SixRing 2G Biofuels: Asia's Unique Opportunity to Enhance Energy Security & Sustainability

Presentation to the Asia Clean Energy Forum
June 2-6, 2025
Manila

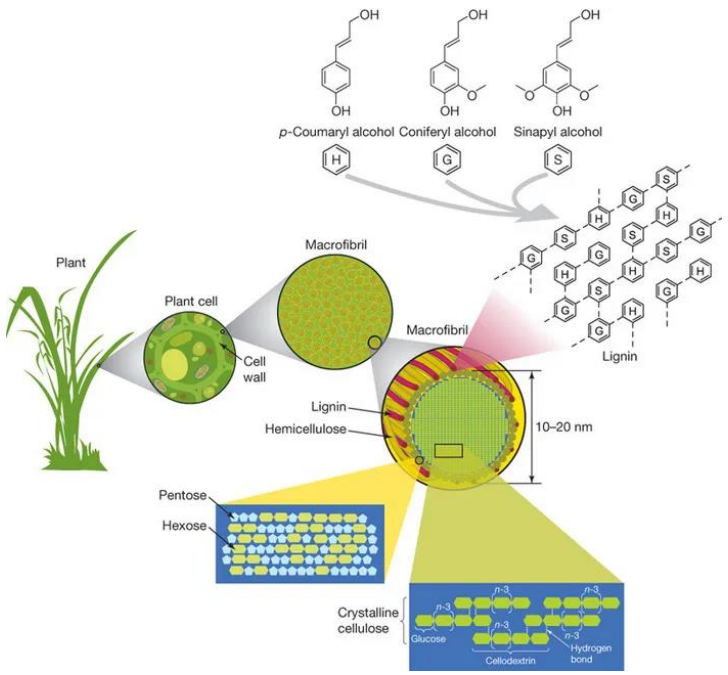
SixRing = Biomass Deconstructed

Low-cost, highly efficient conversion of (non-food) biomass to high-value products – cellulose and highly functional biocrude

- **Feedstock Flexibility**
- **Product Optionality replaces subsidies**
- **Low Process Complexity**
- **Carbon Advantage**
- **Simple Equipment**
- **12+ Years of Experience And R&D**

What is Lignocellulosic Biomass

Background



Three Elements of Biomass

1. **Lignin** — Protective, very durable, and biocidal outer layer
2. **Cellulose** — Inner layer that is protected by the lignin
3. **Hemicellulose** — Branched, linking material

Unlocking the value in biomass

The elements of the biomass (i.e. lignin, cellulose, and hemicellulose) are known to be highly valuable

The problem has always been difficulty in separating the elements without destroying value

Incumbent technologies use high pressure and temperature to destroy the lignin, resulting in lower yields, and *strained economics (even with government support)*

The SixRing™ Solution

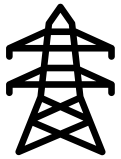
Ambient Conditions

Why are Ambient Temperatures & Pressures Important?

Lower CAPEX

Simple Tanks b/c not under Pressure or Temperature

Lower OPEX

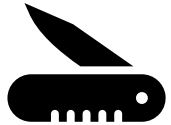


Lower Electricity and Heat

Lower CI

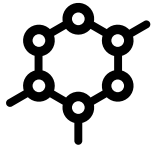
Lower Electricity and Heat

Higher Yields



Delicately Separates instead of destroying components of feedstock[1]

Multiple Products



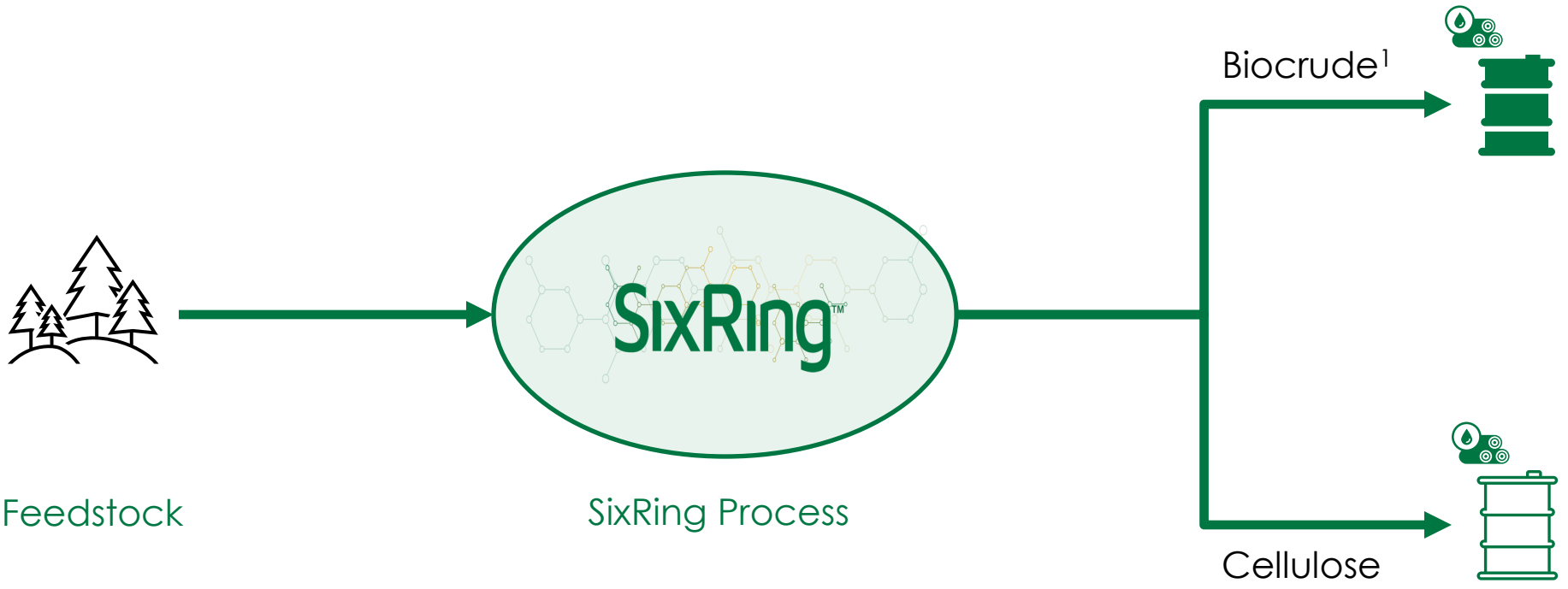
Does not alter or destroy the properties or fine molecules in the biomass

Which equates to *<u>better economics</u>* and *increased sustainability*

[1] The SixRing Process converts over 90% of the biomass into saleable products which is significantly higher than the conversion rate of other 2G technologies (20-50% conversation rate).

The SixRing™ Solution

PRODUCT OPTIONALITY



Saleable Products

Drop-In Fuel Replacement
+ Others
- Sustainable
- Low CI
- Lubricity Improver
- Corrosion Protection
- Static Dissipation
- Reduced Fuel Consumption
- Flexible Concentration
- *No REFINING*
- Product Flexibility

Cellulosic Ethanol
Renewable Natural Gas
+ Others
- Sustainable
- Low CI
- High Yields
- High Demand
- Product Flexibility

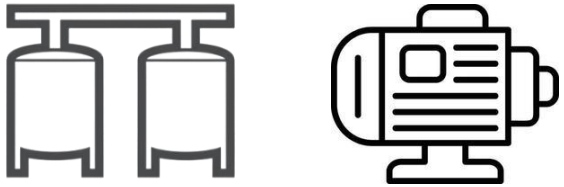
(1) lignin based biocrude – to be fractionated into a heavy and light fraction

SIXRING FACILITIES: CAPEX & Engineering

- SixRing Facilities are Simple
- Engineering Studies (FEL 2+) Complete

Core Process

Ambient Pressures & Temperatures

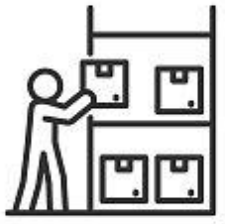


Stainless Steel Tanks and Pumps

~20% of CAPEX

Backend Processes

All Off the Shelf, Standard Processes



Solid-Liquid, and Liquid-Liquid Separation

~80% of CAPEX

The SixRing™ Solution

Concerns with Traditional Biofuels Overcome

1	Not Reliant on Subsidies	Economic without government subsidies or support (although the SixRing Process / Products do qualify)
2	No Feedstock Constraints	Waste, Low-Cost, and Abundant Lignocellulosic Biomass (i.e. crop residue, forestry residue, etc.) leading to less transportation and scalability
3	Low Energy Input	First known process to operate at AMBIENT Pressures and Temperatures
4	Scalability	HIGHLY SCALABLE, due to abundance of existing and replenishing feedstocks and desire to repurpose assets
5	Food vs. Fuel	Uses low value feedstock, such as agricultural and forestry residues – not food feedstock

The Technology is Proven

Each Scale-Up has been successful with efficiency gains

5+ Years of Scale-Up Increased yields & chemical consumption efficiencies

Commercial Scale Reactor (20,000L) operational since 2023

SixRing Facility will use 30,000L All specifications benefit from scale

Technology Readiness Level (TRL) of 8

100's of reactions complete >50 types of feedstock processed

5+ years of R&D on Process 14+ years as Global Leader modifying acids

Process has been verified by many third parties:

license partners project partners offtake partners

engineering partners government agencies

supermajors

A Malaysia Case Study

- Up to 100 million tons of lignocellulosic biomass waste annually
  - i.e. palm oil waste, wood residues, rice and coconut straw/husk, etc.
- Converting 5% of this biomass equals ~21 million barrels of liquid fuel products
  - ~15 million barrels of cellulosic ethanol (from the cellulose stream)
  - ~6 million barrels of drop-in diesel additive (from the biocrude stream
- Reduction in CO_2 of up to ~1.3 million tons per year
  - Equivalent to removing ~300,000 cars
- CAPEX required:
  - North America: USD $2.5-3 billion
  - ASEAN countries: USD ~$0.8-0.9 billion[2]
- **At scale, a cost per flowing barrel of ~$65k-85k, equivalent to that of oil**

1). Malaysia Biomass Action Plan – 2023

2). ICC Index 2024

Malaysia's Pathway to Sustainable Aviation Fuel (SAF) via the SixRing Process

- Globally, only ~1.3 billion liters of SAF was produced in 2024 and is forecasted to reach up to 10 billion liters by 2030
- Malaysia has the opportunity to become a global leader in SAF
- SixRing's cellulose can be converted to SAF via two existing ASTM approved pathways

SixRing Cellulosic Ethanol → **Alcohol to Jet**

5% of available biomass waste → ~15 million barrels of Cellulosic Ethanol → Up to 1.5 billion liters of SAF

SixRing Process | **Approved 3rd Party Pathways**

SixRing Cellulose to HEFA Precursors → **HEFA**

5% of available biomass waste → ~4.2 million tons of HEFA precursor → Up to 5 billion liters of SAF

Malaysia's Pathway to Sustainable Diesel Drop-in Fuel via the SixRing Process

- Light fraction of SixRing's biocrude blended directly into diesel with **no refining** required
  - Similar to that of ethanol blended into gasoline
- SixRing's drop-in fuel increases lubricity, conductivity, and oxygenation compared to traditional FAME biodiesel
- Unlike biodiesel, which requires energy-intensive refining and chemical additives, SixRing's fuel improves diesel engine performance with lower environmental and economic costs

ASTM 3rd Party Tested

SixRing Liquefied Lignin (LHDO) → **6RLu400 Sustainable Green Diesel drop-in**

5% of available biomass waste →

~6 million barrels of Diesel drop-in

Why SixRing & Asia?

- SixRing technology accessible now, without subsidies
- Abundant and aggregated biomass feedstock
- Policy and market demand
- Need for greater energy security
- Compelling CAPEX and OPEX
- Strong infrastructure and logistics
- Export potential
- Multilateral agencies support

Questions?