20 Years of Carbon Capture and Storage

Accelerating Future Deployment

International Energy Agency
Secure Sustainable Together

CTS infrastructure development: challenges and way forward

2nd International workshop on offshore geologic CO_2 storage

Beaumont (US, Texas), 20 June 2017

Thomas Berly (Energy Analyst-CCS)
International Energy Agency (IEA)

Key points

- Focus of this presentation:

⇒ CO_2 transport and storage (CTS) development: How to?

But before, we need to make sure that we understand:

- The “why”
- The “what”
- and finally the “how” which means where?, how much?, by when?, and by who?

<u>Sources of this presentation derived from:</u>

- IEA ETP 2017 (just released)
- IEA CTS infrastructure workshop (Paris, May 2017)

CCS context and current status

- CCS has gained renewed momentum since Paris Agreement
- Significant progress has been made over the past 20 years but…
  - 17 large-scale projects operating and portfolio is becoming more diverse (coal-fired power generation, oil sand upgrading and steel manufacture)
  - New projects advancing: 5 more projects in construction, most due to commence in next 12-18 months and China leads the next wave of projects, with 8 in early development
- Technology is now proven in many applications
- CO2-EOR opportunities have been important for CCS investment
  - CO_2 has been injected for EOR since the 1970's in the USA
  - 12 of the 17 large-scale projects operating are associated with EOR;
    - Most are in North America; 2 projects recently commissioned in Saudi Arabia and United Arab Emirates

BUT in 1996-2016, up to 0.351 $GtCCO_2$ has been injected in the world

⇒ CCS is not on track for 2 degrees or below for Paris ambitions

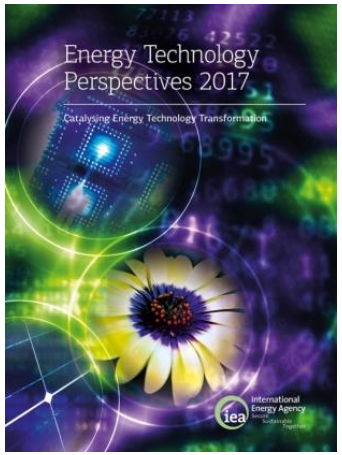

Scotford Upgrader
(Source: Shell)

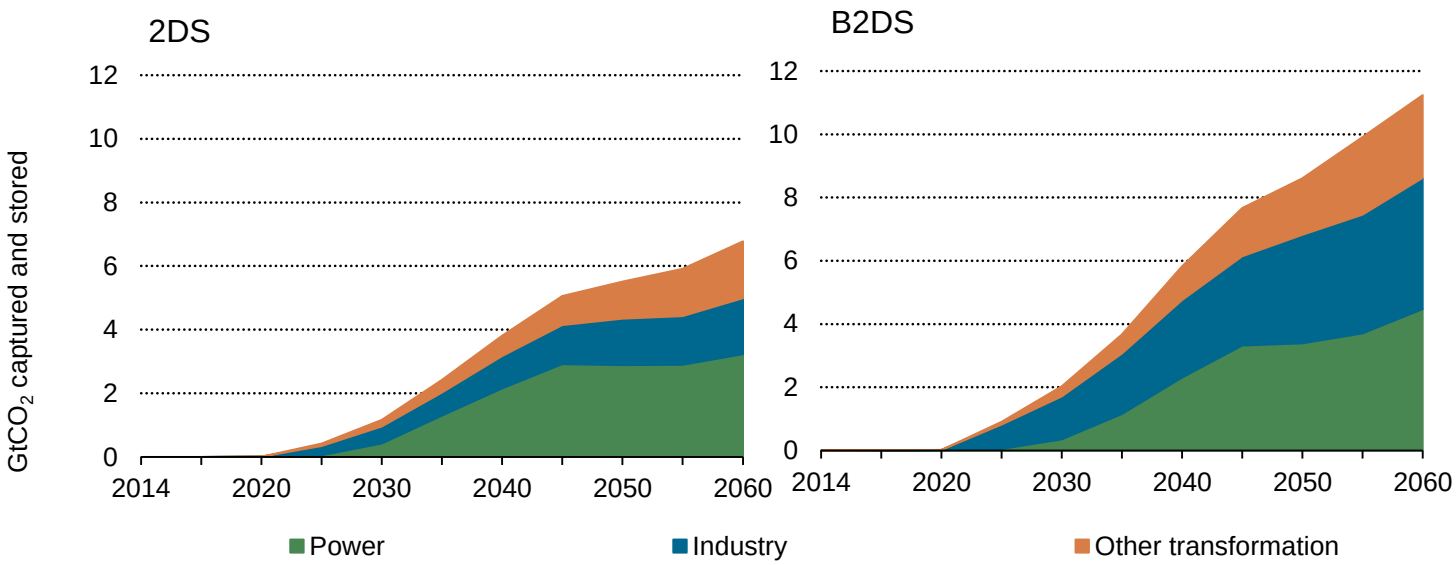
Al Reyadah
(Source: The National)

Parish - Petra Nova
(Source: NRG)


Gorgon
(Source: Chevron)

Putting CCS into perspective



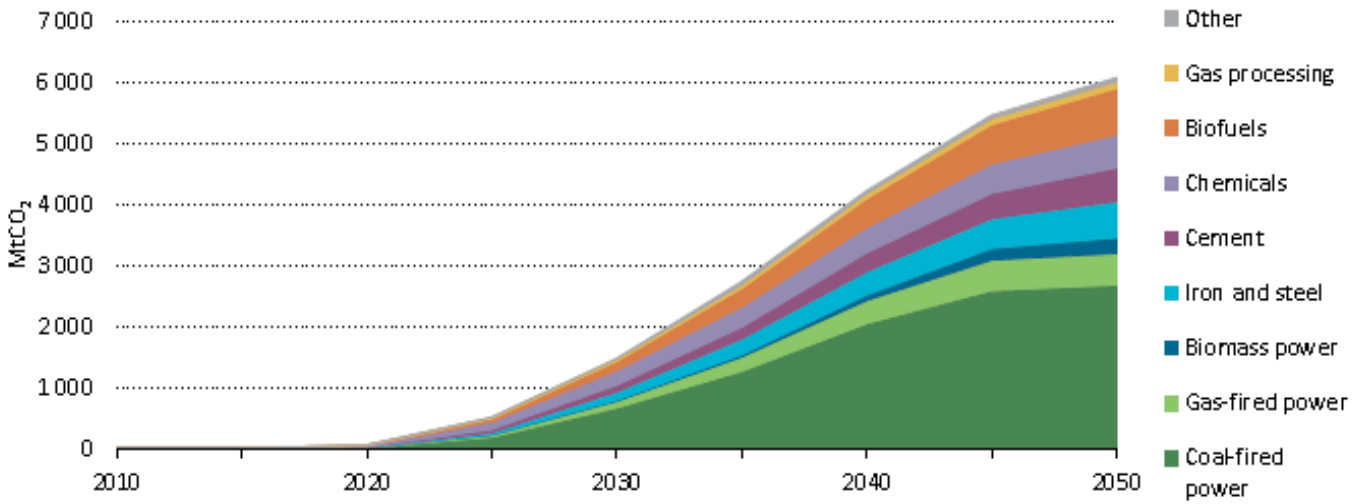


IEA ETP 2017:

- In 2DS, CCS is applied across the economy capturing 6.8GtCO_2 in 2060 and 142 GtCO_2 cumulatively in the period 2015-2060
- In B2DS, annual rate of CCS in 2060 is 11 GTCO_2 (66% higher than 2DS) with 227GtCO_2 captured and stored cumulatively across 2015-2060
- CCS accounts for 32% of the reduction in emissions between 2DS and B2DS

⇒ **A massive, rapid scale-up of CCS is required under a 2DS or well below 2°C target but the task ahead is HUGE…**

CCS Build out rates (IEA GHG, 2016)



Source: Derived from IEA (2016b), *Energy Technology Perspectives 2016*.

- CCS Roadmaps suggest **150-300 Million tonnes CO_2 per year** build out rates of capture and storage
- Equivalent with required build out rates of individual CCS items **per year**:

- 75-150 commission CO_2 capture facilities
- 75-150 ~20 MW compressors
- 4.5-12k km pipeline
- ~ 15-30 Mtpa CO_2 ships capacity added (assuming 10% transported by ship)
- 150-1200 new wells (40-100 rigs)
- 60-120 platforms/wellpads
- 30-60 storage sites
- 150-300 Million tonnes CO_2 stored

⇒ Rapid CCS Industry build-out can technically be realised in a supporting environment, with sustained incentives

Accelerating CCS deployment: focus on CTS

- Fundamentals to accelerate CCS deployment:
  - Increased political and public attention on CCS as a critical mitigation technology meeting climate targets and recognizing CCS value proposition (societal benefits)
  - Comprehensive set of incentive and other policy that can underpin business development for CCS cluster projects in the near- and long-term
  - Strengthened global coordination/cooperation at all levels (local, state, country, intra-regional levels and international) and between government-industry, and;
  - **An increased focus on CO_2 storage assessment and CO_2 transport and storage infrastructure development**

- Focus on CO_2 transport and storage (CTS) infrastructure development is essential
  - To meet CO_2 emission targets, CTS infrastructure development will be required to service multiple sectors of the economy across different regions of the world
  - The development of public common user CTS infrastructure would greatly accelerate the uptake of CO_2 capture.
  - The deployment of CCS will require an up-front development of **large-scale storage (mainly offshore) resources**
  - Governments must play a leading role **in proving up or not** large-scale bankable CO_2 storage

⇒ ***No CCS without the "S": CO_2 storage must come first***

Defining the CCS value proposition

***Reference:* IEA CTS infrastructure workshop (May 2017, Paris)**

CCS benefits

- CCS is a key technology for achieving the Paris Agreement ambitions across various sector of the economics (power, industrial processes, heat and transport)
- CCS is essential for 'negative emissions'
- CCS is a not all about the cost…without CCS, most climate models indicate that total emissions targets can't be achieved.
- CCS has additional societal benefits (grid stability, energy security, jobs, etc..)

CCS challenges

- Governments will be challenged on why spending $ on CCS (instead of hospitals, schools, etc…)
- CCS value proposition is not everywhere the same and changes over time
- Beyond cost, CCS value proposition is hard quantify (quantifiable CCS metrics)
- Proving the value is essential, but it is not more than a first step…need to convince (government, public), design the way to support (governments), implement and develop (government, industry)

Improving CCS narratives…

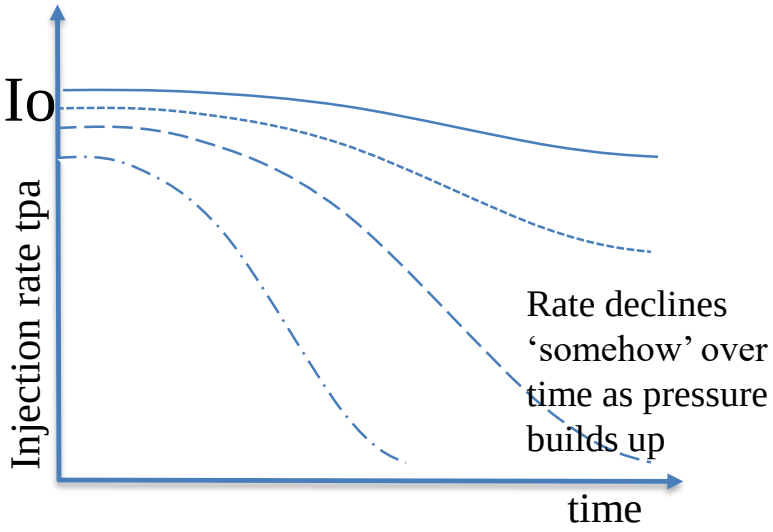
***Reference:* IEA CTS infrastructure workshop (May 2017, Paris)**

- **Proving and communicating CCS value - big challenge**
  - New approach required – marketing CCS, increasing energy literacy
  - New narratives to drive opinion on climate change issues (global climate models have limited impacts)
- **Business case**
  - CCS has a business case if we take into account the societal benefits
- **CO_2 storage costs:**
  - Comparing apple to apple: CO_2 storage cost definition and estimation methodology impact on the $/T as well as the assumptions used
  - Driving forces (+ and -)
- **Containment:** leak-mode analysis with *rate, confidence levels & consequence analysis*

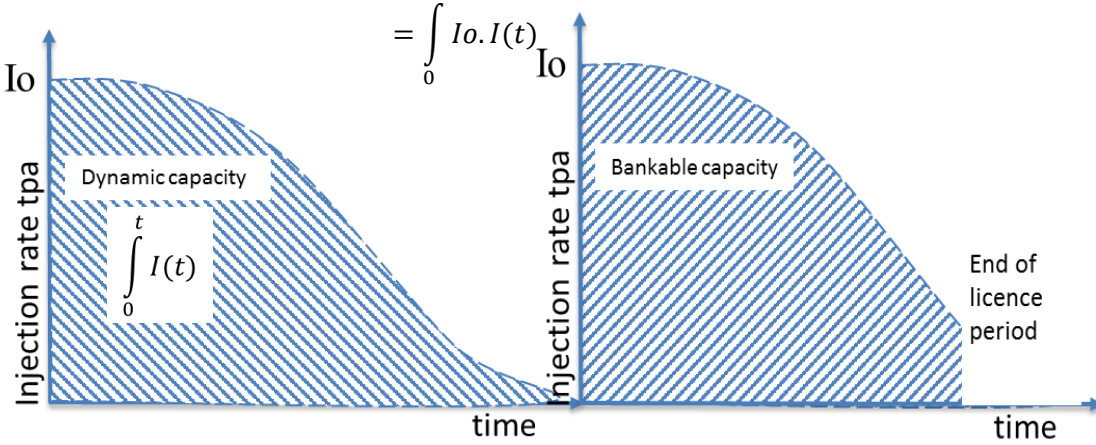
- And the **Capacity**, which is considered the amount of corrected pore space in the container BUT *Rate* defines the value of the resource not total corrected pore *volume*
  - The "Useful Size" of Storage "Container" is not a Function of Static Pore Volume

Resetting capacity…

- ***Reference:*** ***Alf Garnett (UQ) @IEA CTS infrastructure workshop (May 2017, Paris)***



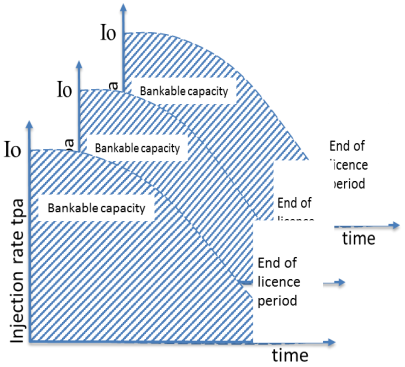
$$Capacity = area\ under\ curve = \int_0^t Io.I(t)$$



=> Capacity is more Usefully a Function of Achievable Injectivity

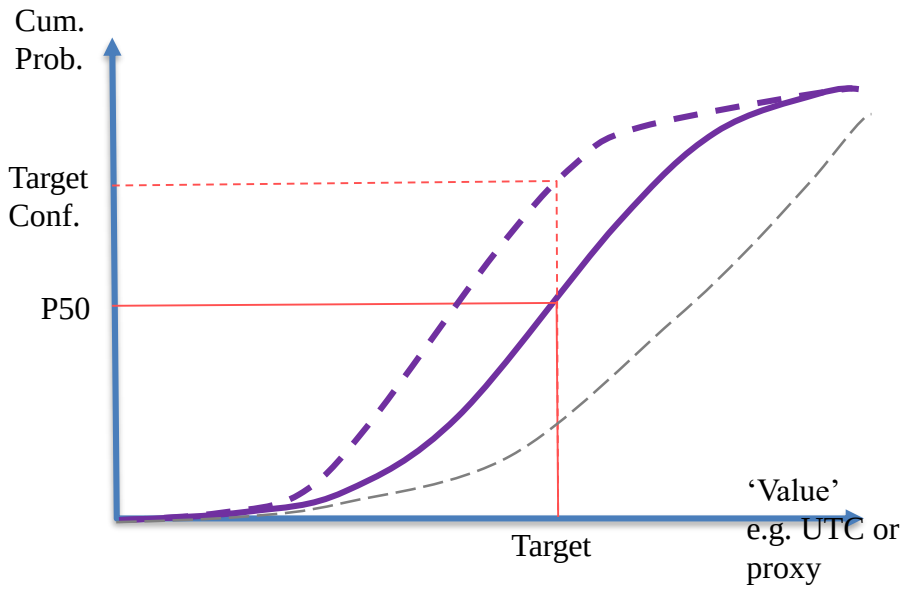
$$Capacity = \begin{array}{c} For\ the\ whole\ licence\ period: \\ sum\ of\ the\ injection\ rate\ for\ all\ individual\ operating\ wells \\ but\ limited\ by\ regs\ i.e.\ drilliable\ area\ and\ allowable\ plume\ spread \\ (economic\ capacity\ is\ -\ this\ achieved\ below\ a\ target\ unit\ cost) \end{array}$$

$$Capacity = \lim_{Area} . \int_{t=o}^{lic.term} . \sum_{wells(t)} Injection(t)$$



Developing CO_2 storage resource portfolios through CO_2 E&A

- Appraising long term injectivity is in fact Appraising the Resource 'Dynamic Capacity'
  - Uncertainties on initial rates & decline rates
- Dynamic testing is key to estimate (dynamic) capacity and reduce uncertainties but **How far you need to go?**
  - **It depends on the risk tolerance of the decision makers?**
- Economics requires decision makers to define "value" (doesn't have to be just $) and this requires a clear strategic purpose
  - "Value" *may* be a rate, cumulative volume and acceptable UTC range
  - Value is information – what rates, where, what confidence levels, what action required to mature, what risks and uncertainties?



Reference: Alf Garnett (UQ) @IEA CTS infrastructure workshop (May 2017, Paris)

- Uncertainty analysis => uncertainty management plan => investment in activity versus uncertainty reduction
- But E&A is a Decision Roadmap not Activity Sequence and E&A is **not** primarily a technical exercise, it is an **economic** exercise
- The first task – figure out why before what !
  - Framing the problem/mandate …store a minimum of XX mln tonnes per annum for XX years at less than $XX/t (T&S UTC) [*with option to expand this rate to XX mln tpa*]
  - Find and appraise suitable site(s) via a stage gated process and clear decision criteria for E&A

Develop CTS infrastructure mapping

- Define CCS potential in key regions to inform climate strategies

How much CO_2 can we pump in, where, at what rate and for how long?

- Geology & Reservoir Engineering
- Constraints
- Wells & Completions
- Field Engineering (FDP)
- Impacts
- Risk & uncertainty analysis
- Field Economics (by area)

What is the best realistic, economic way to 'plumb' this in?

- CO_2 Sources (existing and future
- Constraints
- Synergies/opportunities
- Pipelines (eng. & routes)
- Sequence/timing
- Storage & Transport Economics by area and source-sink match

Examples:
- National Carbon Mapping and Infrastructure Plan – Australia
- UK Appraisal project (PBD)

- CTS Infrastructure mapping
- CTS Deployment scenarios

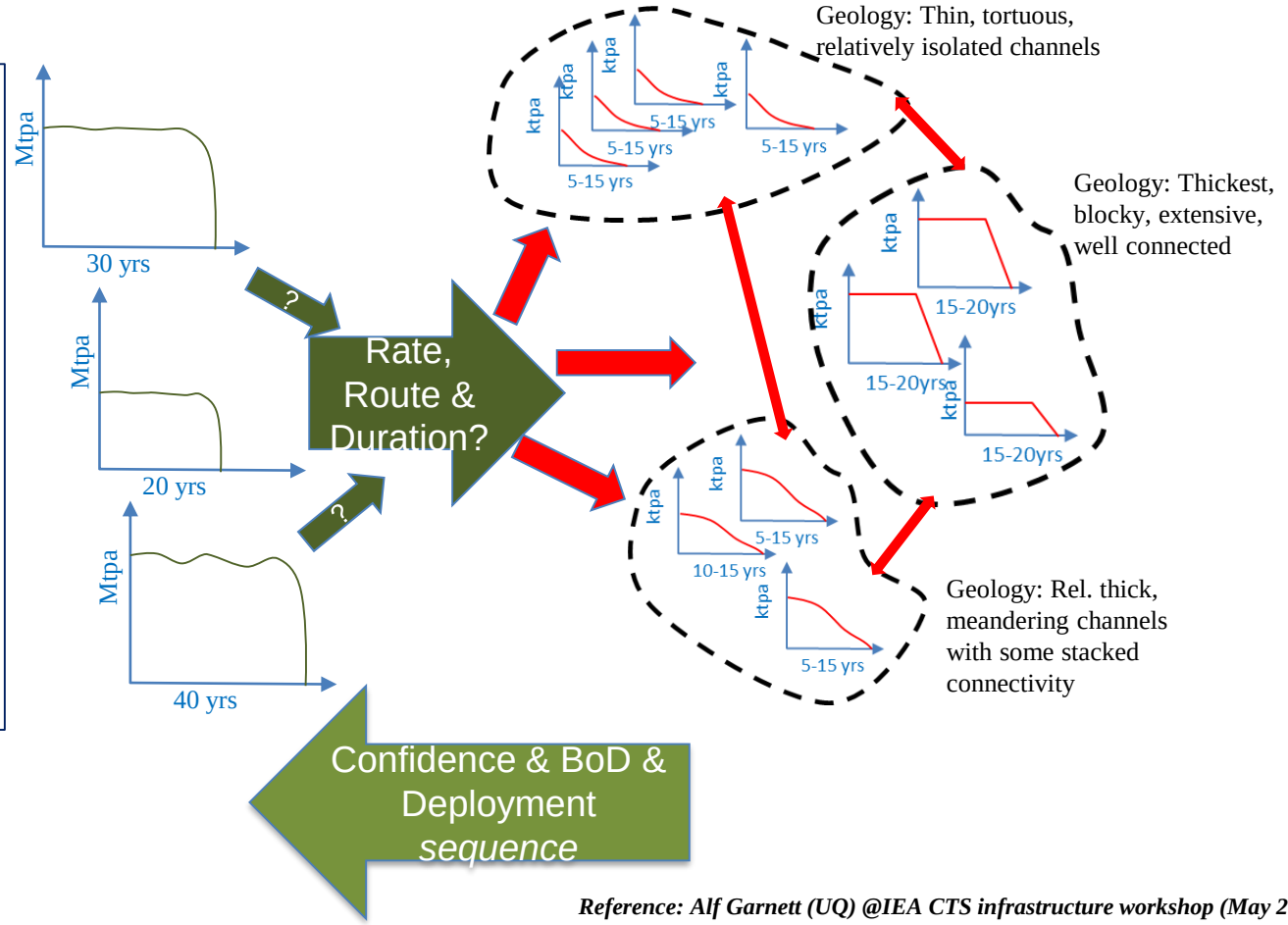
- The first step is to establish, in key regions, the confidence levels in rate and cost for multi-user CO_2 T&S systems through
  - a regional appraisal program with dynamic calibration and matched source-sink scenario analysis, and;
  - considering early deployment opportunities as well as long term deployment targets

CTS development plan

- Dynamic Calibration is needed for Improved Confidence in *Matching Rates & BoD*

CO_2 sources

- Power stations
- Industrial processes
- Other Transformation

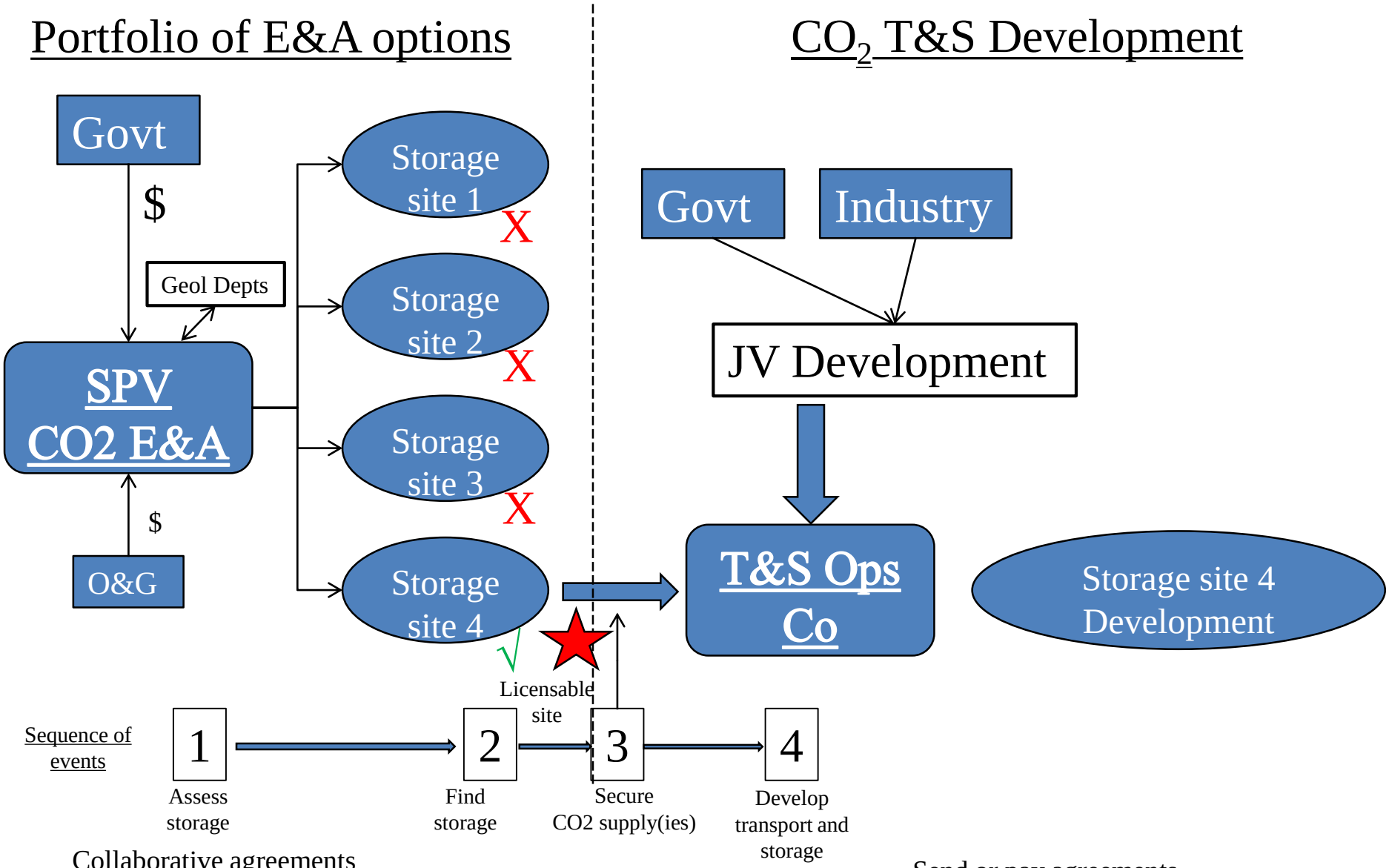


Reference: Alf Garnett (UQ) @IEA CTS infrastructure workshop (May 2017, Paris)

CTS development – possible solutions

- Form “coalition of the willing” between governments or/and states and industry to support CCS and develop common-user CTS infrastructure in key “regions”
- Create “enablers” to develop CTS plans and infrastructure based on:
  - ZEP concept of the Regional Development Organisation (RDO) strategize, plan and develop CTS “systems”
  - ZEP concept of the Market Marker to build the required T&S infrastructure, transports and stores the CO_2 captured by emitters on a commercial contract basis, by taking the operational storage risk
- **The first step will to create a CO_2 Transport and Storage “appraisal” (SPV) entity for each “region” with:**
  - Right competencies (not only technical but project Mgt)
  - Right structure/funding/governance => acceptance of exploration (failure) risk
  - Right level of responsibilities/accountabilities

From CO_2 storage resource assessment to development



Final remarks

Key points:

- Focus on CTS infrastructure development is essential for large-scale CCS deployment
- CCS deployment will require an up-front development of large-scale storage (mainly offshore) resources => a portfolio exploration and appraisal approach is needed
- The role of the government is essential to CTS deployment including CO_2 storage assessment

Actions for Governments:

- Long term commitment through to decarbonisation with CCS
- Shift in policy approach from supporting individual CCS projects to CTS infrastructure
- Specific support mechanisms tailored for CCS early deployment and CO_2 storage development
- Public-private collaboration/partnership to plan, design and develop multi-user CTS hubs

Way forward:

- Why? Prove CCS value; refine CCS narratives
- What? Undertake early deployment of CCS projects enabling long term infrastructure development (expandability/scalability) including CO_2-EOR, depleted gas fields, saline aquifers with data available
- How? Adopt new approach to:
  - Develop coordinated strategic plans for the development of transport and storage systems
  - Develop CO_2 storage resource portfolios and conduct E&A to reduce uncertainties

Time is running out for CCS – the next 10 years will be crucial for large-scale deployment of CCS

We must get it right!

IEA CTS infrastructure workshop (Paris, May 2017)

- First IEA CO_2 storage focused workshop in Paris on 16-17 May 2017
- Aim: CO_2 transport and storage (T&S) infrastructure development
- Attendees: industry experts public policy makers, researchers from twelve different countries
- Key points:
  - Development of multi-user CO_2 transport and storage (CTS) infrastructure is key enabler to CCS deployment
  - Confidence in CO_2 storage is critical for CTS deployment

Over 30 participants gathered in Paris for the IEA CO_2 transport and storage infrastructure workshop (Paris, 16-17 May 2017)

⇒ Key actions:

- Coordinated and strategic action to plan and build CTS infrastructure is required now
- Specific support mechanisms tailored for CO_2 storage assessment and CTS early deployment are needed
- CO_2 storage appraisal and development must be prioritized
- Governments must play a leading role

Clean Energy Ministerial 8: Ministerial side event on CCUS, 6 June

- **China**: Minister Wan Gang
- **Canada**: Minister Jim Carr
- **Norway**: Minister Terje Søviknes
- **United States**: Secretary Rick Perry
- **European Commission**: Energy DG Dominique Ristori
- **Australia**: Under-Secretary Jo Evans
- **Saudi Aramco**: CTO Ahmad Al Khowaiter
- **Oil and Gas Climate Initiative:** Exec Committee Chairman Gerard Moutet
- **Global CCS Institute**: CEO Brad Page
- **CEM**: Head of Secretariat Christian Zinglersen
- **International Energy Agency**: Executive Director Fatih Birol (chair)

"Deployment of CCS will not be optional in implementing the Paris Agreement."

Fatih Birol

IEA Executive Director

IEA CCS Unit

Tristan Stanley
(regulation, policy)

Thomas Berly
(CO_2 transport and storage)

Samantha McCulloch
(policy)

Niels Berghout
(CO_2 capture)

Juho Lipponen
(head of CCS unit)

Simon Keeling
(finance)

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