



SUSTAINABLE ENERGY DEVELOPMENT AUTHORITY (SEDA) MALAYSIA

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# GUIDELINE

**ON BIOMASS POWER PLANT ACCEPTANCE TEST AND  
PERFORMANCE ASSESSMENT (AT&PA) FOR FEED-IN  
TARIFF (FIT) PROJECTS IN MALAYSIA (CHECKLIST)**

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June 2018

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## GLOSSARY OF TERMS

### Abbreviations

AT&PA	Acceptance Test & Performance Assessment
AT	Acceptance Test
EE	Electrical Efficiency
FAT	Factory Acceptance Test
FiAH	Feed-in Approval Holder
FiT	Feed-in Tariff
FiTCD	FiT Commencement Date
IOD	Initial Operational Date
NEC	Net Export Capacity
OPET	Overall Plant Efficiency Test
RE	Renewable Energy
RR	Reliability Run
SAMM	<i>Skim Akreditasi Makmal Malaysia</i>
TMCR	Turbine Maximum Continuous Rating

## GUIDELINE (CHECKLIST)

The Feed-in Tariff (FiT) is a policy mechanism in Malaysia which allows electricity produced from renewable resources to be sold to power utilities at a fixed premium price for a specific duration to enable financial viability of Renewable Energy (RE) plant development. The FiT mechanism was introduced through Renewable Energy Act 2011 [Act 725] in order to promote RE generation in Malaysia. One of the RE resources which qualify under FiT is biomass which available from lignocelluloses materials or waste resources such as agriculture and solid waste.

It is the legal responsibility of SEDA Malaysia, the Authority to ensure that all biomass installations approved are designed and constructed in accordance to the international standards and best practices, while meeting minimum national safety standards for the protection of personnel and equipment. **The Guideline on Biomass Power Plant Acceptance Test and Performance Assessment (AT&PA) for FiT Projects in Malaysia** is prepared to provide assistance to the Feed-in Approval Holder (FiAH) under the biomass installation. This Guideline is useful when preparing the plant performance assessment reporting by the biomass project developers in preparing test report for FiT Commencement Date (FiTCD).

This Guideline/Checklist is in addition to, and intended to complement, not replace, the Electricity Supply Act, the Renewable Energy Act, the Occupational Safety and Health Act, and their related subsidiary legislations. It serves to provide simple yet clearer guide as to the step-by-step in conducting the AT&PA as required by the Authority.

This Guideline/Checklist consists of five (5) parts;

- a) Checklist of AT&PA documentation;
- b) Information about the Project;
- c) Information about the Plant;
- d) Acceptance Test (AT) & Reliability Run (RR); and
- e) Fuel Sampling, Ash Sampling & Overall Plant Efficiency Test (OPET).

The AT&PA must be carried out by the respective FiAH's Competent Persons in the presence of SEDA Malaysia's representatives. A minimum notice of 14 days is required for the AT&PA arrangement, together with the payment of the prescribed fee. The AT&PA fee to be prepared in the form of Bank draft or Bankers cheque in favour of "**Sustainable Energy Development Authority Malaysia**".

Region	AT&PA Fee
Peninsular Malaysia	RM 56,604.00
Sabah & Labuan	RM 60,377.00

In the event the AT&PA works need to be postponed or repeated due to unreadiness or fault by feed-in approval holder, additional charges of RM1,000.00 per day will be imposed to FiAH for the number of days to complete the AT&PA works.

The notice to be sent;

**SEDA Malaysia (AT&PA of Biogas Project)**

Galeria PjH, Aras 9, Jalan P4W, Persiaran Perdana, Presint 4,  
62100 Putrajaya, W.P. Putrajaya

Tel: +603-8870 5800; Fax: +603-8870 5900; Email: [RET@seda.gov.my](mailto:RET@seda.gov.my)

## INTRODUCTION

Presently, direct-firing combustion is the primary approach for generating electricity from biomass plant where the fuel is burned in a boiler to produce high-pressure steam. The steam is then used to drive a steam turbine. The turbine shaft output is connected to an electric generator, to produce electricity. Biomass power boilers are typically in the 20-50 MW range, with typical plant efficiency between 7 – 27%.

The main sections of a conventional direct-firing biomass power plant are the steam generating unit (boiler) and the turbine-generator. The overall performance of the power plants depends on the performance of each of this section, indicated by numbers of key performance indicators. The conventional direct-firing biomass power plant is illustrated in Figure 1.

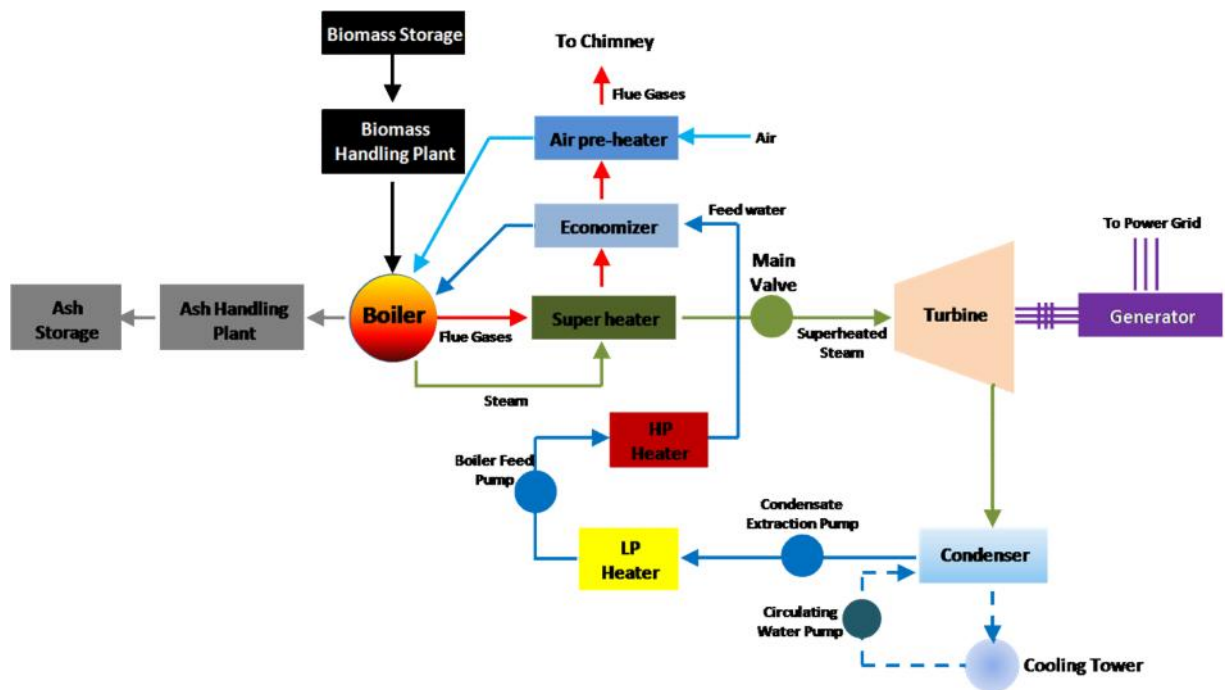


Figure 1: Conventional Direct-Firing Biomass Power Plant

## 1.0 CHECKLIST OF ACCEPTANCE TEST & PERFORMANCE ASSESSMENT DOCUMENTATION

### FORM 1: Checklist of Acceptance Test & Performance Assessment Documentation

No.	Documents	Prepared by FIAH	Checked by SEDA	Remarks
<b>1.</b>	<b>PART - A: Information About Project</b>			
a)	Form 2: Information About Project			
b)	Overall Plant Management Team Organization Chart			
c)	List of Key Personnel that will be present during the test and their contact number (mobile)			
d)	Proposed Test Schedule of Acceptance Test & Reliability Run			
e)	Copy of Initial Operational Date (IOD) approval letter from the Distribution Licensee			
f)	Copy of Competent Person Certificate (Chargeman) under Electricity Regulation, 1994, Energy Commission			
g)	Copy of Competent Person Certificate (Boilerman) under Factories and Machinery Act 1967, Department of Safety & Health (DOSH)			
h)	Copy of Competent Person Certificate (Internal Combustion Engine (ICE)/Steam Engineer) under Factories and Machinery Act 1967 and Factories and Machinery (Person in Charge) Regulations 1970 - P.U.(A) 11/70, Department of Safety & Health (DOSH)			
i)	Copy of <i>Kebenaran Bertulis</i> under Section 19, Environmental Quality Act 1974 and Regulation 6 of Environmental Quality (Prescribed Premises) (Crude Palm-Oil) Regulations 1977 – P.U. (A) 342/77, Department of Environment (DOE)			
J)	Copy of <i>Kebenaran Bertulis</i> under Regulation 36 & 38 of Environmental Quality (Clean Air) Regulations 1978 - P.U.(A) 280/78, Department of Environment (DOE)			

<b>2.</b>	<b>PART - B: Information About Plant</b>			
a)	Form 3: Information About Plant			
b)	Document of overall plant layout inclusive of fuels treatment and processing system, boiler, steam turbine, deaerator, condenser and generator system.			
c)	Electrical Single Line Diagram (SDL) – Generator to PMU			
d)	Boiler technical specification, operation and maintenance manual which include performance, losses and correction curves data.			
e)	Steam turbine technical specification, operation and maintenance manual which include performance, losses and correction curves data.			
f)	Generator operation manual and maintenance manual which include Performance, losses and correction curves data.			

g)	Report of Factory Acceptance Test (FAT) of boiler.			
h)	Report of Factory Acceptance Test (FAT) of steam turbine.			
i)	Report of Factory Acceptance Test (FAT) of generator.			
j)	Data Acquisition System Display Diagram / Schematic and Technical Specifications			
k)	Technical specification for other equipment such as deaerator, surface condenser, economizer, super-heater, re-heater, cooling water cooling system, steam cooling spray system, FD & ID fan specification			
l)	Process Flow Diagram (PFD) Document for overall plant			
m)	Piping and Instrumentations Diagram (P&ID) Document for overall plant			
n)	Fuel (biomass) operation control, monitoring and measurement system manual			
o)	Flue gas monitoring and measurement system manual, CEMS calibration certificates or On-site calibration Procedure, details and Accuracy of Span Gasses.			
p)	Ash / residue monitoring, Measurement and Handling System Manual.			
q)	List of equipment being used for data measurement inclusive of type and location of installation			
r)	Valid Certificate of calibration for installed measuring instrument;			
	a) Flowmeter			
	b) Temperature			
	c) Pressure			
	d) Power/ Energy Meter			
	e) Continuous Emission Monitoring System (CEMS) (Optional)			(if available)

<b>3.</b>	<b>PART - C: Acceptance Test (AT) &amp; Reliability Run (RR)</b>			
a)	Form 4a: Acceptance Test at 50% Turbine Maximum Continuous Rating (TMCR)			
b)	Form 4a: Acceptance Test at 75% TMCR			
c)	Form 4a: Acceptance Test at 100% TMCR			
d)	Form 4b/c: Reliability Run at min 50% Net Export Capacity (NEC)			
e)	Plant operation data during Acceptance Test and Reliability Run in CSV format (CD)			
	i) Acceptance Test			
	ii) Reliability Run			

<b>4.</b>	<b>PART – D: Fuel Sampling, Ash Sampling &amp; Overall Plant Efficiency Test (OPET)</b>			
a)	FORM 5a: Weighing Test			
b)	FORM 5b: Mass Flow of Biomass Fuel			
c)	FORM 5c: Fuel Sampling			
b)	FORM 5d: Overall Plant Efficiency Test (OPET)			
	Detail calculation of Electrical Efficiency			

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		



## 2.0 INFORMATION ABOUT THE PROJECT

### FORM 2: Information about the Project

Project details	
FIT application number	
Name of Feed-in Approval Holder (FiAH)	
Project description	Biomass (Agriculture / Solid Waste)
Site GPS coordinates (Latitude, Longitude)	
Site address	
Date of inspection (dd/mm/yyyy)	

Feed-in Approval Holder (FiAH) details	
Name of Contact (Person in-charge for Acceptance Test & Reliability Run)	
Mobile phone number/Ground phone number	
Email address	
FiT Bonus	<input type="checkbox"/> use of gasification technol <input type="checkbox"/> use of steam-based electricity generating systems with overall efficiency of above 20% <input type="checkbox"/> use of locally manufactured or assembled boiler or gasifier <input type="checkbox"/> use of solid waste as fuel source

Installation details	
Date of completion of installation	
Date of Initial Operational Date (IOD)	
Energy meter reading (kWh)	
<b>Remarks:</b>	

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

### 3.0 INFORMATION ABOUT THE PLANT

#### FORM 3: Information about the Plant

No.	Item	Details
1.	Plant Capacity	<p><u>Feed-in Approval;</u></p> <ol style="list-style-type: none"> <li>1. Installed capacity, kW:</li> <li>2. Net Export capacity, kW:</li> <li>3. No. of unit steam-turbine at site:</li> </ol> <p><u>Actual capacity at site;</u></p> <ol style="list-style-type: none"> <li>1. Generator capacity, kW:</li> </ol>
2.	Biomass Sources	<ol style="list-style-type: none"> <li>1. Type of waste: Agriculture / Solid waste</li> <li>2. Feedstock capacity, (ton/hour or ton/day):</li> <li>3. Range of fuel LHV:</li> <li>4. Average fuel moisture content:</li> <li>5. Retention time: day/week/month</li> </ol>
3.	Boiler Specification	<ol style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Type of boiler</li> <li>3. Technology origin</li> <li>4. Operating pressure</li> <li>5. Operating steam temperature</li> <li>6. Maximum steam flow-rate (MCR)</li> <li>7. Boiler efficiency, <math>\eta_B</math></li> </ol>
4.	Deaerator	<ol style="list-style-type: none"> <li>1. Type</li> <li>2. Rated capacity</li> <li>3. Design pressure</li> <li>4. Temperature of outlet water</li> </ol>
5.	Combustion system	<ol style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Combustion grade type</li> <li>3. Maximum allowable fuel burning rate</li> <li>4. Maximum furnace load</li> <li>5. Draft system</li> </ol>
6.	Steam turbine	<ol style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Tyoe</li> <li>3. No. of stages</li> <li>4. Maximum permitted steam pressure at turbine inlet</li> <li>5. Superheated</li> <li>6. Turbine speed</li> <li>7. Specific steam consumption</li> </ol>
7.	Generator	<ol style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Type of excitation system</li> <li>3. Speed</li> <li>4. Voltage</li> </ol>

		<ul style="list-style-type: none"> <li>5. Efficiency</li> <li>6. Continued rated output</li> <li>7. PF &amp; Frequency</li> <li>8. No. of poles</li> <li>9. Power factor</li> <li>10. Full load current (Amp)</li> </ul>
8.	Isolation Transformer	<ul style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Continue rating</li> <li>3. Nominal system voltage (HV/LV)</li> <li>4. Transformer type</li> <li>5. Type of cooling</li> </ul>
9.	Plant Auxiliary Transformer	<ul style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Continue rating</li> <li>3. Nominal system voltage (HV/LV)</li> <li>4. Transformer type</li> <li>5. Type of cooling</li> </ul>
10.	Sub-station	<ul style="list-style-type: none"> <li>1. Capacity, (KV)</li> <li>2. Type of cable</li> <li>3. Distance cable from plant</li> </ul>
11.	Data Communication System (DCS)	<ul style="list-style-type: none"> <li>1. Manufacturer</li> <li>2. Availability of SCADA: YES/NO</li> <li>3. Minimum interval time, minute/second:</li> <li>4. Storage capacity:</li> <li>5. Data format (CSV) Excel: YES/NO</li> </ul>
<b>Remarks:</b>		

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

## 4.0 ACCEPTANCE TEST & RELIABILITY RUN

### 1.1 Acceptance Test (AT)

- a) A data logger is required to capture all data during AT.
- b) The system shall run at three (3) load points.
  - ✓ Biomass Plant operating with **single steam-turbine**:- Minimum load of **50% TMCR, 75% TMCR and 100% TMCR**. Each test run will be conducted twice and two sets of reading shall be taken for each load. Each test run shall be conducted for a minimum of four (4) hours. For test load at 100%, the following condition shall apply:
    - Ten percent (10%) tolerance will be given relative to 100% TMCR; **AND**
    - The power output must not be less than the Net Export Capacity at any time during the test.
    - SEDA Malaysia may vary the conditions above on a case-by-case basis.
  - ✓ Biomass Plant operating with **multiple steam-turbines**:- Minimum load of **50% TMCR, 75% TMCR and 100% TMCR**. Each test run will be conducted twice and two sets of reading shall be taken for each load. Each test run shall be conducted for a minimum of four (4) hours. Ten percent (10%) tolerance will be given during the test load at 100% TMCR only.
- c) FiAH is required to complete **Form 4a** for the AT documentation.

### 1.2 Reliability Run (RR)

- a) A data logger is required to capture all data during RR.
- b) Test run shall be performed at minimum load requirement of **50% Net Export Capacity (NEC)**.
- c) Test shall be conducted for duration of **336 hours (approximately for 14 days, 24 hours operation) and shall achieve minimum of 90% uptime**.
- d) During RR test, the real time parameters must be sampled at a maximum of one (1) hour intervals for fourteen (14) consecutive days.
- e) FiAH is required to complete **Form 4b** and **Form 4c** for the RR documentation.

**Table 4a: Acceptance Test Form**

Project	:	Date of Test	:	Time Start	:
Plant Name	:	Run Number	:	Time End	:
Type of Assessment	:	Run Load	:		

Time (15 min interval)	Plant Data														Ambient/Surrounding Data		
	Flue gas temp (boiler)  (°C)	Flue gas temp (economizer)  (°C)	Flue gas temp (air heater)  (°C)	Reference air temp  (°C)	Feedwater temp  (°C)	Feedwater pressure (economizer)  (bar)	Feedwater pressure (boiler)  (bar)	Feedwater flow to steam generator  TPH	Steam temperature at super- heater outlet  (°C)	Throttle steam pressure  (bar)	Throttle steam temp  (°C)	Throttle steam flowrate  TPH	Power factor	Generator output  (kW)	Pressure  (mbar)	Temp  (°C)	Humidity  (% RH)

Signature			Remarks:
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>	
Name			
Date			
Designation			

**FORM 4b: Reliability Run (Daily Record)**

Project :	Plant Capacity :	<b>MW</b>	Date Start :
Plant Name :	Net Export :	<b>MW</b>	Date End :
Type of Assessment :	<b>Reliability Run (RR)</b>		Time Start :
			Time End :

**Daily Data Recorded Reliability Run Form**

Date	Time (hourly – up to 24hrs)	Plant Running Power (kW)			
		Present Value	Maximum	Minimum	Average
	0:00				
	1:00				
	2:00				
	3:00				
	4:00				
	5:00				
	6:00				
	7:00				
	8:00				
	9:00				
	10:00				
	11:00				
	12:00				
	13:00				
	14:00				
	15:00				
	16:00				
	17:00				
	18:00				
	19:00				
	20:00				
	21:00				
	22:00				
	23:00				
<b>Average Running Power, kW</b>					
Remarks:					

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

**FORM 4c: Reliability Run (Summary Record)**

Project :	Plant Capacity :	<b>MW</b>	Date Start :
Plant Name :	Net Export :	<b>MW</b>	Date End :
Type of Assessment :	<b>Reliability Run (RR)</b>		Time Start :
			Time End :

**Summary of Daily Reliability Run Form**

Day	Date	Average Power Output During Plant Uptime (kWe)	Energy Exported During Plant Uptime (kWh)	Operation Hour Required (hr)	Downtime Recorded (hr)	Actual Operation (hr)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
<b>Total</b>						

Remarks:

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

## 5.0 FUEL SAMPLING, ASH SAMPLING & OVERALL PLANT EFFICIENCY

In determining the overall plant efficiency, there are two methods namely **Input-Output method** and **Heat Loss Method** can be used.

### 1.1 Weighing Test and Mass Flow of Biomass Fuel;

- The FIAH shall calculate the weight of the biomass fuels per shovel using plant weighing bridge or any available method at FIAH's plant to determine the net weight mass of biomass fuels entering the boiler. In case of more than one type of biomass fuel is used, the weighing test needs to be conducted separately and recorded accordingly.
- This test shall be conducted prior to the steam-turbine efficiency test at 100% TMCR.
- The FIAH is required to complete **Form 5a** to record the Weighing Test and **Form 5b** to record the mass flow of the biomass fuel.
- The test method is not limited to as mentioned above. The FIAH is freely to propose other method as agreed by the relevant parties.

### 1.2 Fuel Sampling & Ash Sampling;

- The fuel sampling shall be conducted by the lab representative or FIAH's personnel and monitored by SEDA Malaysia's representative. Lab representative or FIAH's personnel shall collect at least two (2) samples of biomass fuel (approximately 500 gram per sample).
- The biomass fuel samples shall be packed, sealed and labelled with appropriate information (date, time taken, location, etc.).
- The biomass fuel samples shall be then analysed by an Accredited Laboratory of *Skim Akreditasi Makmal Malaysia* (SAMM) appointed by SEDA Malaysia.
- It is recommended that the fuel sampling be taken during 100% TMCR.
- Minimum parameters of biomass to be analysed, but not limited to;
  - a) Biomass Fuel Sample
    - ✓ Moisture, % (as basis)
    - ✓ Ash, % (as basis)
    - ✓ Volatile Matter, % (as basis)
    - ✓ Fixed Carbon, % (as basis)
    - ✓ Gross Calorific Value, kcal/kg (as dry basis)
    - ✓ Bulk Density, kg/m<sup>3</sup> (as dry basis)
    - ✓ Hydrogen (H<sub>2</sub>), % (as dry basis)
    - ✓ Nitrogen (N<sub>2</sub>), % (as dry basis)
    - ✓ Carbon (C), % (as dry basis)



- ✓ Oxygen (O<sub>2</sub>), % (as dry basis)
- ✓ Total Sulphur, % (as basis)
- b) Biomass Bottom Ash Sample
  - ✓ Moisture, % (as basis)
  - ✓ Carbon (C), % (as dry basis)
- c) Biomass Fly Ash Sample
  - ✓ Moisture, % (as basis)
  - ✓ Carbon (C), % (as dry basis)
- In case the FiAH wants to use Heat Loss Method to calculate the overall plant efficiency, one (1) sample of bottom ash and one (1) sample of fly ash need to be collected during 100% TMCR.
- The ashes need not to be collected if the FiAH wants to use Input-Output Method.
- The FiAH is required to complete **Form 5c** for fuel sampling documentation.

### **1.3 Overall Plant Efficiency Test (OPET);**

- The Overall Plant Efficiency Test (OPET) requirement is to measure the overall biomass plant performance by using actual biomass fuels condition at site. The FiAH is required to complete **Form 5d** for OPET documentation.
- The FiAH needs to provide the OPET details calculation. The plant log data (in CSV format) and laboratory result are to be attached to support the calculation.
- The FiAH is eligible for the FIT bonus of use of steam-based electricity generating systems if the calculation of OPET is above 20%.
- The FiAH may opt for Heat-Loss Method provided the system are equipped sufficiently with a key measuring tools and based on ASME PTC 4 - 2013\_Fired Steam Generator (Performance Test Code) or equivalent as agreed by the relevant parties.

**FORM 5a: Weighing Test**

Project :	Date of Test :	Type of fuel:
Plant Name :	Shovel Type :	
Type of Assessment : <b>Weighing Test</b>	Shovel Number :	

Description	Weighing Time (hour)	Weight (mt)
Empty		
Load 1		
Load 2		
Load 3		
<b>Average Load (mt)</b>		
<b>Average Fibre (mt)</b>		

Remarks:

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

FORM 5b: Mass Flow of Biomass Fuel			
Project :	Date :		
Plant Name :	Type of fuel :		
Type of Assessment :	<b>Mass Flow (Feed Count)</b>		

Start Count (Time)	Feed Count										Stop Count (Time)	Total Count
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		
	1	2	3	4	5	6	7	8	9	10		

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		

**FORM 5c: Fuel Sampling**

Project	:		Date	:	
Plant Name	:		Time	:	
Type of Assessment	:	<b>Fuel Sampling</b>			

Sampling details	<ol style="list-style-type: none"> <li>1. The fuel sampling shall be carried out by an Accredited Laboratory of <i>Skim Akreditasi Makmal Malaysia (SAMM)</i></li> <li>2. Minimum parameters of biomass to be analysed, but not limited to; <ul style="list-style-type: none"> <li>✓ Moisture, % (as basis)</li> <li>✓ Ash, % (as basis)</li> <li>✓ Volatile Matter, % (as basis)</li> <li>✓ Fixed Carbon, % (as basis)</li> <li>✓ Gross Calorific Value, kcal/kg (as dry basis)</li> <li>✓ Bulk Density, kg/m<sup>3</sup> (as dry basis)</li> <li>✓ Hydrogen (H<sub>2</sub>), % (as dry basis)</li> <li>✓ Nitrogen (N<sub>2</sub>), % (as dry basis)</li> <li>✓ Carbon (C), % (as dry basis)</li> <li>✓ Oxygen (O<sub>2</sub>), % (as dry basis)</li> <li>✓ Total Sulphur, % (as basis)</li> </ul> </li> </ol>
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Description of Sampling (to be filled by Accredited Lab's representative)		Remarks
Sample Number	:	
Sampling point	:	
Sample capacity	:	
Sampling method/tool	:	

Signature			
	<b>FiAH's Representative</b>	<b>Accredited Lab's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name			
Date			
Designation			

**FORM 5d: Overall Plant Efficiency Test (OPET)**

Project :	Date :
Plant Name :	Test Number :
Type of Assessment : <b>Overall Plant Efficiency</b>	Biomass Fuel Type :

Fuel Processing				
System/Equipment	Unit	Rated Data	Actual Data	Remark/Reference
Fuel processing capacity/flowrate				
Fuel High Heating Value (HHV)	kJ/kg			
Moisture content	%			
Heat Density of Water	kJ			
Low Heating Value (LHV)	kJ/kg			
Boiler System				
Enthalpy of feedwater	kJ/kg			
Enthalpy of steam	kJ/kg			
Steam pressure	Bar			
Steam temperature	°C			
Steam flow	tonne/hr			
Steam Turbine				
Speed	rpm			
Type of steam turbine				
Steam turbine inlet pressure	barA			
Steam turbine inlet temperature	°C			
Bleed steam	barA			
Condensing pressure	barA			
Turbine isentropic efficiency	%			
Generator				
Power	MWe			
Voltage	kV			
Power factor				
Full load current	A			
Energy generation	kWh			
Overall Plant Efficiency Calculation (to be submit the detail calculations in separate sheet)				
Determine net energy input entering boiler, $E_i$ (kJ) :				
Determine energy output of boiler, $E_o$ (kJ) :				
Determine Maximum Boiler Efficiency, $\eta_B$ (%) :				

Determine net energy input entering turbine,  $e_i$  (kJ) :

Determine energy output of turbine generator,  $e_o$  (kJ) :

**Determine Turbine Electrical Efficiency,  $\eta_T$  (%) :**

**Determine Overall Plant Efficiency,  $\eta_p$  (%) :**

Signature		
	<b>FiAH's Representative</b>	<b>SEDA Malaysia's Representative</b>
Name		
Date		
Designation		