SEI PAGAR PKS CO-FIRING BIOGAS OPERATION AS A STRATEGY PT. PERKEBULAN NUSANTARA V TO SUPPORT SUSTAINABILITY ENVIRONMENTALLY FRIENDLY PRODUCTION

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ABSTRACT

PT. Perkebunan Nusantara V as one of the largest palm oil plantation companies in Riau Province has the potential to implement liquid waste management into biogas. Currently the Palm Oil Factory (PKS) is owned by PT. There are 12 Nusantara V Plantations spread across several districts (Rokan Hulu, Rokan Hilir, Siak and Kampar). PT. Perkebunan Nusantara V also has three Biogas Installation units, namely at the Tandun, Terantam and Sei Pagar Palm Oil Mills. In order to reduce greenhouse gas emissions, PT. Perkebunan Nusantara V makes every effort to utilize liquid waste produced from its production process into other energy sources. One of the uses of liquid waste that has been carried out is converting it into biogas to be used as gas engine fuel for electricity generation or used for additional combustion in boilers (*co-firing*).

Keywords: Strategy, Sustainability, Environmentally Friendly Production

INTRODUCTION

Biogas as a clean energy source has an important contribution in increasing the field of new, renewable energy for energy supply. Biogas consists of CH4, CO2, H2O and small components such as H2S, H2, NH3, O2, N2. The presence of biogas can reduce CO2, CH4 and N2O emissions, thereby reducing global warming. Biogas used as energy to generate electricity can be obtained from industrial waste from palm oil mills.

The crude palm oil (CPO) processed from the fresh fruit by the Palm Oil Factory (PKS) Solid waste in the form of fiber *as* much as 130 kg (13% per ton of FFB) with calories of around 2637-4554 kcal/kg, shell *as* much as 65 kg (6.5% per ton of FFB) with calories of 4105-4802 kcal /kg, empty *fruit bunch* is 230 kg (23% per ton of FFB) with calories of 2492 kcal/kg, while liquid waste or *Palm Oil Mill Effluent* (POME) is around 600-700 kg, (60% per ton of FFB). The composition of palm oil mill waste contains more liquid waste than solid waste.

The negative impact from palm oil mill liquid waste in ponds on the environment, fermentation activities in open ponds produce methane gas (CH4) which is released directly into the air. *The United Nations Framework Convention on Climate Change* (UNFCCC), the UN body that handles climate change, notes that methane gas has an emission level 24 times higher compared to carbon gas (CO2), so it is important to process it first before liquid waste is discharged into the environment.

Palm Oil Factory (PKS) owned by PT. Perkebunan Nusantara V (PTPN V) totaling 12 units spread across several districts (Rokan Hulu, Siak and Kampar) has 3 Biogas Installation units, namely at PKS Tandun, Terantam and Sei Pagar.

PTPN V makes every effort to utilize waste generated from its production process into other energy sources. One of the uses of waste that has been carried out is converting POME into biogas to be used as fuel for gas engines *for* power plants or used for combustion in boilers (*co-firing*).

The concept of sustainability according to experts in the *Brundtland Commission,* sustainable development is development that satisfies present demands without impairing the capacity of future generations to satiate their own needs (Fauzi, 2004). According to *Munasinghe* (1993), the main objectives of sustainable development are: economic, environmental also social *objectives*. Economic goals are related to issues of *efficiency* and *growth* ; environmental goals related to natural resource conservation issues (*natural resources conservation*); and social goals related to issues of poverty *reduction* and *equity* . Thus, the goal of sustainable development basically lies in the harmonization of economic goals, environmental goals and social goals.

The research carried out this time focused on the object of operating the Biogas *Co-firing Installation* at the Sei Pagar PKS located in Perhentian Raja Village, Kampar Regency. Next in this report we will discuss the impact of the Sei Pagar Biogas *Co-firing operation* as PTPN V's strategy in supporting the sustainability of an environmentally friendly industry.

METHOD, DATA, AND ANALYSIS

Theoretical Basis

1. Waste from Palm Oil Factory Processing

There are two forms of waste from processing at PKS, namely solid waste and liquid waste.
1. Solid waste
The solid waste produced is in the form of empty bunches, *fibers* and *shells* .

2. Liquid waste
of palm oil mill liquid waste or POME (*Palm Oil Mill Effluent*) is greater than solid waste, namely 0.7-1 m3 POME per ton of fresh fruit bunches (FFB) processed. POME produces heat (temperature 60-80 ºC), is acidic (Ph 3.3-4.6), thick, brownish in color with solids, oil and fat content, *chemical oxygen demand (COD)* , and *biological oxygen demand (BOD)* tall one. The characteristics of unprocessed POME and quality standards according to regulations can be seen in the table below:

Table 1. Characteristics of Unprocessed POME and Quality Standards According to Regulations

No	Parameter	Unprocessed POME			Quality standards	
		Units	Range	Average	River	Land Application
1	BOD	mg/l	8,200-35,000	21,280	100	5,000
2	COD	mg/l	15.10365.100	34,740	350	-
3	TSS	mg/l	1,330-50,700	31,740	250	-
4	Ammonia (NH_3N)	mg/l	12-126	41	50	-
5	pH		3.3-4.6	4	6-9	6-9
6	Volume	M3/tonne CPO			2.5	

2. Liquid Waste Processing (POME)

POME processing in Indonesia generally uses an open pond system because it considers economy and ease of operation. The following is the POME processing process at the palm oil mill (PKS):

1. POME from the Clarification Station activities is channeled to the Fat Pit tank for oil *recycling* which can be recovered (*oil recovery*) from this unit at 0.8-1.2%. Residence time (*Detention Time*) Td=16 Hours. The dimensions of this unit are an area of 6 x 40 m^2 and a depth of 0.8 m (when calculated from data on residence time and discharge Q of 18 tons/hour). The BOD of this Fatpit is 30,000-40,000 ppm with a pH of around 4-5.

2. The POME enters the anaerobic tank with a residence time (total) Td = 40 days (when calculated by dividing the volume by the discharge, Td = 38.4 days), with the dimensions for

each tank being an area of 20 x 40 m2 and a depth of around 3 – 4 meters. This anaerobic tank is an open tank and is said to have an anaerobic process because the depth of the tank is up to 4 meters.

3. The final process is aerobics which is accommodated in 4 *ponds* . The total area of this aerobics unit is 75 x 40 m2 with a depth of 1.5 meters. Residence Time Td = 60 days (when the volume is divided by the discharge, Td is 62.5 days). The waste BOD that comes out of this unit is around 200 - 230 ppm with a pH of around 7.

3. Biogas Power Plant

To produce biogas, a biogas generator is needed which is called a digester. In the digester, the process of decomposing organic material occurs anaerobically (without oxygen). In general, biogas can be formed 4-5 days after the digester is filled. There are three groups of bacteria that play a role in the biogas formation process, namely:

1. The group of fermentative bacteria are *steptococci*, *bacteriodes* and several types of *enterobactericeae*.
2. *acetogenic* bacteria is *desulfovibrio* .
3. The group of methane bacteria, namely the types *mathanobacterium*, *mathanobacillus*, *methanosacaria* , and *methanococcus* .

The following are some general technologies for anaerobic decomposition of POME:

1. Anaerobic Filter

An active microbes attach to a plastic "carrier" to keep the anaerobic filters from being forced out of the system. Biogas produced by anaerobic filters can have a methane content of up to 85% and be of extremely high quality.

2. Fluidized and Expanded Beds

Microorganism develop colonies by attracting tiny particles to their fluidized and enlarged beds. Because of the system's strong upward flow, the particles float and come into contact with the substrate, allowing the microbes to grow.

3. Uplow Anaerobic Sludge Blanket (UASB)

The Uplow Anaerobic Sludge Blanket Reactor allows microorganisms growing in groups so that the microorganisms remain in the reactor even though the incoming substrate flow is quite strong. This system pumps the waste into the reator quite quickly so that a stirring process occurs and contact occurs among the microorganism also the substrate.

4. Expanded Granule Sludge Bed (EGSB)

Expanded Granule Sludge Bed reactors are similar to UASB reactors, yet with a higher upward flow rate to allow water to pass through the sludge bed. It designed suitable for COD concentrations of less than 1 to 2 g COD/I or for wastewater containing suspended particles that are not easily biodegradable.

5. Covered Pool (*Covered Lagoon*)

A closed pool equipped with a stirring mechanism with a strong covering membrane to store biogas. A sizable space is needed for the 20-90 day hydraulic retention period. A closed pond requires a greater area but has a smaller capital investment than a tank/CSTR system for the same waste processing capacity. This design is typically used to handle waste with a solids contents which less than 3% yet operate in the mesophilic temperature range.

Figure 1. Covered Pool (Covered Lagoon)

6. Continuous Stirred Tank Reactor *(* CSTR *)*

Continuous Strirred Tank Reactor, or contact reactor, is a cylinder made of concrete or metal cylinder that has a narrow diameter to height ratio (Figure 2.3). To concentrate biomass, this system is fitted with a thickener, clarifier, or dissolved air floatiation (DAF). Both termophilic and mesophilic temperatures can be used with CSTR. Gas injection, hydraulics, or mechanical means can all be used to stir in CSTR. A large spectrum of solids can be handled using CSTR. In addition, CSTR is capable of processing a combination of different waste kinds. Typically, trash with a solids concentration of 3-10% is treated with this design. It's just that CSTR requires higher capital and operational costs than closed ponds to maintain the stability and reliability of biogas production.

Figure 2. *Continuous Strirred Tank Reactor* (CSTR) tank

4. Greenhouse Gas Emissions

The primary greenhouse gases found in the Earth’s atmosphere include ozone, carbon dioxide, methane, water vapor, and nitrogen oxides. Each greenhouse gas has a different global warming effect. Based on a gas’ ability to retain heat, the Global *warming potential* (GWP) index calculates each gas' contribution to global warming. The GWP measures how much heat is captured by a specific greenhouse gas in relation to the same mass of carbon dioxide.

Table 2. Global Warming Potential (GWP) Index for Common Greenhouse Gases

Tabel 6.1. Indeks *Global Warming Potential* (GWP) untuk Gas Rumah Kaca Umum

Senyawa	Rumus Kimia	*Global Warming Potential* (GWP) dalam Rentang Waktu 20 tahun	100 tahun	100 tahun	500 tahun
Karbon dioksida	CO_2	1	1	1	1
Metana	CH_4	72	21	25	7,6
Dinitrogen oksida	N_2O	289	310	298	153

Sumber: IPCC Third dan Fourth Assessment Reports (2001 dan 2007)

Based on the table above, the 100 year GWP for methane is 21, methane has a 100-year greenhouse gas potentian of 21 means that in the next century, it will trap 21 times more heat than carbon dioxide if the same quantity of CO_2 and CH_4 enter the atmosphere.

The biggest source of emissions at PKS is POME which is processed in open ponds, the waste releases methane into the atmosphere. The methane capture project in biogas reduces GHG sources from factories while converting methane into a useful energy source.

Table 3. Examples of GHG Emission Values from Palm Oil Plantations and Factories

Tabel 6.2. Contoh Nilai Emisi GRK dari Perkebunan dan Pabrik Kelapa Sawit

Perkebunan				Pabrik			
Sumber Emisi	Unit	Nilai	%	Sumber Emisi	Unit	Nilai	%
Pupuk kimia	$tCO_{2, eq}$	4.571	87,81	Listrik	$tCO_{2, eq}$	933	3
Bahan bakar fosil	$tCO_{2, eq}$	537	10,31	*Input* Proses	$tCO_{2, eq}$	48	0,2
Listrik	$tCO_{2, eq}$	98	1,88	Air limbah	$tCO_{2, eq}$	28.408	90
				Transportasi	$tCO_{2, eq}$	2.158	6,8
Total	$tCO_{2, eq}$	5.206	100	Total	$tCO_{2, eq}$	31.547	100
Hasil TBS	Ton	57.980		Hasil CPO	Ton	55.702	
Total emisi GRK	$kgCO_{2, eq}$/ ton TBS	89,79		Total emisi GRK	$kgCO_{2, eq}$/ ton CPO	566	

Current sustainability standards support methane capture installations at PKS. The table below compares ISPO, RSPO and ISCC standards and their relationship to GHG calculations.

Table 4. Comparison between RSPO, ISCC and ISPO in GHG calculations

	ISPO	RSPO	ISCC
Policy Drivers	The Indonesian government is targeting emissions of 26% with its own efforts or 41% with foreign assistance	There is no specific Policy driver	EU Directive 2003/30/EG: Biofuel use is 5.75% of total fuel used The materials provided for biofuel must meet minimum GHG savings limits
GHG Inventory Considerations	- GHGs and land transfer - Use of fertilizers and pesticides - POME - Fuel for transportation and electricity - The FFB production process becomes factory CPO	- Emissions arising during palm oil cultivation and FFB processing - Emissions arising from changes in carbon stocks during new plantation development and	- Biomass producer - Conversion Unit (solid biomass conversion to liquid biomass or liquid biomass processing) - Transportation

5. *Sustainability Concept*

The human bond with nature was mirrored by the environmental activist movement in the 1800s, where the "modern sustainability" originated. The bond between humans and nature that this environmental activist encourage the intuition and inspiration (Edwards, 2006).

The ability of human civilization to build a society that is socially, environmentally, and economically competent to meet the demands of the people without endangering the potential of future generations is explained by the idea of sustainability (Edwards, 2006).

In the 1972, the idea of sustainability made its debut at an environmental conference held in Stockholm. There were several discussions between developed and emerging nations about which was more crucial, environmental preservation or economic growth.

In the 1980s, accidents that resulted in massive environmental pollution occurred, such as *the Union Carbide* in Bhopal, India (1984), the nuclear reactor accident at Chernobyl, Russia (1986). The release of hazardous and toxic materials and radiation from industrial accidents that occur re-emphasizes the importance of responsibility to the environment.

The UN responded to this responsibility by establishing *the Brundtland Commission* to formulate strategies for improving human life without endangering the environment. *Brundtland*, who led the WCED (1987), defined sustainable development as a process of development that satisfies current requirement without endagering the capacity of future generations to satisfy their own needs (Edwards, 2006).

This concept was then adopted and outlined in the 27 principles of the Rio de Janeiro declaration in 1992, which was resulted from Earth Summit. The declaration emphasizes social, economic and environmental development as inseparable parts. Five years later, the principles of the Rio de Janeiro declaration were adopted in the Kyoto Protocol. The 2002 *World Summit on Sustainable Development*

(WSSD) further focused on greater participation from women, youth, NGOs and scientists (Edwards, 2006). Various other developments continued in the following years to improve and complete the dimensions of sustainable development and encourage global companies to participate in sustainable development.

The case of the *Brent Spar Offshore Facility* , Shell's oil company in 1995, stated with Shells' intention to abandon its outdated platform infrastucture into the ocean. Despite approved by the British government, this idea was abandoned as a result of opposition from Greenpeace activists and other global citizens. Due to this disaster in the North Sea Shell's sales in Germany dropped by 50%. (The Brent Spar, nd).

According to Epstein (2008), the guiding principles of sustainable performance serve as a framework for controlling the effects on stakeholders, namely:

1. Ethics.
2. Governance.
3. Transparency.
4. Business relationship.
5. Financial Returns.
6. Community Engagement and Economic Development.
7. Value of Goods and Services.
8. Worker Hiring Practices.
9. Environmental Protection.

6. Environmentally Friendly Production

Environmentally friendly products (*green products*) or *ecological products* also *environmentally friendly products* products are those that use environmentally friendly packaging, safe, non-toxic components and recycling capabilities to lessen the harmful effects of product consumption on the environment (Shamdasami et al. .al, 1993).

According to another definition, environmentally friendly items are those that are manufactured using natural raw materials, processed organically and sold in a way that is sustainable for the environment (Ishaswini, 2011).

Product that environmentally friendly are typically identified by an ecologically friendly label that is affixed to the item. The product's label serves as both a signal to consumers that the product is distinct from other and as a means for manufacturers to let consumers know that the things they make are ecologically (Ishaswini, 2011).

Rath (2013), stated industrial goods that are made using eco-friendly technologies and don't affect the environment are referred to green product. D'Souza et al., (2006), *green products* are those that benefit consumers both directly and indirectly through social and environmental improvements. Durif et al (2010) an ecologically friendly product is one that is made with recyclable materials, minimized environmental damage, and reduces pollution to the environment over the course of its life cycle.

Makower et al (1993) explain the to determine the product as environmentally friendly or no, as follows:

1. The level of danger of a product for human or animal health. How far a product can cause environmental damage while in the factory (used or thrown away).
2. The level of use of disproportionate amounts of energy and resources while in the factory (used or thrown away).

3. How much product creates waste when the packaging is excessive or for a short time of use.
4. The extent to which a product involves pointless use or is cruel to animals.
5. Use of materials derived from threatened species or environments.

D'Souza et al., (2006) the aspects of *green products* or environmentally friendly products are:
1. Product perception
2. Green or environmentally friendly items are perceived by consumers as those that do not hurt the environment or animals.
3. Containerization
4. Customers perceive product packaging to have specific components and connected to environmental problems.
5. Content composition

Recycled materials can support claims of lower overall usage, usage at certain limits and less environmental harm.

RESULT AND DISCUSSION

ANALYSIS OF THE BIOGAS CO-FIRING PROCESS

Biogas Co-firing Sei Pagar

Biogas is used as additional fuel in boilers to reduce shell use by maximizing *fiber use* .

Liquid Waste (POME)

The Sei Pagar PKS produces around 18 m3 of POME for every 30 tons of fresh fruit bunches processed or 0.6 m3 of POME for every ton of FFB. The POME produced generally has a temperature of 60 ◦C-80 ◦C, is acidic (pH in the range 3.3 – 4.6), brownish in color, has a fairly high viscosity and contains solids, oil and COD (*Chemical Oxygen Demand*) tall one.

Figure 3. POME as Biogas Raw Material

The organic material content in POME can be seen in the table below:

Table 5. Components in POME waste

Komponen	Rata-rata (mg/L)
Minyak	4.000
BOD (*Biological Oxygen Demand*)	25.000
COD (*Chemical Oxygen Demand*)	50.000
TS (*Total Solid*)	40.500
TSS (*Total Suspended Solid*)	18.000
VS (*Volatile Solid*)	34.000
Nitrogen	750

Description of the Biogas Co-firing Process

Biogas production from POME goes through several raw material treatment processes, reaction processes and waste treatment. Based on research from the Agency for the Assessment and Application of Technology (BPPT) conducted by Valentino et al. (2018) the biogas production process from POME waste uses several process units such as *fat pit*, *equalization tank*, *cooling tower*, *buffer tank*, *CSTR (Continuous Strred Tank Reactor), foam arrestor and lamella clarifier, biogas burner*, *flare* and *burner*. Before POME is fed into the reactor, *pretreatment* is first carried out in *the equalization tank, cooling tower* and *buffer tank* to maintain the temperature and pH of the POME so that it meets standards, so that the anaerobic degradation process in the reactor can take place optimally (Valentino et al., 2018). The following is Figure 4 flow diagram of the biogas production process from POME waste at PTPN V Kebun/PKS Sei Pagar:

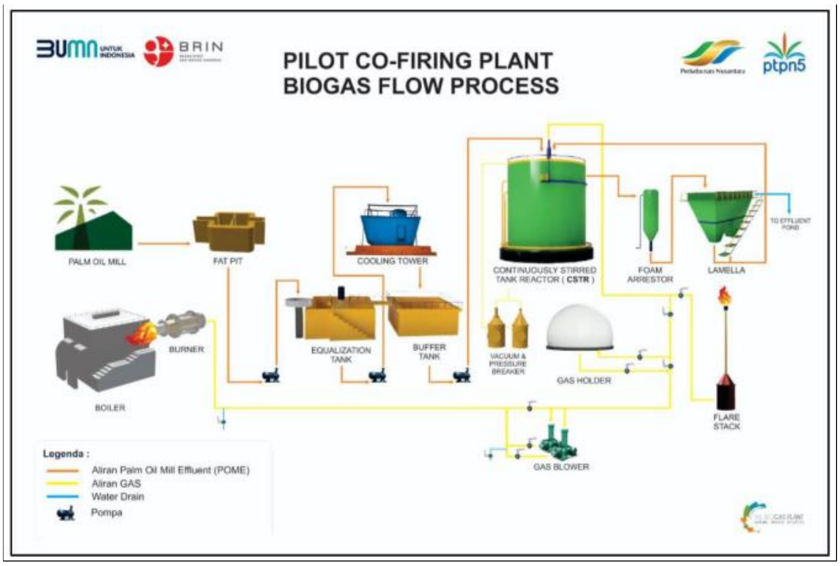

Figure 4. Flow diagram of the Biogas Production Process from POME Biogas *Co-firing* Sei Pagar

1. Fat Pit

A fat pit is a temporary storage pond for liquid waste (POME) from the FFB processing process (Figure 3.2). In this pool, the oil still contained in POME is separated by gravity. Oil will accumulate on the surface of the liquid because the density of oil is smaller than water.

Figure 5. *Fat Pit Unit*

In the Biogas production process at PKS Sei. Fence, POME raw materials are taken from the drab separator. However, to increase the COD concentration in POME, the flow from the drab separator can be mixed with POME from the fat pit in a small tank next to the fat pit as in Figure 3.3 below. This POME mixture will later be sent to the equalization tank using a pump.

Figure 6. POME Storage Tank from *Drab Separator*

2. Equalization Tanks

Equalization tank or commonly abbreviated as EQT is a stirred tank which functions to even out the POME mixture. The capacity of EQT is 98 m3 with dimensions $7\ m \times 7\ m \times 2\ m$. There is a slow speed agitator type agitator with a capacity of 5 HP. The impeller used is a 3 *blade hydrofoil* *type* . Stirring in the equalization tank is carried out to homogenize the POME feed originating from the fat pit, because the characteristics of POME (temperature, pH and COD) in the fat pit reservoir are relatively variable. EQT is also equipped with a level sensor to show the level of liquid in the tank.

Figure 7. *Equalization Tank*

POME from EQT is then pumped to the *cooling tower unit* using a centrifugal pump as in Figure 3.5 with constant power. Therefore, a circulation pipe was installed to reduce the pump workload when the POME flow rate was reduced. The POME flow rate is controlled with several *butterfly valve* type valves. Meanwhile, to monitor the POME flow rate, a sensor flow rate instrument is used.

3. Cooling Tower

Cooling Tower is a process unit that functions to reduce the temperature of POME. *The cooling tower* used is the *induced draft – cross flow type* . In this unit, most of the heat transfer process occurs by convection. To increase the heat transfer rate, a fan with a motor capacity of 3 KW is used. So there is a decrease in the POME temperature before it enters *the buffer tank* . *The cooling tower* in the biogas production process at PTPN V Kebus/PKS Sei Pagar is designed to reduce the POME temperature from 70 ◦C to 40-50 ◦C with a maximum flow rate capacity of 10 m3/hour.

Figure 8. *Cooling Tower Unit*

4. Buffer Tanks

The Buffer Tank is a storage tank *for conditioned* POME before being fed into the CSTR. The POME stored in this unit must meet the characteristics in accordance with the POME parameters in the reactor design. In *the buffer tank* there are 3 inlet pipes, namely from *the cooling tower effluent* , *recycling* from *the clarifier lamella* and circulation from the reactor. Apart from that, there is also a pump circulation pipe to avoid excessive workload on the pump. Next, the output from the buffer tank is channeled to the reactor for the conversion process. Same with EQT, *buffer tank* It is also equipped with a level sensor to determine the level of liquid in the tank. Then the feed flow to the CSTR is controlled using *a butterfly valve.*

Figure 9. *Buffer Tank*

5. Continuous Stirred Tank Reactor (CSTR)

In the biogas production process, CSTR is a unit where the conversion process of organic compounds in POME into biogas takes place under designed operating conditions (mesophilic). CSTR is a cylindrical tank with a hemispherical head type. The CSTR capacity in operation is 2,000 m3. This CSTR is equipped with 1 *central agitator* with a power capacity of 10 HP and 3 units of *side mounted agitator* (*lateral mixer*) with a power capacity of 7.5 HP.

Figure 10. *Continuous Stirred Tank Reactor* (CSTR)

6. Foam Arrestor and Lamella Clarifier

Foam Arrestor is a waste treatment process unit before it is separated in *the Lamela Clarifier*. POME waste that has been processed between waste and air and water. So foam and scum will form solids on the surface of the liquid. Then the liquid will flow into the lamella clarifier for the separation process. *Lamellar clarifier* is a separation unit in the form of a tank equipped with a dividing *baffle*.

The function of this partition is to prevent foam and scum from escaping from the tub through the channels on the surface of *the clarifier lamella . The clarifier lamella has 2 output pipes, namely the over flow* pipe which will flow to pool 2 and the effluent pipe at the base of *the clarifier lamella* which will flow back to the reactor.

Figure 11. *Foam Arrestor* and *Clarifier Lamellas*

7. Gas Holder

Gas Holder is a temporary container for holding gas before use. There are several types of gas holders, namely; *Low-Pressure Gas Storage, Medium-Pressure Gas Storage* and *High-Pressure Gas Storage.*

Figure 12. *Gas Holder*

8. Burners

The burner is a unit that will convert the gas produced into energy. This energy produced is used to help form steam in the boiler. To operate *the burner* , a biogas flow rate of >50 Nm3/hour is required. So biogas production in CSTR must be >70 Nm3/hour. This is done so that there is no reduction in the gas volume in *the gas holder* . Biogas is sent to *the burner* using *a blower* which will flow the biogas through a pipe. *The burner* also requires several supporting equipment such as a compressor, control valve, *cyclone* , pressure measurement instruments, flow rate measurement instruments and others. The burner can be operated via a panel located at the boiler station.

9. Flare Stack

Flare Stack is a process unit that functions to burn biogas when not in use. Biogas will be burned if production is low or when the boiler is not operating. Before being burned, the biogas is contacted with water in the seal drum to reduce H_2S levels. Apart from that, this process also aims for security factors. The flame that burns at the tip of the flare will not spread to other process units because of the presence of water at the bottom of the flare stack. Meanwhile, gas can still escape and burn.

Figure 13. *Flare Stack*

Sustainable Standards in the Palm Oil Industry

The three pillars of sustainability such environmental, social and economic must be considered in a responsible approach to economic development. An industry should ideally uphold environmental standard while fostering community development and long-term economic growth.

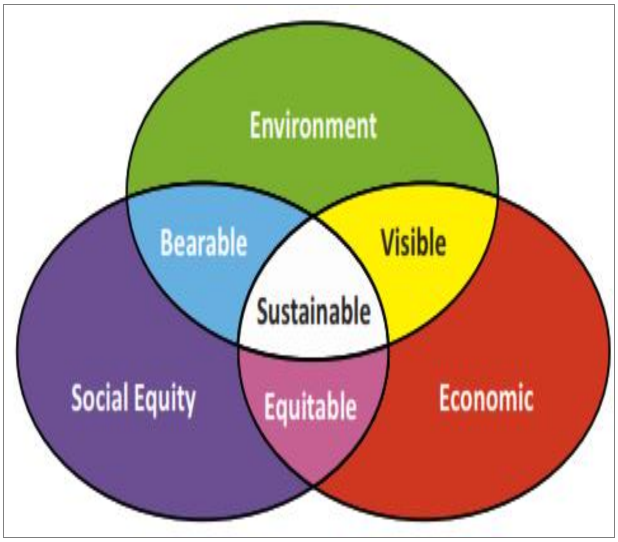

Figure 14. Three pillars of sustainability: Environmental, Social and Economic

Sustainability stated to gain traction since 2005, different types of standards began to develop. Sustainability standards for biomass production over time are shown in the following figure:

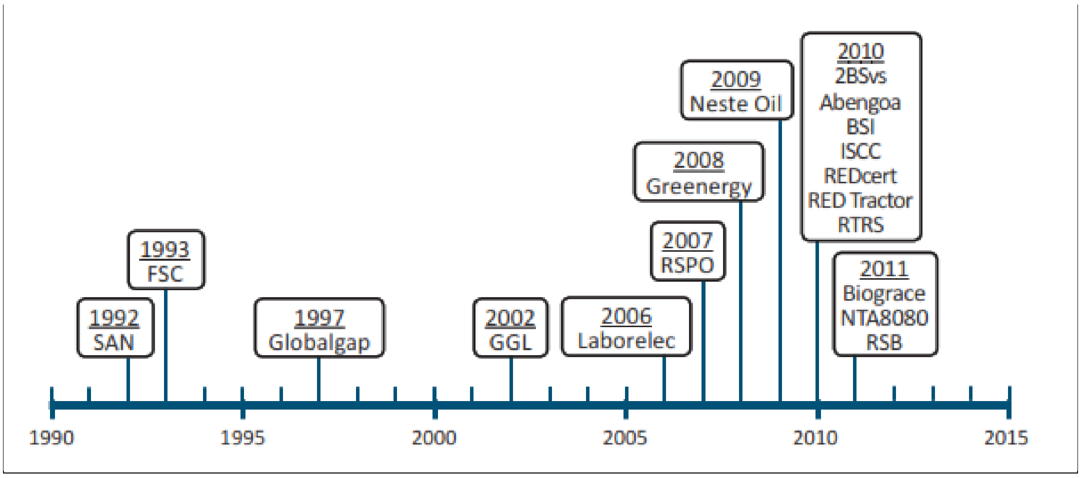

Figure 15. Sustainable Standards for the Biomass Industry

The Palm Oil Industry in Indonesia generally uses two types of international standards for sustainability, namely *the Roundtable on Sustainable Palm Oil* (RSPO) and *the International Standard for Carbon Certification* (ISCC). The following table explains the main principles and criteria of RSPO and ISCC as well as similar aspects between the two:

Table 6. Principles and Examples of Criteria from RSPO and ISCC

Principle	Examples of Criteria
Commitment to transparency (RSPO)	- Providing information to stakeholders on environmental, social and legal issues for effective decision making - Unfair management documents have commercial confidentiality available to the public
Commitment to long-term financial and economic viability (RSPO)	- Business management plan aimed at achieving long-term economic and financial resilience
Biomass is not produced from land with high biodiversity value or carbon stocks (ISCC)	Biomass is not produced in: - Land with high biodiversity value - Areas that are the goal of nature protection - Grasslands with high biodiversity - Peatlands
Environmental responsibility and conservation of resources and biodiversity (RSPO)	- The status of rare, threatened or endangered animals/plants and habitats with high conservation value must be identified and include conservation efforts - Waste minus recycling is reused and disposed of properly - Efficient use of renewable energy - Avoid burning in waste disposal and land preparation - be developed, implemented and monitored
Biomass must be produced in an environmentally responsible manner, including protecting soil, water and air and implementing good agricultural practices (ISCC).	- Land management plan - Minimizes erosion - Maintaining the quality and availability of ground water - Use of integrated pest management - Appropriate use of agricultural chemicals - Appropriate use of agricultural chemicals - Responsible water use and abstraction - Proper disposal of excess chemical mixtures - Facilities to handle spills
Implementation of best practices by palm oil plantations and mills (RSPO)	- Documented product inventory - Appropriate and safe facilities for storing products - Availability of adequate waste disposal
education, use of protective clothing and	- Well implemented occupational health and safety plans - Training for workers, farmers and contractors - Availability of first aid equipment - Wear proper protection - Clean eating area and running water - Procedures and facilities for handling accidents - Livable residence

Table 7. Principles and Examples of Criteria from RSPO and ISCC (continued)

Principle	Examples of Criteria
Biomass production will not violate human rights, labor rights or land rights. Uphold working conditions that are responsible for workers' health and must be based on responsible community relations (ISCC)	- Social impact study - Transparent communication between factories and farmers, communities, government and related parties - System for submitting and handling complaints and grievances - Documented compensation for affected communities - Legal, standard minimum wage - Freedom to form trade unions - No child labor - Protection from sexual harassment - No discrimination
Responsible consideration of work and individuals and communities affected by the activities of palm oil plantation and mill entrepreneurs (RSPO)	- Fair and transparent agreements with farmers - Contribution to sustainable local development
Biomass Production must comply with all applicable regional and national laws and must follow relevant international agreements (ISCC) Compliance with applicable laws and regulations (RSPO)	- Legal rights to land - Compliance with regional and national laws and international agreements - Prior and free consent from local communities regarding land use
Responsible development of new plantings (RSPO)	- Comprehensive and participatory social and environmental impact assessment - Land survey and topographic information for site planning - Avoid planting on steep surfaces - Decent land compensation for local communities - Avoid burning practices in land clearing
Implementation of good management practices (ISCC) Commitment to continuous improvement in key areas of activity (RSPO)	- Routine primary supervision and review - Effective data recording system

The sustainability of the palm oil industry currently receiving serious attention from international *stakeholders* . The sustainability of oil palm plantations in practice focuses on 3Ps: *profit* or economic perspective, *people* or social perspective and *planet* or environmental perspective (Yee Guan Ng et all, 2013) which is shown in a conceptual framework for the sustainability of the palm oil industry in the image below:

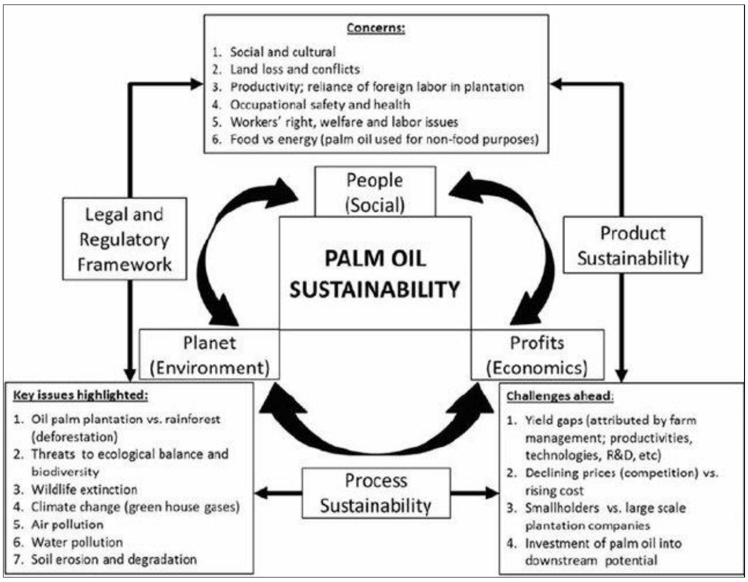

Figure 16 Conceptual Framework for Sustainability of the Palm Oil Industry

1. Environmental Aspects
The operation of Biogas Co-firing in Sei Pagar has a sustainable impact on environmental aspects, namely as follows:

a. Reducing Greenhouse Gases (GHG)
The value of greenhouse gas emissions produced by the Sei Pagar PKS is 148.71 kgCO2-e per ton of CPO, this is very much down compared to before further processing of biogas was carried out where greenhouse gas emissions originating from factory liquid waste were in the range *between* 400 to with 500 kgCO2-e per ton of CPO.

b. Reducing Water Pollution
Palm oil processing liquid waste (POME) at the Sei Pagar PKS, which has been processed as an input source for biogas processing, has been able to overcome the possibility of water pollution from liquid waste.

c. Maintaining natural sustainability
There is no contamination of the water flow around the factory area with factory liquid waste, further protecting existing aquatic life as an effort to preserve nature.

2. Economic Aspects
The operation of Biogas Co-firing in Sei Pagar has a sustainable impact on the economic aspect, namely as follows:

a. Increase *income* from excess shells
Based on data obtained in 2021 during biogas co-firing operations, the shells used for boiler combustion were around 7,080 tons, with a total of 13,820 tons of shells produced. This means that there is an excess of shells of 6740 tons or around 48.8%, an increase from previously which was only around 3000 tons or around 21.7%. This is a source of additional income for the company with an estimated 6.74 billion rupiah a year.

b. Increase income from *green product labels* from ISCC and RSPO certification
CPO products that have been RSPO and ISCC certified receive an additional price incentive of around 8 to 10 US dollars per ton of CPO in 2021, this is able to contribute profits to the company of around 325,992 to 407,490 US dollars a year or the equivalent of 4.9 to 6.1 billion rupiah a year.

3. Social Aspects
The operation of Biogas Co-firing in Sei Pagar has a sustainable impact on social aspects, namely as follows:

a. Prevent environmental community demands
Processing POME into Biogas has shown PTPN V's commitment to caring about environmental issues that have an impact on social life.

b. Provide a positive image for the company
co-firing biogas operation has been able to provide a positive image of PTPN V as a palm oil industry manager who is committed to international sustainability standards.

CONCLUSION

1. Conclusion

Based on the results of the field visit to Biogas Co-firing PKS Sei Pagar PTPN V, several conclusions can be drawn as follows:

1. With the PKS SPA Biogas Plant, liquid waste is processed to produce biogas as boiler fuel. This biogas operation has been able to reduce greenhouse gas emissions.
2. The Sei Pagar Biogas Co-firing operation is one of PTPN V's strategic initiatives in the company's business *sustainability program* .
3. The impact of the Sei Pagar Biogas Co-firing operation on environmental aspects is that it has been able to reduce greenhouse gases, reduce water pollution and preserve nature.
4. The impact of the Sei Pagar Biogas *Co-firing operation* on the economic aspect is increasing income from selling shells and increasing income from green product labels from ISCC and RSPO certification.
5. Sei Pagar Biogas *Co-firing operations on social aspects is preventing environmental community demands and providing a positive image for the company.*

2. Suggestion

The suggestions that can be given are as follows:

1. The concept of sustainability *can* be an interesting research topic in measuring the influence of Biogas Operations on PTPN V's sustainability strategy
2. Other issues that can be discussed regarding Biogas Operations are the project funding business model and technology transfer governance.

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