



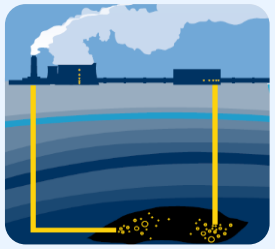



Impact of brine production on aquifer storage economics

energy technologies institute

HERIOT WATT UNIVERSITY

elementenergy

All-Energy 2017

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Element Energy Ltd

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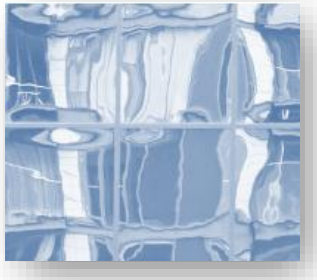
Introduction to Element Energy

- Element Energy is a **specialist energy consultancy**, with an excellent reputation for rigorous and insightful analysis across a wide range of low carbon energy sectors
- These include: **Carbon capture and storage, energy systems, energy networks, renewable energy systems, the built environment, hydrogen** and **low carbon vehicles**
- We apply **best-in-class financial, analytical** and **technical** analysis to help our clients intelligently invest and create **successful policies, strategies and products**

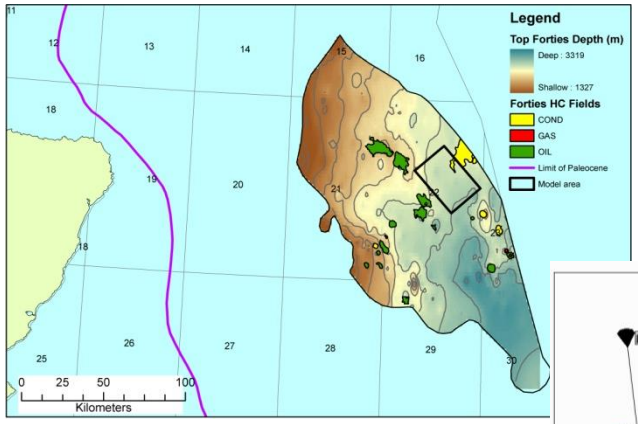
Energy technologies modelling	**Consumers behaviour modelling**	**Energy networks modelling**	**Advanced geographic modelling**	**Project management**
Policy recommendations	**Strategic market analysis**	**Commercialisation strategies**	**Techno-economic studies**	**Project financing**

Background to material presented

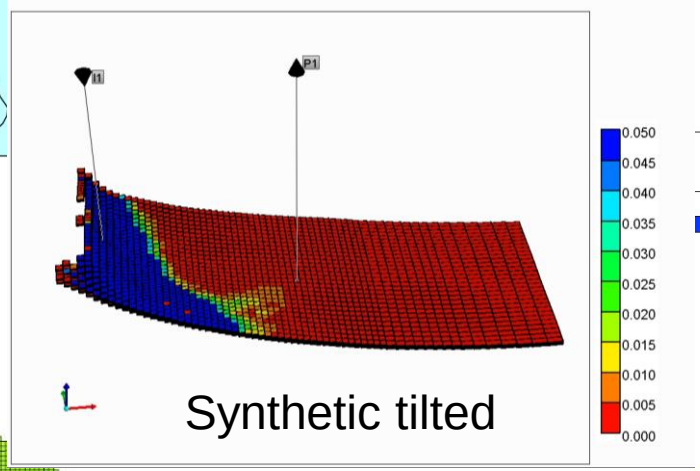
- This talk draws on insights from the “Impact of Brine Production on Aquifer Storage” project, which was commissioned by the Energy Technologies Institute, and led by Professor Eric Mackay from Heriot-Watt University with support from Element Energy along with scientists and engineers from Durham University and T2 Petroleum.
- The team has studied how brine production, more often associated with oil and gas operations, can enhance the storage potential of aquifers (water-bearing rocks) already identified as ideal CO_2 stores.
- The project deliverables will be made available on the ETI website.

DISCLAIMER - all material presented today represents the view of the author, not clients, partners or stakeholders

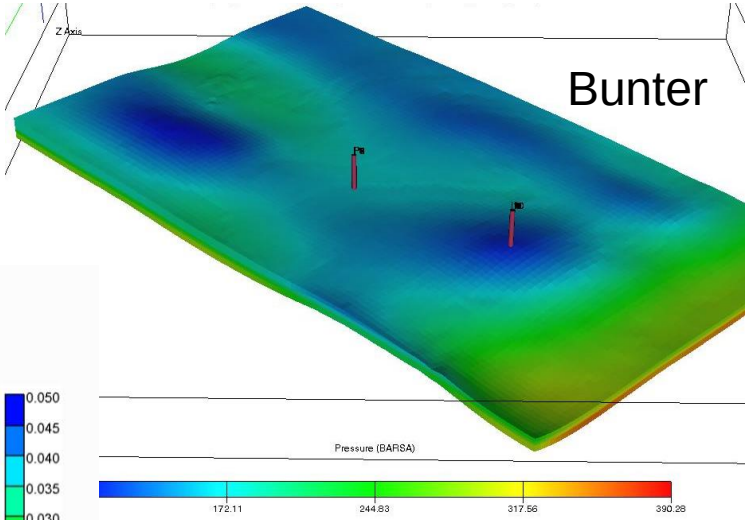
Numerical fluid flow simulations of CO_2 injection into various selected CO_2 storage systems were performed – the primary criteria used are maximum allowable pressure increase and migration of CO_2



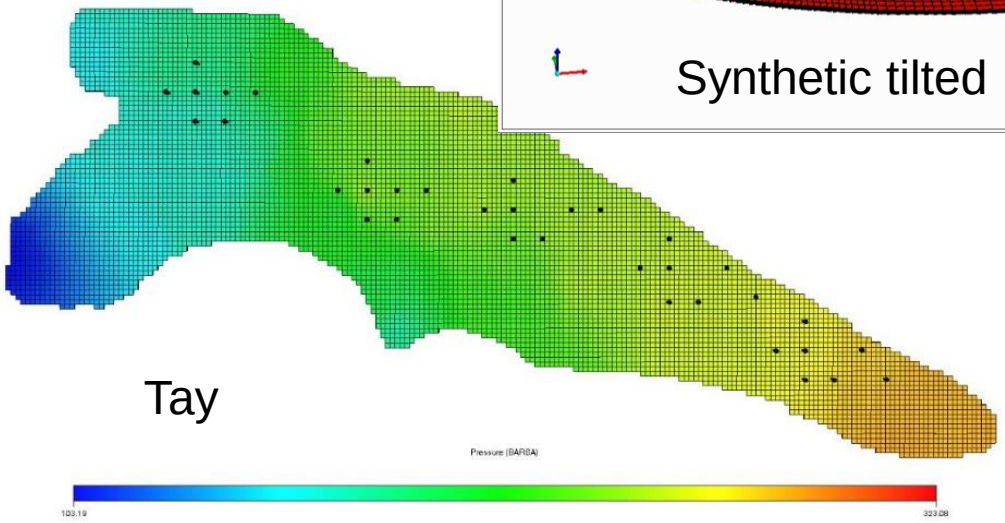
Forties



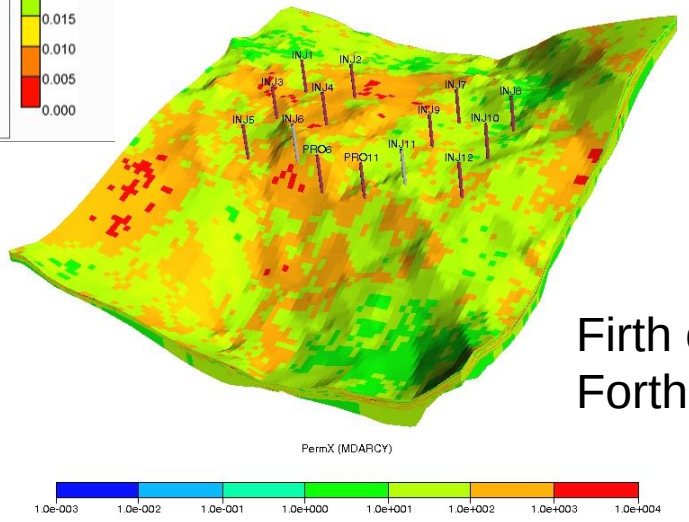
Synthetic tilted



Bunter

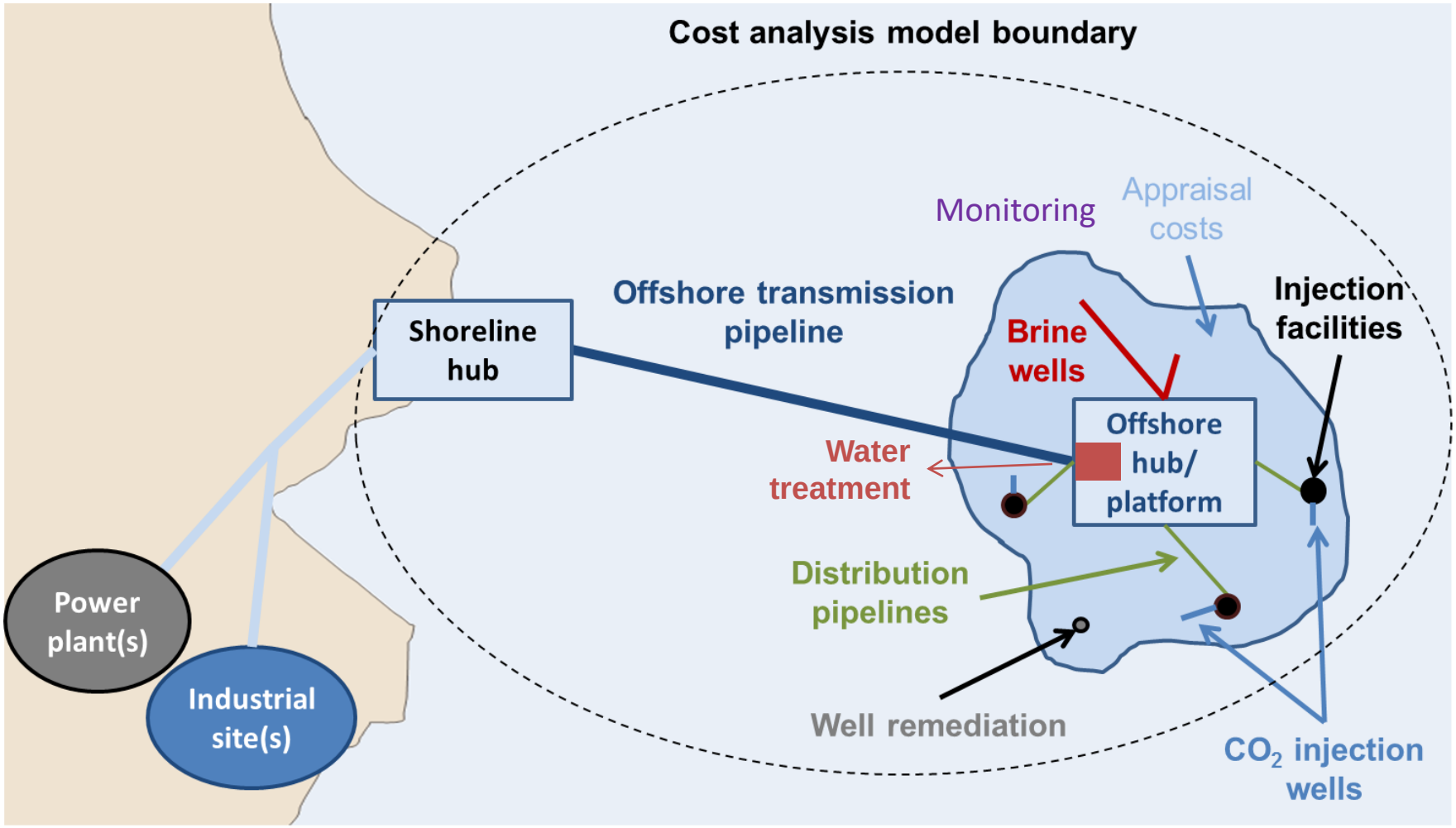


Tay

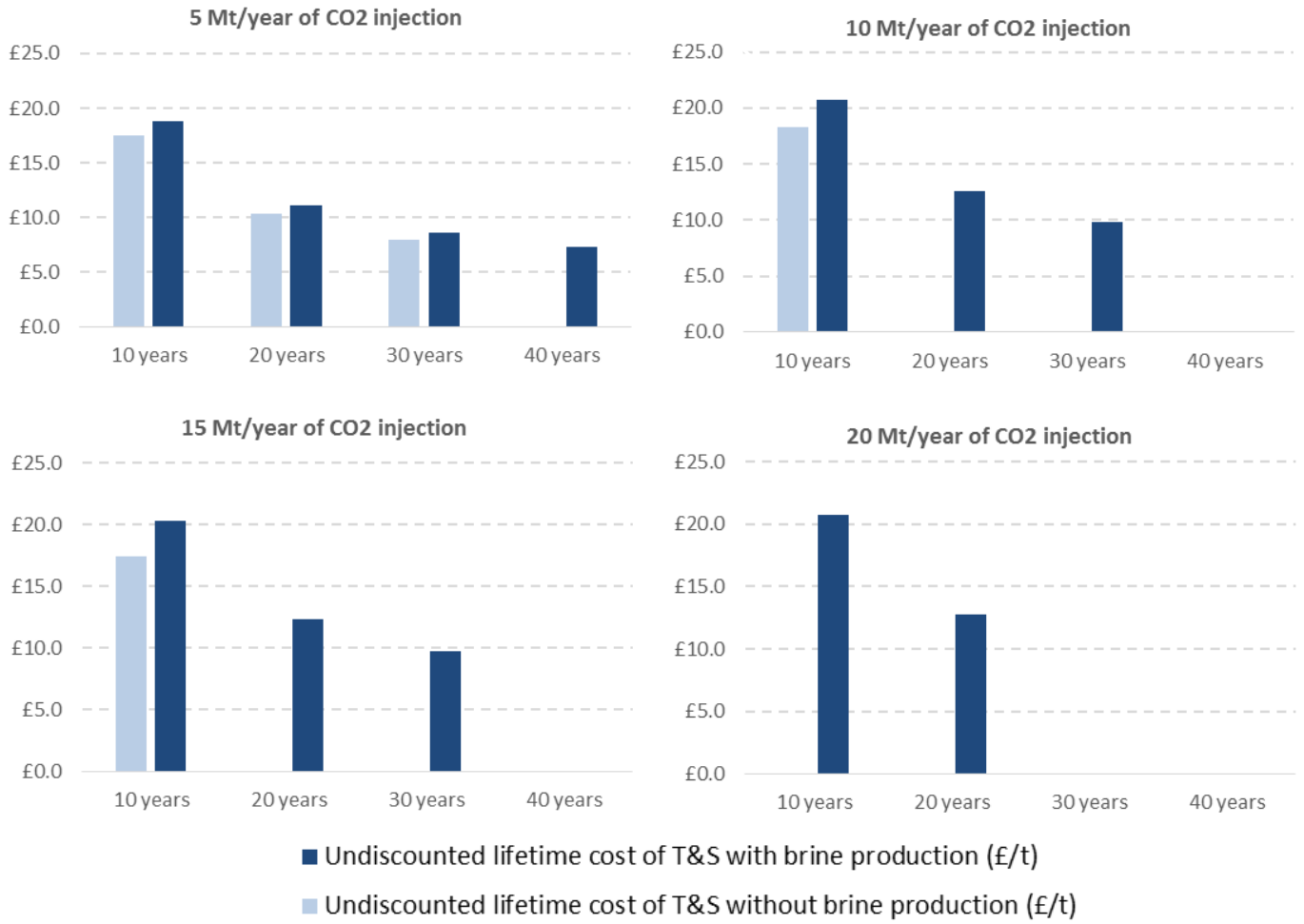


Firth of Forth

Detailed simulation results were used as inputs for a purpose-built Cost Benefit Analysis tool, which enables an economic comparison of scenarios with and without brine production to be made



Example: Impact of brine production on transport and storage costs of Tay for various injection scenarios



- Lifetime T&S unit costs tend to increase with brine production for the injection scenarios that are already feasible without brine production (although some minor savings are observed for some of the units examined); however, more importantly, more injection scenarios with higher storage capacities at similar T&S unit costs become feasible with brine production. In addition to achieving more CO_2 storage capacity with reasonable costs, a lower unit T&S cost is achieved with brine production at Firth of Forth and Tay.

Summary results: Impact of brine production on transport and storage costs

Maximum CO_2 storage capacity (Mt)

	Brine production		
	No	Yes	% increase in capacity
Forties 5	400	450	13%
Bunter_zone4	200	200	0%
Bunter Closure 36*	50	200	300%
Tay	150	450	200%
Firth of Forth	100	300	200%

Summary results – Minimum undiscounted lifetime cost of T&S (£/tCO_2)

	Brine production	
	No	Yes
Forties 5	£17.2	£22.8
Bunter_zone4	£6.8	£7.5
Bunter Closure 36*	£12.6	£7.5
Tay	£7.9	£7.2
Firth of Forth	£8.7	£6.4

*It should be noted that the assessment on Bunter Closure 36 is on the basis of severe impairment of connectivity

Project has identified a number of wider benefits of brine production

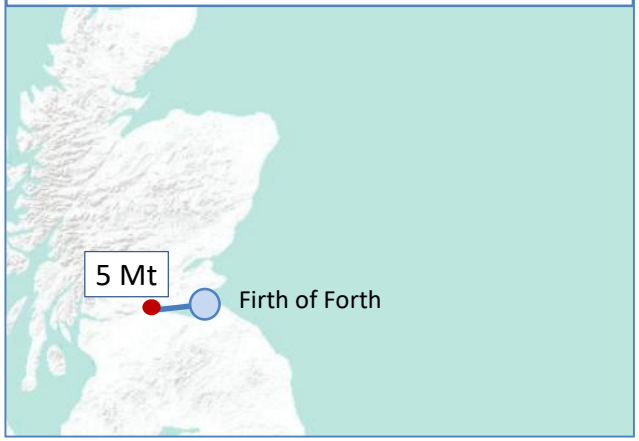
- In addition to increasing storage capacity and achieving lower unit costs at certain aquifers, brine production also has wider benefits including increasing optionality for storage operators/developers and policy-makers.

- The following case studies are examined in order to demonstrate these wider benefits :
  - ✓ Case study 1: Increasing storage duration of a storage site, which is close to the emitters, to avoid additional investment in a secondary storage unit
  - ✓ Case study 2: Increasing injection rate when new emitter(s) join after 10 years of CO_2 injection without brine production
  - ✓ Case study 3: Increasing storage duration after 10 years of CO_2 injection without brine production
  - ✓ Case study 4: Improving performance of an aquifer, which does not perform as expected due to unexpectedly poor connectivity

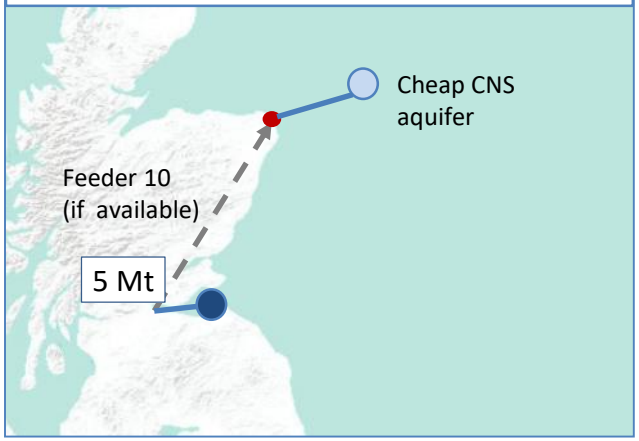
Case study 1 – Increasing storage capacity of a storage unit (Firth of Forth): Transport and storage network development

CCS deployment without brine production

Years 0-20



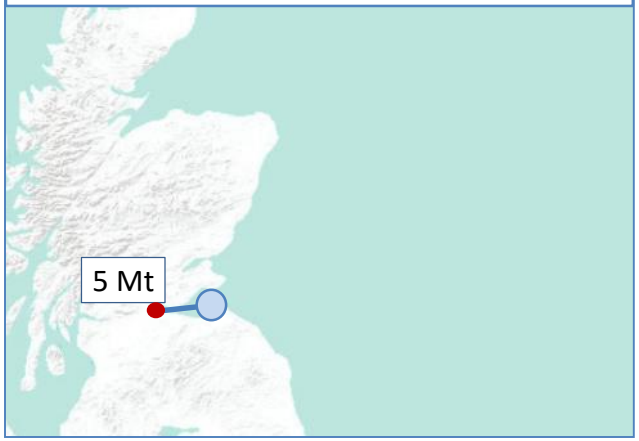
Years 21-40



CCS deployment with brine production

Years 0-20

Years 21-40

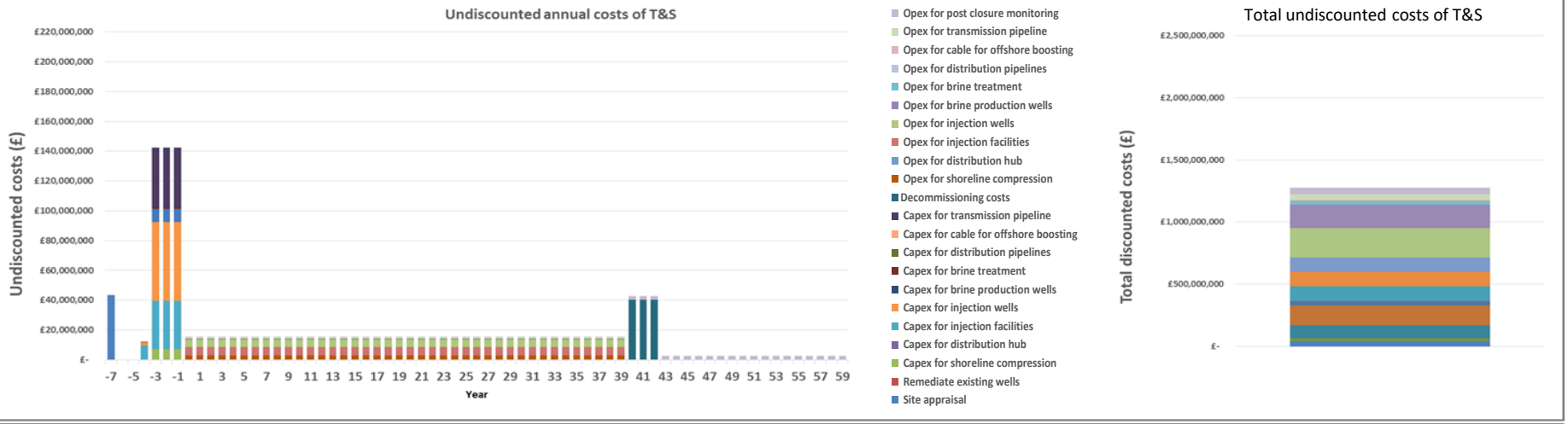


- Shoreline terminals
- Aquifer – operational
- Aquifer – closed
- New offshore pipelines
- New onshore pipelines
- Re-use offshore pipelines
- Re-use onshore pipelines

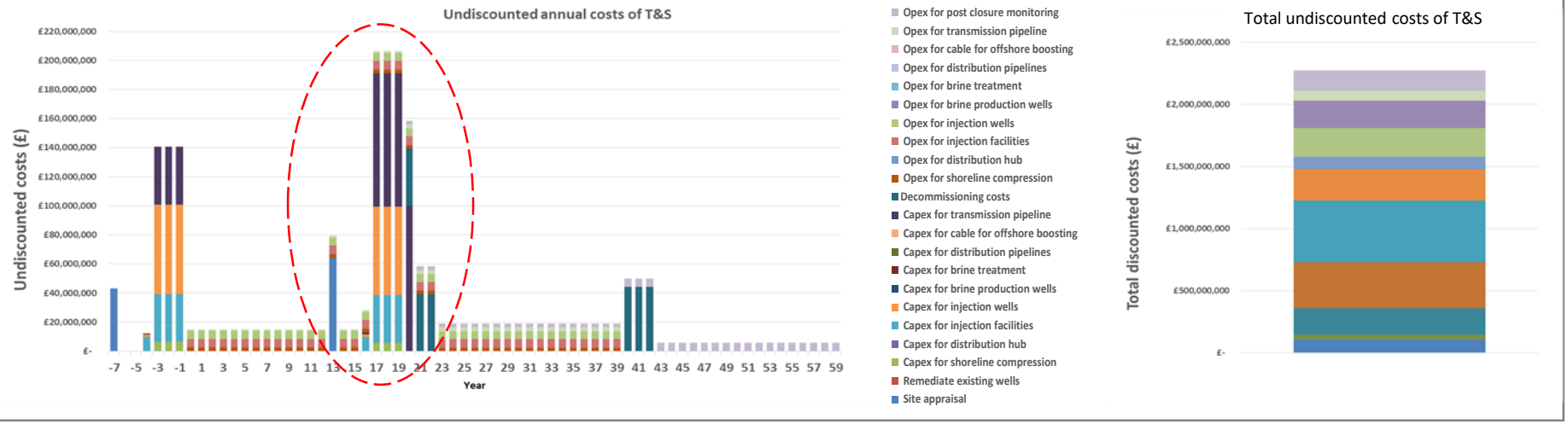
- It should be noted that the results for FoF are still uncertain as data availability is limited
- It is not possible to inject 5 Mt/yr into FoF for more than 20 years without brine production. Based on the technical assessment by HWU, it would be possible to inject 5 Mt/yr for 40 years with brine production.
- Investing in brine production would be economically viable at Firth of Forth – for an injection rate of 5Mt/yr, drilling one brine production well can reduce the number of required CO_2 injection wells by one well so the total number of required wells (CO_2 + brine) does not change.

Case study 1 – Increasing storage capacity of a storage unit (Firth of Forth): Total costs

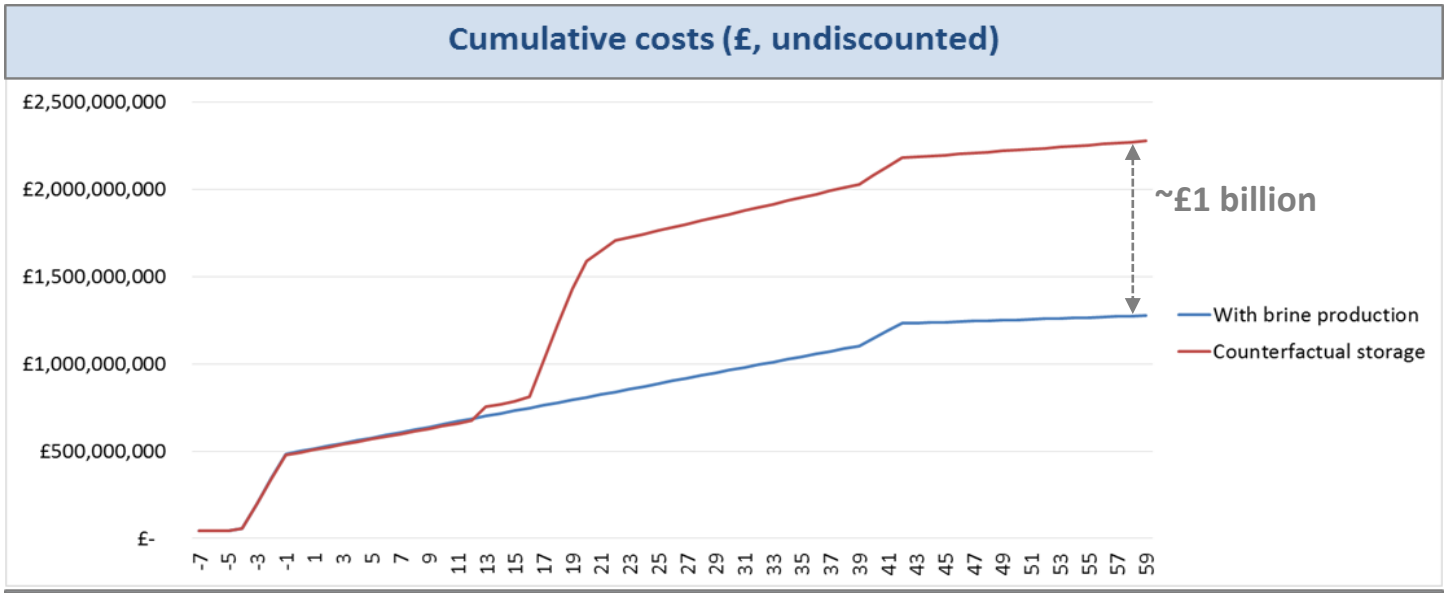
CCS deployment with brine production

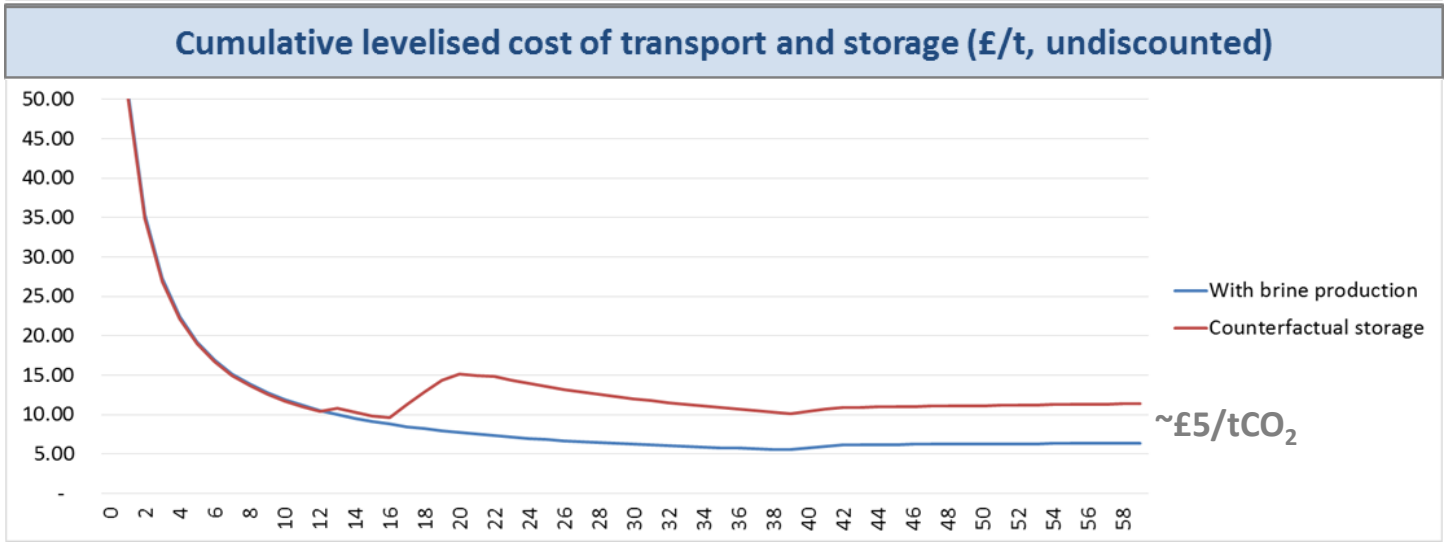


CCS deployment without brine production



Case study 1 – Increasing storage capacity of a storage unit (Firth of Forth): Cumulative cash-flow and levelised cost





Summary results: Wider benefits of brine production (1)

Case study		Total cost saving (Undiscounted)	Reduction in unit cost of T&S
1	Increasing storage capacity of an attractive storage unit	~£1 billion	~£5/tCO_2
2	Increasing injection rate for new emitters	~£0.5 billion	~£2/tCO_2
3	Increasing storage duration after 10 years of injection without brine production	~£1 billion	~£6/tCO_2
4	Improving performance of an aquifer, which does not perform as expected	~£0.1 billion	~£1/tCO_2

Summary results: Wider benefits of brine production (2)

- Brine production has a variety of strategic benefits for both project developers and policy-makers:
  - ✓ Brine production can **increase the storage capacity of a nearby/cost-effective storage site** thus avoiding the need for additional investment in a secondary storage unit.
  - ✓ Brine production can make a number of **small storage sites commercially viable options** by increasing their storage capacity/duration.
  - ✓ Although the UK has sufficient storage capacity for potential CO_2 emitters, brine production could be vital for other regions/countries that have limited storage capacity. This is also important for **petroleum licensees who can only work easily within a defined area.**

- In addition to increasing storage capacity and achieving lower minimum unit costs at certain aquifers, brine production can also increase optionality for storage operators/developers by:
  - ✓ **Increasing injection rate when new emitter(s) join** after several years of CO_2 injection without brine production
  - ✓ **Increasing storage duration when needed** after several years of CO_2 injection without brine production
  - ✓ **Improving performance of an aquifer**, which does not perform as expected, by drilling brine production wells.

- Another potential benefit of brine production could be retaining constant throughput of a CO_2 pipeline towards the end of site life in the event that pipeline pressure rating is reduced.

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