CCUS – Right Sizing. How big (Mtpa) should I build my hub capture and transport infrastructure?

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Introduction

Framing

- Costs in CCUS are heavily weighted to capture and transport. These scale with **rate** (Mtpa)
- Static, pore-volume corrected "storage capacities" don't help at all with investment risk
- Dynamic assessment is needed to answer … *how do we avoid over (or under) build of Capture & Transport capacity?*

Key hub investment (sizing) questions

We know emissions rates and their durations. For a given capture rate …

What is the confidence that injection can be sustained …

1. … for the productive economic lifetime of the major capital assets?

2. … *and*, at or below an economic target e.g. full lifecycle Unit Technical Cost ($/t)?

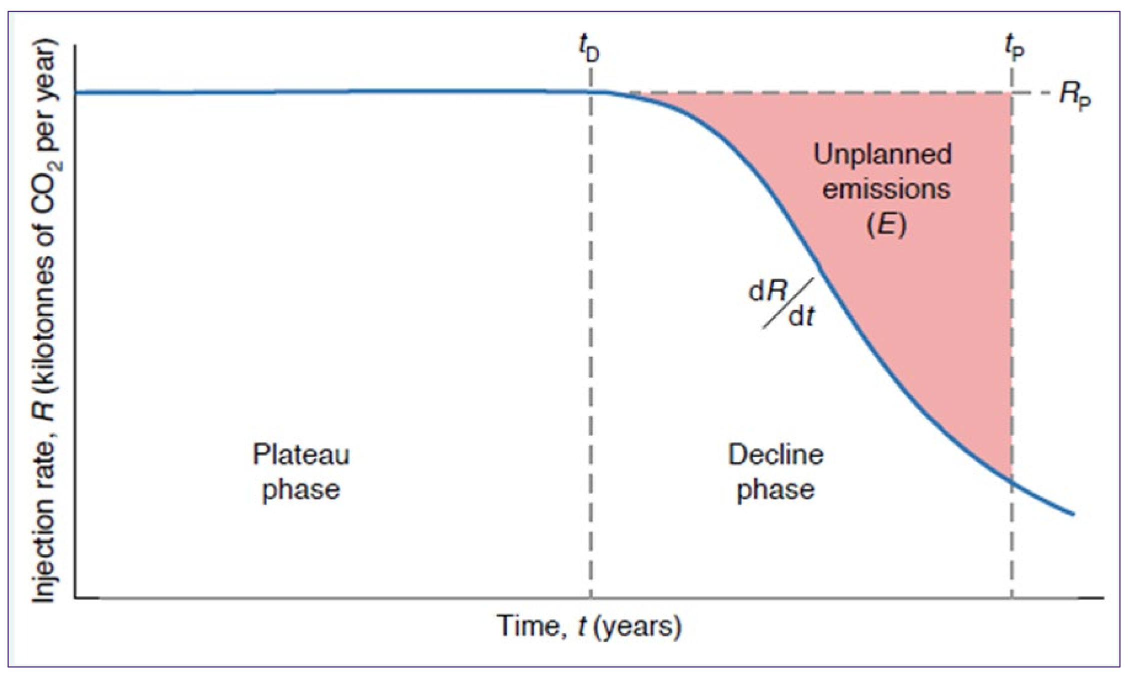

Figure 1: Generic Storage Receiving Profile.
Source: J. L. Lane, C. Greig, and A. J. Garnett, "Uncertain storage prospects create a conundrum for carbon capture and storage ambitions," Nature Climate Change, 2021

Discussion of Fig 1: for any site there will be an (*uncertain*) sustainable plateau rate (R_p) and time (t_D) at which this is caused to decline

For any *given* site, **higher plateau rates will mean quicker onset of decline.** Assume we build capture and transport with an asset life of say 30 years to match the pre-FID estimate of sustainable plateau rate …

[1] If injection starts to *decline before 30 years*, then unplanned emissions will occur => **The capacity built was too big** (wasted $$)

[2] If injection *does not decline*, more capacity *could* have been built => **Abatement was sub-optimal** (more emissions)

Method

[1] Map physical constraints to developable area, well lay-out and surface infrastructure (well number limitations)

[2] Map/model risk-based limitations to injection points (e.g. proximity to potential leak paths such as faults and legacy wells)

[3] Focus on major uncertainties in injection performance – two main forms

[3a] Uncertainty in initial injection rate

[3b] Uncertainty in pressure build up and therefore injection decline rates

Consider a "type well" approach …(Fig 2 & 3)

#1 Model single well … *(c.p.)*

- Informed by wireline, dynamic analogues, models, and EWTs
- An initial injection rate (& uncertainty probability density function - odf)
- Pressure transient (build-up) and consequential injection decline factor (& & uncertainty pdf)

#2 Multiple wells over time …

- Informed by dynamic analogues, extended well tests & sector models
- Modification to single well initial rate (& its pdf) e.g. depending on cumulative injection to date
- Modification to single well decline rate (& its pdf) due to cross-well pressure interference over time (reservoir dependent)
- ***REMEMBER*** **that space to drill / well count is constrained**

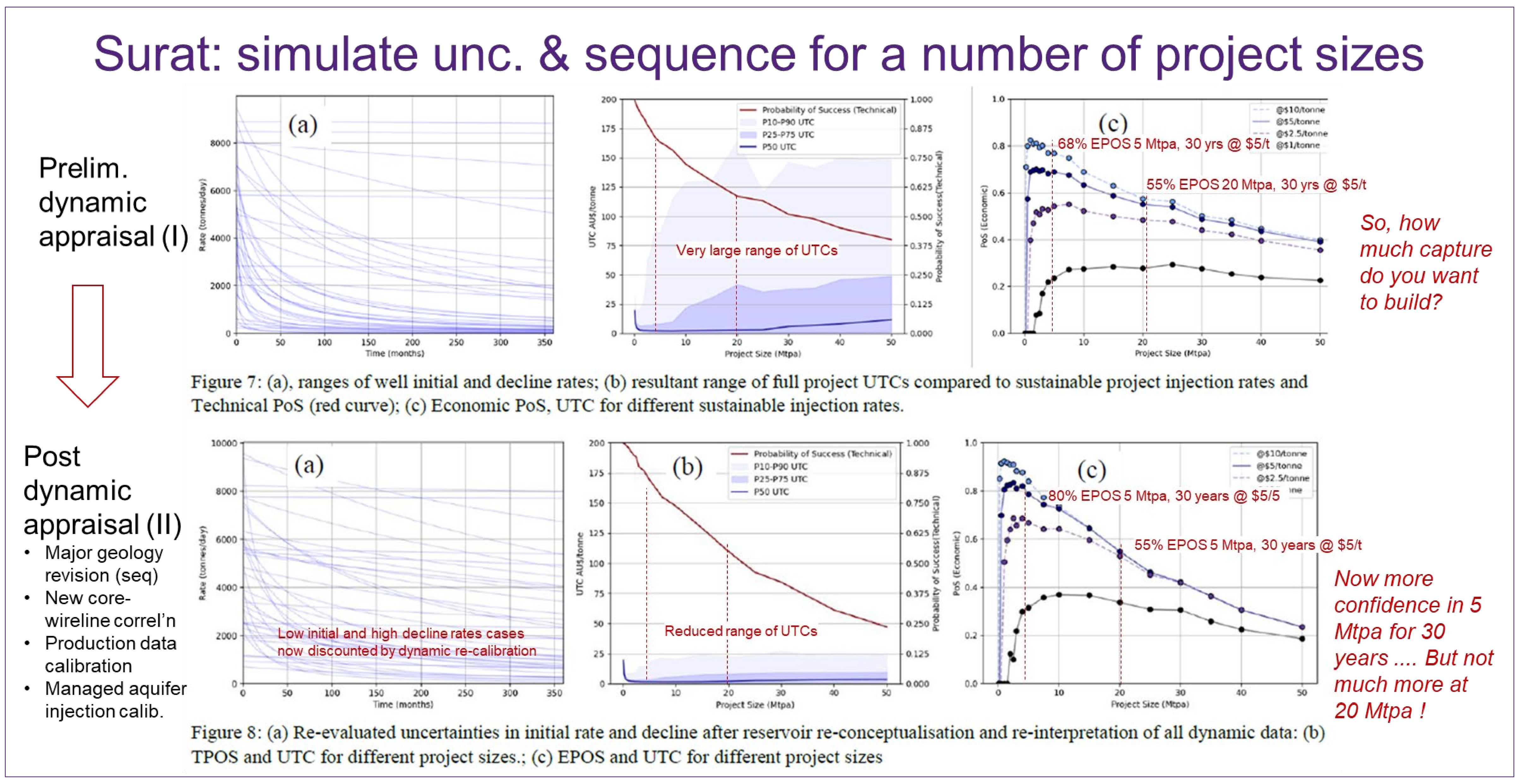

Figure 4: Evaluation of Technical and Economic Probability of Success for different project sizes (Mtpa), assuming a desired injection life of 30 years.

Results – Fig 4 - Upper

Pre-dynamic appraisal

Discussion of Fig 4 Upper. This shows (a) a large injection uncertainty both in well initial rates and in decline rates. This is driven by wide ranges of "kh" from uncalibrated core and log data and by legacy, previous, geological depositional conceptualisation which was then consistent with possible barriers and baffles in the reservoir. This led to - Upper (b) - a very wide range of UTCs (well count driven). Technical probability of success falls rapidly for larger projects as it relies on the smaller proportion of highest performing wells (and/or becomes limited by space to drill). Economic probability of success – Upper (c) – is shown for different target UTCs and project sizes. The highest EPOS is for projects less than 2 Mtpa.

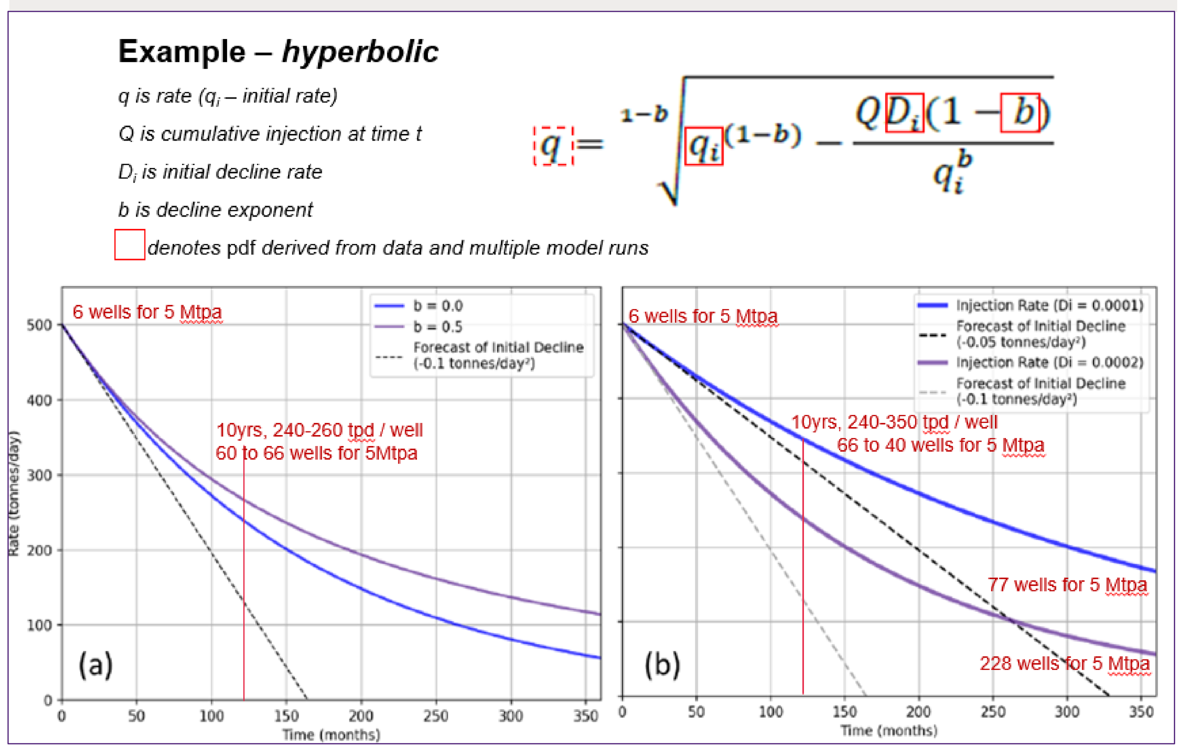

Figure 2: Example of a type-curve approach to injection modelling over time. Note that *uncertainties* are the main focus.

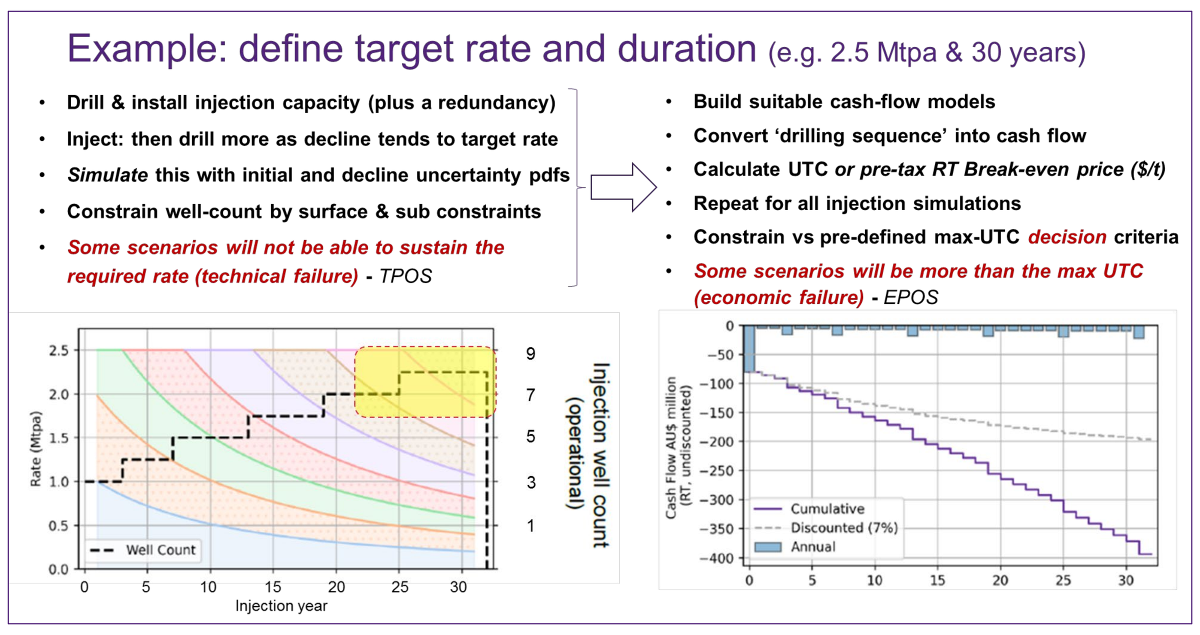

Figure 3: Simulated drilling & injection sequence to match a "target sustainable injection rate (well count limited by constraints). Then simulated FDP & unit technical cost ($/t)

Results – Fig 4 - Lower

Post-dynamic appraisal

Discussion of Fig 4 Lower. This shows (a) that most of the lower well-initial and higher decline-rate well performances have been disqualified. This is because of a complete revision in reservoir sequence / depositional understanding as well as major dynamic injection calibration data sets. This includes (i) detailed matching of oil and water production in the Moonie Field; and (ii) APLNG/Origin's Managed Aquifer Recharge project; as well as town bores and other large scale abstraction. It also includes a re-examination of all DST data sets.

The range of UTCs is significantly reduced (well count reduction for a given plateau rate). However, the overall technical POS still reduce significantly with time mainly driven by restrictions in drillable area and well locations. The economic POS is significantly higher for the lowest risk (~2 Mtpa) project, than before dynamic appraisal.

So what …

Understanding **development constraints** is key.

Dynamic site appraisal – especially long term tests and long term pressure transients – is essential.

After appraisal, high confidence in sustaining 2Mt pa for 30 years. But emitters in region are larger. Confidence is not "high enough" > 2 Mtpa.

Five main investment options ..

1. **No further activity** ... walk away
2. **Take (share) the risk** ... Change the risk tolerance
3. **Invest in further dynamic appraisal** ($10s mln) focussed on *reducing uncertainty* in LT decline factors
4. **Find and *dynamically* appraise more sites**: a portfolio
5. **Phase the hub development incrementally** (appraise while developing, $2 bln): build <3 Mtpa first and monitor

How big should I build …

1) *It depends … on how much risk you want to take i.e. the risk that it's not possible to sustain the injection of the captured rate*

2) You *can* evaluate this risk in a structured way: focus on uncertainties

3) You should undertake a formal economic *Value of Information Appraisal* approach to investing in storage dynamic assessment

   - Capture and transport costs are in $ billions and they scale with Mtpa
   - Dynamic appraisal costs are in $10s millions

4) **Dynamic appraisal's not cheap … but it's a lot cheaper than getting the size wrong**

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