TNB RESEARCH

2017 IERE-TNB Putrajaya Workshop

Innovate With The End In Mind

PROMOTING CIRCULAR ECONOMY TO A COAL-FIRED POWER PLANT: OPPORTUNITIES AND CHALLENGES

Liyana Yahya, Muhammad Nazry Chik, Mohd. Hariffin Boosroh, Ir. Noraziah Muda and Afifi Zainal

- Renewable Energy and Green Technology, Advanced Research Program, TNB Research Sdn Bhd, MALAYSIA

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Contents

- TNBR at a glance
- What is Circular Economy (CE)?
- Why is CE important?
- TNBR's research agenda in CE
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TNBR in brief

A 100% TNB Owned Subsidiary since 1993, specializing in energy & environmental sector R&D, and Services.

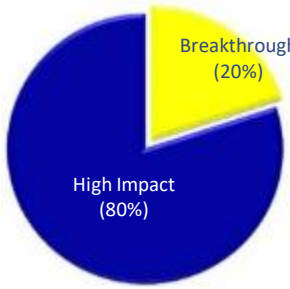
Established as a department in TNB, and evolved into a subsidiary in 1993.

In 1997, TNBR received approval from MIDA as an R&D status company

Eligible for many governmental incentives.

In April 2012, TNBR established its wholly owned subsidiary (TNBR QATS)

Leverage on Advanced & Accredited Laboratories and technical services business.



"Innovate with the End in Mind", focusing on Breakthrough research programs and Commercialization of research outcomes

Our Strength

317

Staff Composition

Technical Expert : 9
Doctorate : 20
Researchers : 99
TNBR QATS: 87
Technical Support: 48

5

Focus Areas

Applied: 3
Advanced Research: 2

‘Sustainability’ is becoming more & more important…

The notion of achieving sustainability has become a global agenda

Forbes Latest News

Morgan StanleyVoice: Is The Circular Economy The Next Disruptor?

NEW STRAITS TIMES

Sustainability, energy efficiency key to M'sia's future success: Energy Ministry

become a supporter theguardian

news / opinion / sport / arts / life

Is sustainability now the key to corporate success?

Our Plastic World: Promoting Sustainability Through a Circular Economy

Business News

Home > Business > Business News

Tuesday, 23 December 2014

Bursa unveils Environmental, Social and Governance Index

Gucci CEO unveils ten-year sustainability plan

- Cross & multi-level widespread to ministries, organizations & businesses
- Varying targets and approaches
- Sometimes as a pre-requisites towards good corporate financial performance

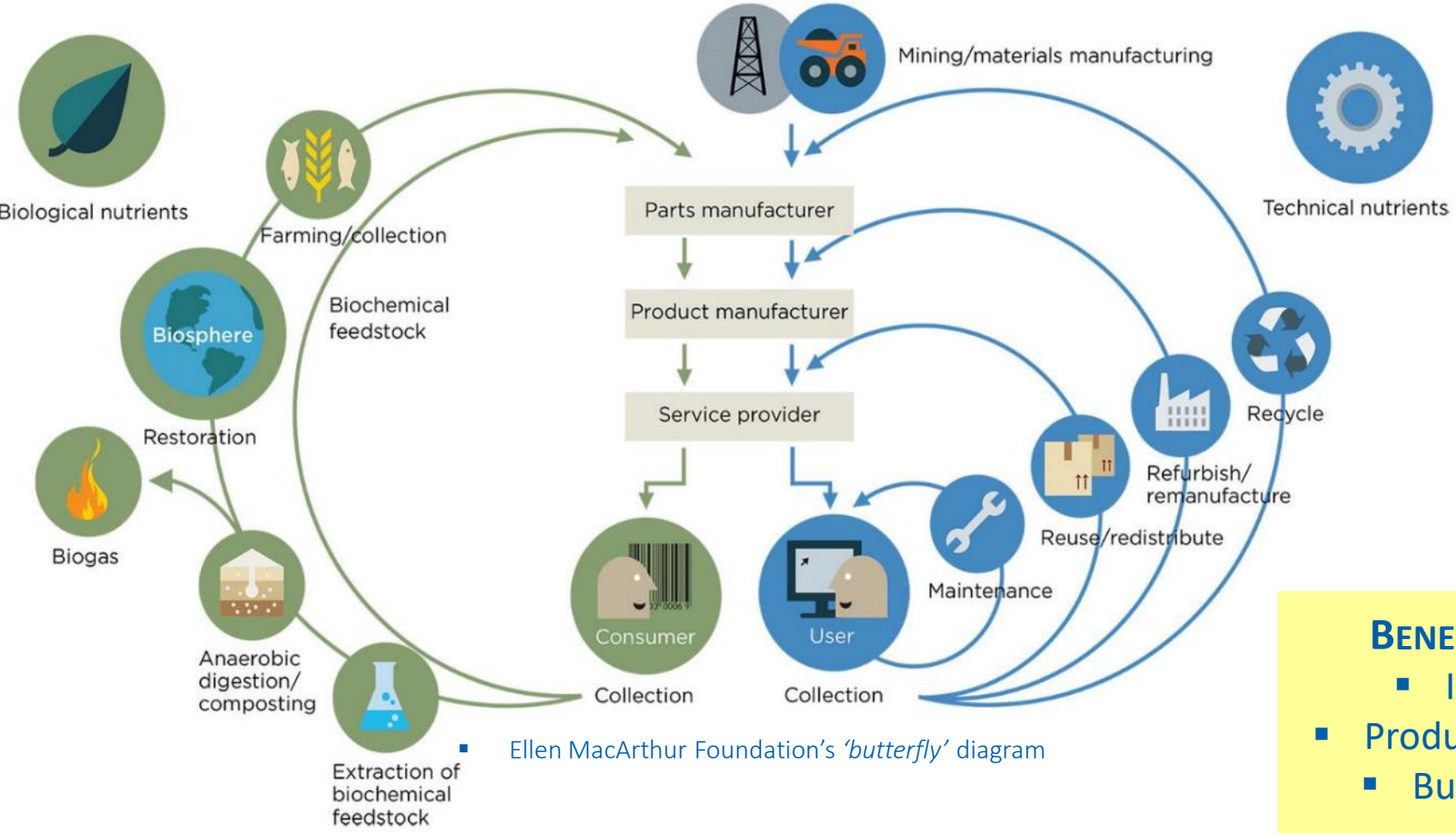
The emergence of Circular Economy

CE is a sustainable Development concept/framework aims to promote a more environmentally benign and innovative use of resources

- Current "Take-Make-Use-Dispose" one-way linear model contributes to un-sustainable development
- Signs of linear model deficiency:
  - Low efficiency gains in manufacturing process,
  - Slow productivity in agriculture, soil fertility & nutritional value of foods are declining
  - Risks to food security
- CE gained momentum in the late 1970s, due to efforts of academics, thought leaders and businesses
- Evolved and refined from various Sustainability concepts: **Regenerative Design, Cradle to Cradle, Industrial Ecology, Biomimicry, Permaculture**, etc
- Recent momentum has been catalysed by the Ellen MacArthur Foundation (EMF), a British charity established in 2010.
- Potential economic benefit from CE is estimated to be **USD 700 billion** in global consumer good materials savings alone

The emergence of Circular Economy

CE works via ecology of interacting components, exchange of material and energy flows, recycling patterns and environmental mimicry



- Ellen MacArthur Foundation's *'butterfly'* diagram

BENEFITS OF CE

- Innovation
- Productive land
- Business/job creation

What areas / industries we can apply Circular Economy?

Most notable are the ones affecting much to us, as consumers

FOOD & BEVERAGES
[USD 1.5 billion]

CLOTHING
[USD1,300/ton of used clothing]

PACKAGING
[USD 200/ton of plastic recycled]

ENERGY GENERATION?

Innovative suggestion

* Monetary figures are as per Ellen MacArthur Foundation's study in UK, released in 2013

Carbon Capture & Utilisation Research Station

A proactive move in managing CO2 as a waste from a live coal-fired power station , whilst adopting the Circular Economy concept

- **Location:** Stesen Janakuasa Sultan Azlan Shah, Seri Manjung, Perak
- 3x700 MW Bituminuous & sub-bituminous coal. Commissioned 2003
- **Year Set-up:** 2015
- **Research activities**
  - Technology / process cost reduction, process improvement & optimisation, improving life-cycle impact
- **Technology employed:**
  - Chemical approach: absorption/adsorption → methanation, chemicals/materials
  - Biological approach: microalgae → feedstock to aquaculture, nutaceuticals, bio-chemicals/materials

Philosophy behind our research program

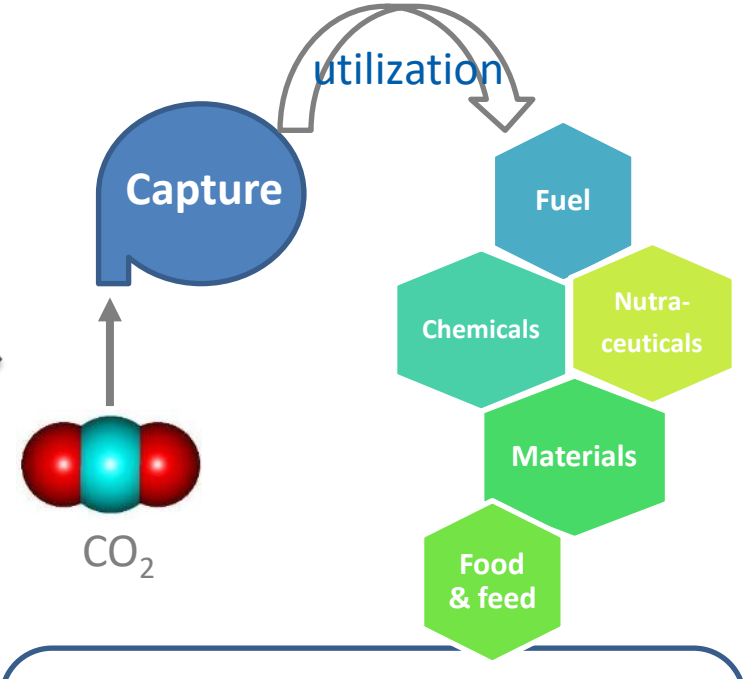
Is upon close environmental mimicry

NATURE

Thick forest, where interdependency and complementary functions between species and resources are best demonstrated.
No wastes, all up-cycled into new use

emulates

APPROACH



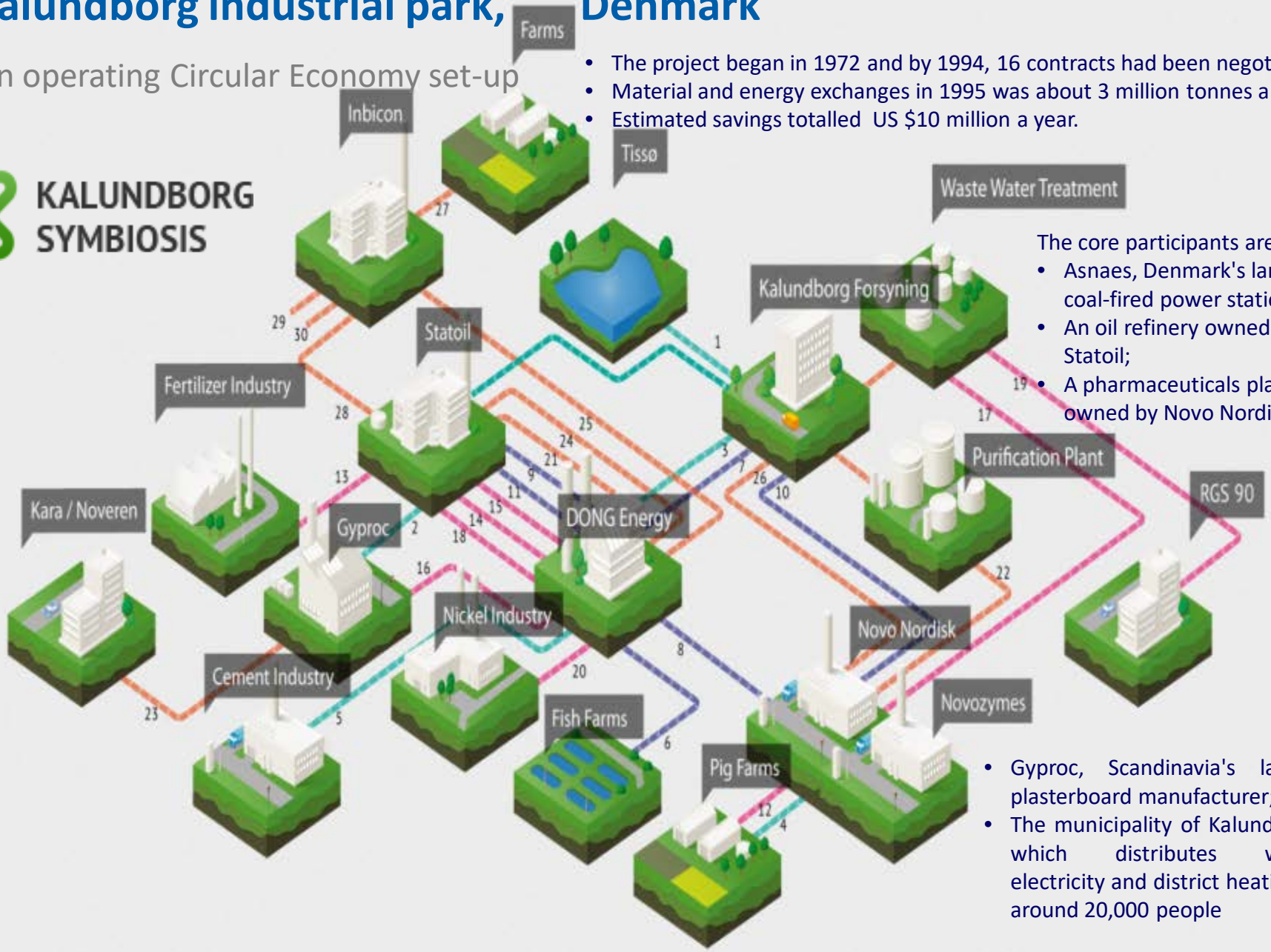
Turning CO2 (wastes) into valuable products, feeding various other industries

Kalundborg industrial park, Denmark

An operating Circular Economy set-up

- The project began in 1972 and by 1994, 16 contracts had been negotiated.
- Material and energy exchanges in 1995 was about 3 million tonnes a year.
- Estimated savings totalled US $10 million a year.

KALUNDBORG SYMBIOSIS



The core participants are:

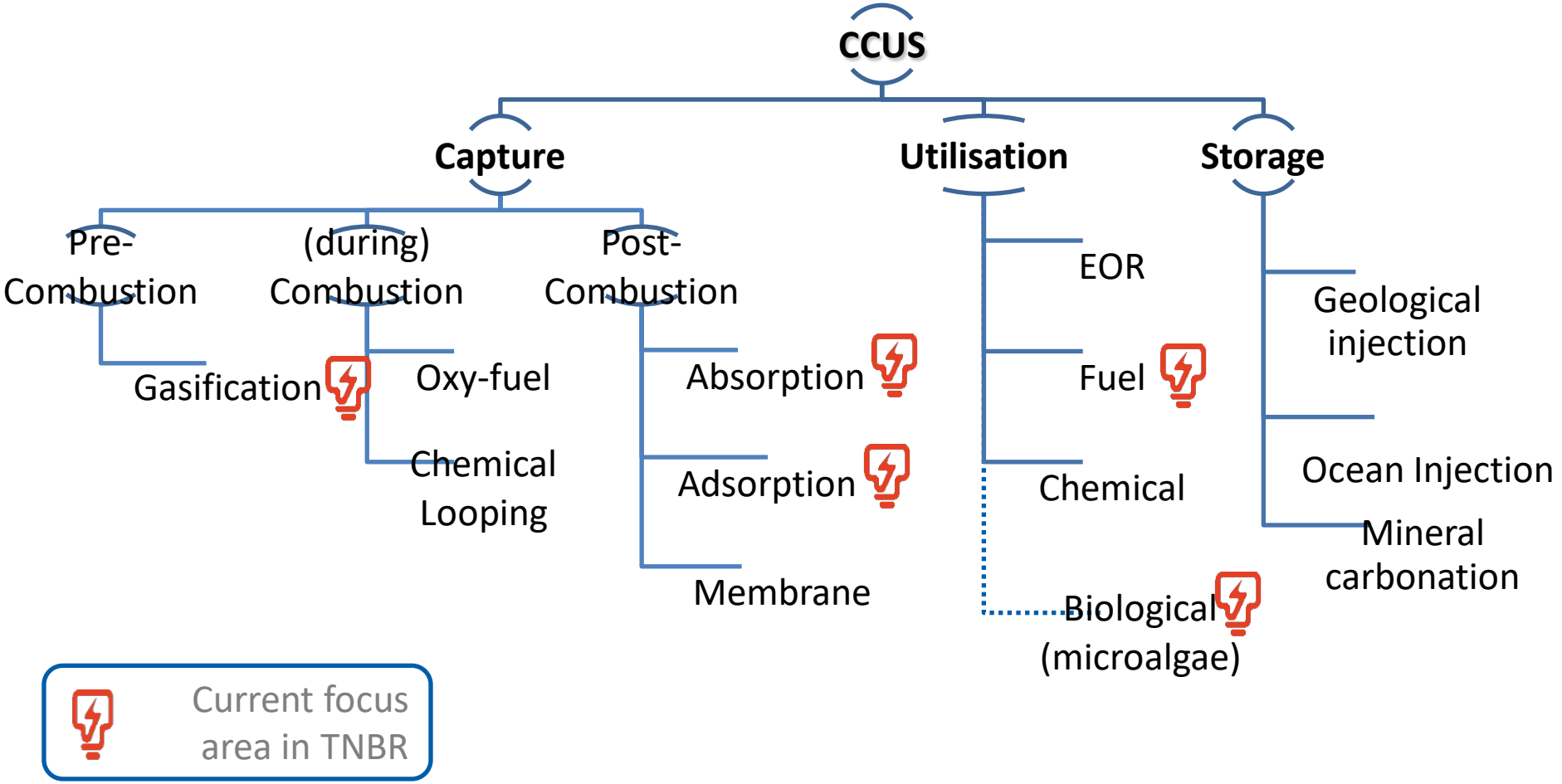
- Asnaes, Denmark's largest coal-fired power station;
- An oil refinery owned by Statoil;
- A pharmaceuticals plant owned by Novo Nordisk;

- Gyproc, Scandinavia's largest plasterboard manufacturer;
- The municipality of Kalundborg, which distributes water, electricity and district heating to around 20,000 people

Source: http://www.symbiosis.dk & www.iisd.org

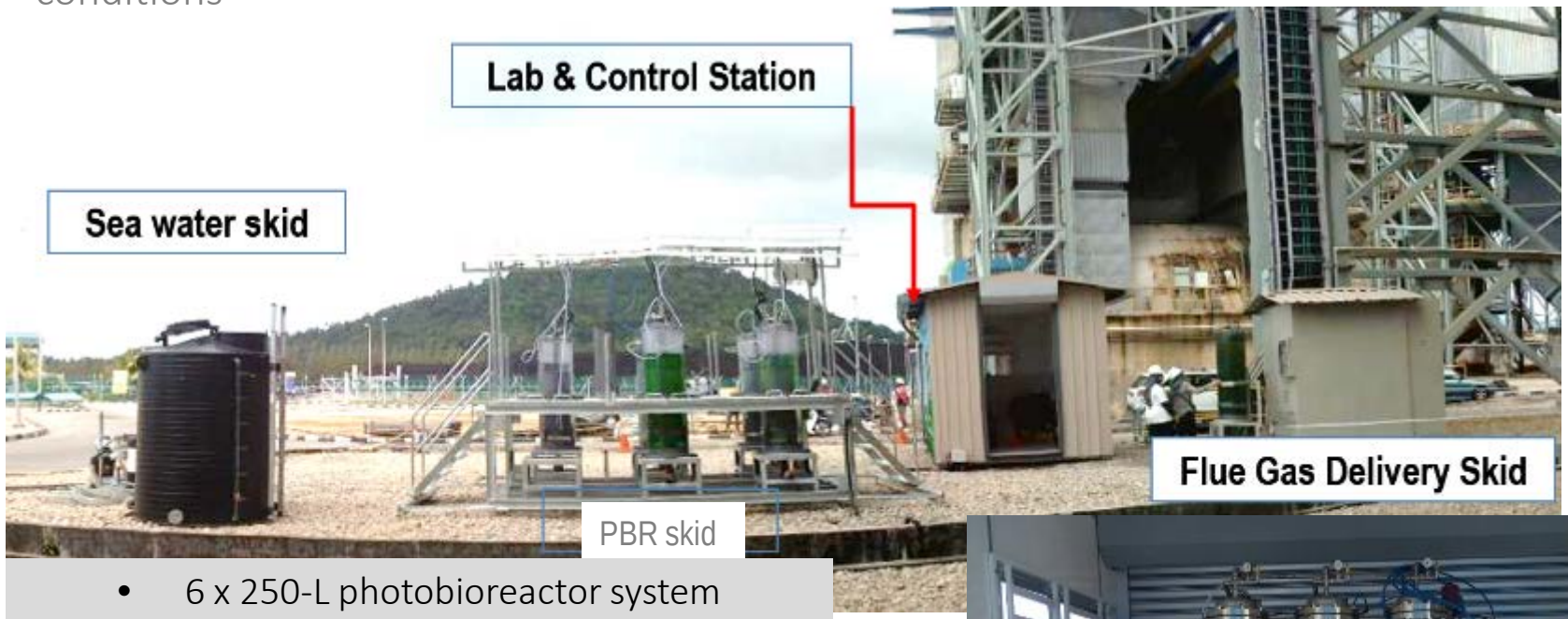
Carbon Capture, Utilisation & Storage (CCUS) Technology

CCUS is an important set of technologies for reducing GHG/CO_2 emission. What matters are how this set of technologies be integrated and employed in a sustainable approach



TNBR's Carbon Capture & Utilisation (CCU) Research Station

Research station was set-up as to study and improve CCU performance from actual conditions



- 6 x 250-L photobioreactor system

INNOVATION

- Nano-tier Device (PI 2017700590)
- Device to increase solubility of CO2 in microalgae culture

- 25 m3/hr vacuum pressure swing adsorption

Summary of CO2 capture projects & results, 2011 - 2016

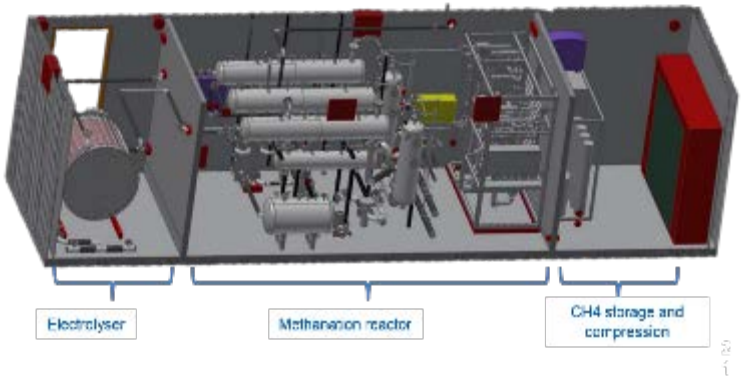
Total of 5 projects, RM 6.2 million

25 m3/hr Absorption Test Rig

A new blend of amine & activators reduce energy consumption by 23%

Impregnation of AC material with Metal Oxides improves adsorption selectivity

Ru/Pd/Mn/Al2O3 as the better catalyst for methanation process at 300°C



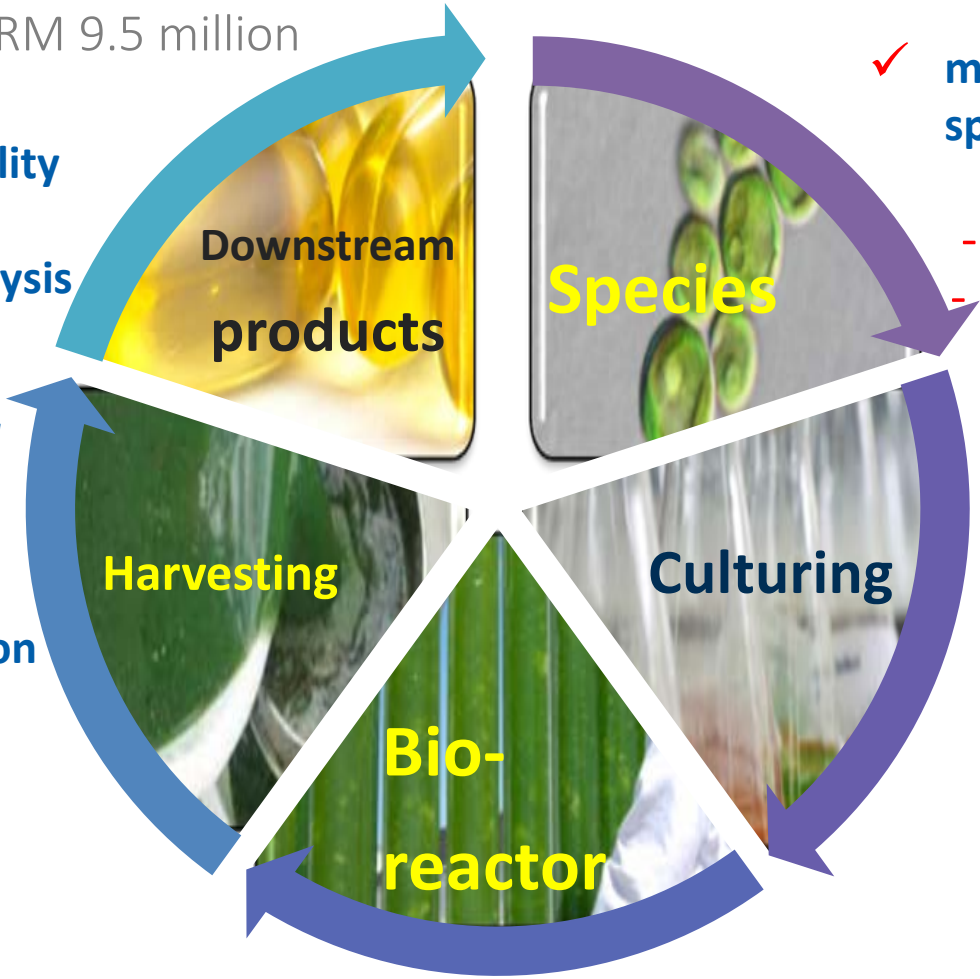
Leads to a new pilot scale of methanation project

INNOVATION

Method for producing impregnated activated carbon for selective removal of NOx and SOx over CO2

Research focus in biological CO_2 utilisation

Total of 7 projects, RM 9.5 million



- ✓ **Biodiesel suitability**
- ✓ **Bioactive compounds analysis**

[To be pursued more actively with other potential collaborator]

- ✓ **mono & consortium species**
  - *Isochrysis sp*
  - *Chlorella sorokiniana*
  - *Chlorella pyrenedoisa*
  - *Amphora sp.*

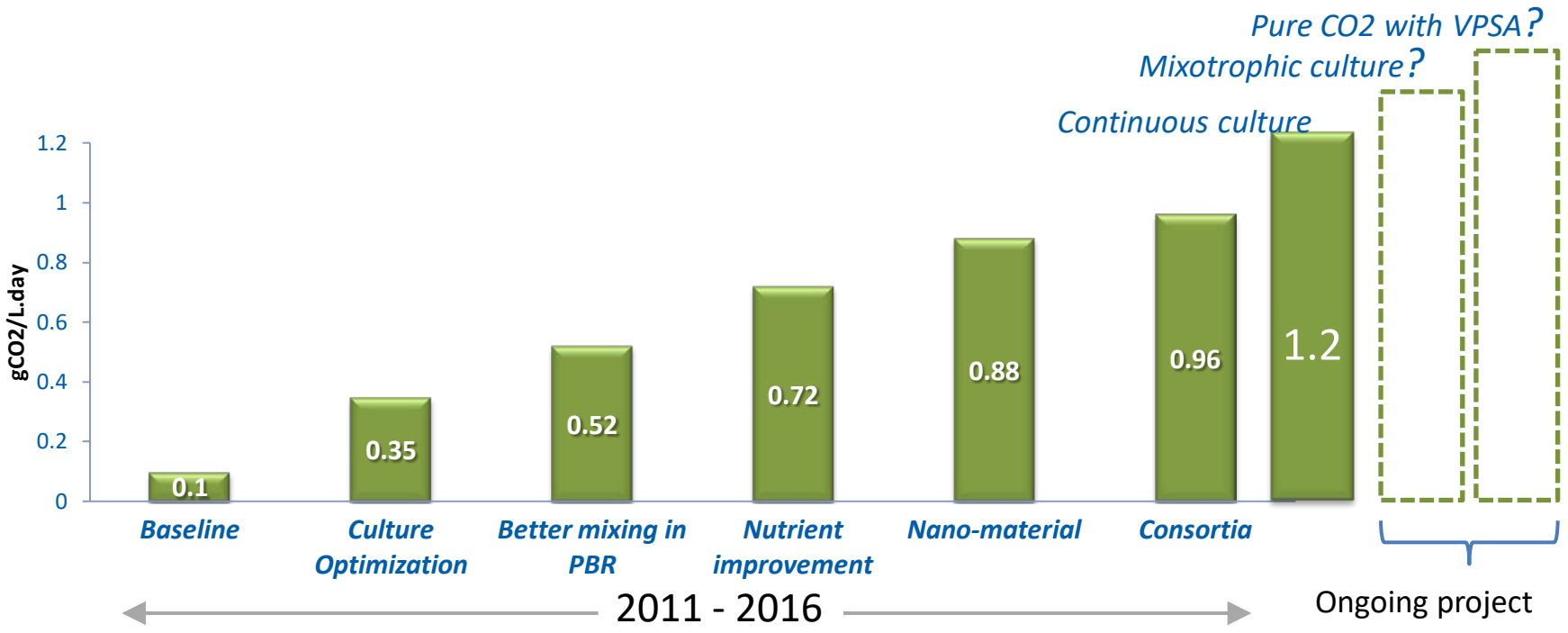
- ✓ **Optimisation of culture parameters**
- ✓ **Nutrient**
- ✓ **Culture techniques**
  - Continuous culture & automation

- ✓ **Bio-flocculation**

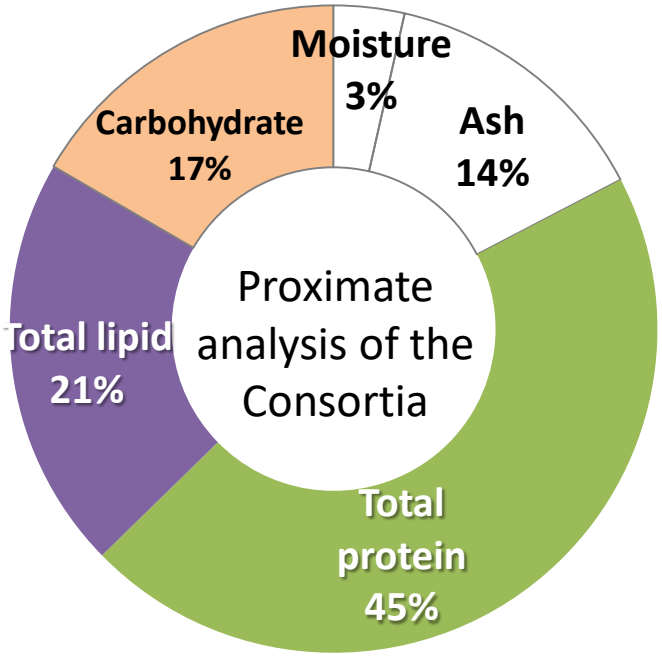
- ✓ **Design & engineering of pilot PBR plant**
- ✓ **Improvement of CO2 admission**

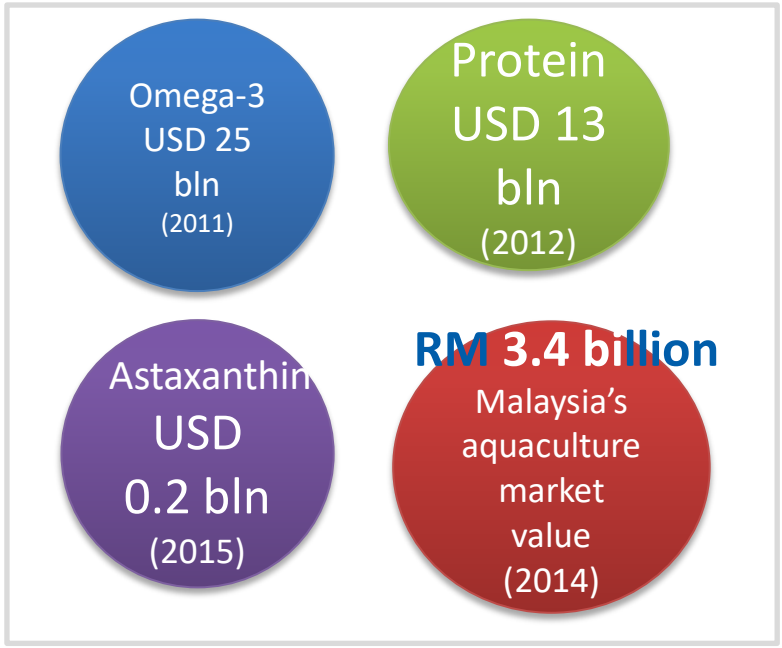
Summary of biological CO2 fixation rate achievement by microalgae consortia

Increasing trend was achieved and result is comparable to the next best: 1.88 g.CO2/L.day (S.H. Ho et al., 2011)



Economic opportunities from algal biochemical properties





Some bio-products market size

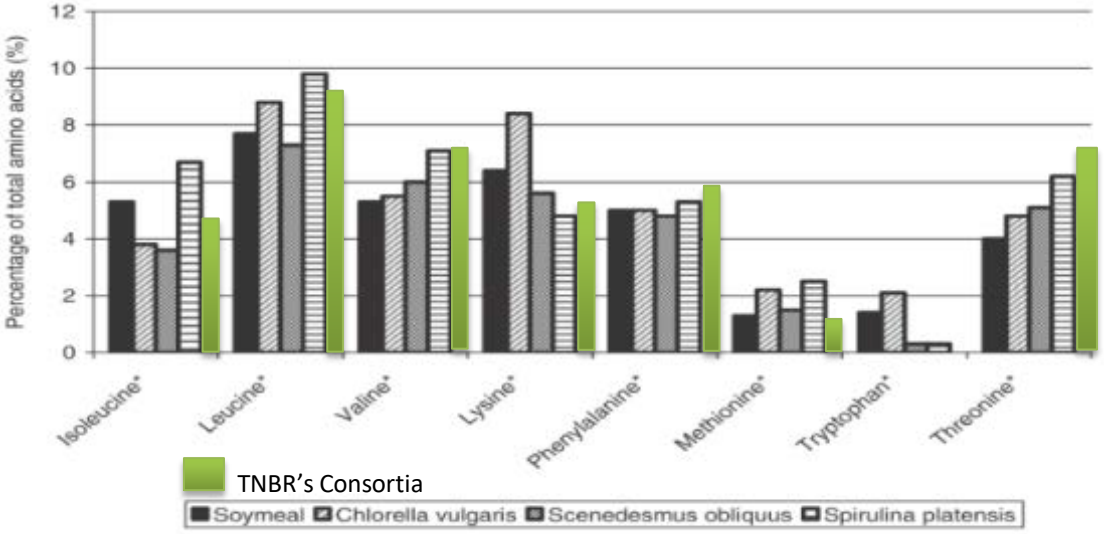


Fig. 2. Amino acid composition of soymeal and three different algal species (Becker, 2007).

Encouraging results on protein, amino acid & fatty acid content, makes microalgae prospective for downstream utilisation


Others wastes & resources that can support CE
CO2
H2 from ECP
Hydrokinetic potential from outfall
Robust algae
Exhaust heat as energy
Bottom ash minerals as adsorbent materials
Boiler blowdown chemicals as cheap nutrient

Conclusion

- Carbon Capture & Utilisation suits Circular Economy model, to ensure CO2 mitigation pursued in a sustainable manner
- Sufficient opportunities to support CE from a coal-fired power plant – wastes & un-tapped resources
- Challenges…
  - Process efficiency
  - Life cycle impact
  - System upfront cost
  - Business model

… can be overcame with continuous focused R&D & close Industry / Network supports

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Thank You

Renewable Energy & Green Technology Unit
TNB Research Sdn. Bhd.

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