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Legacy Wells & CCS: Do They Go Together?

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The Decommissioning Dilemma

- 7,800+ offshore wells exist in the UKCS
- 2,102 wells are slated to be decommissioned between 2024 and 2033:
  - Cost £4 to 6 million per well
  - Environmental concerns: Seabed disturbance and energy intensive/high carbon footprint
  - Inherent safety challenges and risks
- Existing infrastructure still often structurally sound

Decommissioning of Shell/Esso Lima platform (Oil Salvage Ltd, 2024)

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The Opportunity

- **Net Zero 2050 = UK CCS Driving Force**
- Infrastructure snapshot:
  - 4,000+ total wells across UKCS
  - ~250 active O&G platforms
  - 45+ offshore windfarms
- Co-location of wind and oil/gas assets presents integration potential
- Strategic reuse could reduce environmental and economic costs
- > 1,400 legacy wells on current CCS license blocks

Reuse Instead of Remove? (Adapted from the NSTA, 2023)

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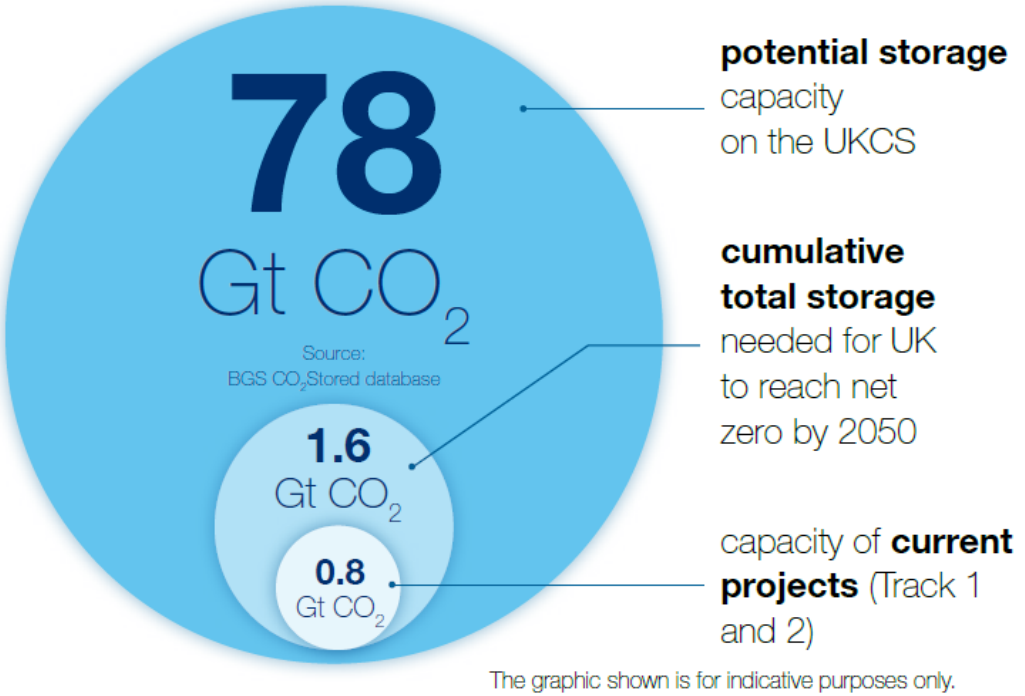
Geological & Technical Fit

- UKCS has high-quality storage units in the CNS, NNS, and SNS
- Depleted O&G reservoirs offer proven traps – good data and proven integrity
- In many cases, however, must revalidate wellbore, caprock, and mechanical elements
- O&G infrastructure and capabilities can be used to support and accelerate the Energy Transition for hard-to-abate sectors



UKCS CO_2 storage potential (NSTA, 2024)

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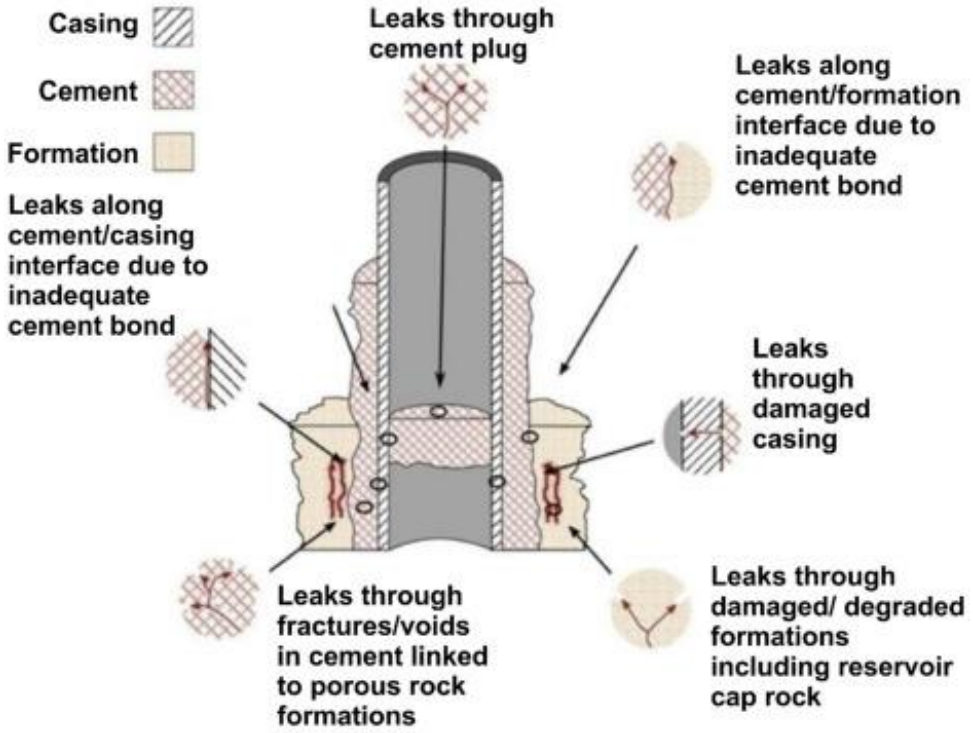
Legacy Wells: Red Flags

- 35% of global legacy wells show integrity issues
- Indicators that a legacy well may be unsuitable for reuse:
  - Missing cement bond logs or plugs verification
  - Unknown abandonment dates
  - Complex well architecture
  - High-risk casing/cement issues
  - Signs of corrosion or historical leakage records
- Age directly affects retrofit viability and risk profile



Wellbore integrity barriers and the ways in which they can be breached by leaks (Wood, 2024)

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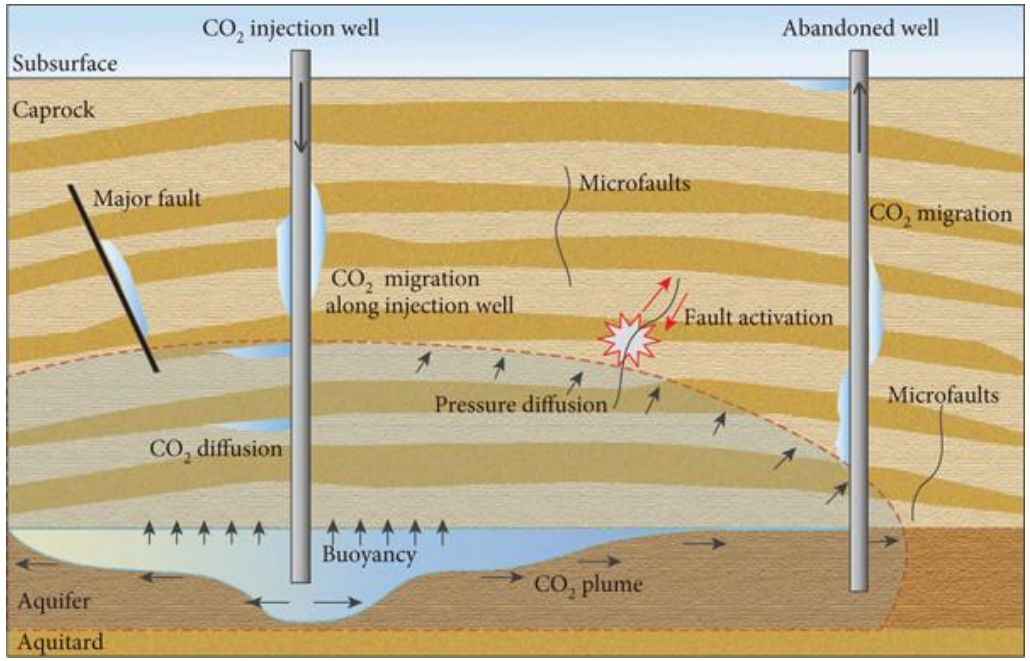
CCS Projects & Legacy Wells

- Safety risks associated with CCS projects with legacy wells on CCS license blocks:
  - Caprock failure
  - Fault reactivation
  - Corrosion and well integrity issues
  - Thermal stress and fatigue
- Continuous monitoring and robust risk mitigation are required



CO_2 migration of sequestration and leakage process (Han et al., 2020)

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Regulatory & Economic Landscape

- NSTA supports reuse initiatives
- Gaps in regulation regarding long-term CO_2 liability and well requalification
- Economic benefits:
  - Reuse reduces need for new drilling
  - Faster permitting and development timelines
- Policy clarity is crucial for industry confidence

North Sea Transition Authority

Department for Energy Security & Net Zero

Marine Management Organisation

Offshore Petroleum Regulator for Environment & Decommissioning

ofgem

HSE

HM Treasury

THE CROWN ESTATE

Strong regulatory support required from all government agencies

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Well Screening

Goal: Identify and evaluate legacy wells for potential CO_2 storage

1. **Data Collection:** Sourced 6 well datasets from UKCS
2. **Screening Criteria:** Well age, type deviation, cement condition, abandonment method, architecture
3. **Risk Scoring Framework:** Low Risk (<0.3); Moderate Risk (0.3-0.6); High Risk (>0.6)

Example of risk scoring framework using well selection criteria

Criterion	Description	Score
Well age	Unknown	5
	Spud pre-1975	4
	Spud between 1975 & 1985	3
	Spud between 1986 & 1997	2
	Spud post 1997	1
Cement top	Unknown	5
	Extremely low	5
	Low	4
	Moderate	3
	Above the surface casing bottom	1

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CCS Site Selection

Goal: Determine the most promising offshore CO_2 storage site

1. **Data Collection:** Sourced 3 field datasets from UKCS (NNS, CNS, SNS)
2. **Criteria:** Beneficial (storage capacity, leakage risks, proximity to shore) and non-beneficial (development cost)
3. **Field Ranking using TOPSIS Method:** Matrix normalisation, + & - ideal solution, Euclidean distance, ranking

Scoring scale used to assign numerical values to each field based

Five Point Scale	
Low	1
Below average	2
Average	3
Good	4
Excellent	5

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UKCS Case Study Dataset

Well-1	Well-3	Well-5
• **Spud date:** Unknown • **Well type:** Producer • **Deviation:** Vertical • **Abandonment:** Post 2012	• **Spud date:** 2010 • **Well type:** Producer • **Deviation:** Vertical • **Abandonment:** Unknown	• **Spud date:** 1972 • **Well type:** Producer • **Deviation:** Vertical • **Abandonment:** 2019
Well-2	**Well-4**	**Well-6**
• **Spud date:** 1985 • **Well type:** Producer • **Deviation:** Vertical • **Abandonment:** Unknown	• **Spud date:** 1989 • **Well type:** Producer • **Deviation:** Vertical • **Abandonment:** Unknown	• **Spud date:** 1972 • **Well type:** Injector • **Deviation:** Vertical • **Abandonment:** 2017

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UKCS Case Study Dataset

Field A: Oil and gas field	**Field B:** Gas field	**Field C:** Oil & gas field
Location: CNS	**Location:** SNS	**Location:** NNS
Area: ~11.33 km^2	**Area:** ~22.8 km^2	**Area:** ~40 km^2
Water Depth: 78 m	**Water Depth:** 21 m	**Water Depth:** 160 m
Predominant Lithology: Sandstone	**Predominant Lithology:** Sandstone	**Predominant Lithology:** Sandstone
Storage Unit Type: Structural / stratigraphic trap	**Storage Unit Type:** Structural / stratigraphic trap	**Storage Unit Type:** Structural / stratigraphic trap
Total no. of wells: 31	**Total no. of wells:** 19	**Total no. of wells:** 165

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Well Evaluation Tool

Input parameters used in the REX-CO2 tool for evaluating the suitability of existing wells for CO_2 storage

Criteria	Description	Response	Colour Code
Cement job	Cement provides adequate barrier?	Do not know	Grey
	Cement verified as a barrier	Do not know	Grey
Leak-off test (LOT) and formation integrity test (FIT)	Is the casing and formation test at the shoe known?	Yes	Green
	Is the test higher than the maximum allowable surface pressure (MASP)?	Yes	Green
	Can the MASP be below the shoe strength?	Do not know	Grey
Liner lap	Presence of liner confirmed?	Yes	Green
Production tubing	Is the production installed at secure formation depth?	Yes	Green
	Has the production been verified as a primary well barrier element (WBE)?	Do not know	Yellow
	Has the tubing hanger been verified as a primary WBE?	Do not know	Yellow
Corrosion	Is casing free of corrosion?	Do not know	Grey
X-mas tree	Tress and valves verified as WBE?	Do not know	Yellow

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Well Suitability

Well-1	Well-3	Well-5
• **Well design:** Simple • **Critical data:** CBL 0.5625 / CML 0.0883 • **Sealing integrity:** Low uncertainty	• **Well design:** Simple • **Missing critical data:** Cement top and abandonment date • **Sealing integrity:** Moderate uncertainty	• **Well design:** Simple • **Missing critical data:** Cement top • **Sealing integrity:** Moderate uncertainty
Well-2	**Well-4**	**Well-6**
• **Well design:** Simple • **Missing critical data:** Cement top and abandonment date • **Sealing integrity:** High uncertainty	• **Well design:** Simple • **Missing critical data:** Cement top and abandonment date • **Sealing integrity:** High uncertainty	• **Well design:** Simple • **Missing critical data:** Cement top • **Sealing integrity:** Moderate uncertainty

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Field Suitability

Field A

Key features:

- May require extensive re-abandonment campaigns
- Contains four communicating reservoir units
- Mixed uncertainty regarding abandonment histories
- Longest distance to onshore terminals

Field B: Gas field

Key features:

- May require extensive re-abandonment campaigns
- Sandstone units are laterally continuous, enhancing predictability in plume movement
- Mixed uncertainty regarding abandonment histories
- Moderate distance to shore

Field C: Oil & gas field

Key features:

- Logistical and financial demands make near-term deployment or pilot projects unlikely
- High density of legacy wells
- Moderate uncertainty regarding abandonment histories
- Moderate distance to shore

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Assessment Performance

- Well-scoring supports prioritisation of reuse candidates
- Interpretation of combined well and field-level data can act as quick and robust tool to appraise candidate wells and storage sites
- Offers a practical framework for screening and validating storage candidates within mature offshore basins

Summary of risk scores and classifications for six candidate wells based on screening criteria

Well	Field	Risk Score	Risk Level
Well - 1	CNS	0.30	Moderate – reusable
Well - 2	CNS	0.68	High – unlikely candidate
Well - 3	SNS	0.60	Moderate – further review required
Well - 4	SNS	0.64	High – unlikely candidate
Well - 5	NNS	0.56	Moderate – further review required
Well - 6	NNS	0.48	Moderate – caution, intervention likely

Summary of TOPSIS performance scores and rankings for the three candidate fields

Site	S+	S-	Pi Score	Rank
Field A	0.071	0.058	0.451	3
Field B	0.058	0.071	0.549	1
Field C	0.056	0.053	0.487	2

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CO_2 Storage Opportunities

- **Mapping and screening** of existing UKCS O&G infrastructure for CCS projects
- **Further development** of the proposed tool to support the reuse of O&G infrastructure
- **Formal review** of environmental risk assessment, containment risk assessment, monitoring plan, corrective measures plan, post closure plan
- **Collaborative partnerships** to overcome legal and contractual challenges whilst meeting compliance

The move to Net Zero (NSTA, 2024)