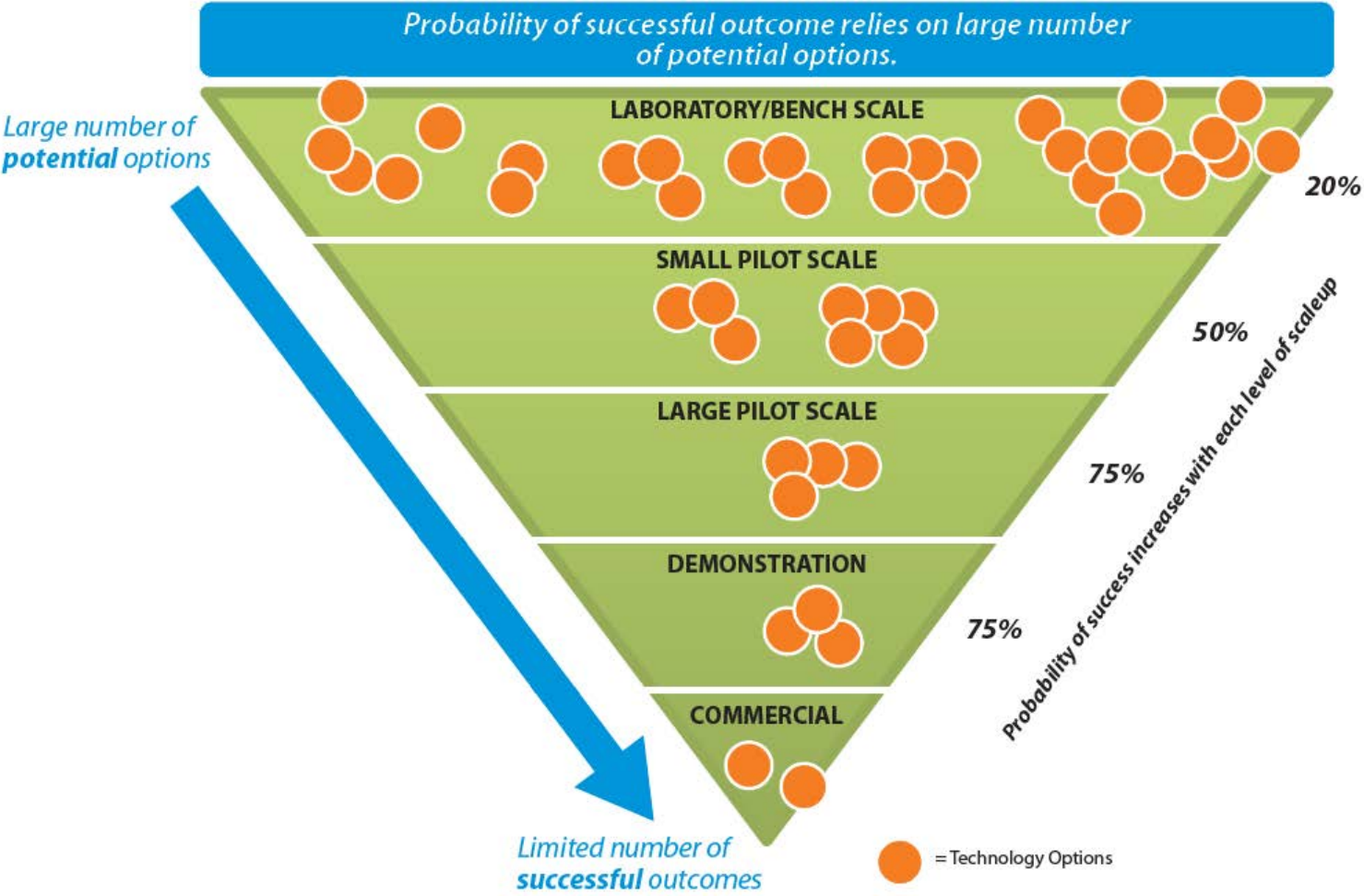


Figure 2-5. CO₂ Capture Technology RD&D Funnel

Research Overview



- Over 35 individuals were interviewed from about 30 organizations in 8 CSLF countries and EU. They advised on:
 - Key barriers
 - Existing Mechanisms that work to accelerate next generation carbon captures technologies
 - Insights on success factors / areas for improvement
 - Highest priorities for Mechanisms that should be the top priorities for policy makers

Breakdown of Interviewees



- Government: Alberta, EC, Norway, The Netherlands, UK, US
- Research Programs, Centres & Networks: Carbon Management Canada, CANMET Energy Technology Centre, RITE (Japan), Korea Institute of Energy Research, Research Council of Norway, CATO2 (The Netherlands), Energy Technologies Institute (UK), GassNova
- Researchers: UBC, UCalgary, Tsinghua University (China)
- Test Centres: NCCC (US), SaskPower, GassNova (TCM)
- Technology Developers: CO2 Solutions, Cansolv, Carbon Clean Solutions, Linde
- Industry Associations: Canadian Clean Power Coalition, Canadian Oil Sands Innovation Alliance, The Carbon Capture & Storage Association (UK)
- Customers/Commercial Facilities: Husky Energy, Shell Global, KEPCO (Korea), SaskPower, Southern Company (for NCCC)
- International Organizations: IEA, IEAGHG

Confirmed Variety of Existing Mechanisms in Use (1)

Mechanism	Application Examples	Stakeholder Priority
Carbon Pricing	Carbon pricing: Norway, the Netherlands, British Columbia, UK Cap and trade: EU ETS, South Korea, WCI, RGGI Hybrid: Alberta	Highest
Government Funding, National Research Funding Programs, Centers, and Networks	US, Norway, the Netherlands, Australia, UK, Canada, China, European Union, South Korea, Japan	High
Tax Incentives for R&D	U.S. (federal and state), Canada (federal and provincial), Australia	High
Operational Support	UK, U.S., Alberta, Saskatchewan	High
Carbon Capture Test Facilities	U.S., Norway, UK, Canada, etc.	High
Cooperation and Knowledge Sharing	Bilateral: Many, such as the U.S.-Canada Clean Energy Dialogue Multilateral: CSLF, IEA GHG R&D Program, Global CCS Institute	High

Confirmed Variety of Existing Mechanisms in Use (2)

Mechanism	Application Examples	Stakeholder Priority
Loans and Loan Guarantees	U.S., Green Investment Bank (UK), European Investment Bank	Supportive
Business Development Programs	Many, including Australia, U.S., UK, Canada, Norway	Supportive
Performance Standards and Deployment Targets	Performance standards: Canada, UK, U.S. (proposed) Portfolio standards: Utah, Illinois	Moderate
Industrial CCS Hubs and Clusters	UK, the Netherlands	Moderate

Feedback from Interviewees

– Common Themes



- Well-Recognized that Market Drivers are lacking for CCS
- Success of 1st Generation CCS is a key driver for next Generations
- 1st Generation CCS Knowledge offers tremendous value to Next Generation technology developers
- Government Funding Programs are generally highly regarded
- Test centers were identified as essential by many stakeholders, since they can accelerate the time to deployment and vastly reduce the costs



EXISTING MECHANISMS FOR 2ND AND 3RD GENERATION CARBON CAPTURE TECHNOLOGIES – SELECT COUNTRY EXAMPLES



US DOE / NETL Carbon Capture R&D Program



- Focus on 2nd/3rd generation capture technologies
 - According to NETL, 2014 program budget was \$92 million
 - Program covers 80% of project costs
- Funding priorities developed in strategic roadmap process with industry, researchers, and academia
 - Time required for advancements is estimated, which is basis for Funding Opportunity Announcement (FOA)
 - A new FOA is issued roughly every 2-3 years
 - Projects from lab to large pilot (10-25 MW) scale eligible*
 - Funded projects leverage public / private partnerships



Norway's RD&D Program

CLIMIT 10 Years

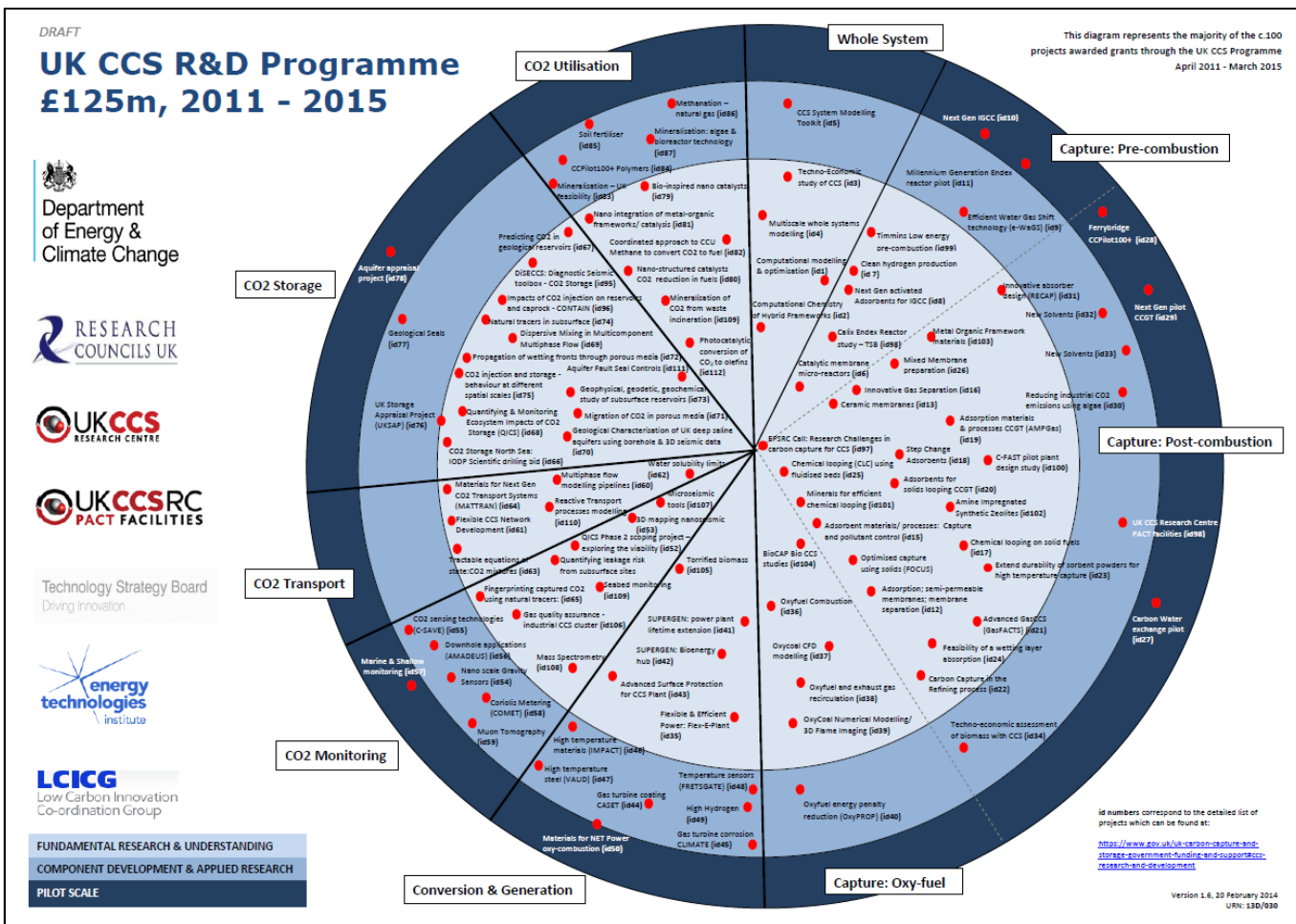


- Led by Research Council (CLIMIT R&D) and Gassnova (CLIMIT Demo) to accelerate CCS commercialization
 - Next generation technologies and cutting-edge solutions that lead to reduced costs and increased safety is one of priorities
- 100% government funding for basic research and industry share rises for more developed projects
 - All projects are required to include PhD students and are assigned to both a research theme and a facility/site





UK CCS R&D Program



UK Government published public investment in capture is £56m over 2011-2015, with total investment costs of £92m. In addition, £13m created the UK CCS Research Centre, including its PACT facilities.



Carbon capture R&D funding from Federal / Provincial Governments

- Government of Canada
 - Natural Resources Canada (e.g. ecoENERGY Innovation Initiative and Program of Energy R&D for federal researchers)
 - Sustainable Development Technology Canada
 - National Research Council Canada
 - Natural Sciences and Engineering Research Council
- Provinces
 - Alberta Climate Change and Emissions Management Corp.
 - Alberta Innovates – Energy and Environment Solutions
 - The Government of Saskatchewan
 - SaskPower (e.g. Crown Corporation funding for CCTF)



European Commission – Cooperation (Twinning) on Carbon Capture R&D



- EU and Australia had bilateral sessions to define R&D priorities, mutual interests, and build relations
- EU and Australia ran separate funding processes
- EC FP7 2013 call for New generation high-efficiency capture processes invited Australia cooperation
 - Call noted EC's right to ask project leads to include collaboration (information/researcher exchanges) with endorsed Australian projects during contract negotiation
- Funders can't prescribe cooperation as call is open and competitive and will depend on funded projects



EC Twinning with Australia – Resulted in 6 Projects



Project	EC Contribution	EC Coordinator	Australian Participant/ Partner
GREEN-CC	5.46 M€	JUELICH (DE)	UNIVERSITY OF QUEENSLAND
MATESA	2.97 M€	SINTEF (NO)	UNIVERSITY OF MELBOURNE, MONASH UNIVERSITY
INTERACT	4.78 M€	TECHNICAL UNIVERSITY OF DORTMUND (DE)	CSIRO
M4CO2	7.93 M€	TUDEFT (NL)	UNIVERSITY OF SYDNEY
ASCENT	6.84 M€	ENEA (IT)	AUSTRALIAN NATIONAL UNIVERSITY, CO2CRC
HiPerCap	4.83 M€	SINTEF (NO)	CSIRO

Source: Update from the European Commission initiatives on CCS from the research and innovation perspective
Dr. Vassilios Kougionas, International Forum on Recent Developments of CCS Implementation, 26-27 March 2015



EC Twinning with South Korea (Next Generation carbon capture)



- EC will repeat this cooperation with South Korea
- EU-Korea twinning workshop in February 2015 and agreed to new generation high efficiency CO₂ Capture, with a call for twinning by the end of 2015
- These ‘families of projects’ can then exchange information and researchers.
 - Plans are to have workshops between the projects resulting from the EU, Australian and Korean funding
 - If all involved agree, other countries could be invited
 - The possibility of establishing a network between all the twinning projects will be explored
- Twinning avoids administrative and legal issues of joint funding calls

Tax Incentives for Research and Development



- Includes tax credits for R&D spending, accelerated depreciation of capital investments, tax exemptions
- Examples: R&D tax credits in Canada (and provinces), US (and states), Australia; accelerated depreciation (US)
- A number of stakeholders, particularly technology developers, reported that both tax credits and accelerated depreciation have been and would continue to be very beneficial.
- Accelerated depreciation is particularly attractive, since capital costs often far exceed other R&D spending

Carbon Capture Test Facilities



- Enable technology developers to test under real-world conditions with significantly lower costs and lead time
- Examples: Technology Centre Mongstad (Norway), National Carbon Capture Center (US), PACT (UK), SaskPower's CCTF
- Identified as critical by stakeholders; required to prove performance across different scales, sectors, and countries (with unique flue gases)
- Staff expertise invaluable for scaling up lab technologies

Operational Support Programs



- Reduce operational risks and improve the business case for CCS projects by providing support with ongoing operating costs
- Offtake arrangements (feed-in tariffs), programs that guarantee a market for some or all output, activity-based tax credits
- Examples: UK Contracts for Difference, US Tax Credit for Carbon Dioxide Sequestration, Alberta and Saskatchewan royalty relief for CO₂-EOR
- One of the highest priorities identified by stakeholders; integral for creating a business case

Early Thoughts to Accelerate - Potential Areas for Discussion



- CCS Test Centre Network is great anchor for accelerating efforts
 - Opportunities to enhance network to cover broader range of regions and sectors?
 - Is there a need to link to / better characterize smaller test facilities to facilitate progression to larger scales ?
- Look at opportunities for replication or network around EU twinning approach more broadly to expand the “families of projects”?
- Encourage sharing of best practices in funding these technologies?
- Look at successful challenges model and see how these can help to accelerate research (Xprize, etc.)?
- Enhance opportunities for researchers and developers to participate in extended visits and staff exchanges to other demonstration projects and test centres (6 months or more)?