TNB RESEARCH

IERE

Innovate With The End In Mind

2017 IERE-TNB Putrajaya Workshop

Technologies Reshaping the Electricity Supply Industry

Improvement of CO_2 Dissolution in Microalgae Culture by Applications of Nano-Material

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Putrajaya Shangri-La, Malaysia
4th – 6th April 2017

Overview

1	TNB Research
2	Trends on greenhouse gas
3	CCUS Technology
4	Bio-CCU Technology
5	Bio-CCU Research Gap
6	Technical Assessments / Research Findings
7	Future Works

1. TNB Research

TNBR is streamlining the aspiration, values and enablers to align with TNB Re-Imagining

- One of the leading & largest R&D company in Malaysia
- Subsidiary of TNB since 1993
- Non-profit driven centre for electricity and environmental research
- Specialize in energy & environmental sector

Awarded R&D Status by MIDA since 1997

Collaboration to obtain governmental incentives

OUR PEOPLE

Technical Expert : 8
Doctorate : 11
Researchers : 84
TNBR QATS: 80

OUR SERVICES

Applied Research

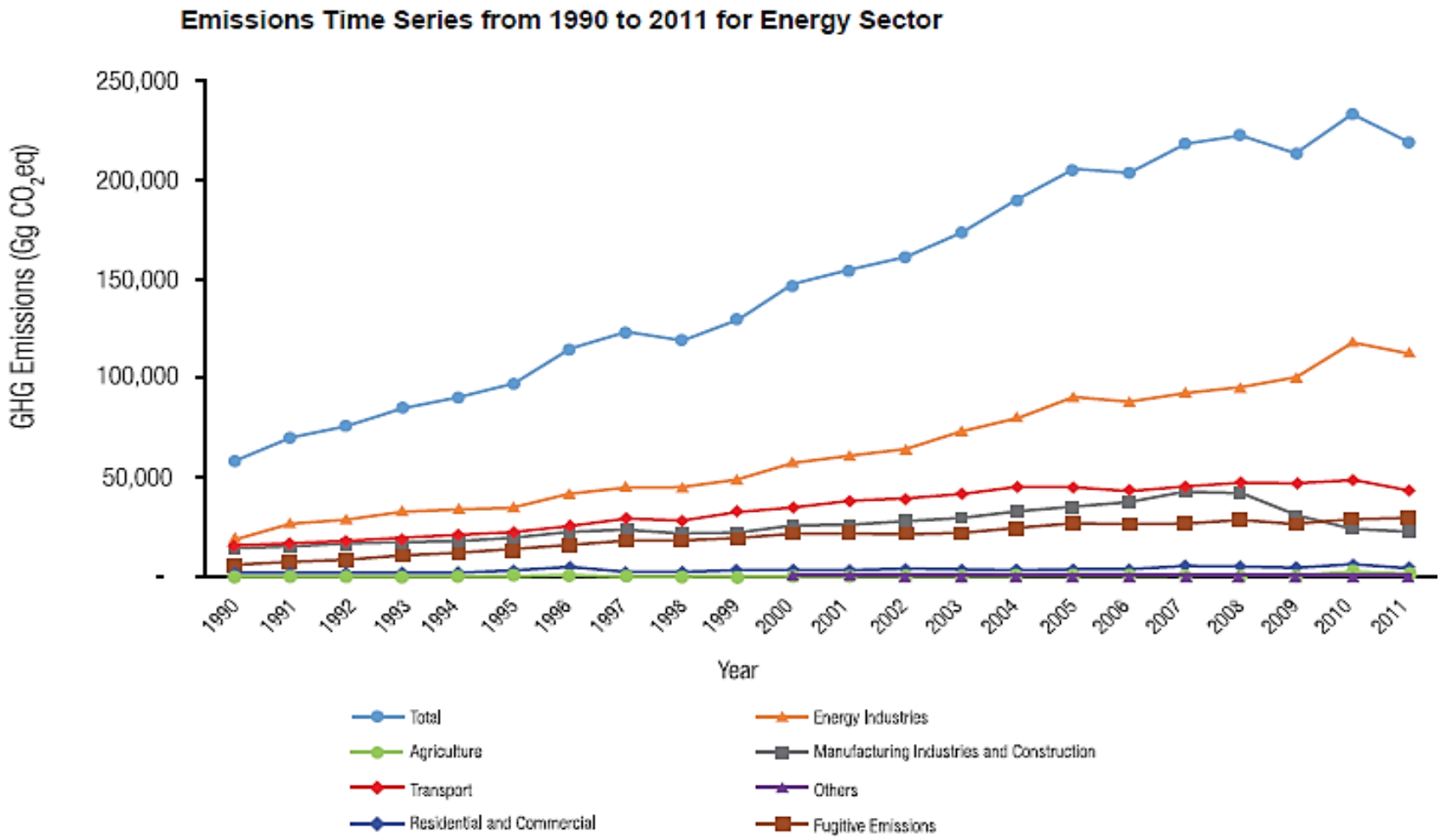
- Power Delivery
- Power Generation
- Environmental Management
- Strategic Research

Advanced Research

- Low Carbon Power Generation Technology
- Emission & Waste Management Technology
- Smart Grid Technology
- Green Energy Technology

2. Trends on greenhouse gas

Current trends on GHG / CO_2 emissions from 1990 to 2011 shows an increasing trend, leads to climate change / global warming



- Malaysia's Biennial Update Report to UNFCC, 2015

3. Carbon Capture, Utilization & Storage (CCUS) Technology

CCUS is an important set of technologies for reducing GHG/CO_2 emission, while enabling important resources (eg. coal) to continue contributing to energy security and economic objective.

CCUS status, globally

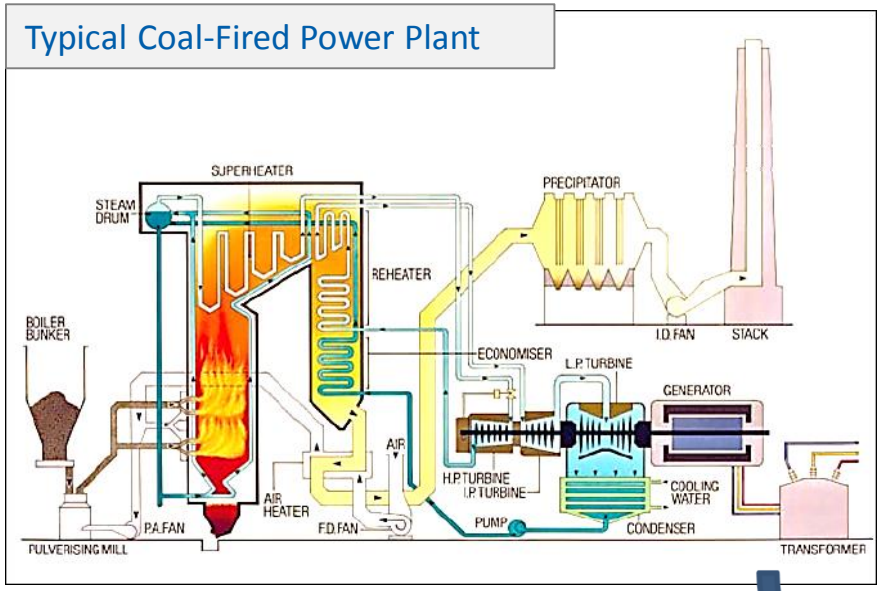
- **CCUS**
  - **Capture**
    - Pre-Combustion
      - Gasification
    - (during) Combustion
      - Oxy-fuel
      - Chemical Looping
    - Post-Combustion
      - Absorption
      - Adsorption
      - Membrane
  - **Utilization**
    - EOR
    - Fuel
    - Chemical
    - Bio-CCU (microalgae)
  - **Storage**
    - Geological injection
    - Ocean Injection
    - Mineral carbonation

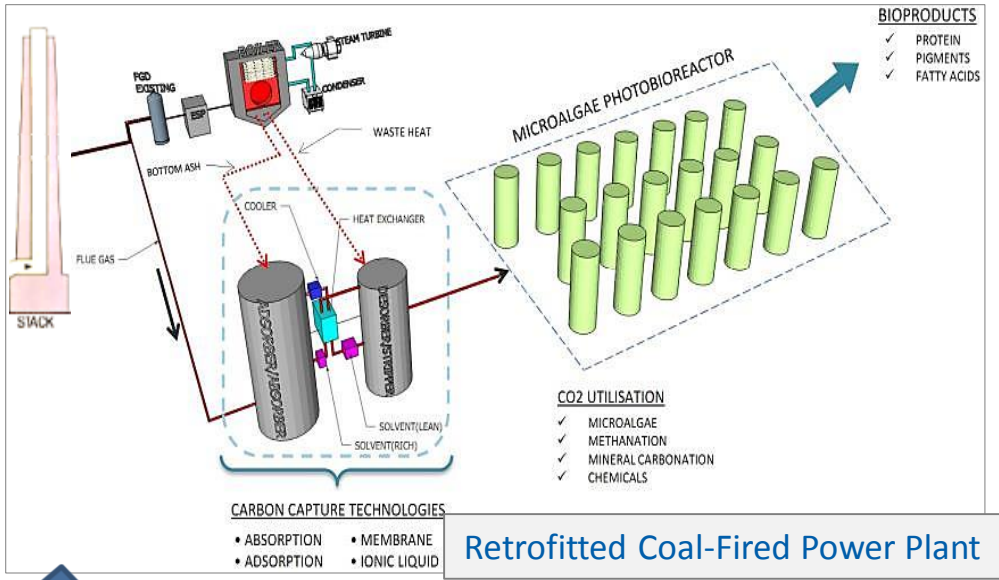
Focus area in TNBR

4. Biological carbon capture & utilization (Bio-CCU)

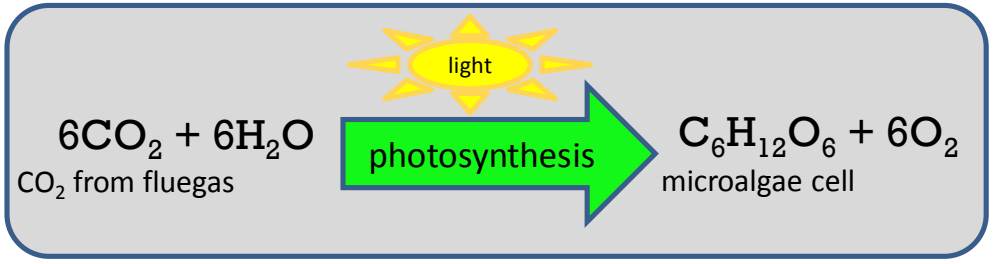
Performing carbon capture & utilization via biological pathway & in parallel harnessing *microalgae bioeconomy* to power plant

Typical Coal-Fired Power Plant





Retrofitted Coal-Fired Power Plant

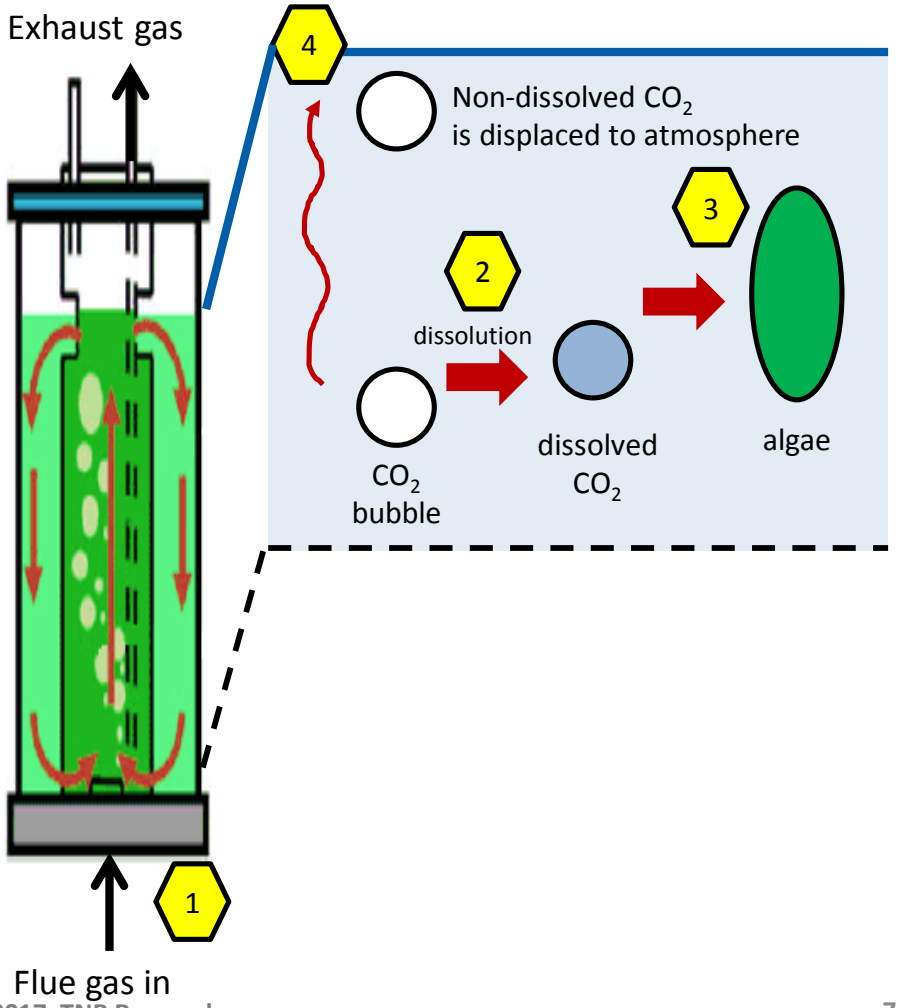


Bio-CCU Pilot Plant at Sultan Azlan Shah Coal-Fired Power Station

5. Bio-CCU research gap

CO_2 dissolution in microalgae culture limits application of Bio-CCU.
CO_2 gas easily lost to the atmosphere and burst premature, leads to low microalgae growth / carbon fixation rates.

1. Flue gas bubbled in through diffuser
2. CO_2 gas bubbles dissolved to liquid phase
3. Consumed by algae
4. Non-dissolved CO_2 gas dispersed to exhaust outlet



6. Technical Assessments

There are mainly three factors that affect the dissolution of CO_2 thus easily escape to the atmosphere which is; **(1)** CO_2 species formation **(2)** Microalgae – Bjerrum plot interaction **(3)** Air-Lift design via CFD assessment (upward flow)

1

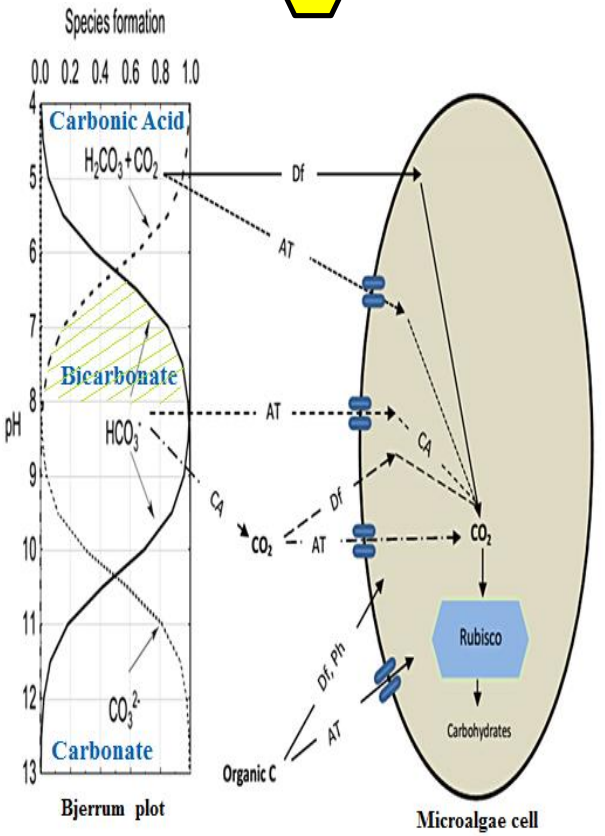
CO2 species formation

$$CO_{2(aq)} + H_2O \xleftrightarrow{pK_1 \approx 3.6} H_2CO_3^* \xleftrightarrow{pK_2 \approx 6.3} HCO_3^- + H^+ \xleftrightarrow{pK_3 \approx 10.3} CO_3^{2-} + 2H^+$$

where, $H_2CO_3^*$ refers to $CO_{2(aq)} + H_2CO_3$

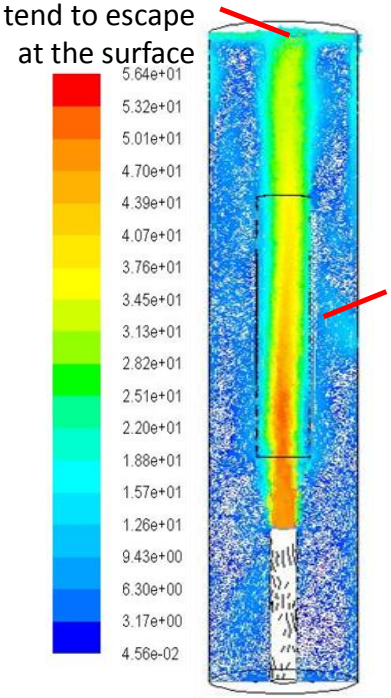
- Species formation of Inorganic carbon depends on pH values.
- Microaglae carbon up-take can work in passive or active transport
- Region pH 6 – pH 8 is preferable as it was optimal pH for algae growth as well as high concentration of bicarbonate promoting active transport

2



Microalgae -Bjerrum plot interaction

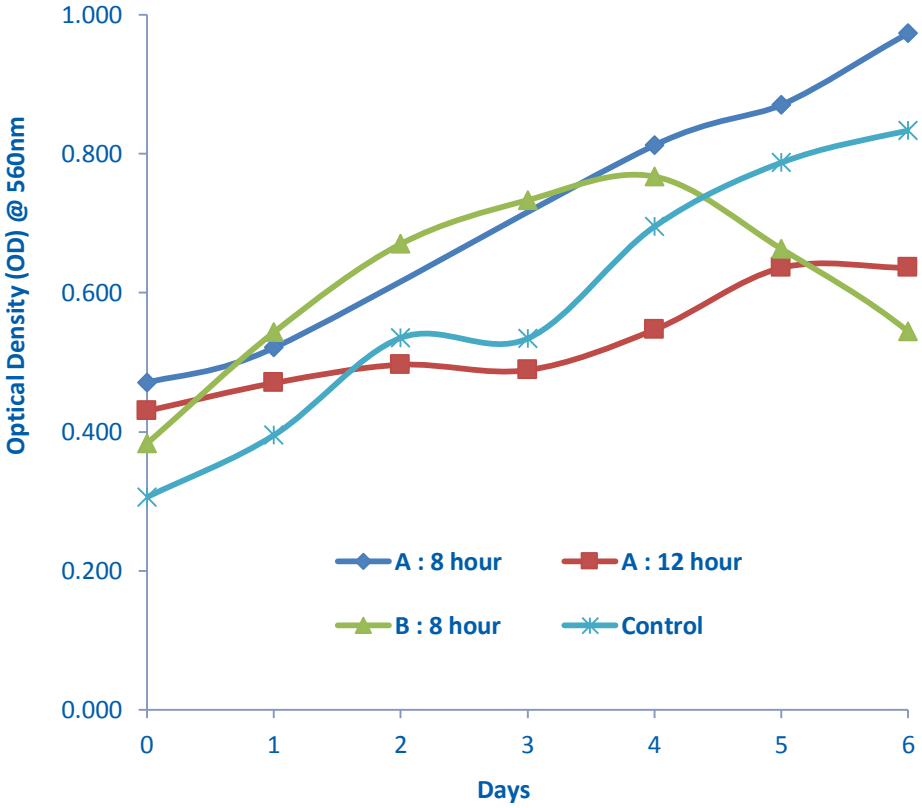
3

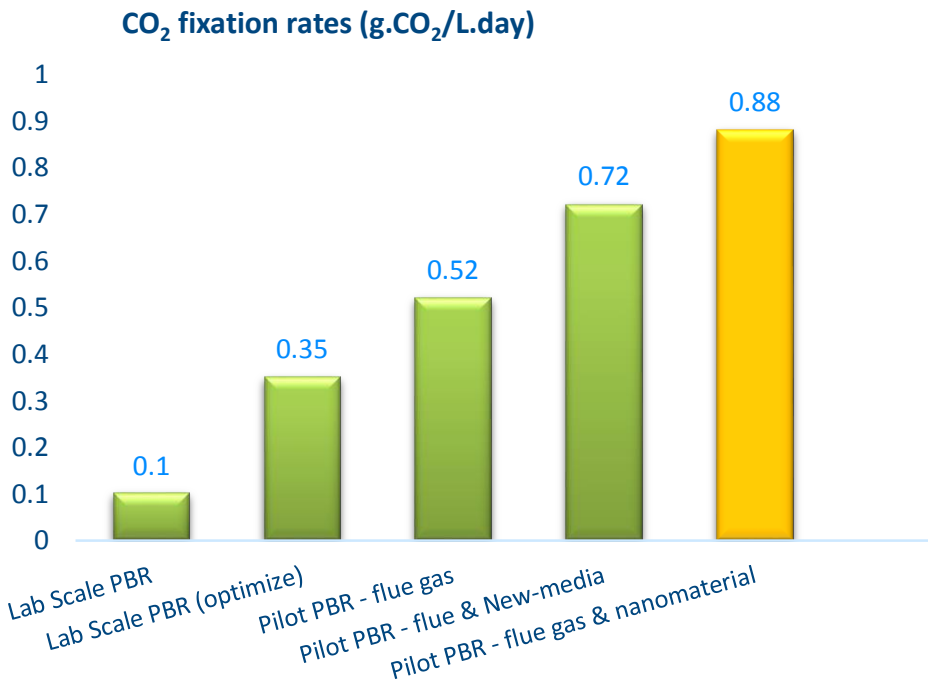


CFD assessment - Velocity vector in an air-lift bubbling column

6. Research findings

Effect of different type of nanomaterial (A & B) and CO_2 exposure time has been determined throughout the study. Incorporating Nano-device into microalgae culture improved the dissolution of CO_2 (dissolve inorganic carbon) - hasten the CO_2 fixation rate to 0.88 g.CO2/L.day





7. Future works

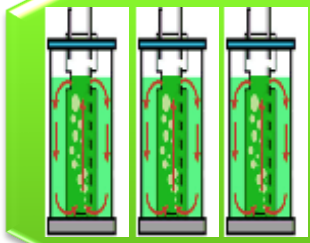
Focus shall be made in improving higher CO_2 fixation rate, high efficiency & low capex photobioreactor (PBR) as well as commercializing algal biomass via downstream process

CO_2 fixation

- Enzymatic technology
- Genetic modification
- Ionic-liquid technology

PBR design

- Cost-effective material
- Efficient lighting system
- Lesser biofilm



Downstream process

- Animal feed production
- Protein/Lipid extraction
- Bioenergy (EtoH/CH4/H2)
- Harvesting process

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THANK YOU

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