International Workshop: Future Perspective of Bioenergy Development in Asia

Session 5:
Future Perspective of Regional Development
1. Definition of Malaysia’s Bioeconomy
2. Malaysia’s Strength in Renewable Products
3. Portfolio Approach and Integration
4. The Bio-Hub Concept; A Circular Economy Model
5. Future Development:
   - Catalyst Project 1: Commercial Biohub & Bioport (Sabah)
   - Catalyst Project 2: 2g Sugar Biorefinery And Biohub (Johor)
   - Catalyst Project 3: 2g Biobutanol Project (Sarawak)
Definition of Bioeconomy in Malaysia vs Global

“Bioeconomy has been identified as a game changer for Malaysia’s economic growth. With our biodiversity and the abundance of biological resources, bioeconomy has the potential to increase the country’s economic competitiveness, create more job opportunities, enhance healthcare, ensure food security as well as address environmental and sustainability concerns.”
Prime Minister of Malaysia, BioMalaysia & Bioeconomy Asia Pacific, 2014

“Bioeconomy is the knowledge-based production and utilization of biological resources, innovative biological processes and principles to sustainably provide goods and services across all economic sectors”
Communiqué, Global Bioeconomy Summit 2015

“Bioeconomy is interpreted in different ways by different actors. The OECD supposes the bioeconomy to be the aggregate set of economic operations in a society that use the latent value incumbent in biological products and processes to capture new growth and welfare benefits for citizens and nations.”
OECD 2006, The Bioeconomy To 2030: Designing Policy Agenda

“The term "Bioeconomy" means an economy using biological resources from the land and sea, as well as waste, as inputs to food and feed, industrial and energy production. It also covers the use of bio-based processes for sustainable industries. Bio-waste for example has considerable potential as an alternative to chemical fertilizers or for conversion into bio-energy, and can meet 2% of the EU renewable energy target”
European Commission, Press Release 2012
Malaysia has the Right Ingredients to be the World Leader in the Production of Renewable Products

**BIO-RAW MATERIALS**

- **Cellulosic biomass**
  - Woody Biomass
  - Short rotation crops
    - napier grass, arundo
  - Palm residues
    - EFBs, PKC, PF
  - Fats, oils, greases ("FOG")

- **Palm residues**
  - crude palm oil
  - Glycerin
    - bio-diesel co-product
  - Animal fats
    - meat processing

**MANUFACTURING HUB AND PORT**

- **Infrastructure assets**
  - Utilities
    - power, steam, water
  - Process
    - Glycell™, H2, O2

- **Logistics**
  - inbound, outbound

**Production assets**

**Bio-PRODUCTS + DERIVATIVE PRODUCTS**

- **Bio-materials** (examples)
  - Plastics
  - Base oil
  - Consumer fibers
  - Rubber
  - Paints; solvents
  - Industrial fibers
  - Fertilizer
  - Consumer prod
  - Packaging
  - Specialty coatings

- **Bio-energy** (examples)
  - Bio and renewable diesel
  - Ethanol
  - Jet fuel
  - Power/heat
  - Hydrogen
  - Methane
  - Bunker fuel
We are Taking Portfolio Approach and Integration Allows a Sustainable and More Resilient Business Model
The Bio-Hub Concept; A Circular Economy Model

WASTE TO WEALTH: INNOVATION IN GREEN SECTOR

- Integrated Hub where waste streams of one company is the feedstock for the other

- In added value: Optimising existing volumes of feedstocks, products and side products that provide synergies for regional biobased industry or companies

- International Collaborations: strategic alliances with industrial companies and suppliers in container and bulk, and localised forestry and plantation waste feedstocks.

- Centralised Utility and Shared Infrastructure, A Plug & Play Model: Tank Storage for Edible Oil, Biofuels, Biopolymer/Biochemical and Agro/Biomass Terminal

- Clean and Renewable Energy for Power Production with Biomass Co-Firing using waste from BioHub

- In efficiency: optimal use of utilities, raw materials and residual streams from companies in various sectors, including a CO2.

- In public-private cooperation: businesses from various sectors, science and government create new investment opportunities, inclusive development model

- Localised knowledge & innovation: Platform for Development of Skilled Workers for BioProcess Industry and Maintenance with World’s leading (technical) universities. (Job Creation)
The Sabah Biomass Industry Development Plan can strengthen Malaysia’s proposition as the Premier Biomass Processing Hub

Could help Sabah capture:

- ~RM3.2 billion* additional revenue per year
- ~25,000+ new Green jobs
- ~RM13.5 billion in investments

Note: The forecast is based on dedicated feedstock supply and not taking into consideration feedstock sharing/optimisation.
Sandakan, Lahad Datu, and Tawau can mobilise 4.8 million dry tonnes of biomass with future potential in Labuk Sugut.
5 investments were identified as opportunities for Sabah within 10 years

1. Commercial-scale Teck Guan plant using EFB and fronds as feedstock
2. N-butanol plant in Tawau with remaining EFB and woody biomass as feedstock
3. Improvement of current pellet plants in Lahad Datu and Tawau to reach profitable commercial-scale industry
4. Integrated xylitol and ethanol plant in Lahad Datu using fronds as feedstock
5a. Integrated MEG and ethanol plant in Labuk Sugut with significant investment on infrastructure (jetty, roads, utilities)
5b. Bio-energy in Labuk Sugut with minimum infrastructure investment
The Sabah biomass industry offers several development opportunities over time

**Phase I (2016)**
- Bioenergy, pellet plants improvement
  - Due diligence for first chemical plants
  - 10 MW biomass power plant / few small plants
  - 3 pellet plants, 383k tons/yr (capture current capacity)
- Investments
  - 2.1 mn dry tons
  - ~200 mn MYR
  - 182 mn MYR
  - 758

**Phase II (2017-2022)**
- 1st wave of bio-based chemical plants
  - OPF mobilisation
  - 3.6 mn dry tons
  - 5.4 bn MYR
  - 1.4 bn MYR
  - 8,586

**Phase III (2022-2027)**
- 2nd wave of bio-based chemical plants
  - Large scale OPF mobilisation
  - 4.5 mn dry tons
  - 8.5 bn MYR
  - 2.1 bn MYR
  - 14,124

**Phase IV (2027-2032)**
- Additional plants
  - Integrated MEG plant
  - Integrated Xylitol plant
  - Integrated n-Butanol plant
- Investments
  - 4.8 mn dry tons
  - 13.5 bn MYR
  - 3.2 bn MYR
  - 25,384
Sarawak has the opportunity to become a leader in high-value biomass industries, and Asia’s First Integrated Biomass Hub

The Sarawak cluster could become Asia’s …

1st Commercial-scale biomass plantation
1st Multi-feedstock Biomass Hub
1st Bio-port
1st 2G Ethanol plant
1st 2G Bio chemicals plant

And could help Sarawak capture:

~RM4.8 billion* additional revenue per year
~35,000+ new Green jobs
~RM18 billion in investments

Note: The forecast is based on dedicated feedstock supply and not taking into consideration feedstock sharing/optimisation.
Sarawak can mobilise 6 million dry tonnes of biomass in 4 main clusters, Bintulu & Miri highest potential

Note: 1 Biomass of harvesting residues from timber and rubber plantations excluding natural forest
Within the next 6 years, 3 to 5 bio-based chemical plants could be established in the relevant clusters.

Sarawak Biomass Industry Development: Plan Phase I and II

1. 1 integrated commercial scale chemical plant in Miri using EFB as main feedstock
2. 1 integrated commercial scale chemical plant in Samalaju using EFB as feedstock
3. Brooke Renewables ethanol plant in Bintulu using dedicated short rotation crops as feedstock
4. For Kuching and Tanjung Manis each …
   a. A demonstration plant using EFB only, or
   b. A full-scale MEG or xylitol plant using EFB as feedstock, or
   c. A pellet plant using only EFB as feedstock
The available biomass at a competitive cost can support new investments in four phases over time

**Focus of evaluation**

**Sarawak biomass industry development plant**

**Phase I (2016)**
- Bioenergy, pellet plant
- Due diligence for first chemical plants
- SRC cultivation for Brooke
- Olive Energy (planned)
- Wood residues pellet plant in Bintulu (planned)

**Phase II (2017-2022)**
- 1st wave of bio-based chemical plants
- EFB mobilisation, SRC plantations
  - Brooke Renewables ethanol plant in Bintulu using SRC
  - 2 commercial scale biochemical plants in Miri/Bintulu using EFB
  - 1 demo scale biochemical plant in Tanjung Manis using EFB

**Phase III (2023-2027)**
- 2nd wave of bio-based chemical plants
- OPF mobilisation
  - Full-scale biochemical plant in Tanjung Manis using EFB and OPF
  - ~3 additional biochemical plants in selected locations using EFB/OPF (Miri, Bintulu, Samalaju)

**Phase IV (After 2027)**
- 3rd wave of bio-based chemical plants
- New plantations generate additional EFB and OPF supply
  - ~4 additional biochemical plants in selected locations using EFB and OPF. Exact location depends on new plantation area but ideally close to processing hubs.

**Investment**

**Biomass mobilized cumulative**

- 0.35 mn dry tons
- 2.1 mn dry tons
- 4.0 mn dry tons
- 6.0 mn dry tons

Note: The forecast is based on dedicated feedstock supply and not taking consideration of feedstock sharing/optimisation.
WHICH CHEMICALS DO WE CHOOSE? WE FOLLOW A 2-STEP APPROACH TO SELECT POTENTIAL CHEMICALS

1. Technical feasibility of 2G technology in 3-5 years
2. Market opportunity and cost competitiveness compared to conventional or 1G chemicals
### BIOMASS PRODUCT OPTIONS

#### SEVEN CHEMICALS PASSED THE FIRST SCREENING STEP

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>C5</th>
<th>C6</th>
<th>Cn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methanol</td>
<td>Ethylene</td>
<td>1,3-Propadienol</td>
<td>n-Butanol</td>
<td>Furfural</td>
<td>Sorbitol</td>
<td>PHA</td>
</tr>
<tr>
<td>Formic acid</td>
<td>Ethylene oxide</td>
<td>Ethyl lactate</td>
<td>1,4-Butadienol</td>
<td>Itaconic acid</td>
<td>Adipic acid</td>
<td>Para-xylene</td>
</tr>
<tr>
<td>Methane</td>
<td>Ethyl acetate</td>
<td>Isopropanol</td>
<td>Iso-butanol</td>
<td>Xylool</td>
<td>Ethylene</td>
<td>Dicarboxylic acid</td>
</tr>
<tr>
<td>Syngas</td>
<td>Ethanol</td>
<td>n-Propanol</td>
<td>Iso-butenes</td>
<td>Isoprene</td>
<td>Ethylene oxide</td>
<td>Fatty acid derivatives</td>
</tr>
<tr>
<td></td>
<td>Glycolic acid</td>
<td>Propylene glycol</td>
<td>Methyl methacrylate</td>
<td>Farnesene</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethylene glycol</td>
<td>Acetic acid</td>
<td>Succinic acid</td>
<td>Glutaric acid</td>
<td>Glutamic acid</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Xyritol</td>
</tr>
</tbody>
</table>

#### Many of the high growth chemicals such as lactic acid and succinic acid were screened out because of the early stage of 2G technology.

**SECOND SCREENING PROCESS RESULTS IN 3 CHEMICALS**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Market opportunities and cost competitiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ethylene</strong></td>
<td>Strong demand for bio-alternative from brand-owners but there is a major cost disadvantage compared to shale-gas based ethylene. The competitiveness of 2G to 1G ethanol as feedstock defines the cost position of ethylene from 2G sugars to sugarcane-based ethylene.</td>
</tr>
<tr>
<td><strong>Ethylene oxide</strong></td>
<td>Ethanol derivative, see above</td>
</tr>
<tr>
<td><strong>Furfural</strong></td>
<td>Current production consists of a large amount of small capacity plants concentrated in China. There are limited new projects and a fear of overcapacity. Pulp mills could produce furfural as a side product but there is not enough demand for such new volumes.</td>
</tr>
<tr>
<td><strong>Ethylene glycol</strong></td>
<td>One of the fastest growing sugar-based chemicals. Strong demand from consumer brands, particularly for 2G feedstocks. Direct conversion of 2G sugars is a much shorter production route than the commercial sugarcane ethanol or fossil ethylene based technologies.</td>
</tr>
<tr>
<td><strong>Propylene glycol</strong></td>
<td>Same technology with ethylene glycol but lacking as strong demand from consumer brands. Bio-based market is still limited in size with only few commercial producers.</td>
</tr>
<tr>
<td><strong>N-butanol</strong></td>
<td>Bio-based production route shorter than conventional fossil based process, and may benefit from the recent shale-gas boom. N-butanol is a commodity chemical but also potential biofuel component. Market opportunities in chemical applications will be determined by the competitiveness with fossil-based n-butanol.</td>
</tr>
<tr>
<td><strong>Xylitol</strong></td>
<td>Growing market as a sweetener and interesting potential as a chemical building block. Xylitol is a natural sweetener with less side-effects as artificial sweeteners, benefits for dental health, and lower calorific value than regular sugar.</td>
</tr>
</tbody>
</table>
**Biomass Product Options**

2. **2G Production Routes Are Much Shorter Compared to 1G Production Routes for the Selected Chemicals**

- **Conventional chemicals** are produced from fossil fuels (crude oil, natural gas, shale gas)
- **First-generation (1G) chemicals** are produced from sugars and starch (corn, sugarcane, wheat)
- **Second-generation (2G) chemicals** are produced from cellulosic biomass (corn stover, rice husk, other agriculture waste)

<table>
<thead>
<tr>
<th></th>
<th>Conventional (fossil)</th>
<th>1G sugar</th>
<th>2G biomass</th>
<th>n-Butanol</th>
<th>1G/2G biomass</th>
<th>Xylitol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene glycol</td>
<td>Crude oil</td>
<td>Naphtha</td>
<td>Ethane</td>
<td>Ethylene oxide</td>
<td>MEG</td>
<td>Sugar</td>
</tr>
<tr>
<td>1G</td>
<td>Sugar</td>
<td>Ethanol</td>
<td>Ethylene</td>
<td>Ethylene oxide</td>
<td>MEG</td>
<td></td>
</tr>
<tr>
<td>2G biomass</td>
<td>Biomass</td>
<td>Ethanol</td>
<td>MEG</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Conventional (fossil)**
- Crude oil
- Naphtha
- Ethane
- Ethylene oxide
- MEG

**1G sugar**
- Sugar
- Ethanol
- Ethylene
- Ethylene oxide
- MEG

**2G biomass**
- Biomass
- Ethanol
- MEG

**n-Butanol**
- Crude oil
- Naphtha
- Propane
- Propylene
- Butyraldehyde
- n-Butanol

**1G/2G biomass**
- Sugar/biomass
- n-Butanol

**Xylitol**
- Biomass
- Sulphite
- Xylose
- Xylitol

1 Pulp mill side-streams
A COMMERCIAL SCALE MEG PLANT REQUIRES 400-500KT OF BIOMASS AND CAN BE INTEGRATED TO ETHANOL PRODUCTION

**Biomass input**
- 400-500k dry tonnes EFB

**Chemical products**
- **Monoethylene glycol (MEG)**
  - 30 kt
  - 3.6 bn PET bottles
- **Monopropylene glycol (MPG)**
  - 30 kt
- **Bio-ethanol**
  - 75 kt
- **Lignin**
  - Plant’s energy consumption/ sale as pellets

**End-use applications**
- PET bottles
- Polyester fibers
- De-icing fluids
- Electronic cigarettes
- Tobacco products
- Pharmaceuticals
- Automotive fuel
- Hand sanitizer
- Hand sanitizer
XYLITOL IS USED AS A SWEETENER AND IS TYPICALLY INTEGRATED TO ETHANOL PRODUCTION

<table>
<thead>
<tr>
<th>Biomass input</th>
<th>Chemical products</th>
<th>End-use applications</th>
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</thead>
<tbody>
<tr>
<td>Biomass input</td>
<td>Chemical products</td>
<td>End-use applications</td>
</tr>
<tr>
<td>Biomass input</td>
<td>Bio-ethanol 115 kt</td>
<td>Automotive fuel</td>
</tr>
<tr>
<td>Biomass input</td>
<td>Xylitol 15 kt</td>
<td>Mint and chewing gum</td>
</tr>
<tr>
<td>Biomass input</td>
<td>Lignin</td>
<td>Plant’s energy consumption</td>
</tr>
</tbody>
</table>

20 Biomass input 400-500k dry tons fronds

Biomass input

400-500k dry tons fronds

Bio-ethanol 115 kt

Xylitol 15 kt
1.7 billion bottles of chewing gum

Lignin

Plant’s energy consumption

Main product
BIO MASS PRODUCT OPTIONS

**N-BUTANOL HAS VARIOUS APPLICATIONS IN FUELS/ CHEMICALS AND REQUIRES SIMILAR BIOMASS INTAKE FOR COMMERCIAL SCALE PLANTS**

<table>
<thead>
<tr>
<th>Biomass input</th>
<th>Chemical products</th>
<th>End-use applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>400-500kt EFB and woody biomass</td>
<td><strong>n-Butanol</strong> 95 kt</td>
<td><strong>Automotive fuel</strong></td>
</tr>
<tr>
<td></td>
<td>~1000 car/year at 15% blending</td>
<td><strong>Intermediate of other chemical products</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Textile</strong></td>
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<tr>
<td></td>
<td></td>
<td><strong>Brake fluid for automotive</strong></td>
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<tr>
<td></td>
<td></td>
<td><strong>Pharmaceuticals</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Acetone</strong> 15 kt</td>
<td><strong>Nail polish remover</strong></td>
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<tr>
<td></td>
<td></td>
<td><strong>Paints and varnishes</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>Pharmaceuticals</strong></td>
</tr>
<tr>
<td></td>
<td><strong>Lignin</strong></td>
<td>Plant’s energy consumption</td>
</tr>
</tbody>
</table>

*Main product*
KEY CONSIDERATIONS FOR BUILDING COMPONENTS TO MAXIMISE POTENTIAL

• Cost Competitiveness of Production in respective States based on Market Pricing compared to Petrochemical Means of Production

• Inclusiveness of the entire value chain and participation opportunities for local companies of all sizes

• Products that have regional demand and mass market appeal

• Sustainability issues addressed upfront
Malaysia has already implemented a wide number of incentives to facilitate further industry development

<table>
<thead>
<tr>
<th></th>
<th>Incentive Grant</th>
<th>Incentive Grant</th>
<th>Incentive Grant</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Feed-In Tariff (FiT)</td>
<td>Techno Fund</td>
<td>Investment Tax Allowances (ITA)</td>
</tr>
<tr>
<td>2</td>
<td>Domestic Investment Strategic Fund (DISF)</td>
<td>Intellectual Property Financing Scheme (IPFS)</td>
<td>Business Start-up Fund (MTDC)</td>
</tr>
<tr>
<td>3</td>
<td>Green Technology Financing Scheme (GTFS)</td>
<td>Pioneer Status</td>
<td>EPP 6 Developing Oleo Derivatives</td>
</tr>
<tr>
<td>4</td>
<td>Commercialisation of Research &amp; Development Fund</td>
<td>BioNexus Status</td>
<td>Credit Guarantee Corporation (CGC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Financing Support</td>
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</tbody>
</table>
Catalyst Project 1: Commercial Biohub & Bioport (Sabah)
The Gateway For Biobased Industry In South East Asia

The Sabah’s BIOBASED Industry Opportunity …

1st Certified Sustainable Forest
1st Multi-feedstock 2G BioHub
1st Bio-port
1st Wood Biorefinery
1st Dedicated Circular Economy and Waste Park

Could help Sabah capture:

~ 2500 new Green jobs
~ RM12 billion in investments
SIPITANG: The Location

Identified as the Most Strategic location due to:

- Ability to anchor hub on Sustainable Forest and expansion to other feedstock options
- Strategic location and components to catalyst the BioHub model:
  - Ownership of Strategic Assets SFI (Sabah Forest Industries); allowing possibility of integrated play
  - Interest from International Companies and Support from Foreign Governments

ACQUISITION OF DISTRESSED SFI ASSET
RM 1.2 Billion (SPA signed) ex. Reinvestment -10% paid
SUPPLEMENTARY FEEDSTOCK STRENGTHENS BIOHUB DEPLOYMENT
SABAH HAS GREAT BIOMASS AND WASTE RESOURCES FROM OIL PALM

THE BIOMASS CLUSTERS IDENTIFIED FROM LABUK SUGUT, SANDAKAN, LAHAD DATU, AND TAWAU WILL PROVIDE SUPPLY FOR SIPITANG BIOHUB WITHIN 200-260KM DISTANCE

- **23 million** (dry tonnes) of Palm Oil Waste throughout Sabah across 4 major clusters and more >100 mill operations*

- Decentralised production of intermediate products) allowing a Centralised Hub in Sepitang to high value added biomanufacturing

- Sabah’s opportunity maximised despite Security Concerns by Investors in the East Coast

*huge biochemical and downstream applications require around 500,000 dry tonnes of biofeedstock thus creating opportunity for multiple biorefineries in Sabah

Source: Sabah Biomass Industry Development Plan 2016 and NBS by AIM
Catalyst Project 2: 2g Sugar Biorefinery And Biohub (Johor) Biohub Development In Segamat

**Upstream – biomass supply chain**
- Agricultural waste value uplift
- Ancillary industrial and service opportunities
- Local employment (agricultural & industrial)

**Midstream – Biohub ecosystem**
- Technology transfer enables new industries
- Long-term national wealth creation
- Local employment (construction & industrial)

**Downstream products**
- Product differentiation
- Product expansion
- Global distribution

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**Segamat, Johor BioHub represents significant economic & social benefits…**

- **Opportunity**: Transition from the current crude oil-based economy to a more sustainable ‘green’ economy
- **Business**: Convert low value raw material (e.g. palm waste (EFB)) into high value chemical intermediates (e.g. C6, C5 sugars)
  - Ultra-clean C6, C5 sugars enable the production of even higher value, higher margin bulk and specialty chemicals

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<table>
<thead>
<tr>
<th>Projections for Phase I</th>
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<tbody>
<tr>
<td>Annual GDI:¹</td>
</tr>
<tr>
<td>Direct investment:</td>
</tr>
<tr>
<td>Construction jobs:¹</td>
</tr>
<tr>
<td>Manufacturing jobs:¹</td>
</tr>
<tr>
<td>Technology transfer:</td>
</tr>
<tr>
<td>Feedstock (dry):</td>
</tr>
<tr>
<td>Production:</td>
</tr>
</tbody>
</table>

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**Upstream**
- Palm oil mill

**Mid-stream**
- Intermediate production facility

**Downstream**
- Chemical, fuel production facility
Catalyst Project 3: 2g Biobutanol Project (Sarawak)
World’s 1st Integrated 2G Biobutanol Project

Value of investment: RM1 billion
Jobs creation: 750 jobs
Spill-over effect:
Local industry development
NEWS COVERAGE ON CURRENT PROJECTS
BioHub Projects under Development

LEAF – 2G SUGAR BIOREFINERY PLANT

US company to invest RM600mil in Segamat plant

TRADEWINDS GROUP - INTEGRATED BIOHUB

Ballarpur Industries to sell Malaysian unit for $ 310 mn

GS Caltex – 2G BIOPHUB PLANT

South Korea firm keen to invest in state’s biomass industry