THE EDGE MALAYSIA

SARAWAK MERDEKA 60 TAHUN
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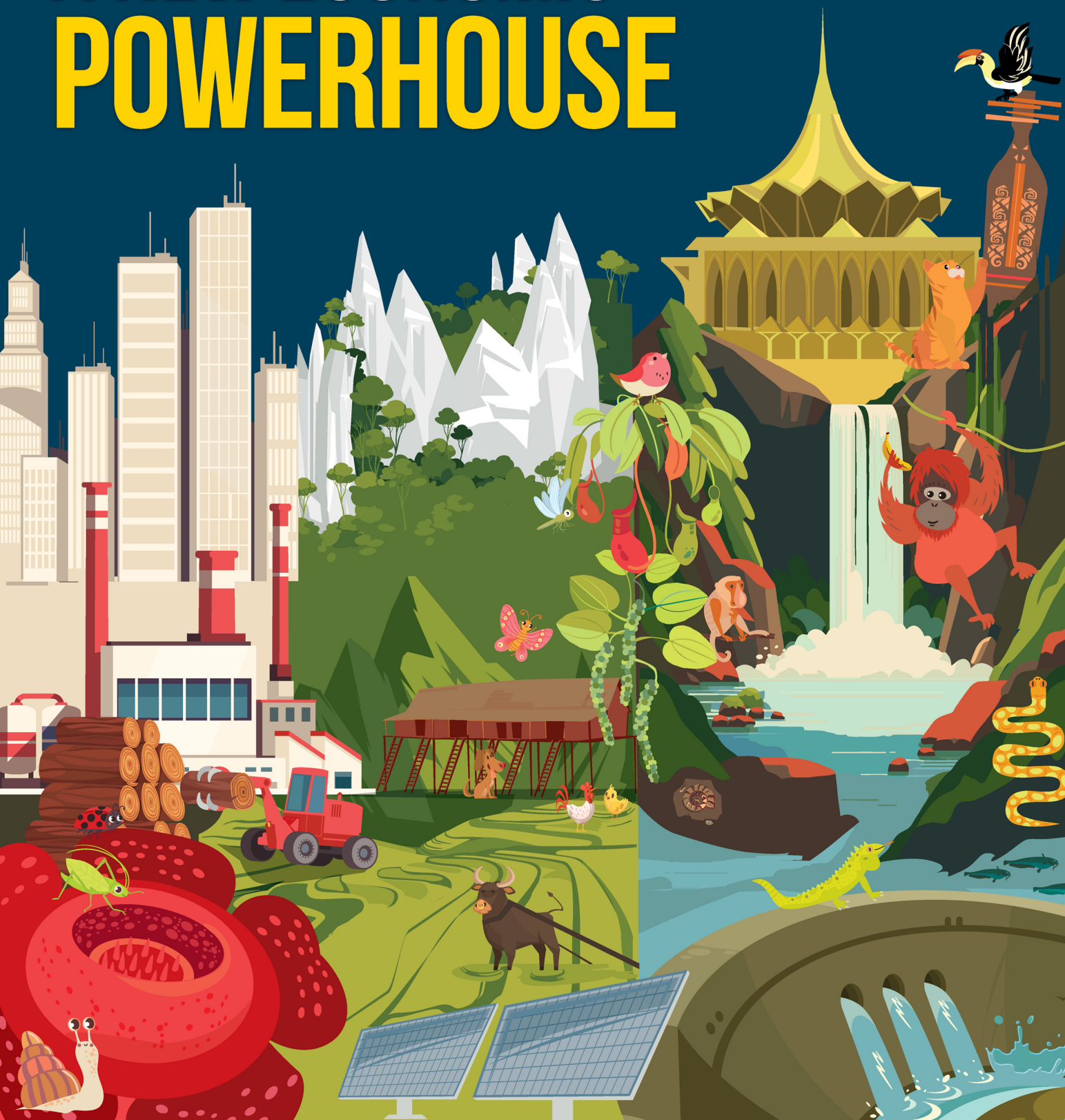
SARAWAK: A NEW ECONOMIC POWERHOUSE



ESG

A PROMISING GREEN FUTURE WITH MICROALGAE

BY PATHMA SUBRAMANIAM

SUSPENDED ON NEAT rows of horizontally erected metal railings on a 1,000 sq m pilot plot at the Sarawak Biodiversity Centre (SBC) in Semengoh, Kuching, are transparent rectangular plastic bags — known as flat-panel photo-bioreactors — containing swirling greenish slime growing on a steady diet of sunlight, water, carbon dioxide (CO2) and fertilisers.

The slimy substances are unicellular photosynthetic microorganisms — also known as microalgae — and the cornerstone to meeting Sarawak's sustainable energy agenda. It is the quintessence of a promising economically viable and environmentally friendly biofuel technology solution critical to the global transition to a cleaner energy alternative.

The world's reliance on non-renewable fossil fuels is becoming increasingly unsustainable, and its footprint on the environment and climate change is driving a global push towards adopting renewable energy sources, says Charlie Yeo, CEO of SBC.

Microalgae and their many uses have been steadily gathering scientific momentum for their unique features such as adaptability in growing in controlled laboratories as well as open ponds, high CO2-sequestering capability and high-lipid productivity.

Moreover, biomass can be processed for various commercial applications such as jet fuel, plastics production, paints, surfactants, truck fuel, proteins, feed for aquaculture and food products, as well as for pharmaceutical and cosmetics purposes.

For biofuel production, the raw component — or lipids — extracted from microalgae can be chemically converted into different feedstock for fuels.

"Algae is not only relevant as a big part of Sarawak's biodiversity, but they are also an important source that can be developed for renewable energy. The characteristics of algae include rapid growth rate, ability to be cultivated in non-arable land, and needing only light, warm temperature, water with nutrients and carbon dioxide to grow," says Yeo.

Sarawak is looking to reduce its carbon emissions by at least 30% to 40% over the next eight years as the state embarks on its low-carbon journey towards 2030. Premier Tan Sri Abang Johari Tun Openg emphasises that Sarawak aims to reduce its CO2 emissions by 600,000 tonnes a year by 2030.

According to research papers, to produce 1kg of dry biomass of algae, 1.88kg of CO2 will need to be absorbed or used.

Yeo says: "SBC is working on algae research and cultivation because Sarawak is moving to a sustainable bio-industry that is related to algae. Together with Japan's Mitsubishi Corp, we decided to address the issue of a global challenge by harnessing Borneo's microalgae biodiversity to produce biofuels and as a sustainable source. In 2012, we signed a research collaboration agreement to start exploring Sarawak's microalgae biodiversity as a potential source of renewable energy."

The microalgae project is funded through Mitsubishi Corp's wholly-owned company, Diamond Gas Holdings Sdn Bhd. "The partnership aims to open a new chapter in efforts to spur green technology innovations and offer an alternative to achieve sustainable renewable energy production," says Yeo.

"Microalgae is different from other plant-based feedstock biomass as it represents a complete biorefinery concept for obtaining multiple products from one strain. It does not compete for arable land, exhibiting a high growth rate and high lipid content. This makes algae an exciting addition to the sustainable fuel portfolio.

For every 1kg of dried algae biomass produced, about 1.8kg of CO2 is absorbed

PATRICK GOH/THE EDGE

The cost effective flat-panel photo-bioreactor system developed in-house by Sarawak Biodiversity Centre with Mitsubishi Corp and Chitose Laboratory, is built with smart digital monitoring and artificial intelligence for detecting contamination

"Also, microalgae is reported to be able to naturally fix CO2 from 10 to 50 times that of terrestrial plants to produce oxygen and generate value-added products."

The biological capture of CO2 using microalgae is considered an attractive solution for recycling the excess CO2 generated from, among others, heavy industries, transport and natural disasters such as volcanic eruptions and wildfires.

Although the partnership between SBC and Mitsubishi Corp was established in 2012, it was quite a challenge to set up the pilot facility in 2019, says Yeo.

Among the difficulties involved in the commercial deployment of microalgae biofuel technology, cost and efficient extraction of lipids remain a major bottleneck.

Algae cultivation facilities in the US and Japan commonly use tubular glass vessels to grow the substance, but it is a costly method. This is one of the reasons that has deterred commercialisation, despite much of the research on the usefulness of algae, he adds.

"One of the questions we often get from the public is, if microalgae is so good and can be used to make biofuel, how come no one in the world is pursuing this? Well, that is because wider adoption has been hampered by the cost of the entire process," says Yeo.

"To make it commercially attractive, algae production needs to be scalable and we need to be able to produce enough for a big supply. For that, we need to expand to 1,000ha to 5,000ha."

Moreover, unlike terrestrial oilseed crops, lipids cannot be pressed out of microalgae, considering its minute cell size, complex cell membrane, and thick and rigid cell wall. According to the research paper "Enhancement of lipid extraction from marine microalga, Scenedesmus, associated with high-pressure homogenisation process" published in the *Journal of Biomedicine and Biotechnology* in 2012, oil extraction from algae is performed using non-traditional, costly techniques such as organic solvents, electroporation, ultrasonic and supercritical CO2 methods.

Later studies and experiments on using durable plastic bags as simple photo-bioreactors instead of tubular glass vessels also drastically reduced the cost.

Despite the limitations, the SBC and Mitsubishi Corp partnership has endured, as the ample sun and rainfall makes Sarawak an ideal location for the microalgae farm, owing to the humid temperature throughout the year and abundance of fresh water, says Yeo.

"Sarawak is also strategically located to access major international markets such as Japan, Taiwan, China and Singapore, as well as having the availability of qualified and skilled local workforce."

EXPANSION PLANS

Ever since Abang Johari launched the pilot in 2019, SBC — the state's statutory agency in charge of harnessing traditional knowledge, bioprospecting and commercialisation of research — has been working to realise the state's agenda for diversifying its revenue stream with biofuels.

Yeo says: "SBC, together with our partners in the innovation cluster of Post-

Covid-19 Development Strategy 2030, are involved in the implementation of several of Sarawak's catalytic initiatives such as the establishment of the first Sarawak Bioindustrial Park, and the initial phase of the BioHub port project, which is related to biomass conversion and green innovations.

"Other projects under the PCDS 2030 cluster include commercialising digital-based research and development, and empowering digital and innovation ecosystems, as well as setting up a venture capital for investing in technologies."

Thanks to the successful pilot, the world's largest mass microalgae biomass production facility, Chitose Carbon Capture Central (C4), spanning about five hectares, is set for its official opening in Sejingkat, Kuching, in April.

The C4 is adjacent to the Sejingkat power station and Sarawak Energy Bhd (SEB) will supply exhausted gas containing CO2 for microalgae cultivation.

According to *Borneo Post*, Chitose Laboratory Corp executive officer and chief bioengineer Takanori Hoshino says the project — which is being funded by the Japanese government for about ¥2.5 billion (RM83.4 million) until 2024 — involves a collaboration with SBC, SEB and ENEOS Corp.

Once the five-hectare plant is rolled out, the plan is to expand the farm to 100ha in three years and 2,000ha towards 2030.

SBC's speciality is the ability to culture different species of algae and experience in operating a flat-panel photo-bioreactor system developed in-house over the last five years with Mitsubishi Corp and Chitose Laboratory, says Yeo.

The photo-bioreactor system is supported by smart digital monitoring and artificial intelligence for detecting contamination. These technology-aided tools have been very useful in developing algae-growing protocols, he adds.

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YEO

The pilot test beds have been crucial to determining the engineering requirements and cost analysis for a commercial-scale algae cultivation facility.

"Our focus on establishing the protocol for outdoor [field condition] pilot scale production of different species of algae enables the study of its production rate, the yield of components such as protein, carbohydrate, lipids and bioactive compounds that are important for the next stage of commercial production. It is also important to develop an economically viable media formula that will allow the cost for large-scale production, which can reach up to five million litres of culture, to be lower," he explains.

In collaboration with Mitsubishi Corp, the Japanese government and Chitose Laboratory between 2012 and 2020, SBC was able to establish that there was a "live" collection of more than 600 strains of algae from Sarawak.

"Sixty-five per cent of strains in the library were identified with known applications in biofuel, health supplements, pigments, nutraceuticals [nutrition that is also used as medicine] and cosmeceuticals. Interestingly, 35% of these strains have not been studied in terms of their potential industrial application," says Yeo.

Apart from the work SBC is undertaking, Petronas Research Sdn Bhd (PRSB), a subsidiary of Petroliam Nasional Bhd (Petronas), and SEDC Energy Sdn Bhd, a subsidiary of Sarawak Economic Development Corp (SEDC), signed an agreement on Jan 19 to develop technology for microalgae oil production.

Under the agreement — undertaken to further Petronas' "Net Zero Carbon Emissions by 2050" aspiration — PRSB and SEDC Energy will jointly develop algae production technology, which includes cultivation, harvesting and extraction of crude algae oil to be refined to produce sustainable aviation fuel.

Both parties will also dive into the commercial production requirements for crude algae oil, including developing algae strains with high oil content at a competitive production cost.

Microalgae can be processed for pharmaceutical and cosmetics purposes, in addition to commercial applications such as jet and truck fuel, plastics production and paints, among others