A Novel Solvent Instrumentation System for Flexible Carbon Capture

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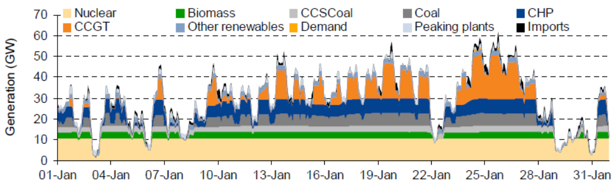
Introduction

Low carbon electricity systems are expected to have a heterogeneous mixture of dispatchable and non-dispatchable generation assets.

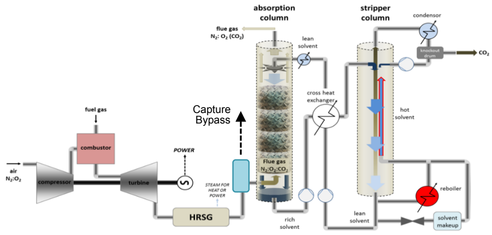


Future UK electricity scenarios indicate that fossil fuel plant will have to perform more dispatchable electricity services (ie. load following and frequency response duty) due to high penetration of intermittent, non-dispatchable renewable generation capacity (Poyry 2009).

The growing portion of non-dispatchable renewable assets along with the increasing electrification of other energy vectors (ie. heating and transport) increases the demand for **dispatachable low carbon electricity services** to maintain grid stability.

Flexible Generation with Carbon Capture

Fossil fuel generators fitted with post-combustion capture (PCC) technology are well suited to provide dispatchable low carbon electricity services on a large scale due to the flexible nature of the power plant, capture plant, and the connection between them.



In practice, generators fitted with PCC would provide dispatchable services while attempting to **optimising profit**, **minimising cost**, or **meeting cumulative emissions regulations**. Operating in this manner requires the **development of fit-for-purpose process models**, **control systems**, and **instrumentation**.

Project Objective

In the field of fit-for-purpose instrumentation, **solvent concentration** and **solvent loading** measurements were determined to be a critical area of need because the control of these parameters is essential to **efficient, low cost operation of the capture plant**.

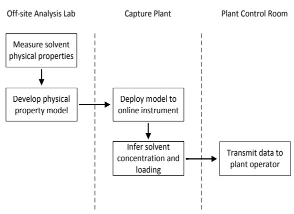
This research project sought to develop a novel solvent concentration and loading measurement method which would be **faster**, **more robust** and **more economical** than current state of the art.

Technology Solution: In-Situ Inferential Analysis from Physical Measurements

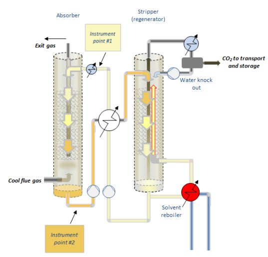
Current state of the art solvent measurement methods utilise **off-line periodic batch sampling methods** and **lab based chemical analysis techniques** to determine solvent concentration and loading (i.e.. gas chromatography, titration). As a result, these methods are **less robust** and **more expensive** than other industrial measurement systems, but critically also provide data on 30-60 minute timescales, **far too slow** for flexible PCC plant operation

The technical solution proposed in this work infers solvent concentration and loading from **in-situ solvent physical property measurements** made at **flow conditions** after a solvent specific calibration procedure is performed and a reference point is established.

In-situ Inferential Analysis Steps



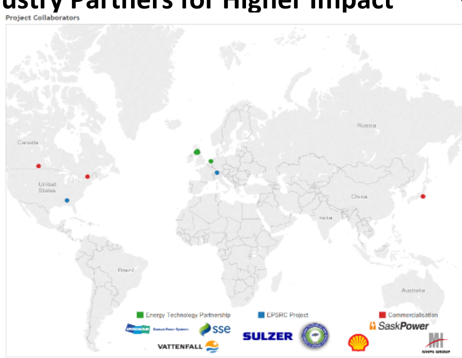
Instrument Placement



The technical solution can deliver solvent concentration and loading measurements in a continuous (~1 Hz) manner at flow conditions, providing the capture plant operator and control system with a **real time critical process variable**. Further, the physical properties can be determined **using robust**, **industrially proven**, and **low cost instrumentation**.

Leverage Industry Partners for Higher Impact

Sponsorship by the **Energy Technology Partnership** provided **access to key industrial partners** Doosan Power Systems, SSE, and Vattenfall. Which enabled the technical solution to be developed as an **industrial instrument system** and **deployed in realistic conditions** at the CCPilot100+ carbon capture pilot at Ferrybridge Power Station in Yorkshire, UK.



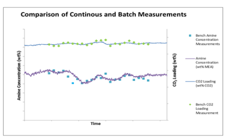
Map of industry collaborators throughout the project

Industrial Demonstration Results

Results from the demonstrations **have been promising** so far. The prototype has demonstrated a **robustness and speed** superior to state of the art as well as **lower capital and maintenance costs**. The system has an **inferior measurement accuracy** to state of the art, however this is expected to **improve following a prototype redesign**.

Top Left: Prototype instrument system deployed for demonstration at the National Carbon Capture Center.

Bottom Left and Right: Instrument results from the demo compared to industry state of the art.



In addition to economic and control system benefits, the instrument prototype has **provided higher quality data** to capture plant modellers and designers. (Tait et al., 2015, Morgan et al., 2015)

Identify Weaknesses of State of the Art

Develop Novel Measurement Technique

Develop Prototype Instrument System

Deploy Prototype in Industrial Demonstration

Commercialise Instrument System