THE UNTAPPED POTENTIAL OF OIL PALM BIOMASS AND ITS POTENTIAL APPLICATIONS

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Ministry of Plantation Industries and Commodities, Malaysia
• Introduction
• Types and quantities of oil palm biomass
• Potential Applications and Current Status
• Issues and Challenges
• Way Forward
• Conclusion
INTRODUCTION
Abundance of Oil Palm Biomass

- FRESH FRUIT BUNCH
- OIL PALM TRUNK
- OIL PALM FRONDS
- Palm oil mill effluent (POME)

10% oil
90% biomass

Crude Palm Oil & Crude Palm Kernel Oil

Shell
Meso carp fibre
EFB

Palm Biomass

Relatively Untapped

RM 53 billion Gross National Income mainly from this

Abundance of Oil Palm Biomass
A hectare of oil palm

Replanting OPT
- Dry wt: 74.48 tonnes/ha

Palm Fronds
(a) During replanting (Dry wt: 14.47 tonnes/ha)
(b) Annual pruning (Dry wt: 10.40 tonnes/ha)

Fresh Fruit Bunches (FFB)
- Annual product: 20.08 tonnes/ha
- Dry wt: 10.59 tonnes/ha

Empty bunches (EFB)
- EFB 22% FFB: 4.42 tonnes/ha
- Dry wt: 35% EFB = 1546 kg/ha

Mesocarp fibers: 13.5% FFB
- = 2.71 tonnes/ha
- Dry wt: 60% fibers = 1626 kg/ha

Sterilizer condensate
- 12% FFB = 2.46 tonnes/ha

Shell 5.5% FFB
- = 1.10 tonnes/ha
- Dry wt: 85% wet shell = 938 kg/ha

Hydrocyclone washing
- 5% FFB = 1.10 tonnes/ha

Effluent

Centrifugal sludge
- 50% FFB = 10.04 tonnes/ha

DISTRIBUTION OF OIL PALM BIOMASS
### OIL PALM BIOMASS IN 2009

<table>
<thead>
<tr>
<th>No.</th>
<th>Biomass</th>
<th>Amount (dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>OPF (from pruning activity) OPF (from replanting activity)</td>
<td>42.21 million tonnes 3.28 million tonnes</td>
</tr>
<tr>
<td>2.</td>
<td>OPT (~5% replanting rate)</td>
<td>33,299,000 trunks 17.5 million tonnes</td>
</tr>
<tr>
<td>3.</td>
<td>From the 415 palm oil mills operating at total capacity of 95.40 million</td>
<td>20.99 million tonnes</td>
</tr>
<tr>
<td></td>
<td>tonnes of FFB, ~ Estimated EFB = 22% x 92 million tonnes</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Mesocarp fibers</td>
<td>7.73 million tonnes</td>
</tr>
<tr>
<td>5.</td>
<td>Palm kernel shells</td>
<td>4.46 million tonnes</td>
</tr>
<tr>
<td>6.</td>
<td>POME generated from per tonne of FFB is about 67%</td>
<td>62 million tonnes ** (million M³)</td>
</tr>
</tbody>
</table>
POTENTIAL APPLICATIONS OF OIL PALM BIOMASS

- BIOFERTILIZER
  - Mulch*
  - Compost*
  - Heat & Power*
- RENEWABLE ENERGY
  - Solid, liquid and gas bio-fuels **
  - MDF**, Plywood, Fibremats etc.
- BIO COMPOSITE & AGRO-PRODUCTS
  - Cellulose, **
  - Lignin, Vitamin E, Carotenes, Squalene, etc.
## Current Biomass Utilisation (EFB and POME)

**EFB:**
- Mulching: 41%
- Multiple applications including mulching: 39%
- Fiber processing: 3%
- Biofertiliser/composting: 3%
- Boiler fuel: 3%
- Incineration: 10%
- Others: 1%

**POME:**
- Biogas Trapping Facility*: 7%
- Open ponding: 73%
- Open digester: 6%
- Tertiary Treatment: 6%
- Compost: <1%
- Others: ~7%
BIOFERTILIZER APPLICATIONS
CURRENT APPLICATIONS

Normal composting and application in the oil palm plantation

Mulching Mat
PRODUCTION OF COMPOST FROM EFB AND EFFLUENT – ASIA GREEN
Innovative replanting technique – Young palms planted into residue rows
Improved accessibility & efficiency of nutrient
Able to reduce 50% of fertilizer input
Pruned Fronds Stacking - Mulching
OPT being shredded and use for land application, act as natural fertilizer to the soil
### Fertilizer Equivalent of Oil Palm Biomass at Replanting

(Tonnes / Ha.)

<table>
<thead>
<tr>
<th>A/S</th>
<th>CIRP</th>
<th>MOP</th>
<th>KIES.</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.06</td>
<td>0.37</td>
<td>2.77</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Theoretically can supply N, K, Mg for 5-6 years and P for 2 years.
RENEWABLE ENERGY
RENEWABLE ENERGY (RE) DEVELOPMENT FOR OIL PALM INDUSTRY

Untapped Potential of Oil Palm Biomass:
• As fuel for combined heat and power (CHP)/power generation
• For conversion to transportable 1st generation biofuels.
• For conversion to 2nd generation biofuels
# PROPERTIES OF VARIOUS OIL PALM BIOMASS

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture Content, %</th>
<th>Calorific Value (CV), Average (MJ/kg)</th>
<th>CV, Range (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil palm Biomass</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFB</td>
<td>66 - 69</td>
<td>18.88</td>
<td>18.00 - 19.92</td>
</tr>
<tr>
<td>Mesocarp fibre</td>
<td>35 - 48</td>
<td>19.06</td>
<td>18.80 - 19.58</td>
</tr>
<tr>
<td>Shell</td>
<td>11 - 13</td>
<td>20.09</td>
<td>19.50 - 20.75</td>
</tr>
<tr>
<td>Oil palm frond (replanting &amp; pruning)</td>
<td>62 - 77</td>
<td>15.72</td>
<td>15.40 - 15.95</td>
</tr>
<tr>
<td>Oil palm trunk (replanting)</td>
<td>67 - 81</td>
<td>17.47</td>
<td>17.00 - 17.80</td>
</tr>
<tr>
<td>POME</td>
<td>90 - 95</td>
<td>16.99</td>
<td>16.10 - 17.65</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Commercial Fuels</th>
<th>(MJ/kg)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bagasse, Cereal Straw</td>
<td>19.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illinois bituminous, Coal (Anthracite)</td>
<td>28.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North Dakota lignite, Coal (lignite)</td>
<td>27.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reed Sedge peat</td>
<td>14.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Commercial Fuels</th>
<th>(MJ/m³)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>37.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LPG</td>
<td>93 - 124</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Oil Palm Biomass as Fuel for CHP / Power

- All palm oil mills use palm residue (palm shell and mesocarp fibre) for CHP generation for process steam and electricity for the mill.

- EFB and biogas from POME also used to generate power for on-grid and off-grid purpose.
### Max RE Potential* from EFB and POME

### RE Target for On-Grid Connection

- **Malaysia plans to generate 8% or 2,560 MW of the National Grid load from RE, most of which will be from Palm Oil Biomass or Biogas.**

<table>
<thead>
<tr>
<th></th>
<th>tonne/year (mil.)</th>
<th>Peninsular (MW)</th>
<th>Johor</th>
<th>Kedah</th>
<th>Kelantan</th>
<th>Melaka</th>
<th>N. Sembilan</th>
<th>Pahang</th>
<th>Perak</th>
<th>P. Pinang</th>
<th>Selangor</th>
<th>Terengganu</th>
<th>Sabah (MW)</th>
<th>Sarawak (MW)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EFB</strong></td>
<td>20</td>
<td>626</td>
<td>183</td>
<td>19</td>
<td>17</td>
<td>7</td>
<td>36</td>
<td>168</td>
<td>120</td>
<td>3</td>
<td>42</td>
<td>31</td>
<td>330</td>
<td>109</td>
<td>1065</td>
</tr>
<tr>
<td><strong>POME</strong></td>
<td>58</td>
<td>159</td>
<td>46</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>9</td>
<td>43</td>
<td>30</td>
<td>1</td>
<td>11</td>
<td>8</td>
<td>84</td>
<td>27</td>
<td>270</td>
</tr>
<tr>
<td><strong>Installed Capacity</strong></td>
<td>-</td>
<td>20,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>720</td>
<td>950</td>
<td>21,670</td>
</tr>
<tr>
<td><strong>Current Demand</strong></td>
<td>-</td>
<td>12,500</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>720</td>
<td>950</td>
<td>14,170</td>
</tr>
</tbody>
</table>

* Assuming 100% EFB & POME are utilized. Total MW will reduced proportionately according to actual % utilisation of EFB & POME.
OIL PALM BIOMASS – AS SOLID FUEL FOR POWER GENERATION
Mesocarp fibre and shell – main fuels for combined heat and power (CHP) plant used in palm oil mills

Off-grid energy generated from shell and fibre used in POMs in year 2009 (based on 415 mills, 88.74 million tonnes of FFB processed at 20 kwh/tonne) was 1714 GWh

At 400 hrs/month, total off grid generating capacity was 357 MW
EFB Pretreatment Plant for EFB Fibre (Fuel Preparation)

• EFB requires physical pretreatment to reduce size and moisture content to enable EFB be more efficient to be used as fuel

• EFB in fibrous form can be potential as feedstock for various technology of solid fuels or for 2nd Generation Biofuel
Briquetting & Pelletizing

- Process of compressing/ compacting the loose biomass into shape of briquette and pellet via mechanical treatment for easy handling, transportation and storage of material.

- Typical diameter sizes: briquettes Ø < 9cm, pellet Ø <1cm

- Can be further treated into charcoal or torrefied pellet / briquette
Torrefaction & Carbonization

- Process of heating of biomass in the absence of $O_2$ to a temperature of 200 – 300º C within certain retention time. The process will reduce the weight of the biomass and increase the CV.

- The loose torrefied and carbonized biomass could be pelletized into uniform fuel
EFB PRE-TREATMENT TECHNOLOGY FOR FUEL PREPARATION

1. Empty Fruit Bunches
   → Screw press cum shredder
   → Hammer mill
   → EFB Juice for Oil Recovery
   → EFB fibre as fuel
   → Dry and short EFB Fibre as feedstock for the production of briquettes and pellets fuel
   → Post Treatment – Drying
   → Biomass boiler / power generation
UNIFORM-SOLID FUELS FROM OIL PALM BIOMASS (EFB FIBRE, BRIQUETTES & PELLETS)

Palm biomass briquettes – piston press technology

Charcoal briquettes

Biomass Pellet

Palm Biomass Briquettes – Screw Extrusion Technology

Torrefied Pellet

Fibrous EFB & Bale
Briquetting is a process of converting low bulk density biomass into uniform and higher density solid fuels at high pressure and temperature.

Two types of biomass used: EFB fibre and palm shell.

Characteristics:
- Calorific Value 17895 – 18235 kJ/kg
- Moisture content < 6.0%
- Ash content < 6.0%
- Specific Density 1100 – 1300 kg/m³
PRESENT & POTENTIAL USAGE OF EFB AND PALM BIOGAS AS RENEWABLE ENERGY FUEL

• EFB Fibre and biogas from POME is also being used to produce energy to a limited extent in palm oil complexes or mills that require extra energy for downstream activities (KCP, EFB Fibre Plant)

• EFB fibre – being used as substitutes to fossil fuel (diesel, coal & medium fuel oil) especially in palm oil mill complex (refinery & kernel crushing plant) and other industries.
Identified as main feedstocks for Small Renewable Energy Power Programme, SREP (grid connected power plant) & CDM (mitigation of Greenhouse Gases, GHG) projects

EFB can be upgraded into useful and uniform solid fuels (briquettes & pellet, charcoal)

Feedstocks for the development of 2nd generation biofuel
## STATUS OF SREP PROJECTS

<table>
<thead>
<tr>
<th>Type of Fuel</th>
<th>No of approved project</th>
<th>Total installed capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mini Hydro</td>
<td>13</td>
<td>61.3</td>
</tr>
<tr>
<td>Palm biomass</td>
<td>19</td>
<td>189.0</td>
</tr>
<tr>
<td>Palm biogas</td>
<td>6</td>
<td>7.85</td>
</tr>
<tr>
<td>Others</td>
<td>5</td>
<td>28.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>43</strong></td>
<td><strong>286.15</strong></td>
</tr>
</tbody>
</table>

To date, 10 projects are in operation with total installed capacities of 56.7 MW

* 5 projects use palm biomass and biogas with total installed capacities of 41.7MW
SECOND GENERATION BIOFUELS – PALM LIGNOCELLULOSIC BIOMASS
BIOMASS TO LIQUID (BTL)

- Bio-oils
  - Carbonisation slow & Fast
  - Pyrolysis, Rapid Thermal
    Processing (RTP), BTG

- Synthetic diesel
depolymerisation
  - Thermal/Catalytic

- Bioethanol
  - Pretreatment
    - Fermentation
    - Thermomechanical/
      Thermochemical hydrolysis,
      mechanoenzyme

- Hydrocarbon
  - fuel
    - Hydrotreating/hydrogenation,
      catalytic cracking, Hydrocracking,
      Fischer-Tropsch
COMMERCIALIZATION OF 2ND GENERATION BIOFUEL

- Under NKEA – palm oil sector: one initiative is to set up commercial bio-oil plant using EFB as feedstock.
## Pyrolysis of Palm Biomass

### Products - Bio-oil, biochar and gas

<table>
<thead>
<tr>
<th>Properties of bio-oil</th>
<th>Temperature (°C)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>400</td>
<td>500</td>
<td>600</td>
</tr>
<tr>
<td>Calorific Value (MJ/kg)</td>
<td>20.23</td>
<td>21.41</td>
<td>21.17</td>
</tr>
<tr>
<td>Total Ash, %</td>
<td>0.49</td>
<td>0.65</td>
<td>0.37</td>
</tr>
<tr>
<td>pH</td>
<td>3.4</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>17.89</td>
<td>18.74</td>
<td>18.21</td>
</tr>
<tr>
<td>Density (g/cm³)</td>
<td>1.00</td>
<td>0.90</td>
<td>0.99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of Oil Palm Biomass</th>
<th>Bio-oil (%)</th>
<th>Char (%)</th>
<th>Gas (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFB</td>
<td>38.28</td>
<td>23.05</td>
<td>38.67</td>
</tr>
<tr>
<td>Trunk</td>
<td>29.39</td>
<td>16.76</td>
<td>53.86</td>
</tr>
<tr>
<td>Frond</td>
<td>25.74</td>
<td>42.54</td>
<td>31.72</td>
</tr>
<tr>
<td>Shell</td>
<td>18.93</td>
<td>55.13</td>
<td>25.94</td>
</tr>
</tbody>
</table>

**MPOB Pyrolysis Experimental Rig**

- **Biochar**
- **Bio-oil**
Catalytic Depolymerisation (CDP) of Palm Biomass Product - Synthetic Diesel

The catalyst cracks the long molecular chains of the hydrocarbons and shortens them in a specific way.

The CH\(_2\)-Molecule structure remains and the molecule length is only reduced (optimally on C15).
Fermentation of Palm Biomass

Product: lignin, fermentable sugars, bioethanol

Bioethanol production from palm biomass:

Stage 1: Pre-treatment

Fractionation of lignocellulosic component of EFB by using thermo-mechanical/chemical digestion process

Stage 2: Sugars hydrolysis & extraction

Production of fermentable sugars from palm biomass (EFB) as bioethanol feedstock

Stage 3: Fermentation

Fermentation of sugars from EFB to bioethanol

--- **tedious processes due to the complicated cell wall of palm biomass.

--- Special microorganism is required to break open the cell wall to convert cellulose to glucose/xylose.
Bioethanol Production from Empty Fruit Bunches (EFB)

1. Inoculated with *microbe*
2. Treated Palm Biomass (Hydrolysate)
3. Incubation
4. Distillation at 75°C
5. Fermentation broth
6. Analysis
7. Mixture of fermentation product (bioethanol)
R&D Focus on Sustainable Development of Bioconversion of Oil Palm Biomass to Bioethanol

- Palm lignocellulose
  - Enzymatic approach for pre-treatment
  - Cellulose
    - Hemicellulose
    - Lignin
      - Fuel or binder
    - Cellulase strains screen and genetic improvement
    - Cellulase production
      - Solid State Fermentation
        - Ethanol
      - Yeast screen and genetic improvement
Bioethanol Production from Oil Palm Trunk

- Oil palm trunk
- Removal of bark
- Mechanical extraction (pressing)
- Sample analysis (moisture content, sugar content and fermentation)
Biomass to Gas (BTG)

- Producer gas (syn-gas)  
  - Combustion
  - Gasification
  - BTG

- Biogas (POME)
  - Biomethane
  - Biohydrogen
  - Anaerobic Digestion
  - Fermentation
  - Fuel cell (Catalytic process)
Gasification of Palm Biomass Product

- Syngas

- Other Gasification pilot plant
  Capacity: 30 kW, Fuel: EFB briquettes

  • MPOB in-house technology – pilot scale down-draft fluidized sand bed gasifier
  • Feed: Empty fruit bunches, palm shell and fiber
  • Process optimization in progress to achieve: $H_2$ (40%); CO (30%); $CH_4$ (10%)
Biogas from Palm Oil Mill Effluent (POME)

• About 0.65 – 0.675 m³ of POME is generated for every 1 tonne of FFB processed

• Biogas is produced during the decomposition of organic matters in anaerobic pond

• It contains about 60-70 % Methane (CH₄), 30-40 % Carbon Dioxide (CO₂) and trace amount of Hydrogen Sulphide, (H₂S)

• Methane - the global warming potential – 21 times higher than CO₂
Trapping of Methane at Palm Oil Mills

• Under NKEA – palm oil sector: all palm oil mills to have methane trapping facilities by 2020

• 16 – 20 million tonnes of carbon dioxide equivalent per year mitigated
Palm Oil Mill Effluent Based Biogas Plant

- For on & off grid application
- Digester and covered lagoon technology
- Steam and electricity applications
- Co-firing in biomass boiler and diesel genset to reduce the utilization of the palm shell and diesel
- Capable to generate about 1 -2 MW from 60t/hr POM
Avoidance of Methane

Utilisation of POME:
- Co-Composting: EFB co-compost with POME, decanter cake and boiler ash

Utilisation of Non-oil Component:
- The non-oil fraction can be used as a novel palm-based food source that contains macro and micro nutrients including carbohydrate, protein, fat as well as lipid- and water-soluble vitamins.
BIO-COMPOSITE & AGRO PRODUCTS
Current Applications

(i) Shredded EFB fibers (~40% moisture content), suitable for bio-energy and bio-composite.

(ii) Cleaned EBF fibers (~10% moisture content), suitable for exports, mattress filler and wood plastic composite.

(Source: Synn Palm Oil Mill)
Oil Palm Automotive Components

Rear Parcel Shelf for Gen 2

Shelf Centre Trim for Proton Waja

Rear Parcel Shelf for Proton Persona

Rear Parcel Shelf for Proton Perdana V6
Automotive Component

Dampening Sheet

Dampening sheet:
Up to 25% blending of biomass, comply with the international standards (ES-X 62223/6 Mitsubishi Motor Corporation Test Standard) for automotive industry.

Industry: Base Components Sdn. Bhd.
Particle Board and Eco-pallet

Commercialization R&D on the production of particleboard and Eco-pallet from oil palm biomass

Pulp and Paper from Oil Palm Biomass

STATUS:
- Commercialized
- Huge capital investment
- Issues on competitiveness
- Issues waste water

Pulp and Paper Products

Kraft Process

Oil Palm Biomass
- Chipping
- Cooking (digester)
- Washing
- Bleaching
- Paper Forming
- Roller Drying
- Packaging
- Storage
Oil Palm Plywood and Products From Trunk

Potential products from OPT:
- Palm plywood has been commercialized.
- Palm lumber for furniture, with specific drying and chemical treatment has been commercialized.
- MDF from OPT has shown great interest from the industry player.
Charcoal and Activated Carbon from Oil Palm Biomass

Carbonization for charcoal  Activation for activated carbon

Products and potential products

- Activated carbon
- Carbon cloth
- Charcoal soap
- Charcoal tablets
- Charcoal toiletries
- Wood vinegar
PHYTOCHEMICALS
High Value Added Products from Oil Palm Biomass

Fine chemicals: cellulose, xylan, lignin
PHYTONUTRIENTS from Palm Biomass

- Production of minor components from palm biomass e.g. mesocarp fibre (tocopherol, tocotrienols, carotenes, sterols co-enzymes Q, squalene, etc).
- To convert palm phytonutrients into nanoparticles and
- To encapsulate the nanoparticles.
PRODUCTS FROM AQUEOUS STREAM

Oil Palm Phenolics (OPP)

Liquid

Powder

Crystals
BIOLOGICAL ACTIVITIES OF OIL PALM PHENOLICS

- Antioxidant
- Anti microbial
- Anti atherogenic
- Anti cancer
- Anti diabetic
- Anti hypertensive
- Anti inflammatory
- Anti obesity
- Anti spasmodic
- Anti thrombotic
- Anti allergenic
- Anti ulcer
- Memory enhancing

confirmed

In vitro, whole animal and microarray studies
OIL PALM PHENOLICS

- Confirmation of shikimic acid in oil palm
- Highly valuable
- Substrate for synthesising tamiflu
- Current source is star anise
- Oil palm phenolics- largest potential source of shikimic acid in the world
ISSUES & CHALLENGES
ISSUES AND CHALLENGES

• Competitive uses of biomass.

• Interconnection issue / load demand – location of the power plants (for grid connected power plant)

• Uncertainties of long terms biomass supply & pricing mechanism, logistic and transportation cost

• Need for more financial support / incentives / REPPA

• Inconsistency of biomass fuel quality – require EFB pre-treatment plant

• Inefficient / low efficiency of CHP used in palm oil mills – increment of efficiencies may generate more excess energy and palm biomass
WAY FORWARD
WAY FORWARD

• Increase boiler efficiency to increase availability of shell mesocarp fibre.
• Focus on commercialisation of ‘low-hanging fruits’ (biogas), while awaiting maturation of technologies on ‘high-hanging fruits’ (2nd Generation Biofuels).
• Take advantages of incentives given by the Government (Pioneer Status, Investment Tax Allowance)
CONCLUSION

• There is huge untapped potential from oil palm non-oil biomass as compared to the oil.

• However, many issues & challenges need to be overcome.
Thank you