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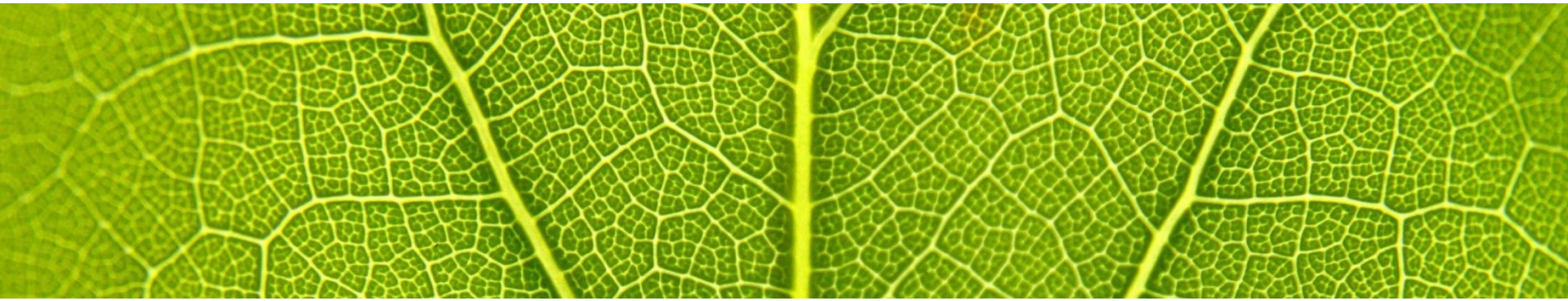

ICCUS Readiness of UK industrial clusters

An assessment

19/01/2017

Michiel Stork, Mark Schenkel

Executive Summary

- BEIS would like to better **understand the position key clusters are in with regard to industrial carbon capture usage and storage (ICCUS)**
- This document describes an **assessment approach** to this ICCUS Readiness of various UK clusters based on seven defined ICCUS Readiness dimensions: Motivation, Skills, Culture, Organisation, Infrastructure, Technological Potential and Investability.
- This method is then **applied to seven clusters**: Grangemouth, Humberside, Merseyside, Port Talbot, Scunthorpe, Southampton and Teesside by means of literature and desktop research and through interviews with key cluster stakeholders.
- **These assessments yield insights** as to how these clusters are organized and positioned towards ICCUS deployment along various dimensions and reveal areas where there may be room for improvement. There are large differences noticed across the clusters, where some can be progressed considerably with relatively low effort. This will be expanded on in the pages to follow.
- **Cross-cutting observations** are that the deployment of ICCUS will benefit from a consistent financial incentive. In absence of this there are a number of other clear steps that can be taken to aid ICCUS. An important activity is the development of cluster-specific organisations where these do not exist currently. Some of the lesser engaged clusters could also be stimulated to develop new thinking on ICCUS.
- Finally, **policy recommendations are formulated** by varying degrees of effort level and attributed to the seven defined ICCUS Readiness dimensions. These are rooted in the cross-cutting observations and the identification of improvement areas on the ICCUS Readiness Scale. These recommendations range from the stimulation of cluster-organisations and generation of new thinking on ICCUS through low-carbon cluster roadmaps to the development of a consistent and long-term fiscal policy.

Acknowledgements

- The assessments were executed through literature and desktop research and corroborated through interviews with key stakeholders. With no exception these individuals (listed below) proved to be very supportive and cooperative.
- The final scoring on the ICCUS Readiness scale is executed by Ecofys and was not checked by these stakeholders. The resulting assessments are by no means a mathematical exercise, but meant as a constructive base to sharpen thinking and further decide on development steps. No value judgement is implied.
- (Parts of) this work have been review by Ann Gardiner (principal consultant Ecofys) and Paul Stevenson (independent consultant)

Cluster	Name
Grangemouth	John Hand
Humberside	Chris Bowlas
Merseyside	Bruce Adderley
Teesside	Sarah Tennison
Scunthorpe	Katie Hedges
Southampton	Don Spalinger and Francis Clarke
Humberside	Emma Toulson
Merseyside	Joe Howe
Port Talbot	Christopher Jones
Southampton	Howard Forti

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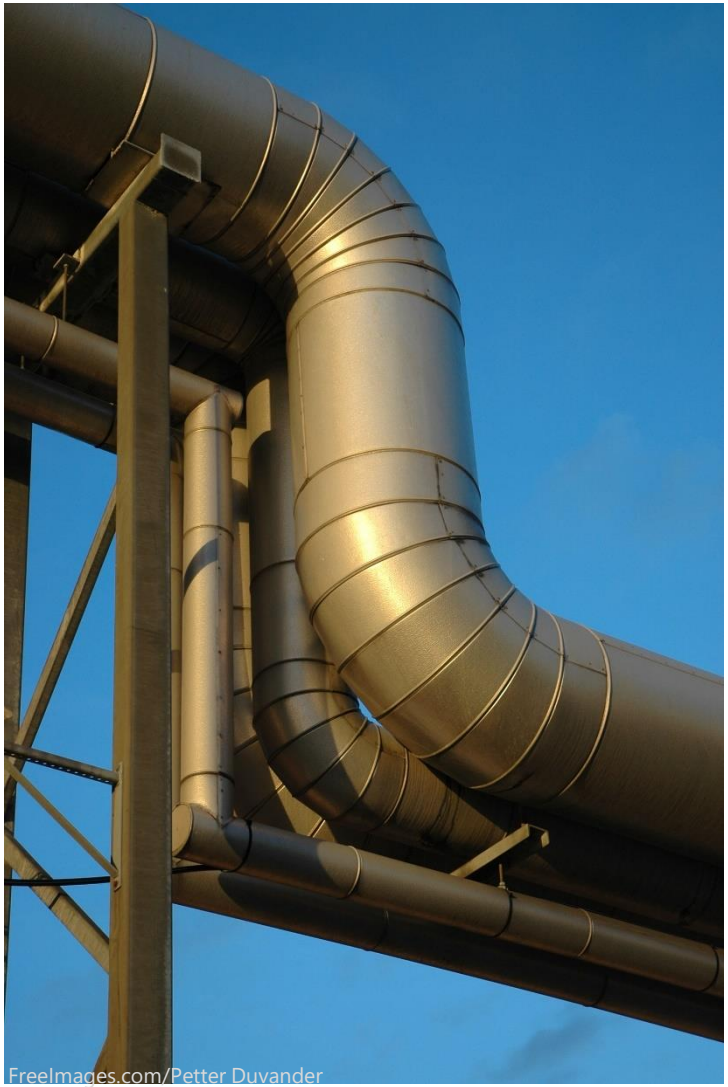


Introduction

In a low-carbon society, Industrial Carbon Capture, Usage and/or storage will play a key role

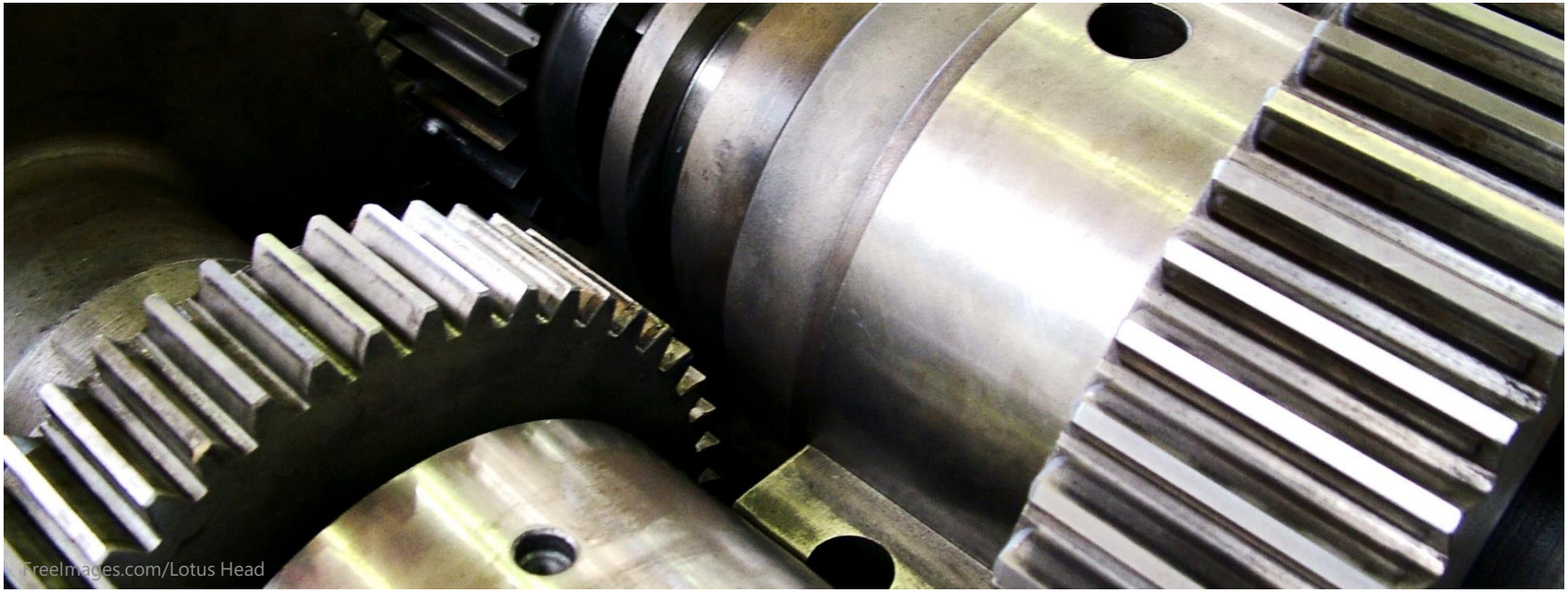
At the COP21 in Paris, the world agreed to strive for at most a "2-degree scenario": a low-carbon economy limiting the worst implications of climate change

The UK government in combination with Industry is preparing to meet this challenge amongst others through their work on the Industrial 2050 Roadmaps

As part of this, **BEIS would like to better understand the position key clusters are in** with regard to industrial carbon capture usage and storage.

How can industrial clusters make ICCUS work and how can the government support?

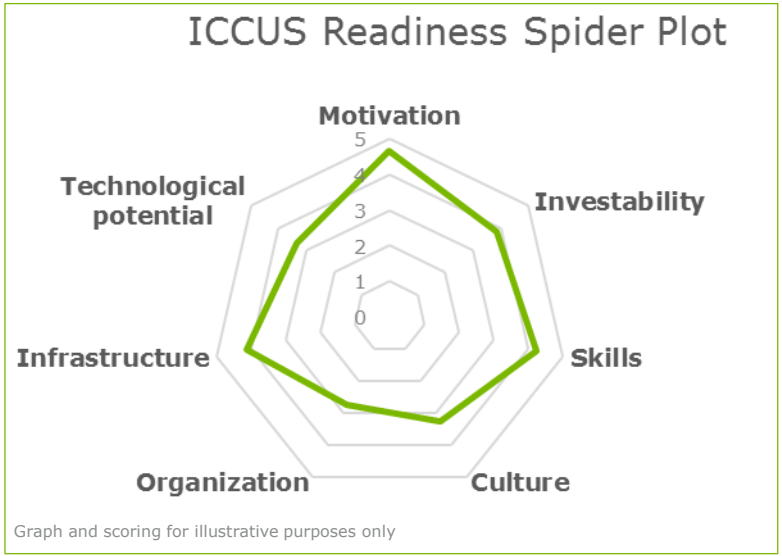
ICCUS Cluster Readiness Scale



BEIS and Ecofys co-developed the ICCUS Cluster Readiness scale

- The scale reflects cluster readiness on seven distinct dimensions
- Scoring is done per dimension, based on a number of sub-questions (next slide)
- The spider plot enables identifying strengths and areas of improvement across all dimensions and allows comparison between clusters
- An overall score is determined from all seven dimensions and its implication can be assessed through the five level descriptions

Dimension	Score
Motivation	4.7
Investability	3.8
Skills	4.3
Culture	3.3
Organization	2.8
Infrastructure	4.1
Technological potential	3.3
Overall Score:	**3.7**



Graph and scoring for illustrative purposes only

Level 1	Level 2	Level 3	Level 4	Level 5
Not prepared Hope someone will do the right thing	**Ready to react** React to what ever happens; lots of surprises	**Basic readiness** Able to work with a new opportunity; basic understanding of requirements.	**Situational readiness** Ready to deploy for a multitude of opportunities. Identified strenghts and potential barriers.	**Ready to lead** Clearly defined command structure. Ready to hit the ground running. Creates opportunity.

Inspired by Project Management Institute (PMI)

BEIS and Ecofys co-developed the ICCUS Cluster Readiness scale

Infrastructure

- Is a significant portion of the infrastructure shared?
- Does a feasible route from the site to the storage area exist for CCS?
- Is integration of CCUS within existing industrial processes possible/likely?
- Do you consider power generation in or close to your cluster and are they part of your approach?
- How easy is CO2 collection onsite? Is there one large point-source or are sources more scattered?
- Is there a CO2 pipeline in the cluster or are there concrete plans to deliver this?
- Are there any current uses for CO2 in your cluster?
- Is sufficient surface area / site extension available to facilitate a CCU plant?

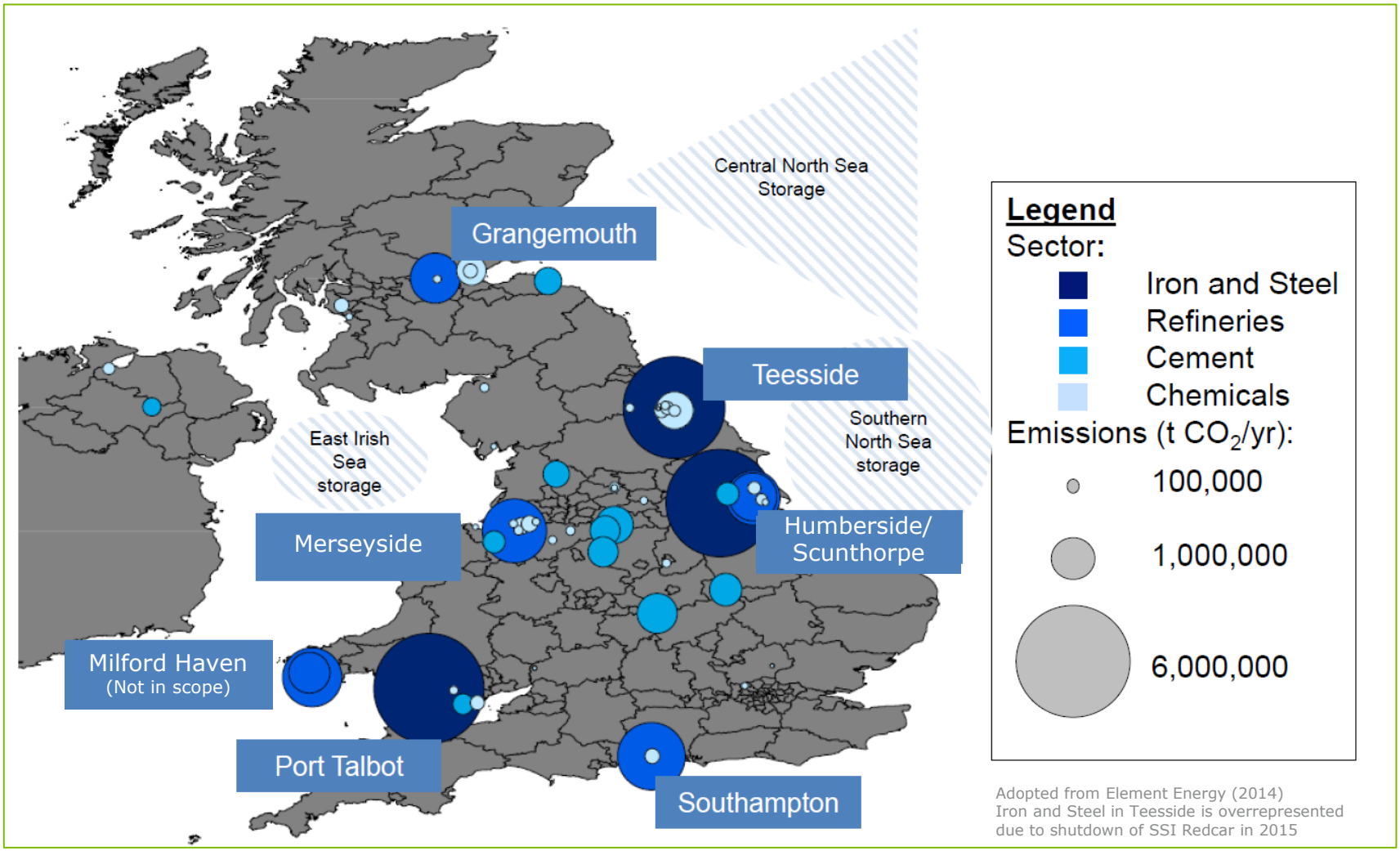
Likert Scale	1	2	3	4	5	4.1
Infrastructure						
I'd hardly call us clustered			x			Fully integrated
Non-existent				x		We're sitting on top of it
Impossible					x	Easy as pie
Not part of cluster					x	Fully integrated
Many small sources			x			One large point-source
No				x		Connecting all sites
None				x		Multiple
There is no room					x	Plenty

Scoring for illustrative purposes only

- Every dimension is assessed through a number of sub-questions
- These questions have been answered through literature research and interviews with key stakeholders
- Sub-questions are scored using a Likert 5-point semantic differential scale; i.e. the endpoints are given explicit meaning to aid an objective, semi-quantitative assessment
- In this scoring, Ecofys strived to differentiate between clusters
- This is an interpretation of dimensions that are sometimes difficult to compare
- The resulting assessments are therefore by no means a mathematical exercise, but meant as a constructive base to sharpen thinking and further decide on development steps. No value judgement is implied.
- Therefore, it is decided to let all sub-questions be weighted equally in a calculated dimension score
- The total score of the dimension is indicated in the top right corner of the table
- All scoring has been reviewed (four-eye principle)

The state of ICCUS readiness per UK cluster

UK clusters: overview



Adopted from Element Energy (2014)
Iron and Steel in Teesside is overrepresented due to shutdown of SSI Redcar in 2015

UK clusters: overview

- **Grangemouth** is a long-standing oil refinery and petrochemical cluster near Falkirk, Scotland.
- The Yorkshire and the **Humber** region in fact spans >100km from Bradford to the Humber Estuary, and includes a large chemical industry
- For the purpose of this study, **Scunthorpe** was considered separately. Its biggest source of CO_2 is the British Steel plant, formerly Tata Steel.
- **Teesside** consists of energy-intense industry, predominantly with the steel and ancillary sectors, chemicals (fertilizers, petrochemicals, etc.), oil-refineries and others.
- For the purpose of this study, **Merseyside** is considered to represent all industrial organisations located within 30km of Mersey, with several chemicals, food & drink and high-temperature operations.
- The **Port Talbot** cluster is dominated by steel production and includes some cement and chemical production sites, all in the Neath Port Talbot County Borough
- The **Southampton** cluster consists of the Fawley refineries and chemical processing plants in the south and includes some cement production sites.

Grangemouth

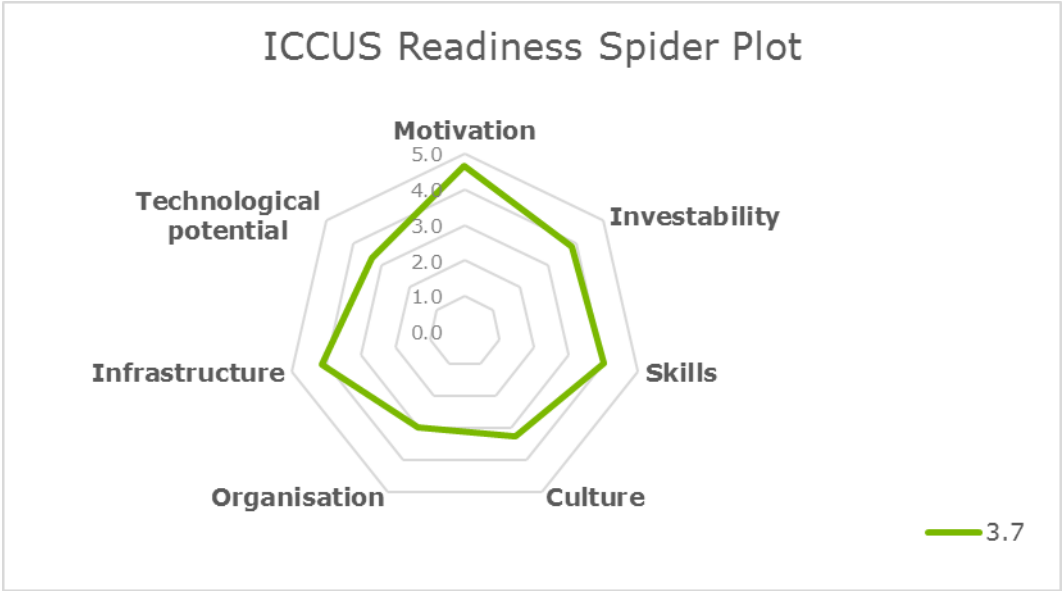
Key strengths

Grangemouth and its supporting organizations clearly demonstrate a willingness to pursue ICCUS opportunities.

There is a well-sourced skill base; ICCUS is a theme in interaction with external knowledge sources and internal experts. The current BP degasser is an example of in-house carbon purification engineering knowledge.

Points of improvement

Although there are active industrial bodies (notably Chemical Sciences Scotland and Chemical Growth Partnership) there is scope for better organisation on the operational and cluster level. This would aid the pursuit of industrial symbiosis opportunities in the cluster.



Dimension	Score
Motivation	4.7
Investability	3.8
Skills	4.0
Culture	3.3
Organisation	3.0
Infrastructure	4.1
Technological potential	3.3
Overall Score:	3.7

Humberside

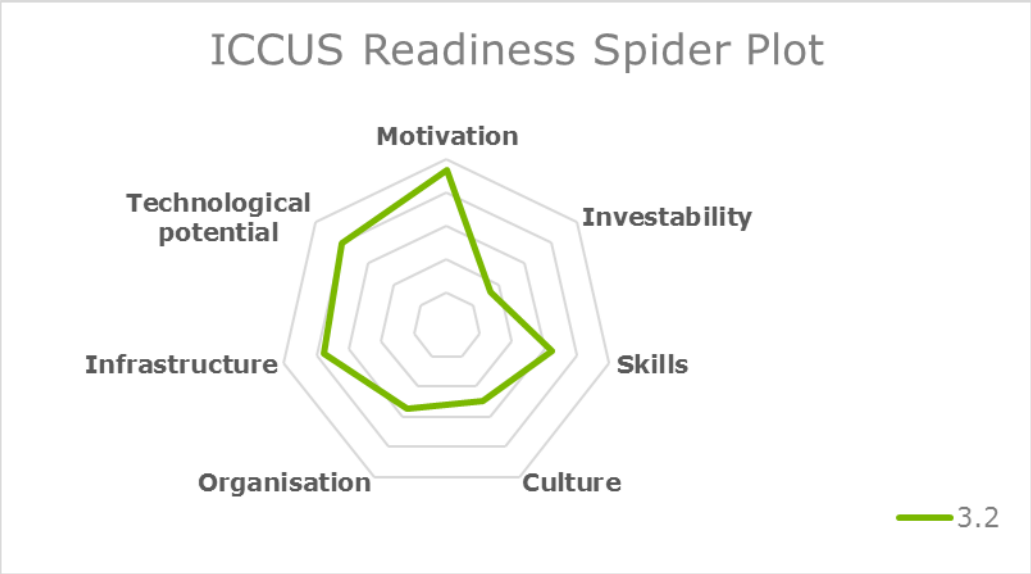
Key strengths

Humberside exhibits clear and strong motivation for ICCUS, as is shown by their White Rose CCS project.

Points of improvement

Even though White Rose and other examples (e.g.: clustering in Saltend, ConCom centralised sourcing project) prove the cooperation in the cluster, several consulted stakeholders agree the region would benefit from a more structured organisation approach. HCF Catch and/or Humber LEP are in a position to grow into this role for the cluster.

The current level of investability is hampered by a lack of recent public and private investments in the cluster. Progression of the ConCom project and the development of a central utility will strengthen investability.



Dimension	Score
Motivation	4.7
Investability	1.7
Skills	3.3
Culture	2.5
Organisation	2.8
Infrastructure	3.8
Technological potential	4.0
Overall Score:	**3.2**

Humber - Scunthorpe

Scunthorpe as a cluster mainly consists of the British Steel plant. To view Scunthorpe as a separate cluster from the wider Humber region negatively affects and skews its ICCUS Readiness assessment to a degree that it no longer reflects reality. Therefore, only qualitative statements are made for Scunthorpe specifically. For a wider view, a referral is made to the Humberside assessment.

Assessed in its isolation, British Steel as the single largest source of emissions is not a very resilient starting point for ICCUS development; closure of its operations would be the end of any such project.

The steel plant does not share any infrastructure with external parties.

Key Strengths

The steel plant is part of an integrated Humber cluster vision towards ICCUS. With its level of emissions, British Steel would be a significant player on a cluster-wide ICCUS approach.

A single tie-in could capture roughly 70% of emissions coming from the the blast furnace of the plant – this is a relatively high share.

Merseyside

Key strengths

Key cluster bodies are the Cheshire Energy Hub and the Mersey-Dee Alliance, both aiding knowledge and skills availability.

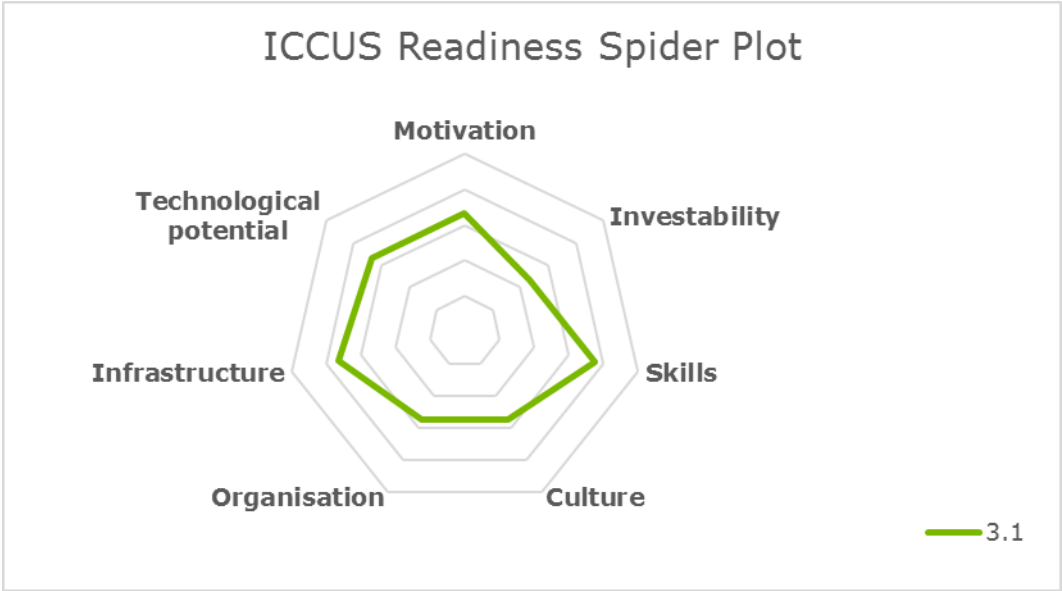
The role of Peel Energy as an infrastructure investor is viewed as aiding further infrastructural integration, also from a financial perspective.

Points of improvement

The cluster may lack one strong voice to engage the regulator.

Even though there are a number of initiatives ongoing to propel ICCUS, there is no clear shared vision or stance towards this development from the cluster (companies).

With the foreseen closure of a large coal-fired power plant, the technological potential is reduced.



Dimension	Score
Motivation	3.3
Investability	2.3
Skills	3.8
Culture	2.8
Organisation	2.8
Infrastructure	3.6
Technological potential	3.3
Overall Score:	3.1

Port Talbot

Key strengths

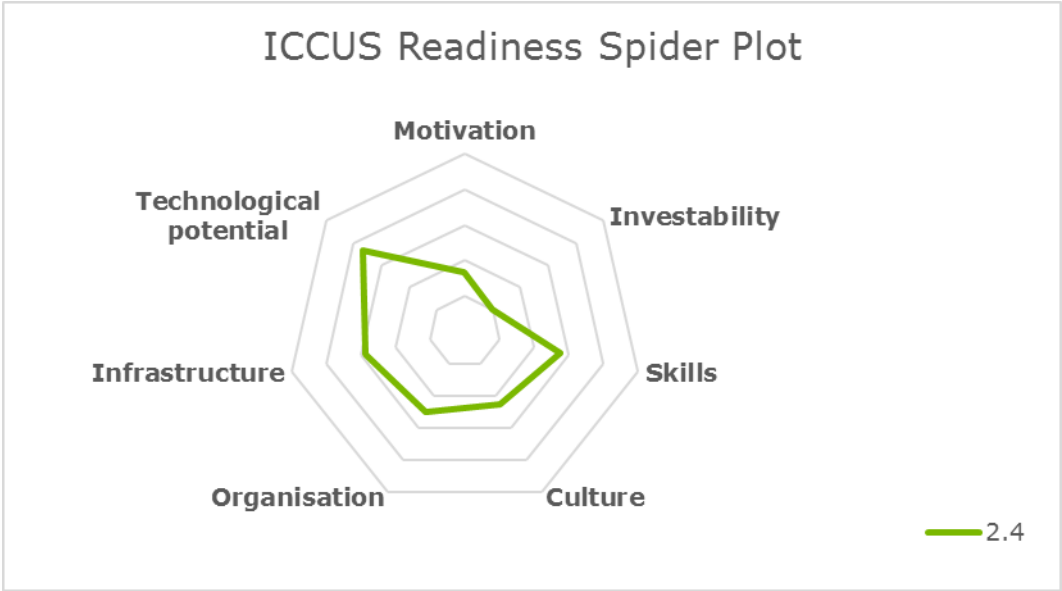
The technological potential benefits from the steel plant but is also largely dependent on this same plant, affecting resilience.

Points of improvement

Port Talbot has no clearly defined stance or strategy towards ICCUS and would gain considerably from more information and knowledge on this subject.

There are some signals for industrial collaboration (e.g. a "Future Energy Systems" City Deal and a district heating study), but the cluster is not yet at a fully cooperative level and thus would benefit from a more structured approach.

The current level of investability is low due to a lack of recent public and private investments in the cluster.



Dimension	Score
Motivation	1.7
Investability	1.0
Skills	2.8
Culture	2.3
Organisation	2.5
Infrastructure	2.9
Technological potential	3.7
Overall Score:	2.4

Southampton

Key Strengths

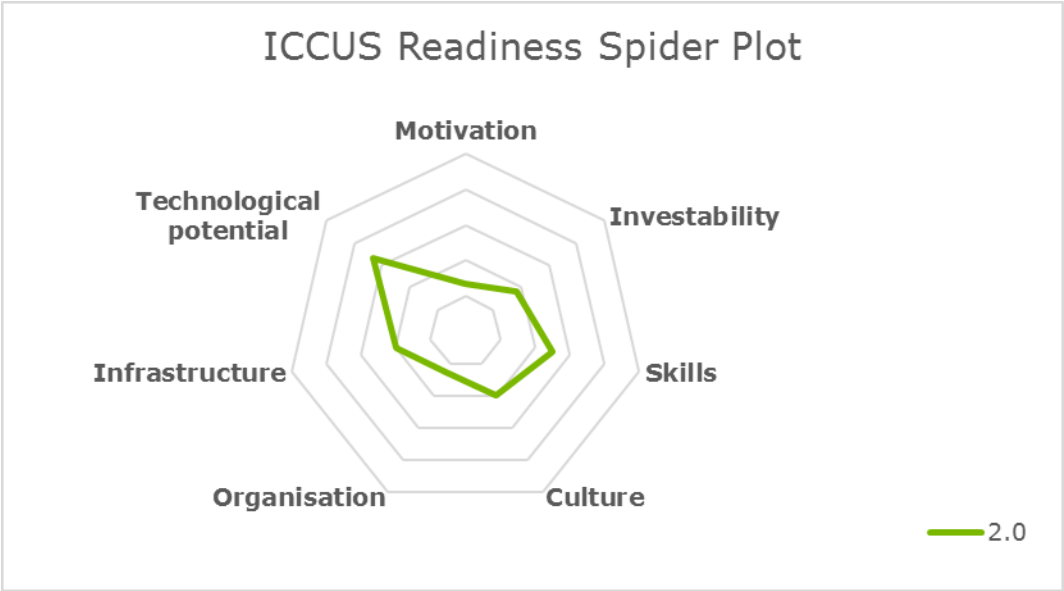
Fawley's parent company Exxon has significant CCS expertise in-house.

Points of improvement

Contacting various local stakeholders indicates there is little to no interest in ICCUS in the region.

Even though there is key CCS knowledge available through the University of Southampton, Ecofys is not aware of any connection with the Fawley refinery.

Distance to any offshore storage location is larger compared to other clusters, rendering tie-in more complex and costly.



Dimension	Score
Motivation	1.3
Investability	1.8
Skills	2.5
Culture	2.0
Organisation	1.3
Infrastructure	2.0
Technological potential	3.3
Overall Score:	**2.0**

Teesside

Key strengths

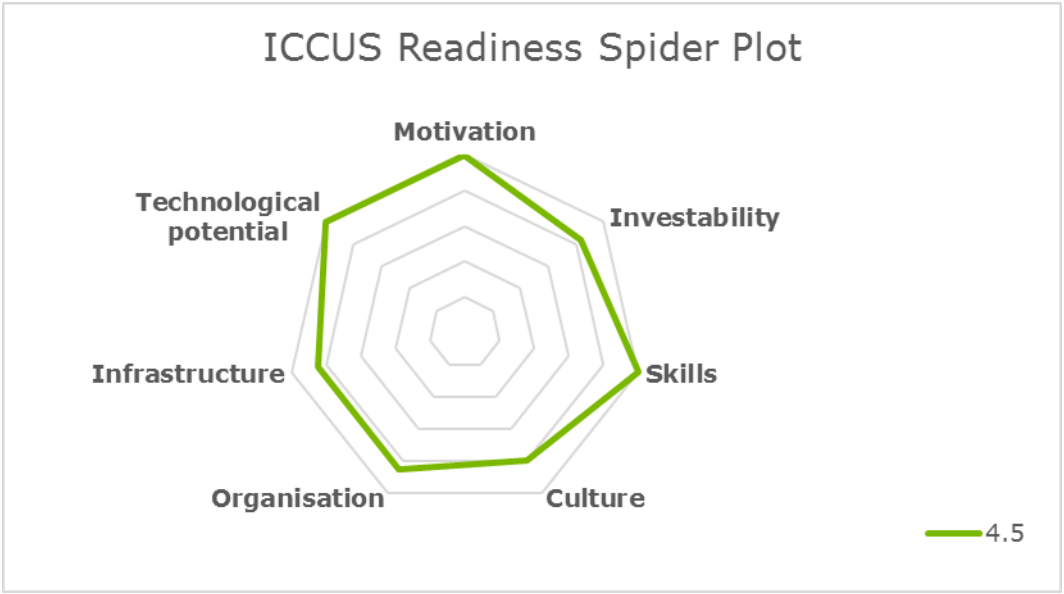
Teesside is a frontrunner on all dimensions save a few sub-questions.

The overall score reflects this leading position, and supporting evidence suggests the Tees Valley Combined Authority is pro-actively pursuing clustering opportunities and industrial symbiosis, of which ICCUS is a subset.

The availability of highly pure CO_2 underpins the opportunity for ICCUS in this region.

CCU is already happening; Praxair offers CO_2 in gaseous and liquid form for a.o. beverages and food, using gas from CF fertilizers. CO_2 is also piped to greenhouses.

ICCS blueprint is ready, including a business case and a financing approach. It needs a funding source.



Dimension	Score
Motivation	5.0
Investability	4.2
Skills	5.0
Culture	4.0
Organisation	4.3
Infrastructure	4.3
Technological potential	5.0
Overall Score:	**4.5**

A direct comparison brings forward distinctions and common patterns on ICCUS Readiness

Summary

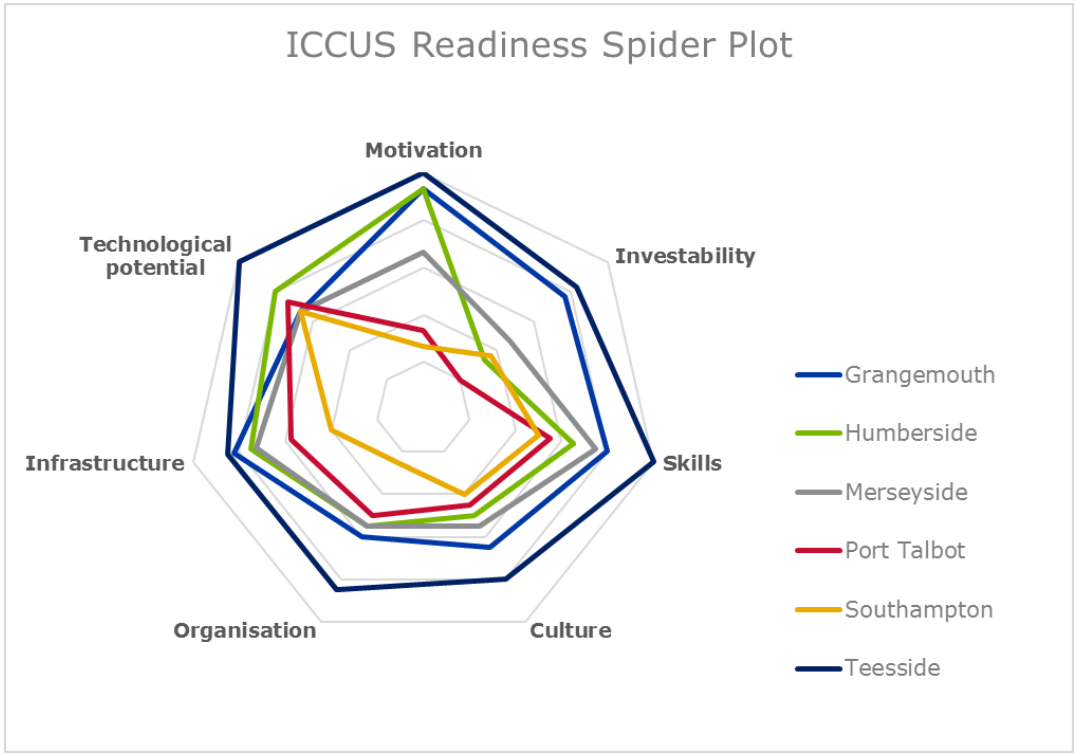
3/7 clusters display motivation towards ICCUS deployment. Not all of these have demonstrable relevant skills and are directly in a position to invest once the opportunity arises.

The overall emerging pattern shows Teesside scoring well across the board.

Some clusters with promising technological and/or infrastructural potential could well benefit from targeted support to structure / focus the organisation on cluster ICCUS. Examples are Humberside and Grangemouth.

Port Talbot and Southampton would benefit from a long term strategy and from enhancing skills and organisation to enable successful ICCUS.

Addressing these and other gaps is the focus of the next section.



Recommendations

Government policy recommendations per dimension

Dimension	Policy Effort Level		
	Low	Medium	High
Motivation	Develop low-carbon cluster roadmaps		Develop and maintain consistent policy
Skills	Distribute knowledge and case studies of CCU		
Culture	Promote socio-economic benefits, develop new thinking		Carbon price
Organisation	Stimulate development cluster-wide org.		
Infrastructure		Incentivize viable CCU, spatial planning	
Technological potential		Consider minimum requirements	
Investability	Investigate stability of carbon supply, Stimulate utility, Deep dive into local differences in competitiveness	Construct guarantees	Financing instruments, fiscal policy, Boost competitiveness

Government policy recommendations - detailed

Level**: Low**

- Stimulate **the development of cluster-wide organisations** to promote cooperation along various themes; industrial symbiosis, circular economy as well as ICCUS (see page 24)
- Facilitate and promote industrial cluster organisations to **develop low-carbon cluster roadmaps** to enable the development of long-term strategy incorporating ICCUS
- Distribute knowledge and **case studies of successful CCU projects** to both inspire and educate stakeholders on potential in UK clusters. (Example: Ecofys, 2016). **Developing new thinking** on ICCUS should stimulate fostering a more innovative culture (page 25).
- To promote long-term investment, facilitate research into stress-testing long-term **stability of carbon supply** at various clusters. Research, data and scenarios on the robustness of future emissions in a cluster will inform ICCUS investment decisions in that cluster.
- Promote the **socio-economic benefits** of large-scale ICCUS development in the UK, both to aid this development and ensure local buy-in from residents and neighbours once large-scale ICCUS takes off
- **Stimulate utility** knowledge sharing in clusters which at the moment have no organisation in place to fulfil such a role (page 25)
- **Deep dive into local differences in competitiveness** and investment levels affecting the investability of clusters including against international competitors

Level: **Medium**

- Develop a next (post-2023) generation of Climate Change Agreements (**CCA**). Suggestion is to include a requirement to have in place (and follow) a sufficiently ambitious low-carbon roadmap, where appropriate including ICCUS stimulus.
- Consider **minimum requirements** for site-licensing any greenfield large-carbon emitting industrial projects. Ensure carbon capture is feasible and storage location is proximate from an economically viable transport viewpoint
- Construct **guarantees** to reduce exposure to long-term carbon supply and demand risk for ICCUS projects
- In case that constructing a complex and largely integrated carbon infrastructure would prove challenging, incentivize clusters to take a first step towards integrated ICCUS through one or two **viable CCU** connections that may act as enabler for larger ICCUS additions at a later stage (page 26)
- Provide a **supportive spatial planning** policy for ICCUS infrastructure development. Example is to support greenhouse gas developments near carbon sources

Level: **High**

- Develop favourable **financing instruments** to aid the development of a large-scale CCS project; such as (see also page 24)
  - Promote a meaningful **carbon price**, either through specific additional measures in EU ETS or a UK specific successor of this scheme following if Brexit results in exiting the EU ETS scheme
  - Formulate tax incentives through favourable **fiscal policy** for investing in ICCUS infrastructure and technology
- Government policy on CCS has been inconsistent[14]. This has created a trust barrier. In order to rebuild this trust, any future CCS policy or strategy will need to be **consistent and maintained long-term**

Based on the assessments, the following cross-cutting observations can be made towards successful ICCUS

Deployment of ICCUS needs incentive through financial means

- All clusters, regardless of their ICCUS readiness, express the view that to achieve successful deployment of ICCUS, consistent government policy or government funding will be needed
- This can be either done through setting a higher price on carbon (beyond current EU ETS levels) or by subsidizing the development of large-scale ICCUS projects
  - Some stakeholders warn that UK-only price signals would damage competitiveness of UK-based industry

Development of cluster-specific organizations needs support

- Most clusters would benefit from a more structured cooperation at the cluster level
- In some instances, there is no single entity that encompasses all important CCS issues for a region. Focussing some organizations or regional economic entities on cluster-compatible geographies will help (Merseyside interviews and [12]).
- Some areas could be supported by providing existing organisations with knowledge, mandate and incentive to focus on industrial symbiosis and ICCUS, for instance HCF or Humber LEP in Humber. The next slide shows an example of how this support may look like.
- The Teesside Collective is viewed by many as a successful organizational public-private structure to be emulated; a clear cluster focus and emphasis on knowledge sharing and industrial symbiosis.

Based on the assessments, the following cross-cutting observations can be made towards successful ICCUS

Support the role of a central utility towards industrial integration

- Industrial integration as well as structured cooperation benefits from a central utility that may act as a broker
- Some clusters benefit from such an organisation, CalaChem in Grangemouth and, in a different form, Peel in Merseyside. In Teesside a utility is coming in.
- Humberside would benefit from such an organisation in particular, as there is no heritage of a shared infrastructure in large parts of the region and therefore no coordinated way of indeed sharing infrastructure with the exception of the Saltend subcluster.
- Starting point of setting up this organisation can be a combined workshop with key local stakeholders in combination with one or more industrial utility players.

Stimulate new thinking on ICCUS in the less engaged clusters

- Some clusters, notably Southampton and Port Talbot and, to a lesser extent Merseyside, may benefit from the development of a long term strategy where ICCUS is a key factor
- These clusters could emulate clusters that are currently higher on the Readiness scale and build on work that is publicly available that could be actively brought to their attention
- The starting point of such a process can be an interactive multi-stakeholder workshop to identify cluster potential and develop further cooperation
- In particular a connection of industrial players with a local knowledge hub is advised. A prime example of an area that may benefit is Southampton; the University of Southampton has a wealth of CCS knowledge and research yet no connection to the Fawley refinery (as far as Ecofys is aware).

Based on the assessments, the following cross-cutting observations can be made towards successful ICCUS

Promote establishing a long-term local view on industrial resilience

- In the lower scoring clusters, the overall resilience to a low-carbon competitive future may be a local blind spot
- This in turn may hurt long term economic growth and employment in the region
- A wider scope, above and beyond ICCUS could aid thinking on this future, i.e. "what if" – scenarios. How can resilience be enhanced in this region? What type of industry would need to be attracted to enhance chances of long term thriving? How does this fit in a low-carbon future?
- It is worth verifying if the 'Grangemouth Renaissance' is an apt example of this type of strategy development

Support (existing) CCU project infrastructure as stepping stone

- The start of a CCU or CCS project can be viewed as the starting point of a cluster wide infrastructure for carbon sequestration
- By accounting for future tie-in of significant nearby carbon sources, further ICCUS deployment is supported
- The White Rose CCS project development included thinking on future cluster tie-ins and throughput accommodation from other sources than Drax and can be seen as a good example of this type of planning

Based on the assessments, the following cross-cutting observations can be made towards successful ICCUS

A distinction between CCU and CCS is often unnecessary in this work

- In assessing the UK clusters, more often than not a distinction between CCU and CCS does not need to be made
- Clear examples are the dimensions organisation, motivation and culture where explicitly trying to make this distinction in interviews does not result in a different appraisal
- However, in this report this distinction between CCU and CCS is made occasionally where examples or assessments require it

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