PACECCS

BRAG Classification Methodology

for continuous CO_2 stream impurities for full chain CCS systems

30th September 2025

What is the Problem?

- A CCS network may contain:
  - Different emitters,
  - Different CO_2 sources,
  - Different capture processes
  - *…therefore, producing different levels of impurities*
- This means an impurity may be more significant to one emitter than another
- CO_2 stream may contain up to 80 different impurities
- Monitoring all may be costly and unstable to control

What is the Solution?

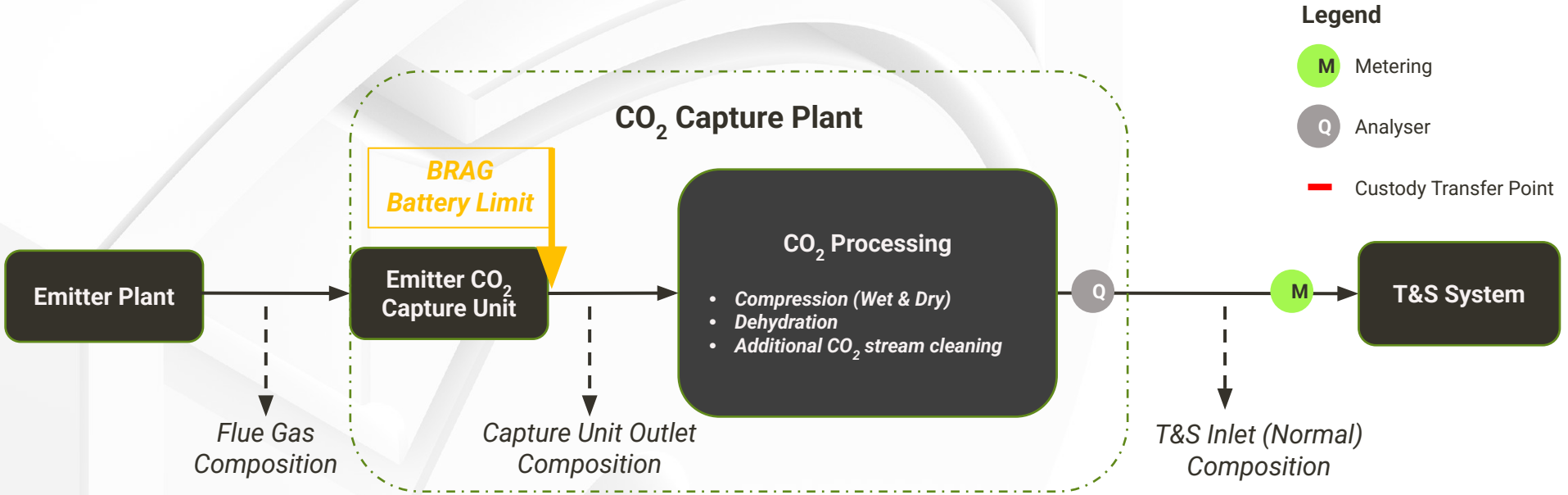
- Pace have developed a system to classify and categorise impurities within a CO_2 stream using a traffic light system (**BRAG**):
  - Black (High-likely Impact)
  - Red
  - Amber
  - Green (Low-unlikely Impact)

- **BRAG** is being implemented during the design stage of the project, done through a multidisciplinary workshop.
- **The goal** is to help emitters understand: **What monitoring is needed** & **What control requirements** they must follow.
- This approach avoids adding excessive control complexity.
- This can reduce expense from avoiding complicated monitoring systems.
- **BRAG** can set the premise of a safe-guarded CCS system operation on a case-by-case basis (**at the emitter side**).

What is the Solution? – BRAG Categories

	Colour	Level	Description	Type of Monitoring
B	LACK	Safety Critical	*Detrimental to short term integrity of the system downstream the capture plant.*	• Continuous online monitoring
				• Real time analysis sent to the control room
				• Automated alarms at upper limits
				• Automated closure of XV valve at “trip” points
R	ED	Important	*Critical to short term operability and detrimental to long term integrity of the system downstream the capture plant.*	• Continuous online monitoring
				• Real time analysis sent to the T&S control room
				• Automated alarms at upper limits
A	MBER	Basic	*Non-critical to operability however required to be logged (i.e., daily). This is due to possible operational upset over a prolonged time period.*	• Compositional analysis onsite
				• Results communicated to the T&S control room
G	REEN	Periodic	*Non-critical to operability and long-term integrity however required to be logged (i.e., quarterly) for housekeeping records.*	• Full compositional analysis offsite
				• Results communicated to the T&S control room

How do we apply it? – BRAG Assumptions



For each emitter, a design must be known or assumed:

1. Emitter
2. Capture Technology
3. Dehydration Technology
4. Facility (Constant operator presence or Automated)
5. Transport System (Pipeline or Ship)
6. CO_2 Phase

How do we apply it? – Decision Tree

- How can an excursion take place?

Process change or unit/equipment failure.

- Impurity margin to specification limit?

If there is a significant margin or slow excursion reduces concern.

- Prior indicators?

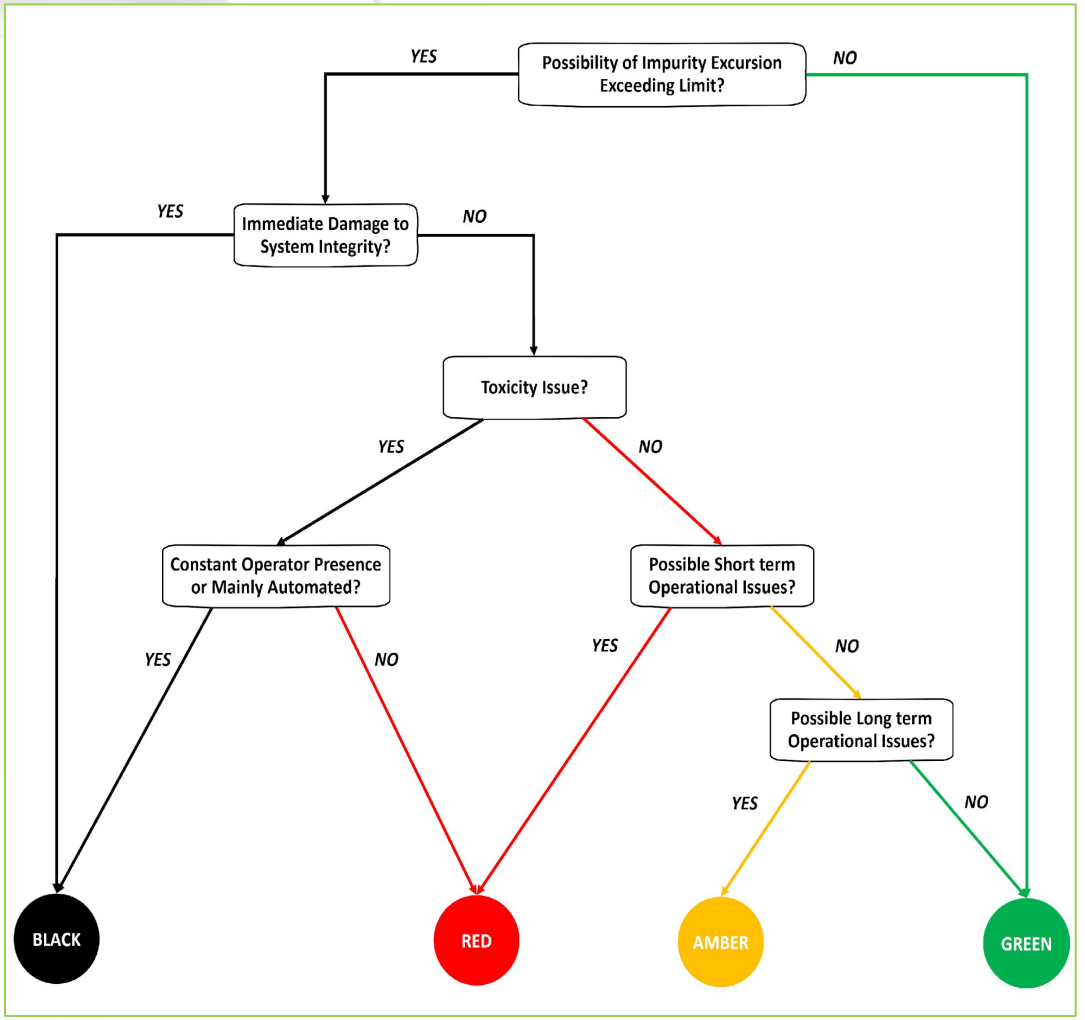
Upstream indicators than may initially signal excursion.

- Impurity interaction?

Managing one impurity may indirectly manage the risk of another.

- Cost effectiveness & measurability?

Can't monitor what can't be measured. Costly to monitor some impurities, hence must add significant value to do so.



Thank You

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