Overcoming CO2 transportation infrastructure deployment challenges - pipeline network or single source?

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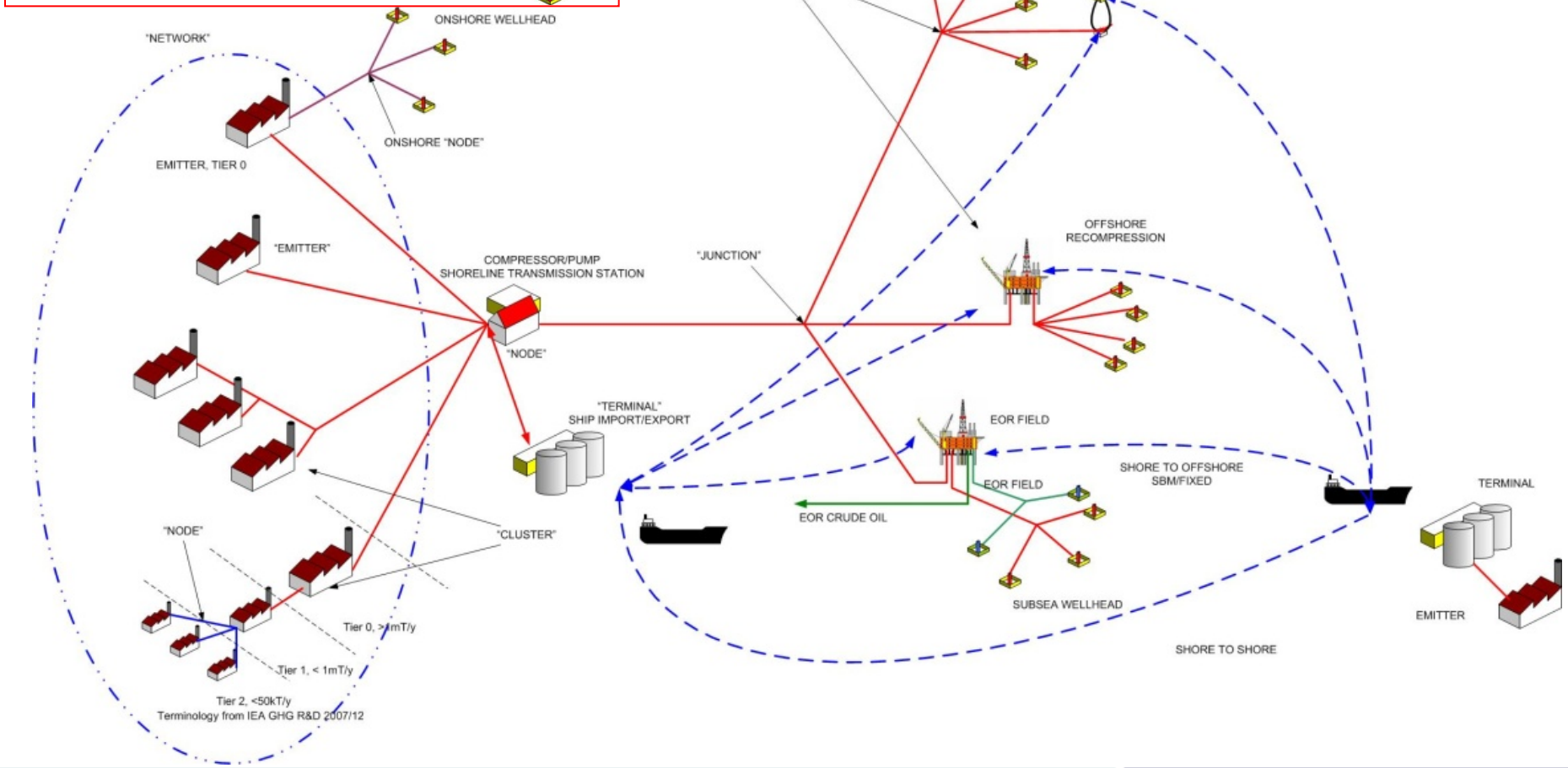
Definitions



Deployment challenges

- First projects not here yet – source to storage only
- FUNDING!!
- Planning
- Regional “cluster” thinking
  - Teesside
  - Humber
- Policy is unclear – DECC competition is helping but not thinking about next phase
- Which project
- Which store
  - Type, location, volume, is it assessed/surveyed yet
- Impact of EOR – will we/won’t we
- Re-use is more complicated than previously envisaged

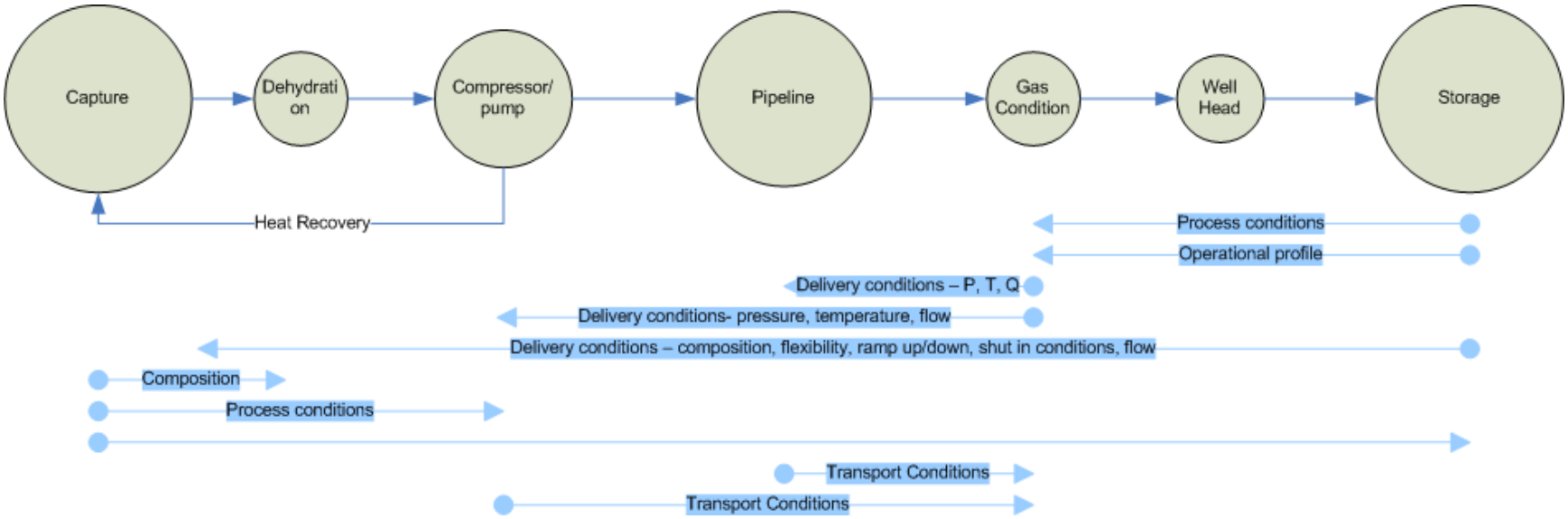
Things to resolve

- Research needs
  - Dispersion modelling
  - Pipeline failure – understanding behaviour
  - Clustering – better understanding of behaviours
  - Flexibility
- Legislation/guidance
  - Position on dense phase or liquid pipelines in seems unclear again
  - First project will need to find a way
- Impact of shipping on clusters and pipelines
- Public engagement, stakeholder education

AMECs Key Learning so far,…

- Competency
- Requirements for good quality activities
- In multi-partner schemes
  - Basis of Design – not transport specific, full chain
  - Overall philosophies for scheme need to be considered
  - Communication and collaboration plans
  - Significant culture issues in consortium
  - Reliability and Availability needs to be considered across the chain
- Flexibility impacts everyone
  - Compressors are not necessarily flexible
- Be realistic about;
  - Flexing
  - Impact of storage – location, schedule, conditions
  - Transport conditions

Execution Strategy - End-to-end strategy

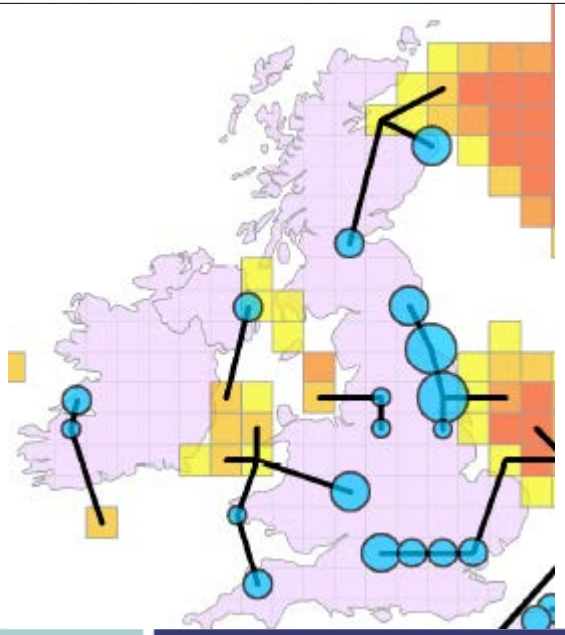


- Critical influences come from downstream and upstream sources (above)
- Requires high level information exchange and co-ordination
- End-to-end philosophies and specifications
  - Operations (including flexibility), control, RAM, Emergency, Start-up/shut-down, commissioning, composition specifications
  - Design basis at every battery limit

High level transport influences

- Emitter and storage site size and location
- Conditions – received and required
- Route parameters
  - Legislation (trans-boundary, regulations)
  - Level of study
- Route constraints
  - Terrain
  - Environment
  - Population – numbers and attitude
- Compression philosophy
- Re-use
- CO-ORDINATE – timeline, entry specification, access, flexibility

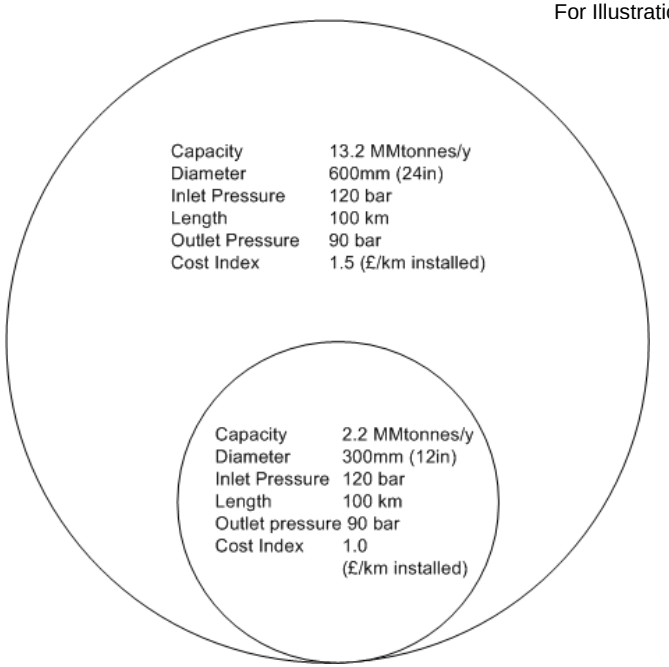
AMEC Infrastructure Model Diagram - deleted



Right-sizing

- Right sizing is;
  - Sizing for future users
  - Sizing for future plant size
  - Investing in future network
- Why?
  - Finite number of pipelines in one geographical area
  - Minimise disruption to local environment
  - Cheaper - x3-8 times less expensive per tonne than A to B pipelines
- Higher cost of investment
  - CO2Sense study showed 11-16 year “no-regrets period”

For Illustration Only



Common Infrastructure Cost

- Common infrastructure costs difficult to analyse
  - The assumptions aren't often clear
  - Economics differ
- Preference for comparison based on overnight cost per tonne
- Followed by the complex economics

- Modelled cost per tonne
  - Humber region £1.7/t
  - Scotland c. £8/t
  - Tees £2-4/t depending on storage target
- Influences on cost per tonne
  - Period of operation
  - Scenario's
  - Emitter size
  - Right sizing of pipelines

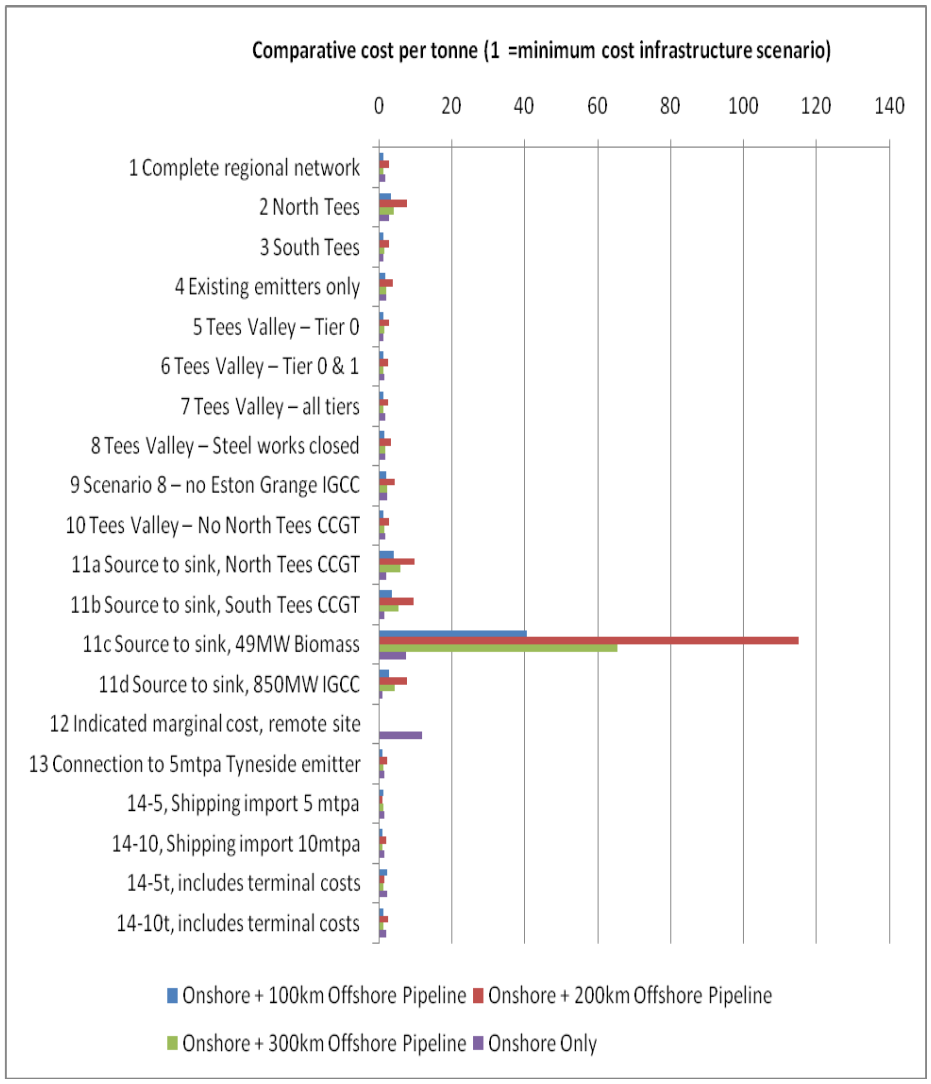
Examining Right Sizing

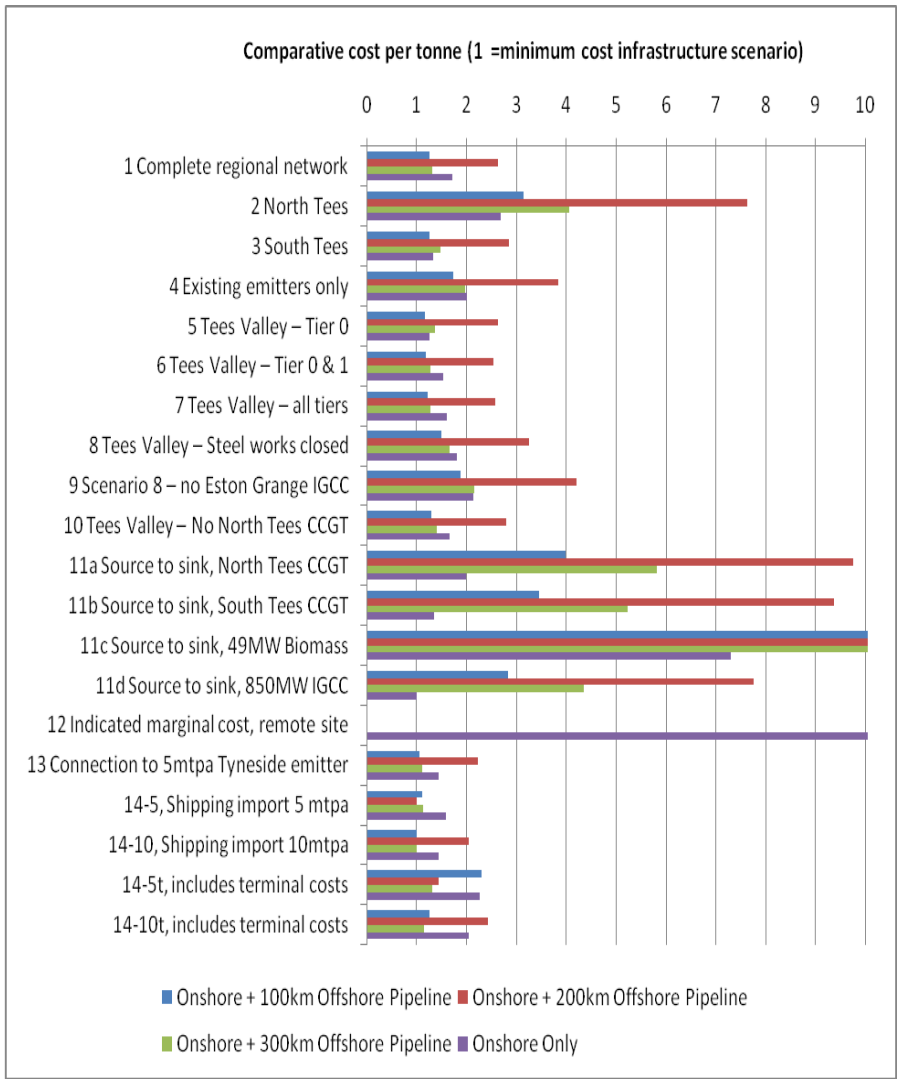
- The CO2Sense Humber study focused on network comparisons
- Two large 4MMte/y emitters with A-B solutions - £481m
- Networked - £322m
- Add a third - £334m
- Major savings offshore
- If you add the Aire valley the saving is 25% of the CAPEX

Diagram 3: costs of a standalone pipeline from the Aire Valley means a total cost of £896m for phase 1 and 2.

Diagram 4: integrated phase 1 and 2, with potential CO_2 vessel capability in the Humber.

Scenario Costs (Overnight CAPEX) - Teesside





Cost of Infrastructure Schemes

Re-use

- Re-use is something to potentially consider
- Issues with age of asset will be key driver
- Do not assume that ROW agreements will continue to apply
- Effectively seeking permission for a new pipeline
- Has technical restrictions
  - Materials
  - Original design
  - Switch out of valves
  - Gas phase dramatically increases compression costs CAPEX and OPEX
- Longannet highlighted key considerations
  - Costs and extent of modification
  - Disinvestment from existing assets (compressors and multi junctions)
  - Changes of use impact on land use, permissions etc
- Indicative costs of;
  - £0.3 million/km
  - £0.2 million/km without “land” charge

Costs issues for the future

- Pipelines are fairly robust
  - Comparable design
  - Good body of costs
- Some reductions may emerge
  - Conservative design
  - Lack of experience
  - Lack of knowledge
- Understanding flexibility

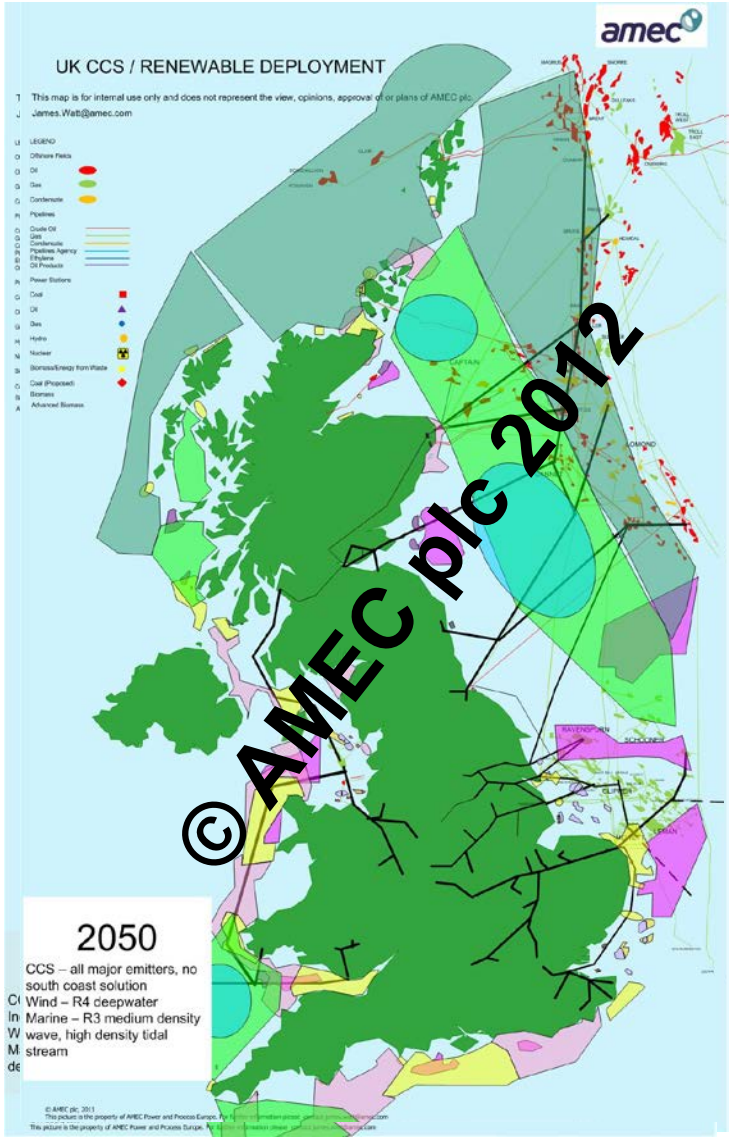
- Compression at source
  - Increasing levels of integration
  - Heat recovery
  - Interaction with capture plant
- Conditioning and dehydration options
  - Needs examination
- Experience will tend to impact OPEX more than CAPEX

Experience, engagement and education

- Experience – translating to CCS market from EOR, pipelines and acid gas
- Raising knowledge levels
  - Pilot and demo programs
  - Second generation development
  - Academic research
  - Transfer to industry
- Public engagement
  - From other CCS projects
  - Gas storage and wind farms
- Education
  - Ensuring skills are taught now for future resource
  - Training current resource with new skills

Consider this,… a slightly different North Sea

- The animation is one scenario being examined by AMEC CCS team
- It includes marine and wind roll out
- It is viewed as a positive deployment rate
- There are assumptions behind this of course
- But over time this is one way CCS may deploy
- There are other pressures that will affect this;
  - schedules
  - routes
  - access



Its not all bad,…

- UK leads the way on clustering
  - Humber
  - Teesside
  - Scotland – emitter and storage clusters
  - Mersey & Dee
  - Thames & South East (high level)
- Research is being driven by UK bodies, much better than 5 years ago
- Knowledge levels are increasing – de-risking projects as it goes
- Experience levels are increasing
- Regardless of cluster or single source to store we need a project, we need to move on.

Thanks

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