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CONSULTING CHEMICAL ENGINEERS

Research, Development and Design
CHEMICAL, BIOCHEMICAL, ENVIRONMENTAL & ALTERNATIVE ENERGY

"Magnesium Carbonate via CO2 Capture using the DGC Reactor"

Prof. J. M. Winterbottom

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BACKGROUND

- **CHEMICAL ENGINEERING CONSULTANCY - SME**
  - Customised Contract Research and Technology Transfer
  - Conceptual Process Design and Scale-up
  - Detailed Engineering and supply of key-equipment, from Laboratory Scale to Commercial Plant
  - New Process Development and Feasibility studies

- **Developed Proprietary Technology:**

"The DGC (Downflow Gas Contactor) Reactor"

PATENTS : UK PATENT APPLICATION No. 1213583.6 - for CO2 Entrapment from Air & Biogas Enhancement using a DGC Reactor – "APPARATUS & METHOD FOR SEQUESTERING A GAS" – (July 2012)

"GOLD PRIZE" Award"

SEOUL INTERNATIONAL INVENTION FAIR, Korea, Nov 30th – Dec 3rd 2017

"Carbon Dioxide (CO2) Capture using the Downflow Gas Contactor (DGC) Reactor"

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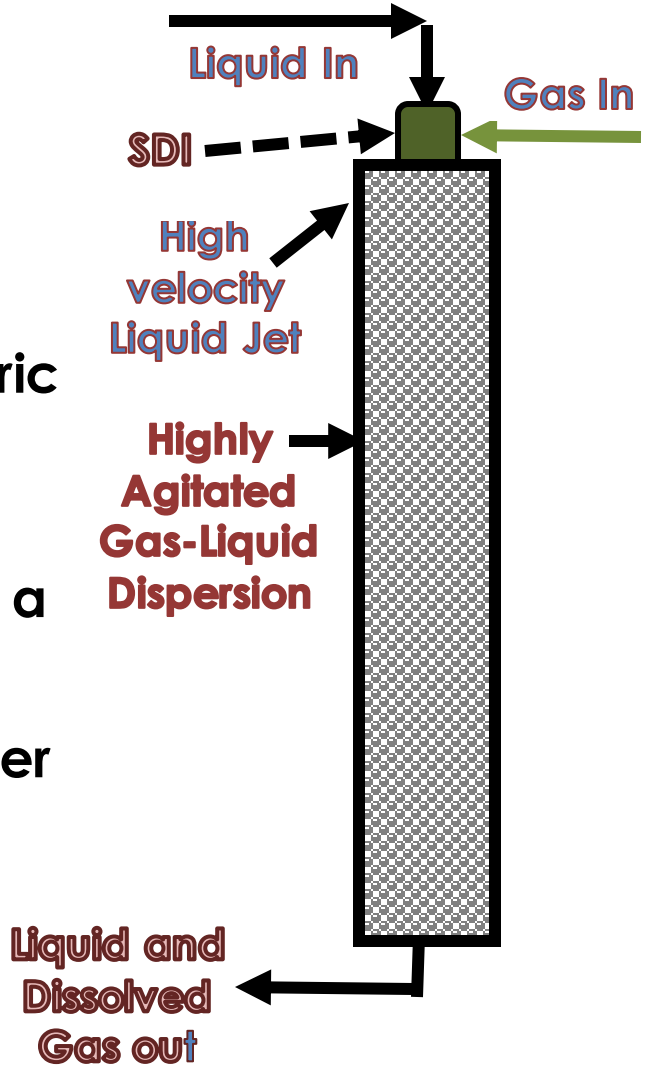
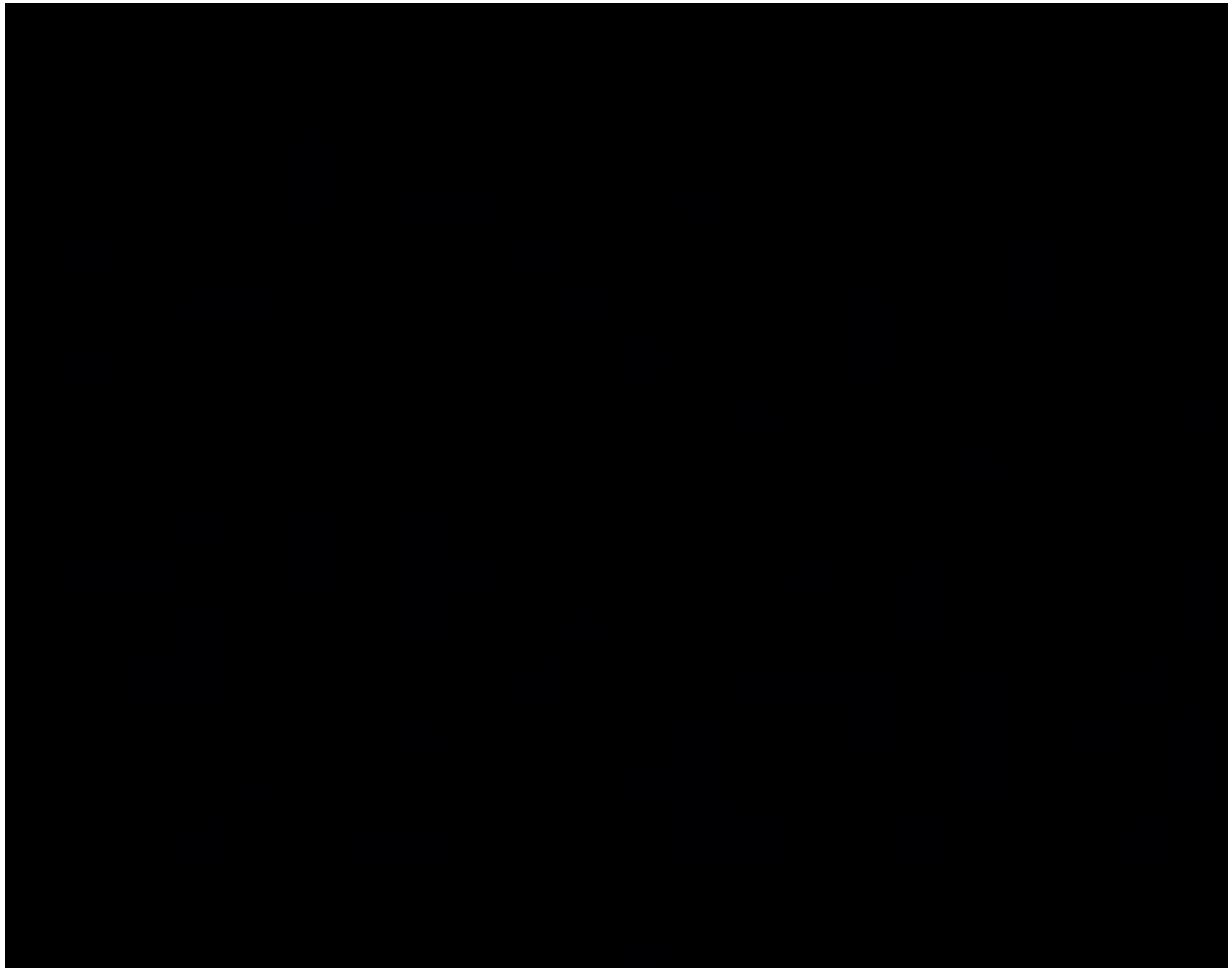
The DGC (Downflow Gas Contactor) Reactor

- Downflow Co-current device with Specially Designed Inlet (SDI)
- Contacting of Liquid continuum with dispersed Gas through SDI (Atmospheric or at Pressure)
- High Velocity Liquid input through SDI generates intense shear and produces a highly agitated Gas-Liquid dispersion
- Highly Efficient & Improved Mass Transfer
- Single Stage System



The DGC (Downflow Gas Contactor) Reactor
(Video)



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ADVANTAGES

- Lower power consumption
- Smaller operating volume - Smaller footprint
- No Foaming possible
- 100% Gas utilisation and >95% approach to equilibrium in short contact times
- High and accurate control of interfacial areas (1000 M2/M3 to 6000 M2/M3 depending on bubble size)(See picture later)
- Higher gas hold ups (40–50%)
- Tolerance to particulates
- No internal moving parts
- Can be operated at any pressure
- Low CAPEX & OPEX costs
- Simple, compact and flexibility of design
- Easy Scale-up without loss of efficiency
- Ease of Automation & Control
- Easily retrofitted and integrated into existing processes or Stand-alone as required

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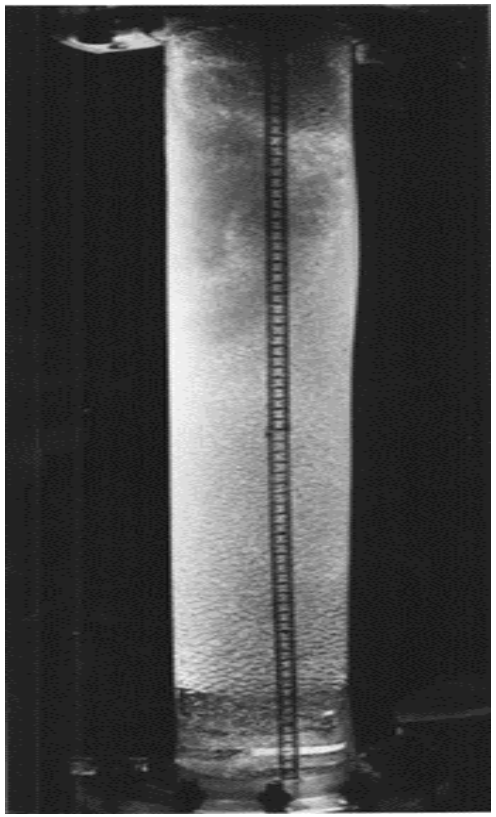
The DGC (Downflow Gas Contactor) Reactor

PICTURES of GAS LIQUID DISPERSION in a DGC REACTOR



INLET CONDITIONS in DGC REACTOR

BUBBLE DISPERSION in TAP WATER

BUBBLE DISPERSION in SIMULATED SEAWATER

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INDUSTRIAL APPLICATIONS

- The main areas of application of the DGC Reactor are:
  - **GAS ABSORPTION**: Oxygen in water, Carbon dioxide in water/seawater or Carbonation, Ammonia
  - **CARBON CAPTURE**: Selective capture of Carbon dioxide from Air or Mixed Gases
  - **BIOGAS UPGRADING**: Upgrading of Biogas by removal of CO_2 and H_2S
  - **EFFLUENT TREATMENT; CHEMICAL REACTIONS; STRIPPING; AIR FLOTATION**

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CARBON CAPTURE

- The DGC reactor has been successfully used for selective Capture of CO2 from AIR
  - Up to 100% of the CO2 content in AIR easily captured
  - Different Absorbent solutions [Sea-salts, Sodium carbonate, Sodium hydroxide, Monoethanolamine (MEA), Magnesium hydroxide] used.
  - Specially formulated Absorbent solutions – ABSOLV - also used
  - Lower Absorbent concentrations required than current alternative systems due to increased gas-liquid mass transfer
  - Higher mass of Carbon dioxide capture achieved per unit power requirement
- Recovery of the captured CO2 from the Absorbent solution, undertaken - with increase in temperature.

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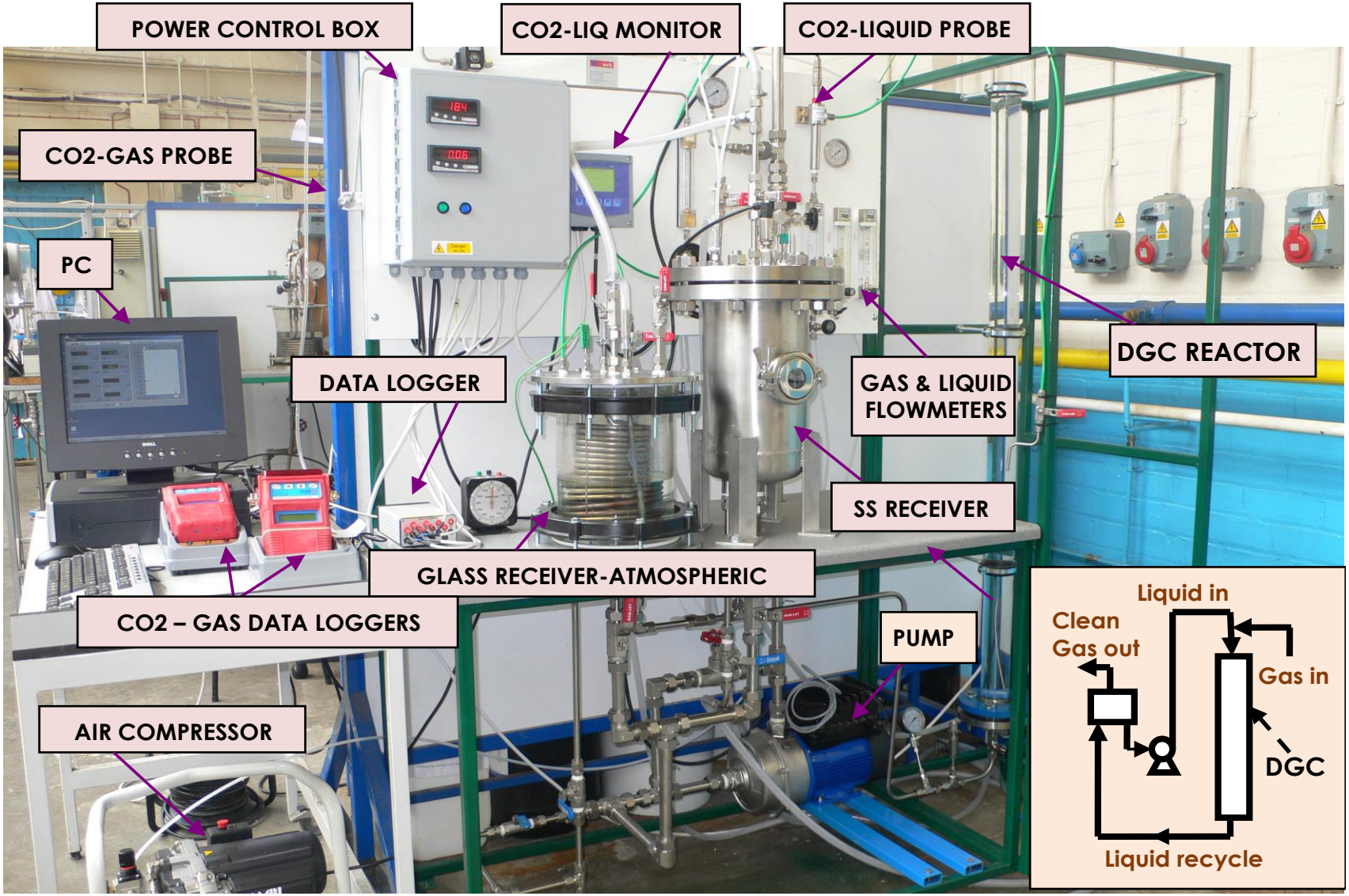
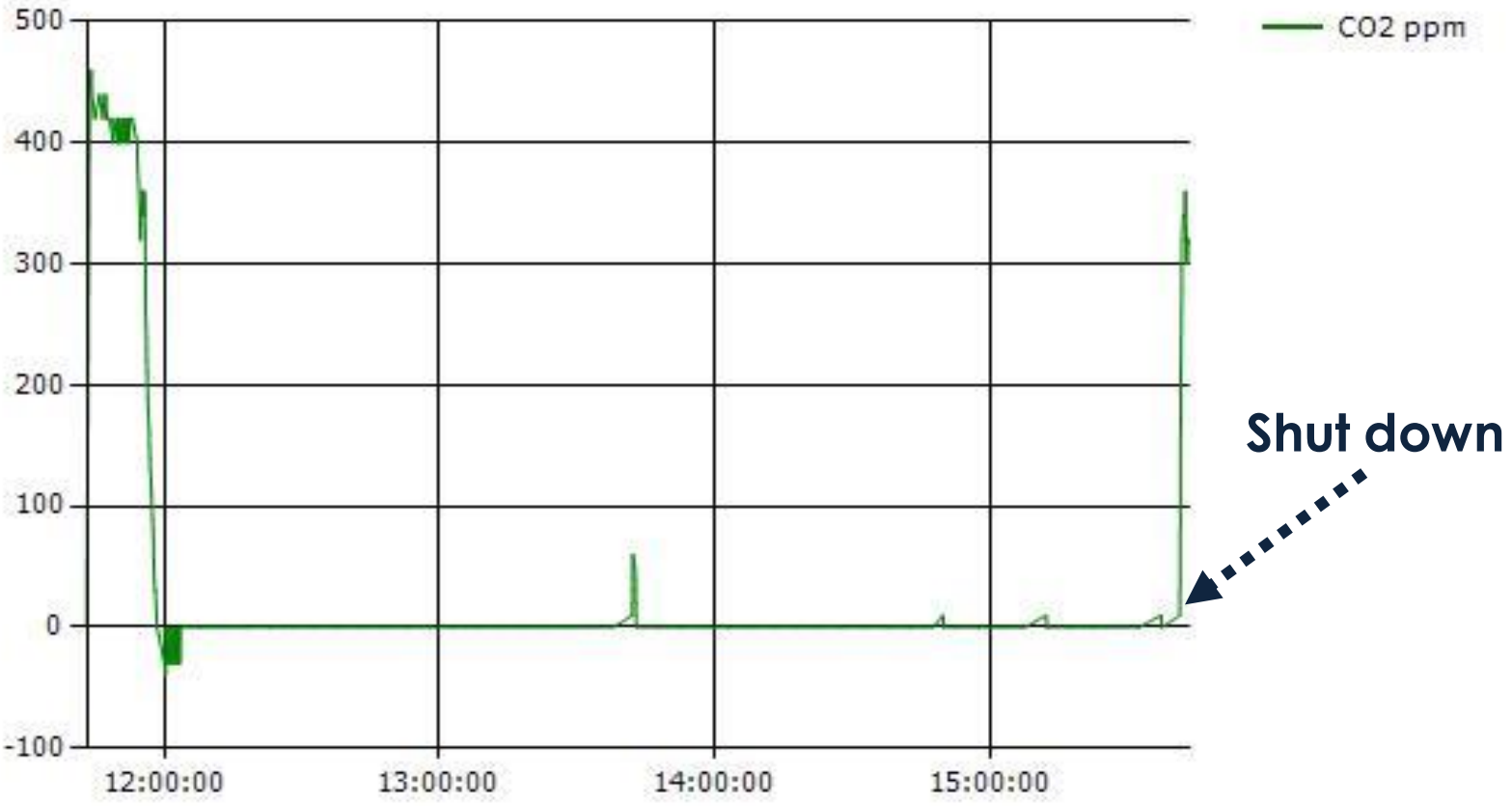
CARBON CAPTURE RIG



CO2 ABSORPTION DGC REACTOR UNIT

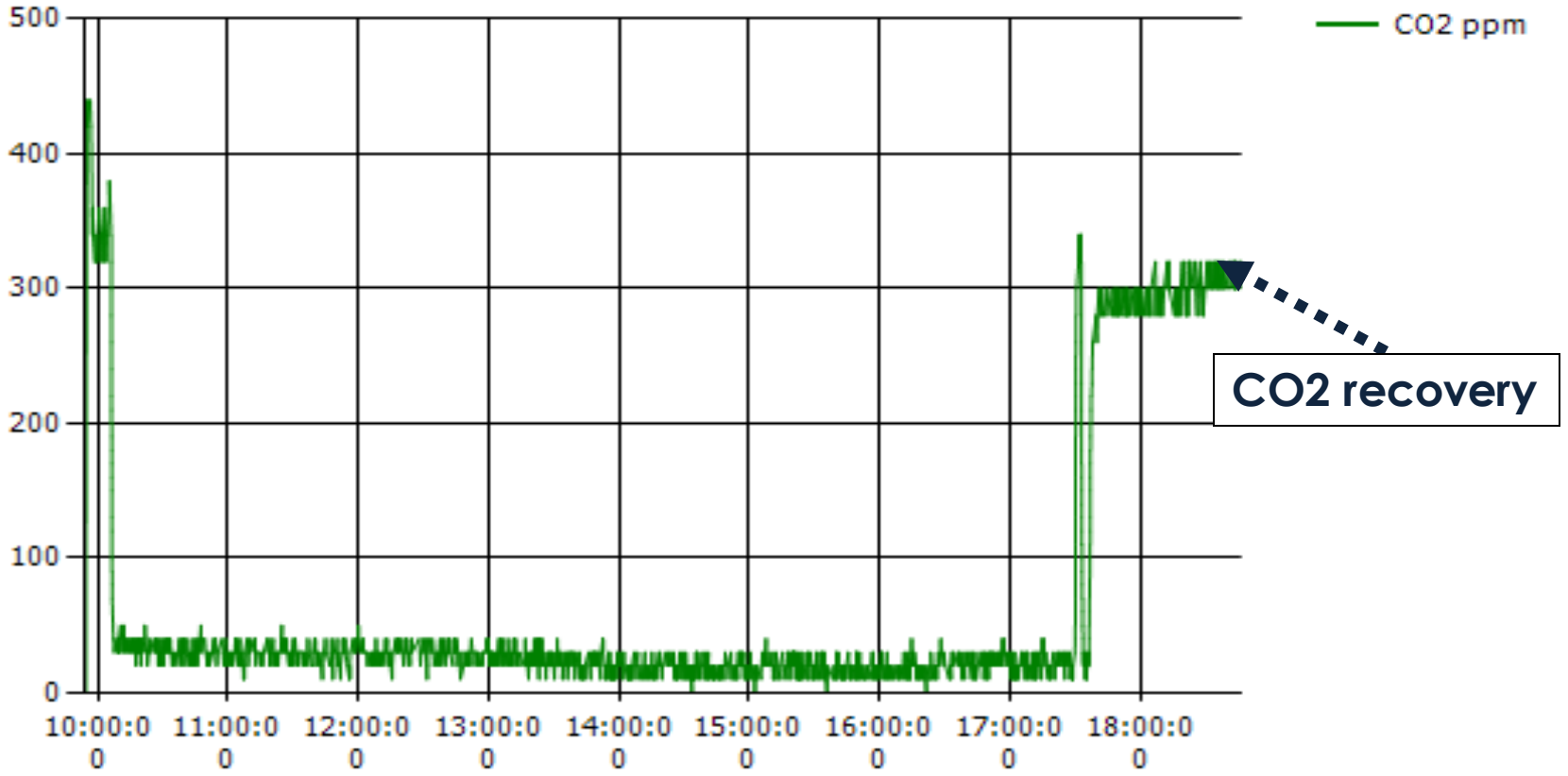
CARBON CAPTURE

Selective CO2 CAPTURE from AIR (ABSOLV-A)



CARBON CAPTURE

Selective CO2 CAPTURE from AIR & CO2 Recovery (ABSOLV-B)



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BIOGAS UPGRADING

- DGC used for BIOGAS UPGRADING by removal of Carbon dioxide & Hydrogen sulphide content :
  - Complete absorption of the CO2 and H2S content in simulated BIOGAS
  - Methane concentrations in the gas outlet attained was > 99%
  - Absorbent solution used – ABSOLV- of higher pH
  - Not affected by fluctuations in BIOGAS feed rates or CO2 and H2S concentrations in Gas feed

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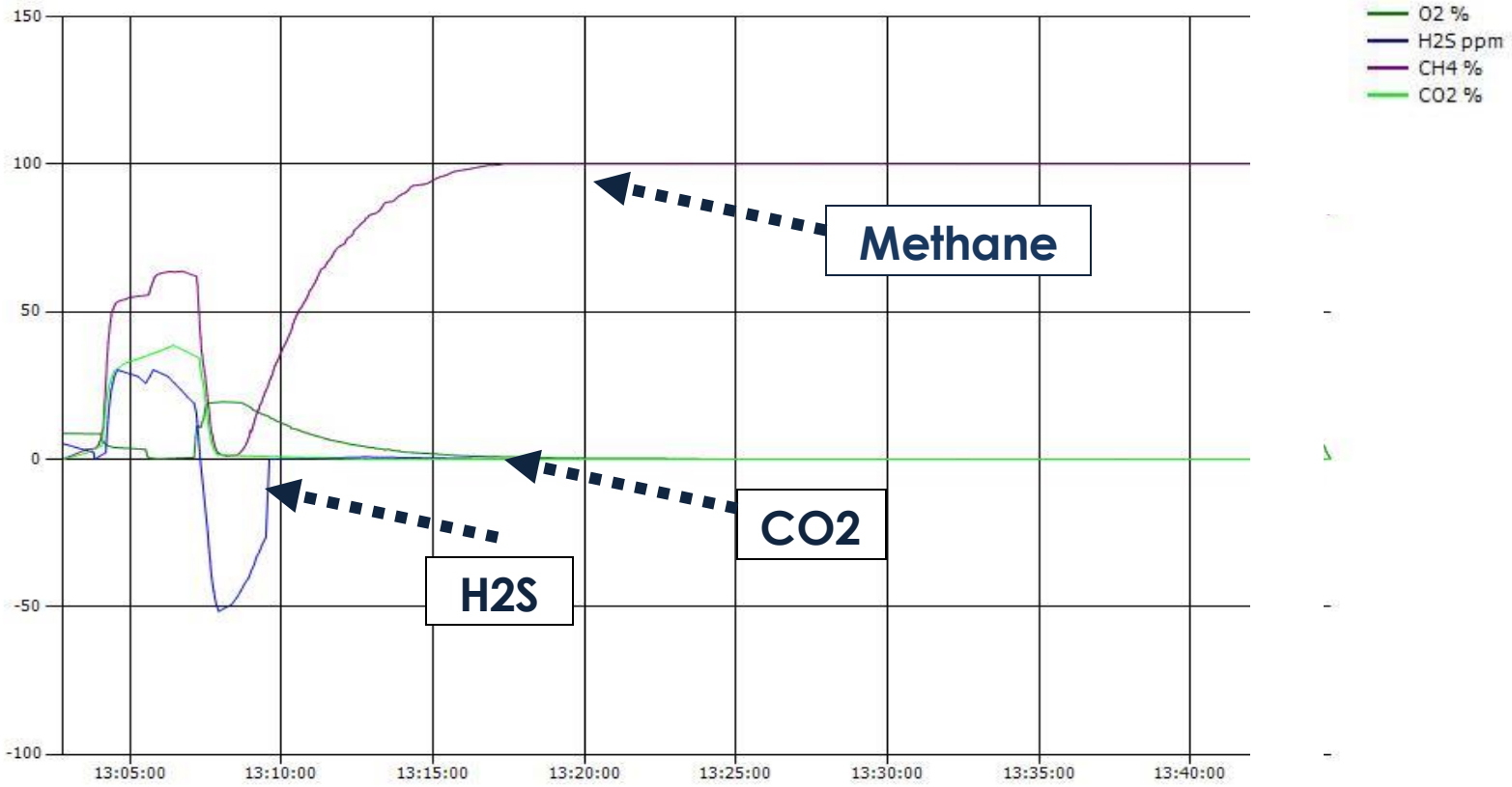
BIOGAS UPGRADING

Removal of Carbon dioxide and Hydrogen sulphide (Simulated BIOGAS [60% CH4 - 38% CO2 - 2% H2S])

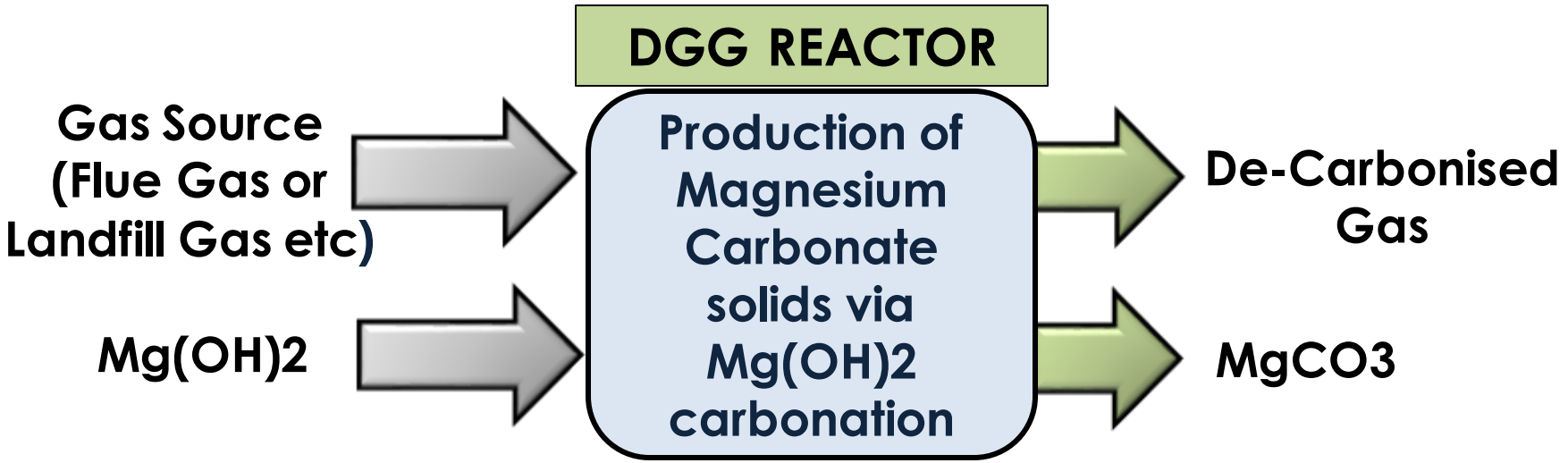


CAPTURED CO2 - RECOVERY & UTILISATION

- WRK is working on CAPTURING CO2 from various sources and UTILISING the CO2 to produce useful products so that the process can be fully Carbon Neutral
- Captured CO2 can be RECOVERED by INCREASE OF TEMPERATURE of saturated Absorbent solution (approx 70-80 degC) depending on Absorbent solution used
- Many USES OF CAPTURED & RECOVERED CO2
  - could be used as a feedstock for Methanol, Gasoline or Aviation Fuel production
  - Could be used for Algal Bio-fixation
  - Could be used for Horticulture requirements

CAPTURED CO2 - UTILISATION

- Low-cost MAGNESIUM HYDROXIDE is used (as aq.Slurry) to strip CO2 directly from Flue gas, Landfill gas or Air to permanently sequester and MINERALISE CO2 to form solid MAGNESIUM CARBONATE powders (various high-value commercial markets)



- Overall Process:
  - $Mg(OH)_2 + CO_2 \Rightarrow MgCO_3 + H_2O$

- Chemical Steps:
  - $2CO_2 + 2OH^- \Rightarrow 2HCO_3$
  - $2Mg(OH)_2 + 2HCO_3^- \Rightarrow 2MgCO_3 + 2OH^- + 2H_2O$

CURRENT PROJECTS

CAPTURED CO2 - UTILISATION

- WRK is currently working in collaboration with Cambridge Carbon Capture (CCC) in an INNOVATE UK funded Project for capturing CO2 using its DGC Reactor from Landfill Gas and convert CO2 into a commercially useful mineral by-product - MAGNESIUM CARBONATE - using Mg(OH)2 obtained from Serpentine/Olivine (CCC's patented CO2LOC Technology).
- A Demonstrator Unit is being fabricated for handling 5 M3/hr of Landfill Gas Input. Should be in operation by February 2019.

BIOGAS UPGRADING

- A DGC Demonstrator Unit is currently being set up in Poona, India in collaboration with UEPL/STEP for handling 50 M3/hr of BIOGAS for a project to UPGRADE BIOGAS and capture CO2.
  (DGC Reactor - 5 Meter height & 16 cm diameter)
  Ready for operation in end November 2018.

FURTHER INFORMATION

- **WRK is in discussion with 'MERIDIAN' – exploring the potential and possibility of a collaborative Project on Capture and Utilisation of waste CO2 in their plant Flue gas emissions, using WRK's DGC technology:-**
  - **Capture the CO2 for RECYCLING AND REUSE back into the MERIDIAN Die Casting process.**
  - **Utilise captured CO2 to produce MAGNESIUM CARBONATE**

- **COLLABORATION AGREEMENT :**
  STEP PRIVATE LTD, Mumbai, India – for use of the DGC Reactor for CO2 Capture & Recovery, Effluent Treatment, Environmental Projects & Fine Chemicals production in India (Sep 2013).

- **COLLABORATION :**
  WRK is in discussion with Birmingham City University and exploring the possibility of a Joint Project for an OUTDOOR "DGC FOUNTAIN" CONCEPT which will be capturing CO2 from atmospheric AIR. It is planned to use Magnesium Hydroxide as the Absorbent salt. See proposed initial "CONCEPT" later.

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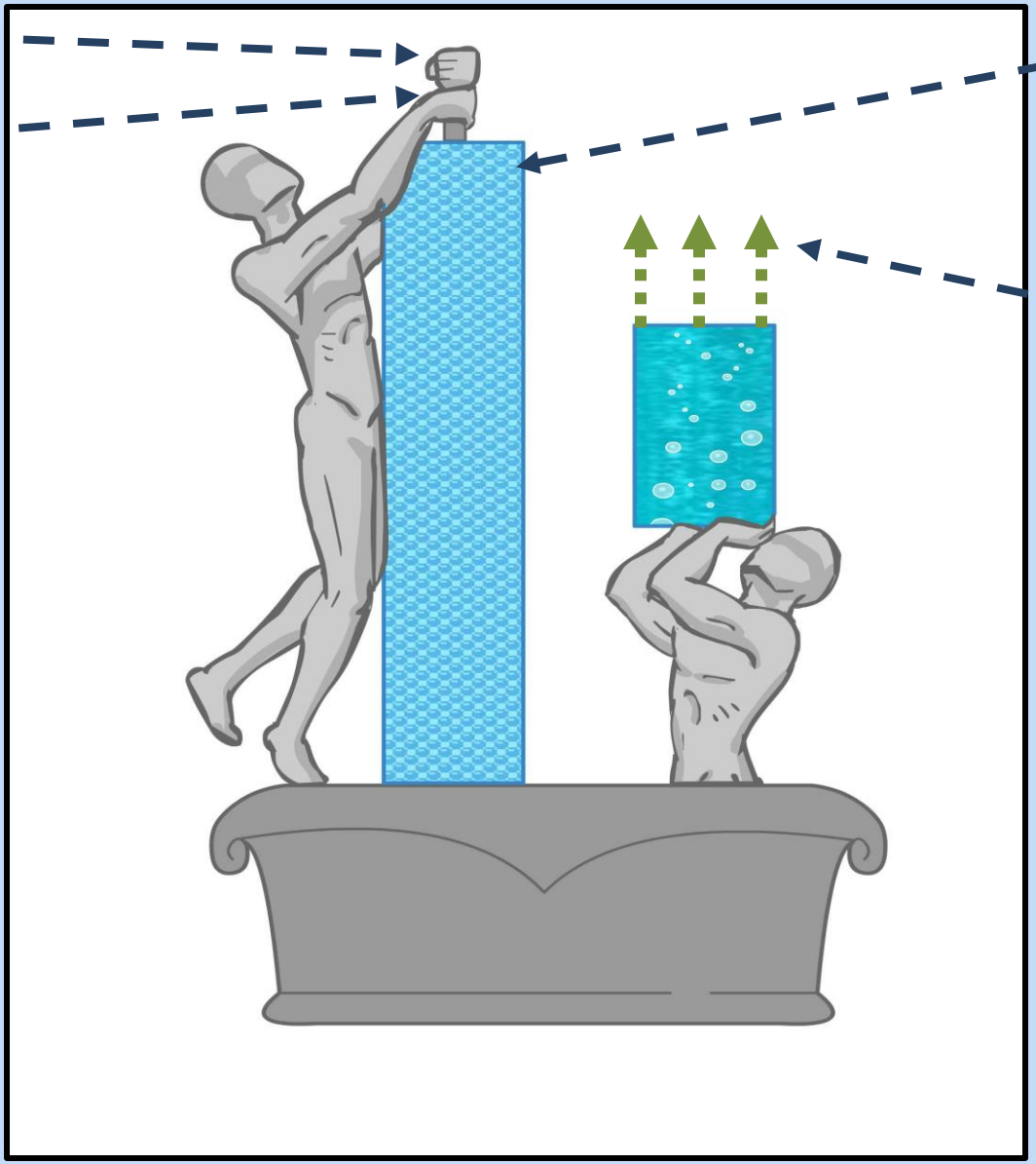
OUTDOOR "DGC FOUNTAIN" CONCEPT



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