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1. Executive Summary

The Kyoto protocol, although not ratified to the extent intended, has become a major issue for governments worldwide.

Concern over global warming and the effect of pollution caused by the burning of “brown” fuels cannot be neglected.

In order to supervise the energy sector more specifically, the Government established the Malaysian Energy Commission (MEC), with effect from 1st May 2001.

Among others, the MEC is responsible for promotion of new renewable sources of energy.

The promotion of renewable energy and more efficient utilization of local energy resources is part of Malaysia National Strategy on Fuel Diversification.

According to MEC Chairman Datuk Mohd Annas Mohd Nor, about 50 to 60 renewable power plants will be set up by 2005 to meet the targeted 5 per cent or 750 megawatt (MW) of the total estimated national power supply.

The MEC, however, has yet to determine the number of companies to participate in the renewable energy sector, but anticipates each company to take up and manage at least two to three power plants.

Study performed by the Government in year 2000 and 2001 has shown that the renewable sources of energy available in Malaysia have an annual energy potential equivalent to more that 36 million tones of crude oil.

This is a huge potential that has to be utilized for energy generation.

Energy production from renewables, and the common desire to use the sustainable fuel sources will all help to increase the use of biomass based fuels for generating electricity and heat.

Malaysia has over 3.5 million hectares of oil palm plantation capable of producing about 16 million tones of biomass annually.

The use of biomass for energy production is one of the major actions that are environmentally friendly and are also economically sensible.

In relation to utilization of biomass for power generation, the following shall be highlighted:

- The Government of Malaysia has a strong interest in promoting implementation of biomass waste for energy generation because it would help improve the productive value of the finite energy resources.
- By introduction of biomass based energy production also the environment would benefit. A 10 % saving in fossil fuel consumption will immediately translate into 10 % reduction in emissions into the environment.

- ❖ Malaysia has an abundant supply of agricultural wastes that can be used to generate energy.
- ❖ Power plants based on biomass fuels will be relatively small in size (optimal 5 – 10MW) due to low energy content (heating value) and low bulk density of the fuel, which prevents, from economic point of view, transportation of fuel over long distances.
- ❖ The above fact will promote localized (distributed) energy production. One typical biomass power plant could produce enough energy for up to 1,700 households.
- ❖ The proximity to estates and plantations, in this case oil palm plantations, will enable easier transportation of biomass fuels to the power plant.
- ❖ This would enhance the economic viability of putting such power plants fuelled by biomass.
- ❖ While the population in Malay Peninsula is well served by an extensive grid system, supported by major centralized power plants, the Government appears committed to securing better use of indigenous energy sources, rather than imported coal that has been considered for recent IPPs.
- ❖ It is estimated that a total of 42 million tones of Oil Palm Fresh Fruit Bunches (FFB) were produced in Malaysia by end of last decade. The resulting waste would translate to a total waste volume of over 17 million tones of biomass.
- ❖ For low-pressure systems with an assumed energy convertion rate of 2.5 kg of palm oil waste material per kWh, potentially over 7,000 GWh could be generated in an overall capacity of over 1,000 MWe.
- ❖ Present Malaysia has both, the political focus on renewable energy and the will to implement it within this decade.

However, the renewable energy generation is not competitive at present market conditions.

Therefore, subsidies in the form of guaranteed higher tariffs (16 – 17 sen / kWh), exemption of import duties on machinery and equipment that are not produced locally, exemption of sales tax on machinery and equipment that are produced locally, income tax exemption on 70% on statutory income for five years and investment tax allowances have to be used to compensate for higher energy generation cost.

Worldwide great efforts are made to develop technologies, which can use difficult surplus residual biomass products from agriculture and forestry and also from municipal waste as a fuel at power plants.

Investment in renewable power energy generation is considered as a great challenge for each modern Investor and Project Developer.

2. Introduction

2.1 Background

Malaysia has been an energy exporter for the last 2 decades but its oil reserves are likely to be depleted within a decade and the gas reserves in about 50 years. Most of the coal is imported. There is no nuclear power generation nor are there plans for the future.

Until last year, renewable energy figures did not appear in the National Energy Balance although much biomass in the palm oil industry is available.

In the past, this area has been very much neglected partly because of the complacency generated by the oil and gas reserves.

Over the past couple of years, there have been attempts to introduce energy efficiency measures, but mainly in the electricity field.

But by 1999, both the Prime Minister and the Energy, Communication and Multimedia Minister were publicly stating that renewable had the potential to be a 5th fuel source in the country's energy supply scene. There is now an attempt to set up major demonstration projects using biomass from palm oil mills.

The development of renewable energy in Malaysia is still in the early stage, with few concrete policies for renewable energy.

In the Eighth Malaysia Plan (2001-2005), the government plans to replace the Four Fuel Diversification Policy with a Five Fuel Diversification Policy, which will add renewable energy as a potential source.

Utilizing only 5% of renewable energy could save the country RM 5 billion over 5 years (*The New Straits Times, 29/06/2000*). Therefore, government concern on renewable energy is beginning.

Government and non-government agencies are already taking proactive actions to coordinate and promote energy generation based on renewable resources such as inventory of renewable sources, identification of suitable technologies, create incentives for appropriate practical application and a better national renewable energy policy to allow more participation from government, non-government and public.

Financial institutions are urged to assist producers of renewable energies such as biomass and biogas to help realise the Government's target of generating about 750MW or 5 per cent of total power generation from new energy sources by the year 2005.

Malaysia has a good start since the programme kicked off in May last year.

It is estimated that about 16 million tonnes of waste generated yearly from the palm oil industry was more than enough to fuel small power and cogeneration plants.

Tenaga Nasional Bhd has shown commitment in supporting the Government's effort.

To date, the Malaysian Energy Commission has approved and granted licences to four renewable energy producers.

Tenaga has signed renewable energy purchase agreements with two producers under the **S**mall **R**enewable **E**nergy **P**rogramme (SREP).

The two producers are Bumibiopower Sdn Bhd and Tenaga's wholly-owned subsidiary, Jana Landfill Sdn Bhd. Both plants are still under construction.

In October last year Tenaga agreed to buy electricity generated by Bumibiopower at 16.7 sen per kWh (kilowatt hour) for 21 years, and from Jana Landfill at 16.5 sen per kWh for 15 years. More licences would be granted by year-end.

The Malaysian Energy Commission had introduced SREP to encourage producers to increase renewable power generation capacity.

Between 50 and 60 renewable power plants, costing RM40-RM50 million each, will be set up by 2005 to meet the Government's target.

The national electricity supply is projected at 15,000MW by 2005. To attract more players into the renewable energy sector and to compensate those already in the industry, the Government has granted these companies a 70 per cent tax-exemption on their statutory income for five years or a tax allowance of 60 per cent of capital expenditure incurred during the period.

In addition, the companies will also enjoy import duty and sales tax-exemption on machinery and equipment not available locally.

In the Eighth Malaysia Plan, the Government allocated RM500 million for renewable energy activities and RM300 million for energy efficiency activities.

The Government of Malaysia has a strong interest in promoting implementation of renewable energy generation because it would help improve the productive value of the finite energy resources the country has and develop national energy resources and power assets in a more sustainable manner.

In addition to bringing national benefits and savings to individual companies, introduction of renewable energy production would also benefit the environment.

A 10 % saving in fossil fuel consumption will immediately translate into 10 % reduction in emissions into the local and global environment.

But there is still much to done before renewable play their rightful role in the Malaysian energy set-up.

2.2 Biomass

Biomass is the name given to any recent organic matter that has been derived from plants as a result of the photosynthetic conversion process.

Biomass energy is derived from plant and animal material, such as wood from forests, residues from agricultural and forestry processes, and industrial, human or animal wastes.

The energy value of biomass from plant matter originally comes from solar energy through the process known as photosynthesis.

The chemical energy that is stored in plants and animals (that eat plants or other animals), or in the wastes that they produce, is called bioenergy.

During conversion processes such as combustion (burning), biomass releases its energy, often in the form of heat, and the carbon is reoxidised to carbon dioxide to replace that which was absorbed while the plant was growing.

Essentially, the use of biomass for energy is the reversal of photosynthesis.

$$\mathbf{CO_2 + 2H_2O \leftarrow_{light\ /\ heat} \rightarrow [(CH_2O) + H_2O] + O_2}$$

In nature, all biomass ultimately decomposes to its elementary molecules with the release of heat.

Therefore the release of energy from the conversion of biomass into useful energy imitates natural processes but at a faster rate; this means that the energy obtained from biomass is a form of renewable energy.

Utilizing this energy recycles the carbon and does not add carbon dioxide to the environment, in contrast to fossil fuels. Of all the renewable sources of energy, biomass is unique in that it is effectively stored solar energy.

Furthermore, it is the only renewable source of carbon, and is able to be processed into convenient solid, liquid and gaseous fuels.

Biomass can be used directly by burning for steam generation or indirectly by converting it into a liquid or gaseous fuel (for example ethanol from sugar crops or biogas from animal waste).

The net energy available in the biomass when it is combusted ranges from about 8MJ/kg for green wood, to < 20MJ/kg for oven dry plant matter (e.g. oil palm biomass with moisture content <10%; Appendix 7.3), to 55MJ/kg for methane; compared with about 23 - 30MJ/kg for coal.

The efficiency of the conversion process determines how much of the actual energy can be practically utilized.

2.3 Biomass Resources

Residues from palm oil mills, rice mills and wood mills as well as landfill gas (methane) are the main types of biomass resources that are considered as potential renewable energy for power generation (refer also to Appendix 7.2). Forest residues and biogas (pig waste) utilization are not significant.

Up till May 2001, there were 352 oil palm mills, 39 palm kernel crushers, 46 refineries and 16 oleo chemical plants in the country. They are producing about 16 million tones wastes of empty fruit bunches with an equivalent energy potential of more than 3 million tones of diesel oil, which represent about 10 % of the total national energy supply (status 2002).

Over the last decade production has increased and continues to grow rapidly. Typically palm oil mills consume less than half of their solid waste for energy requirements. The remainder is composted, incinerated, dumped or returned to the plantation.

Oil palm is the top agricultural commodity of Malaysia. Oil palm planting was expected to increase from 3.376 million hectares in 2000 to 3.547 million hectares in 2001. This constitutes about 60 percent of the total cultivated area in the country.

The recycling of waste products from the palm oil mills is a very important commercial opportunity and, more so, it has become a great environmental concern.

The empty fruit bunches; shell, fiber and liquid effluent can be used much more efficiently to fuel biomass power plants, which provide the mills' steam and power requirements and substantial surplus electricity to feed to a local or national grid.

At the same time, fossil fuel use is reduced and Greenhouse Gas emissions mitigated.

2.4 Opportunity for Small Biomass Power Plants in Malaysia

The concept of marketing biomass energy has a huge potential in Malaysia considering that the country has an abundant supply of agricultural wastes that can be used to generate energy.

There are around 352 palm oil mills in operation in Malaysia. They are using at least part of their waste material for process heat and power generation.

An estimated aggregate of 200 MWe capacity is installed at various palm oil mills. Power is generated to meet their own demand.

One typical biomass power plant could produce enough energy for up to 1,700 households.

Biomass power plants usually are sized between the range of 5 MW to 10 MW and are therefore more suitable for small housing areas, preferably those located near estates and plantations.

The proximity to estates and plantations, in this case oil palm plantations, will enable easier transportation of biomass fuels to the power plant. This would enhance the economic viability of putting such power plants fueled by biomass.

Research works were carried for almost 2 decades how to utilize oil palm biomass as raw material in wood based industries.

Many products with good potentials for commercialization have been developed and presented to be taken up by the industry. In spite of great efforts, the commercialization of oil palm biomass power generation projects is slow.

One of the major reasons is probably the availability of rubber wood, which is still obtainable in reasonably large quantity. However, the area under rubber plantation now is getting smaller and smaller, and in the near future, there may not be enough supply of rubber wood for industrial uses.

Wood from natural forest is also dwindling in supply due to the government strict control for sustainable forest management.

The time is ripe now to consider oil palm biomass to replace rubber wood and wood from forest resources as raw materials for wood-based industries.

While the population in Malay Peninsula is well served by an extensive grid system, supported by major centralized power plants, the government appears committed to securing better use of indigenous energy sources, rather than imported coal that has been considered for recent IPPs.

Superficial estimates of the potential for biomass generation range above 2000 MW using the discarded dried fruit bunches, biogas and the regular felling of the palm trees themselves.

It is estimated that a total of 42 million tones of Fresh Fruit Bunches (FFB) were produced in Malaysia by end of last decade.

FFB contain approximately 21 % palm oil and 6-7 % palm kernel. The resulting waste together with fiber and shells amounts to 42 % of the FFB, and would translate to a total waste volume of over 17 million tones of biomass.

For low-pressure systems with an assumed energy convertion rate of 2.5 kg of palm oil waste material per kWh, potentially over 7,000 GWh could be generated in an overall capacity of over 1,000 MWe.

The introduction of new and more efficient process heat and power generation equipment in existing palm oil mills will take center stage as co-generation is already widely practiced. In addition, for every tone of palm oil produced, 2.5 m3 of waste-water (POME) is generated.

Anaerobic digestion of this wastewater results in a biogas consisting of 60–70 % methane, 30–40 % carbon dioxide and trace amounts of hydrogen sulphide.

At many palm oil mills, this process is only done in order to meet water quality standards for industrial effluent. The gas is flared off. Potentially 1 m^3 of this biogas could produce additional 1 kWh of electrical power.

With the anticipated possible waste shortages in palm oil mills, these biogas resources may offer an alternative.

2.5 Environmental Aspects

Carbon dioxide from the atmosphere and water from the earth are combined in the photosynthetic process to produce carbohydrates that form the building blocks of biomass.

The solar energy that drives photosynthesis is stored in the chemical bonds of the structural components of biomass. If we burn biomass efficiently, oxygen from the atmosphere combines with the carbon in plants to produce carbon dioxide and water.

The process is cyclic because the carbon dioxide is then available to produce new biomass.

While there are already many uses for biomass besides using it as a fuel, it is useful to try to estimate how much biomass is available in terms of its energy content. The total annual worldwide production of biomass is estimated at $3*10^{13}$ GJ

Estimated annual world energy consumption is $3.6*10^{12}$ GJ

This means that biomass production is about eight times the total annual world consumption of energy from all sources.

Therefore, biomass represents not only very large energy resource but also great and very important potential for protection of our environment.

Another very important environmental aspect is the utilization of boiler waste product, the ash.

Currently, almost all plantations in the country are using chemical fertiliser. This may cause the soil to become acidic, resulting in the introduction of diseases like Ganoderma.

During the rainy season, the chemical runoff of rain water-chemical fertilizer can also affect the quality of ground water.

The biomass ash is an excellent organic fertiliser. With biomass ash, the soil can be revitalised back to mother nature’s fertile. It can be used in power plant own plantation or it may be sold to other plantations.

At present the world population uses only about 7% of the annual production of biomass.

Therefore, we are only partially exploiting nature's abundant renewable resource. For more details refer to Appendix 7.4.

2.6 Problems in using Biomass

It is clear that we view biomass most favorably, but there are some issues that need to be considered.

First the disposal of the biomass ash produced in the burning process.

At the moment, the ash, which contains an amount of nutrients, is dumped in landfills rather than being returned to the forests or to the oil palm plantations.

Some of the disadvantages of the use of oil palm biomass are:

It cannot be stored for more than a few weeks;

Oil palm biomass waste can undergo fouling process if not properly stored; and

Oil palm biomass is bulky in relation to its calorific content, and therefore uneconomical to transport very long distances by road.

3. Project Description

3.1 The Site

3.1.1 Site Conditions

Typical biomass power plant shall be preferably located near estates, plantations small housing areas.

Flat land areas within large oil palm plantations, with already existing hard surface access road, near by cooling water source (river, aquifer, large lake, sea, etc.) and not far away from the national grid network are most preferred for construction of biomass power plant (cost reduction).

Areas, which are periodically flooded, shall be avoided.

For climatic conditions, please refer to Appendix 7.5.

3.1.2 Site Access

The proposed site shall have a proper road access necessary for transportation of power plant equipment during construction activities and later for biomass fuel transportation trucks as well as for equipment transportation during major overhaul of main equipment.

3.1.3 Cooling Water Conditions

Direct, one through, cooling of the steam turbine condenser would be the most efficient and economical method.

However this is feasible if the power plant is proposed in near vicinity (<500m) of cooling water source.

Otherwise, other cooling methods have to be applied (wet cooling tower, air cooled condenser).

Typical, acceptable, river water specification, as well as recommended cooling water design temperatures are included in Appendix 7.5.

3.1.4 National Network Interconnection

In order to safe costs and transmission & transformation losses, the injection to the existing TNB shall be made at “lover” distribution voltage level, maximum at 33 kV.

3.2 The Modular Approach

3.2.1 General

In order to achieve the target of developing a highly standardized and most flexible power plant, the modular approach will be considered for its designing.

In this concept, the power plant is broken down into three levels of “modules”.

Level 1 → Defines the overall system packages like boiler, biomass (fuel) storage, W/S Cycle, BOP Systems, etc.

Level 2 → Divides the overall systems packages into sub-systems that again can form independent “modules”.

Level 3 → Defines the physical modules for each of the subsystems.

In all levels, a classification with regards to standardization will be carried out and certain parameters will be defined as “frozen” or “variable”.

Options should be, whenever possible; in such case they will be defined as separate modules.

With this approach, it is possible to identify the systems and areas which can become highly standard and those for which standardisation is not useful or even not possible due to inherent parameters.

For those systems, prior to the project start, it need to be decided if more alternatives or options shall be considered or if those systems will just be designed on a project specific case by case basis.

The modular approach orientates itself at the rule that standardisation starts from inside.

This means the further the design of the plant moves from the heart (generating equipment) to the peripherical systems (e.g. BOP systems), the standardisation becomes less and less.

Modularisation helps the standardisation of products as it can break down a system into subsystems that are relatively independent from the main system.

Such subsystems can be standardized again and can be used as a physical module in conjunction with other systems or processes.

The largest common denominator in such a system could be physical module size or a simple process chain.

3.2.2 Definitions

System → Functional units.

Module → A group of single components and elements which, from a logistical and productional point of view, can form an efficient unit.

Plant Module → System related elements arranged in physical modules (so called “Blackboxes”) with clearly defined interfaces.

3.2.3 The Modules

In defining practicable and standardised modules for a 10 MW biomass power plant the main target was to transform, wherever possible, complete **systems** into **standard modules**.

By doing so, it will become easier to transform the **modules & submodules** into **power plant modules**.

The definition of the modules and submodules and the potential for standardisation is shown in the 7.12.

Thus, a total of eleven modules and approx. 40 submodules have been defined for this type of power plant.

This is very much in line with the applied systems and subsystems.

3.2.4 The Power Plant Modules

All system related elements, which from a practical point of view can be arranged in preassembled modules will be designed and delivered as such.

Due to the standard grid system used by the power plant modules, the modules will become easily exchangeable without changing the overall layout, which provides the required flexibility, optimization and standardisation for this type of power plant, resulting in cost saving.

Even minor project specific changes and modifications inside a power plant module will not effect its overall arrangement and will therefore be the key to standardisation and optimization without giving up flexibility and customisation.

It becomes even possible to design more alternatives or options into one power plant module that will make the plant modules easily exchangeable – similar to LEGO blocks.

Besides the advantage of flexibility in mechanical and electrical design, the power plant modules will provide a highly standard and most optimal input into civil design and construction.

This will allow very simple, fast and economical civil construction works at an early stage of the project (which typically is creating a lot of problems in the conventional power plant design and construction approach).

As the power plant modules will also form the building structure (containerisation), no building works becomes necessary anymore, thus reducing civil construction costs of a project and eliminating interface problems between Civil and M& E works.

All power plant modules will be delivered completely pre assembled and where possible pre commissioned units to the site, thus reducing site installation time drastically and increase product quality significantly as assembly will be carried out by experienced labour at manufacturing or assembling workshops.

Due to the lower workshop labour costs and the increased productivity, which will continuously improve with the learning curve, the overall product costs will continuously decrease.

For standardized, modularized 10 MW biomass power plants, most of the modules would be built and assembled in Malaysia, whereas main (hi-tech) equipments and components would be sourced in SEA, US and Europe.

Design would be partially carried out in Europe and Malaysia.

3.2.5 Mechanical Modules

Mechanical modules (M-Modules) will mainly be provided for the W/S Cycle and the BOP Systems, but also for boiler auxiliary systems (2 – 3 modules).

The steam turbine will also be delivered fully modularised with all its auxiliary systems arranged in one module (appr. 12.2 x 4.8m)

For all other modules the Connec-T standard modules Type M Frame 401212-200/400 with base dimensions of 12.2 x 3.7m shall be used.

A maximum of two modules will be installed on top of each other.

All modules will be equipped with necessary access platforms and will be covered by a welded roof.

Besides the ST module, which will be covered by an outdoor acoustic enclosure, all modules will be designed for outdoor use.

For details on the individual modules please refer to the data sheets under Appendix 7.12.

3.2.6 Electrical Modules

Entire power plant electrical equipment will be located in electrical modules (E-Modules).

Depending on the power plant layout, particularly for the BOP systems, it might be reasonable to provide a separate E-Modules for systems at decentralised locations, close to the electrical consumers. Otherwise the E-Modules will be clustered in close proximity to the main power plant systems.

All E-Modules will be similarly to M-Modules delivered fully preassembled and tested to the site.

E-Modules will be on top of, so-called, cable base modules, from where cable distribution to the power plant functional areas will be arranged.

For all modules the Connec-T Standard modules Type E Frame 401209-150 (incl. access platforms at both ends).

All modules will be fully ventilated and (if required) air-conditioned.

For details on the individual modules please refer to the data sheets under Appendix 7.12.

3.3 Scope of Equipment Supply

3.3.1 Steam generator (Boiler) and associated auxiliary equipment suitable for burning oil palm biomass waste material capable of generating multi-pressure steam for steam turbine operation, mainly comprising:

Boiler casing
Water piping and valves

Burning equipment (grill)
Air preheater
Induced draught fan system (if required)
HP and LP steam and water piping and valves
HP and LP drums
HP economizers
HP evaporator
LP evaporator
HP superheaters
LP superheater
Condensate pre-heater
Ash handling & removal & storage
Structural steel and support
Insulation and cladding
Exhaust gas and flue gas ducting
Flue gas exhaust main stack
Electrical equipment
Control and instrumentation equipment
Ladders & stairways

3.3.2 One axial exhaust, 10 MW rated, condensing steam turbine and associated auxiliary equipment, mainly comprising:

Steam turbine module consisting of one combined HP/LP and auxiliaries
HP combined emergency stop and governing valve
Gland sealing system
Control & instrumentation system
Protection devices
Bearings and couplings
Lubrication and control oil system
Drain and vent system
Associated electrical equipment
Compressed instrument air system as part of the service air system
Thermal insulation with functionality of acoustic isolation as far as applicable
All necessary anchor bolts and base plates

3.3.3 Gearbox between the steam turbine and the generator to reduce the design ST speed to required 50 Hz (3000 r.p.m.) generator speed.

3.3.4 One air cooled generator and associated auxiliary equipment, mainly comprising:

Generator
Lubrication oil system as integral part of the complete STG system

Generator cooling system
Excitation system
Voltage regulators
Automatic synchronizing equipment
Protection equipment
Generator output system (generator bushings and connection box)
Generator circuit breaker
Isolated phase bus duct or cabling
Rigid coupling at gearbox side

3.3.5 Feedwater, steam and condensate system, mainly comprising:

Feedwater storage system
Feedwater pumps
Feedwater heating system
Main steam piping system
HP steam turbine bypass systems
LP steam turbine bypass systems
Condensate pre-heating system
Condensate system
Condenser with hotwell
Drain pipework
Condenser air extraction equipment
Condenser tube cleaning system
Condensate pumps
Isolating and safety valves
Associated electrical system
Associated control and instrumentation
Anchor bolts and plates

3.3.6 Main and closed water cooling system including wet cooling tower system suitable for recommended river water or deep well water and all related auxiliaries, mainly consisting of:

River water screen system
Make-up water pumps
Make-up water treatment plant including flocculation
Wet cell cooling tower
Cooling tower purge system
Main circulating cooling water pumps
Closed cooling water system circulating pumps
Cooling water / demineralized water heat exchangers
Closed cooling water expansion tank
Associated piping system
Associated valves and fittings

Associated electrical systems
Control and instrumentation system
Anchor bolts and plates

3.3.7 Chemical dosing and sampling for feedwater, make-up cooling water and for main circulating cooling water system

3.3.8 Oil palm biomass (Fuel) unloading, storage, treatment and supply system suitable for continuous operation of one, 10 MW rated, steam turbine, mainly consisting of:

Raw (biomass) fuel unloading
Raw fuel storage
Raw fuel treatment (fuel drying, crushing & mixing)
Treated fuel storage
Treated fuel forwarding/ feeding system
Treated fuel metering (weighting) equipment

3.3.9 Demineralized water treatment system suitable for continuous operation of 10 MW rated steam turbine, mainly consisting of:

Water demineralization trains
Acid storage tank incl. unloading and metering pump
NaOH storage tank incl. unloading and metering pump
All system related auxiliary mechanical equipment
Associated piping, valves and fittings
Associated electrical equipment
Control and instrumentation system
Anchor bolts and plates

3.3.10 Water storage and distribution system including common raw (service), fire fighting and demineralized water storage tanks with sufficient capacity for supply of fire fighting and service water for entire power plant as well as supply of demineralized water for operation of one 10 MW rated steam turbine, mainly consisting of:

Raw water supply pumps
One raw (potable water quality) / fire water storage tank with capacity sufficient for minimum seven days of base load operation of 10 MW power plant and for storage of fire fighting water with capacity as required by BOMBA Malaysia.
One demineralized water storage tank with capacity sufficient for seven days of base load operation of 10 MW power plant in case that the demineralization water plant is out of service
Make-up water supply pumps
Associated piping, valves and fittings
Control and instrumentation system

3.3.11 Compressed air system sufficient to supply power plant service and instrument air system with technically oil free air.

3.3.12 Fire detection and protection system, mainly consisting of:

AC electric motor driven fire fighting water pump
Emergency diesel engine driven fire fighting water pump
Hydrant system pressure maintaining AC driven jockey pump
Fire hydrant system
Fire monitoring system through the essential power plant areas
Associated piping, valves and fittings
Control and instrumentation system
Associated electrical system

3.3.13 Waste water system, mainly consisting of:

Sump pumps and drain pumps
Oil separators
Sanitary waste water treatment system
Associated piping, valves and fittings
Control and instrumentation system
Associated electrical system

3.3.14 Lifting equipment necessary for maintenance, equipment replacement and installation, mainly consisting of:

One ST overhead crane
Miscellaneous hoists

3.3.15 Ventilation and air-conditioning system designed for serving the power plant and associated equipment, covering the following areas:

ST Building;

Mechanical ventilation unit with wall mounted supply louvers and air filters

Control Room

Air conditioning system with humidity control.

Administration & Operation Offices

Window AC unit for each office room

Demineralization Water Plant

Filtered air unit for laboratory container
Window AC unit for water treatment control container room

Switchgear Rooms & Battery Container

Forced draft ventilation

3.3.16 Medium voltage power distribution system and associated auxiliaries, each mainly comprising of (MAY BE NOT REQUIRED!!!!!)

6.6 kV switchgear and associated control and instrumentation
Relaying and protection system

3.3.17 Low voltage, AC, power distribution system and associated auxiliaries, mainly comprising of:

415 V switchgear and associated control and instrumentation incorporating 415 V motor control feeders
Relaying and protection system

3.3.18 Direct current (DC) power distribution system and associated auxiliaries, each mainly comprising of:

Sets of 220 V DC power batteries incl. battery chargers and related accessories
Sets of 220 / 24 V DC converter systems and related accessories

3.3.19 Uninterruptible power supply (UPS) system and associated auxiliaries for furnishing highly reliable 240 V AC power for vital electrical loads.

3.3.20 Power plant transformers and associated auxiliaries as shown on single line diagram Appendix 7.9-1, including mainly the following equipment:

Main step up transformers (Voltage is depending on final generation voltage and available grid interconnection voltage
Unit auxiliary transformers
Control and instrumentation system
Associated electrical system

3.3.21 TNB grid interconnection facilities (Power Plant → Switchyard → TNB grid) designed and sized to satisfy power plant's requirements. The interconnection facilities shall mainly consist:

Generator transformer incoming feeder
Outgoing feeder
Two (2) spare diameter for outgoing overhead line feeder
Connection from main step-up transformers to switchyard
EHV circuit breakers
Disconnecting switches
EHV Insulators
Current and voltage transformers
Lightning arresters
Busbar and accessories
System grounding and bus grounding switches
Lighting
Control, protection & metering

3.3.22 Other electrical systems as necessary for safe and reliable operation of the power plant, mainly comprising of:

General earthing and lightning protection
Lighting system including complete lighting systems for buildings, outdoor yards and roads.
Necessary 240 V AC sockets at strategic locations around the power plant

3.3.23 Instrumentation and control system as required for safe and reliable operation of:

Steam generator (boiler) and auxiliaries
Water steam cycle and auxiliaries
Steam turbine and auxiliaries
BOP systems

Refer also to Appendix 7.9-2

3.3.24 Operation and monitoring system (located in control room), mainly consisting of:

Processing unit
Operator terminals
Synchronization clock
Miscellaneous color monitors, printers
Operator Console, Printer Desk (1 set)
AC power distribution cabinet

3.3.25 Other control and instrumentation equipment and systems

Plant communication system
All necessary supervisory control and data acquisition systems
All necessary power plant local control rooms and panels (as requested by manufacturer's design)
Field Equipment including field instruments for control, operation and monitoring

3.3.26 Special equipment

Spare parts and consumables required during plant commissioning, testing and first year of operation
Special maintenance tools

3.4 Scope of Services

The following services related to turnkey delivery of entire power plant have been considered for budget price estimation:

Structural, civil and engineering works for the entire power plant, mainly comprising:

Site study and soil investigation
Site preparation
Necessary temporary site facilities as required for all site activities such as containerized site offices, sanitary system and similar
Temporary site material & equipment covered and uncovered storage and working area
Excavations & earth works
Storm and plant drainage system
Sanitary wastewater sewer system
Oil-water separator
Primary grounding (embedded concrete part)
Design and fabrication structural steel
Foundations and structures for power plant equipment
Steam turbine building

Potable water distribution system
Make up water intake structure at the riverbank
Fencing along the perimeter of the site, complete with security gate for access
Construction of all permanent roads and walkways within the power plant boundary
Removal of temporary works after main works are completed
Gravelling and crushed rock surfacing
Landscaping

3.4.2 Other Services

Basic and detailed engineering
Project management including construction site management
All necessary drawings and diagrams as well as complete construction and as-built drawings and documentation
Operation and maintenance manuals according to Contractor's standard
Equipment classification and labeling
Factory testing and quality control
Packing, transportation and delivery of power pant material and equipment to construction site including unloading and storage on site
Full erection, commissioning and site testing
Factory and site training for the Owner's personnel
All necessary permits and governmental approvals

3.5 Technical Descriptions

Introduction

To generate electricity from biomass need to miscellaneous systems and equipment that work together.

These are a supply system that produces, collects and delivers the fuel, and a power station that generates, and sells, the electricity.

This section describes briefly the systems and equipment that can be used in proposed biomass power plant.

In this proposed power plant biomass is burned in an excess of air to produce heat that is in turn used to raise high-pressure steam in a boiler.

The energy stored in the steam is converted into electricity by expanding it through a turbine, which in turn drives an electrical generator. For pure electricity generation the steam is expanded down to a very low pressure in a condenser. (Please refer alsoto Appendix 7.6, 7.7, 7.8 and 7.9)

3.5.1 Boiler and Auxiliaries

The design of boiler and power plant systems involves attention to many different factors, all of which must be considered carefully so that the system is robust and efficient.

Treated biomass fuel is supplied by feeding units, which puts a relatively small and evenly distributed layer of fuel on grate, and is combusted on a travelling grate firing system.

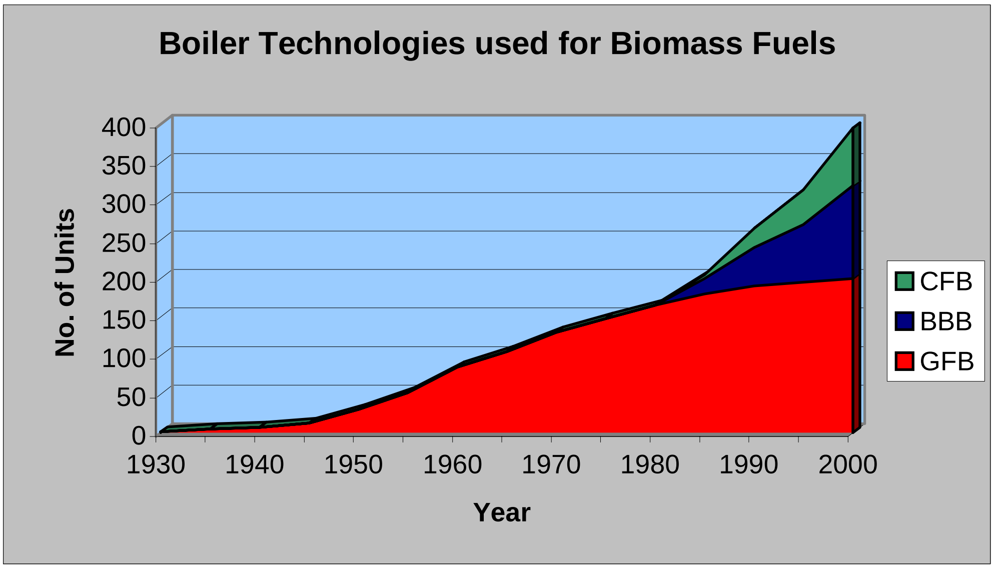
During it moves, the fuel dries in flight (slightly) and on the grate (mostly), where it devolatilizes. The volatiles consume the local oxygen and create a plume of oxygen-depleted gases that do not fully mix until well past the furnace and convection pass exits.

The advantage of this system is, that in a travelling grate boiler the fuel is fed on one side of the grate and has to be burned when the grate has transported it to the ash-dumping site of the furnace. Combustion control is considerably improved here.

Because of the small layer of fuel on the grate, carbon burnout efficiency is also better in comparison with the stationary sloping or vibrating grate boiler.

Grate-fired boilers have special merits for certain biomass fuels. Applications such as burning dry olive waste or oil palm waste are good examples.

The chart shown below is divided into three different boiler technologies, namely bubbling bed boilers (BBB), circulating fluidized boilers (CFB) and grate-fired boilers (GFB).



Water from the feed pipe is heated in two stages in the biomass-fuelled boiler plant

Steam from the boiler is led to the high-pressure steam turbine.

Flue gas from the boiler's flue-gas duct is purified by means of flue gas precipitators before being emitted.

Fly ash is transported by a pneumatic ash transportation system to a big-bag system. Ash from the precipitators can be reused in industrial processes.

3.5.2 Steam Turbine – Generator and Auxiliaries

The steam turbine (ST) is dual-casing condensing, high speed ST with integrated gearbox and packaged in standardized, modular skid mounted design.

In order to make best use of large changes in volumetric flow during steam expansion the ST design is based on multiple cylinders and multiple speeds, which allows each cylinder to be optimized with respect to the steam flow passing through it.

The configuration of ST combined with automated control, permits considerable operational flexibility.

The start-up time is less than 25 minutes and the low thermal and mechanical inertia allow very rapid load changes.

Optimum ST performance is ensured by:

- Choosing dimensions for each cylinder appropriate to volumetric flow;
- Using two rotation speeds, thus optimizing the efficiency;
- Reducing steam leakage, eliminating leakage at HP inlet shaft end;
- Recovering kinetic energy following expansion by means of an axial exhaust diffuser.

The design of ST results in high performance and compact dimensions (appr. 3x3x3m / 14 tons).

The air cooled, cylindrical rotor type generator is connected to the ST via reduction gearbox.

The reduction gears are taken from the existing range of world-class gear manufacturers and have proven high reliability and performance.

In order to reduce the time for erection, commissioning and manpower on site, the ST-Generator unit is packaged in the factory.

The ST-gear box-generator unit is arranged on common frame, which also houses the local instrumentation panel and the lubricating system.

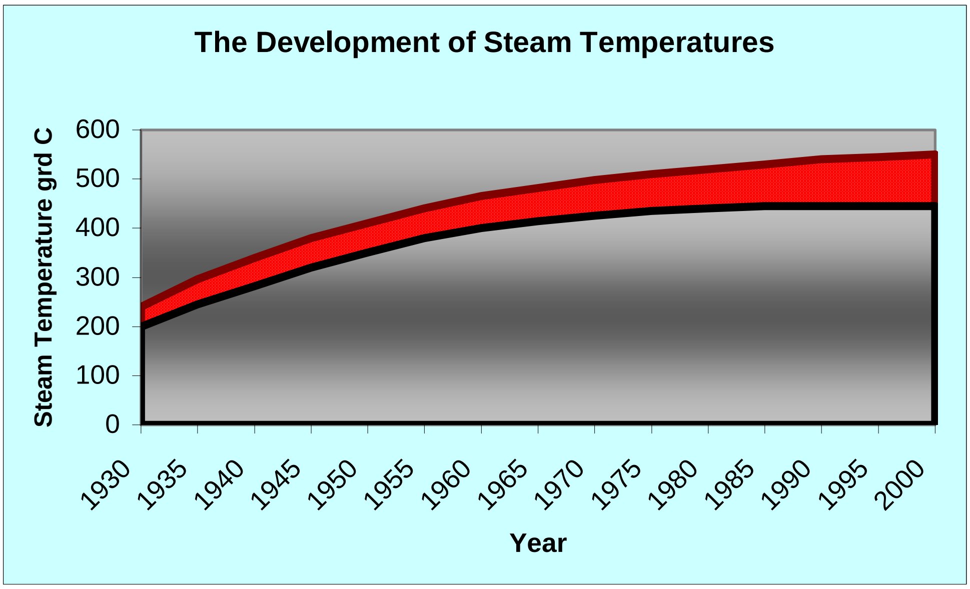
The lube oil tank is incorporated into the base frame.

The overall approximate package dimensions (LxWxH=9x4x5m / 50 tons) ensure compact and most optimal layout of this important equipment within power plant.

The construction of entire package allows the cost of associated civil works to be reduced.

The whole package is installed at ground floor level for simplicity of installation and ease of access for control and maintenance.

The diagram below shows the development of steam temperature over the years.



Today the live steam temperature varies from 450°C to 550°C depending on application and fuel quality.

3.5.3 The Condenser

The condenser is cooling down and condensates the steam exhausted from the LP steam turbine and produces and maintains as high as possible vacuum in order to increase the heat drop, which can be utilized in the turbine.

The condenser body is connected to the LP steam turbine exhaust casing and forms an integral part of it.

The condenser is a box-type surface heat exchanger with water boxes.

The steam space is designed in such a way that an optimum utilization of the enclosed volume for the necessary condensing surface can be achieved.

3.5.4 Feed Water System

The feed water system supplies feed water from the condensate preheater to the boiler during start-up, shutdown and normal operation of the power plant and also maintains constant water level in the steam drums over a wide range of steam demands.

The system shall also deliver injection water to the HP reducing station and to the spray attemperator in the HP main steam.

The feed water is usually routed from the common header upstream of the condensate preheater in separate suction line to the feed water pump via strainers located upstream of the pumps.

An automatic recirculation check valve for the pump minimum flow requirement is usually located downstream of the feed water pump.

In the event that the pump discharge valve is closed or feed water mass flow is insufficient, the minimum flow will be returned to the condensate preheating system upstream of the condensate pre-heater by means of the minimum flow check valve via a common header.

Hand-operated isolation valves are provided at the suction and discharge side of the pump for isolating the pump during maintenance or repairing period.

Drainage lines and valves used only for maintenance purposes or first filling of the system are usually led to the power plant drainage system.

The safety valve discharge lines, which possibly can be actuated during power plant operation, are led to the start-up/shutdown steam system.

3.5.5 Condensate System

The condensate system removes condensate from the condenser hotwell, increase its pressure, and deliver it to the feed water pumps.

Steam exhausted from the LP turbine enters the main condenser. Condensate from the main condenser hotwell flows to the condensate pump. The condensate pump is provided with a strainer installed in the suction piping.

At the discharge side of the pump a minimum flow check valve is provided to ensure minimum flow required by the pump. In case that the condensate flow to the condensate preheating system is too low, the minimum flow from the pump will be returned to the condenser hotwell by the minimum flow check valve.

During start-up a part of the condensate flows to the deaerator and removes dissolved oxygen and other noncondensible gases from the condensate.

Condenser hotwell level is controlled by condenser makeup water control valves.

3.5.6 Cooling Water System

Main Cooling Water System

The main cooling water system provides cooling water to the condenser and to the closed cooling water system.

The circulating water system generally consist of the wet cooling tower system, circulating main water pumps and the circulating water piping and valves required to feed circulating water to and from the condenser.

Circulating water is pumped from the wet cooling towers to the condenser by main cooling water pumps. Heated circulating water from the condenser is returned to the wet cooling towers via cooling water return pipes.

Necessary make-up water is pumped from the river by make-up water pumps to the sand traps. From there it is forwarded by make-up water transfer pumps to the clearified raw water basin via the flocculators. From the clearified raw water basin the water flows geodetically to the cooling towers.

The objective of the main cooling water system shall be:

To absorb the steam turbine exhaust heat from the condenser and to transfer this heat to the cooling tower
To absorb the heat from the closed water cooling system and to transfer this heat to the cooling tower

Closed Cooling Water System

The closed cooling water system provides cooling water to miscellaneous systems and equipment of the power plant in order to remove excess heat from the system and reject it back to the main cooling water system.

In this manner, closed cooling water shall be distributed to the following major consumers:

- ST Lube Oil Coolers
- ST Generator Coolers
- ST Seal Oil Coolers
- Sampling Cooler
- Gland Steam Condenser
- Condenser air evacuation pump coolers
- Cooling water supply to other systems as per particular design requirements

The closed cooling water pump circulates the water through the closed system and the heat exchangers and provides the means for dissipating heat to the main cooling water system.

3.5.7 Demineralized Water System

The demineralized water system serves to remove dissolved matter from the raw water by means of ion exchange.

The result is ultra clean demineralized water, which complies with the guidelines for feed water for high-pressure boilers.

The treatment of raw water in the demineralizied water system is generally performed as follows:

- ❖ Replacement of cations by hydrogen ions (H^+) in the cation exchanger.
- ❖ Removal of carbon dioxide (CO_2) by degasifier.
- ❖ Replacement of anions by hydroxide ions (OH^-) in the anion exchanger.
- ❖ Removal of last vestiges of ions by mixed-bed exchanger.

The raw water pump delivers a flow of water through the demineralized water system, which is usually started and shut down according to the water level in the demineralized water tank.

The further details are depending on chosen technology and equipment manufacturer.

The possibility of using a mobile demineralized water plant, which could be moved to different power plants should be considered as an alternative to fixed plant.

3.5.8 Biomass Fuel System

After delivery to power plant site, the biomass fuel is stored and treated for burning. The fruit bunch stalk is stored separately from the other waste (trees, etc.).

The fuel treatment consists mainly from open air pre-drying, shredding and mixing (please refer also to Appendix 7.3 and 7.8).

Fresh fruit bunches

Empty fruit bunch shredder

The treated fuel is stored separately and in covered bunker storage area from where it is transferred via conveyor belt and feeding units to the boiler.

Feeding units put always a relatively small and evenly distributed layer of fuel on boiler grate, and is combusted on a travelling grate firing system. During it moves, the fuel dries in flight (slightly) and on the grate (mostly).

3.5.9 Other Small Systems

<u>Chemical Feed System</u>

The chemical feed system consists of packaged, skid-mounted units for feeding ammonia, hydrazine and phosphate.

Chemicals feed system generally consists of a solution tank, metering pumps and accessories including tank mixers, level gauges, low-level switches, pump isolation valves and pressure gauges.

Water and Steam Sampling System

A sampling system is provided for monitoring various parameters in the boiler water, steam and condensate-feedwater system and to automatically control the feed rates of ammonia.

The sampling system takes samples from the water steam cycle and auxiliary systems for continuous measurements and for laboratory analysis.

Raw Water System (supplied from town water system)

The raw water system feeds the demineralization water plant system fire fighting system.

Compressed Air System

Compressed air system supplies oil free compressed air throughout the power plant.

Generally, the system fulfills the following requirements:

- Supply of compressed service air to different power plant areas (compressed air supply for tools and special equipment).
- Supply of compressed air to air operated instrumentation within the power plant as required by design.

Compressed air quantity and quality (i.e. pressure, temperature, cleanness, etc.) is based on the compressor's design operating conditions as well as on power plant requirements.

Modularized stationary compressed air supply system mainly consists of compressor, air dryer, filter, air receiver (storage tank) and a piping network for distribution.

Fire Protection & Detection System

The entire power plant is protected against fire by a comprehensive fire detection, alarm, and protection system.

The fire detection system provides the means to detect fires, visual and audible alarms both locally and remotely, and, where required, actuate the fire protection system.

The power plant is protected against fire by any one or a combination of the following systems:

- Power plant water hydrant system
- Water spray systems
- Water spray deluge systems
- CO_2 systems (if required by BOMBA)
- Portable and mobile extinguishers

Generally the following equipment and areas are protected by fire detection and protection system:

- Steam turbine lubricating and control oil area
- Oil filed transformers
- Motor-driven boiler feed pumps
- Main cooling water pumps
- Control rooms (detection only)
- Electronic equipment rooms
- Computer rooms (if applicable)
- Battery rooms
- Uninterruptible power supply system

3.5.10 Electrical Systems

The electrical systems and equipment are designed to assure high availability and reliability of the power plant in all modes of operation, using well proven standardized equipment complying with the relevant international and local standards and regulations, mainly VDE, IEC and DIN standards and regulations.

The AC, DC and UPS power supply system provides source of AC and DC power for the entire power plant and its auxiliary and ancillary systems.

The AC power supply and distribution system includes all electrical sub-systems, equipment and components necessary to supply and distribute AC power for all Facility auxiliaries at grid (HV), Generator (MV), 415V, 240 V and DC power for all 220 V and ± 24 V DC systems and sub-systems.

Facility System Voltages

System	Rated voltage	Rated Frequency
Grid Interconnection	~ xy KV[1)]	~ 50Hz
Generator main circuit	~ yz kV[2)]	~ 50Hz
Low Voltage system	~ 415V	~ 50Hz
AC UPS system	~ 240V	~ 50Hz
DC system (power)	=220V	~ 50Hz
DC system (control)	=24V	~ 50Hz
Motor voltage	~ 415V	~ 50Hz
Lighting System	~ 240V	~ 50Hz
Small Power System	~ 415V	~ 50Hz

[1)] Depending on available grid voltage
[2)] Depending on manufacturer's standard

The ST generator is connected to the generator transformer via cables or via an isolated phase bus.

A generator circuit breaker is provided between the related generator and the generator transformer.

The unit auxiliary transformer is connected to the ST generator bus and is rated to supply both the unit auxiliaries and the station service.

The high voltage bushings of the generator transformers are designed for connection to the HV switchyard via cable or an overhead line.

The secondary winding of the unit auxiliary transformer is connected to the low voltage (LV) unit switchgear via single core medium voltage cables.

The LV switchgear supplies loads up to 250kW. Air circuit breakers are used for incoming feeders to the power centers, for coupling connections, and for large loads.

The 220V-DC system provides power for switchgear control, protection, UPS, and emergency oil pumps, thus ensuring a secure run down of the turbo-generator without the need for manual intervention in case of total loss of the AC supply.

The battery shall have an adequate capacity to supply the emergency loads for a discharge time of at least one (1) hour.

The 220V-DC system is fed from one (1) battery charger and one (1) battery. Another battery charger and one battery shall be provided for station consumers.

The 24V-DC loads are powered via DC/DC converters from the 220V-DC system.

AC consumers who are sensitive to short power failures, e.g. the operation and monitoring computers for the operator, are powered from the uninterruptible power system.

This system is fed from the 220V-DC system via an inverter, which shall provide a regulated single-phase 240V-AC supply.

The generator transformer and the unit auxiliary transformer are installed outdoor next to E-Modules. The generator circuit breakers are installed either indoor or outdoor.

A substantial portion of the electrical equipment of the power plant is installed in standardized, modularized, prefabricated Power Control Centers (PCC).

The use of the PCC technique should offer the following main advantages:

- Basic pre-commissioning of the electrical and C&I equipment by well educated and specialized Contractor's staff at the manufacturing plants.

- Minimizing of transportation risks due to special dispatch of the complete PCC modules.
- Shortened final commissioning and on time start-up at site.

The basic electrical circuit is shown on the attached electrical single line diagram (Appendix 7.9).

3.5.11 Instrumentation & Control

The Control and Instrumentation system proposed for the power plant is of modern compact design incorporating the latest proven state-of-the-art of engineering technology.

The C & I system proposed is designed to reduce the actions required by the control room personnel to a minimum.

Once certain manual preparation actions in the fields have been performed, automatic operation of the whole plant will be obtained simply by entering the desired power output into a unit coordinator.

This will coordinate the operation of each power plant area during all normal operating modes including start-up, normal operation and shutdown.

All components are of an approved and most reliable design and manufacture. The highest possible extent of uniformity and interchange ability is reached.

The equipment is as far as practicable pre-assembled and pre-tested to the highest extent and standard in the manufacturer's workshops.

A consistent control and instrumentation philosophy will apply through the power plant and will be implemented in terms of a range of equipment exhibiting a minimum diversity of type and manufacture.

As already stated in this document, one of the main objectives is to standardize all control and instrumentation equipment throughout the whole power plant in order to rationalize the operation, maintenance and spare parts holding.

Generally the equipment will be supplied by reputable manufacture(s) of international standings and shall have a minimum of two (2) years successful operational record on similar installations.

The control and instrumentation system will comply with applicable IEC, ISO, DIN and other equivalent internationally recognized Codes, Standards and Recommendations.

3.5.12 Civil Works

The power plant layout considers all aspects related to an optimized design of the layout plans and the size and allocation of the power plant buildings and structures.

All reasonable requirements, systems, physical arrangement of the components, piping and cables are incorporated in the building and plant concept.

The functional power plant concept considers safety related aspects, economic viability, valid standards, rules and guidelines of the mechanical and electrical systems.

Overall designs will be carried out according to good civil and structural engineering practice, in line with specified acceptable Codes and Standards and shall ensure a safe and efficient use of materials.

The design will take account of all loads applied, including dead, live, impact, wind, thermal, dynamic, settlement, movement, seismic and other loading conditions where appropriate.

3.5.13 Services

The services that are provided for this project generally cover the project management, turnkey design, engineering, quality assurance services, equipment transportation, installation & construction, commissioning, startup, and performance testing, reliability run, staff training, handing over, warranty and any other services and systems necessary to provide the complete functioning and commercial operation of one 10 MW oil palm biomass fired power plant.

3.6 Time Schedule

The anticipated, realistic time schedule for substantial completion dates, applicable for first unit, from the date of authorization to proceed (start of basic engineering) is shown in the following table.

Activity	Starting Month No.	Ending Month No.	Number of Months
Basic engineering & main equipment selection	0	3.5	3.5
Detailed engineering	2	6	4
Main equipment manufacturing & delivery to site	2	15	13
BOP equipment manufacturing & delivery to site	2	12	10
Site construction & erection works	6	15	9
Interconnection to TNB grid	15	16	1
Commissioning & testing	14	17	3

The delivery time for following units can be substantially reduced (learn & modularization effect).

For more details please refer to Appendix 7.13.

4. Commercial Aspects

4.1 Project Cost Estimates

The total project cost for the proposed 10 MW biomass power plant is estimated at 63.5 mio RM which includes the interest during construction and other development and financing cost amounting to 12.2 mio RM (appr. 24% from EPC cost).

The cost of power plant equipment is based on preliminary quotations and estimations based on similar projects.

More detailed cost estimations are given in section 4.2 (Key Assumptions).

The actual project cost may differ from the present estimates for one or more of the following reasons:

- Changes in interest rates and fees
- Variation in exchange rates
- Changes in applicable laws
- Changes in imposition of any taxes
- Project delay beyond the control of the Investor
- Changes in financing draw-down schedule
- Variations in scope of supply
- Events or circumstances not within reasonable control of the Investor.

Please refer also to section 5 (Project Risk Aspects)

4.2 Key Assumptions

The assumptions detailed in this section are provided by **I&C AG** to assist the Investor to undertake its own independent analysis and associated due diligence to determine the viability of the Project.

This section details the assumed operating parameters used to develop the financial pro forma (the “Pro Forma”) used to calculate indicative revenues and expenses of Investor arising from the anticipated commercial agreements.

The assumptions have been separated into the following areas, which are detailed below:

- Capital cost
- Operational cost
- Revenue
- Expense
- Financing
- Taxation
- Economics

4.2.1 Capital Cost Assumptions

Capital cost of the Project amounts to RM 63.5 million and a breakdown of costs is summarised as follows:

Capital Cost Breakdown	RM x 10^6	Note
Turnkey Price (EPC)	51.30	Incl. Power plant, grid connection, spares
Site Preparation	0.50	Site clearing, levelling, temp. access
O & M Mobilization	0.50	
Contingency	1.60	3%
Land Costs (13'600m^2→16RM/m^2)	0.20	Based on appr. 40'000-60'000 RM / acre
Land Conversion Costs	0.50	Only build-up area
Reimbursed Development	2.50	Developer expenses, fees, office staff, etc.
Insurance during Construction	0.40	0.75%
Consultants' and Advisors' Fees	2.50	Financial, Legal, Tax, Engineering, EIA
Import Duties and Sales Tax	0.00	
Financing Fees	1.00	
Interest during Construction	2.50	
TOTAL	63.50	

Developer Equity	**25%**	**15.88 mio RM**
Commitment	**75%**	**47.22 mio RM**

Please refer also to section 4.1 (Project Cost Estimates).

4.2.2 Operational Assumptions

Operational Period

An operational period of twenty one (21) years is assumed.

Power Plant Capacity

The assumed capacity and degradation of the Power Plant is as follows:

Net Capacity at metering point	After Degradation of 4.0 %
9.0 MW	**8.68 MW**

Power Plant Availability

Availability is calculated as the total available hours in a year less any hours when power plant is not available due to planned maintenance outages, unplanned maintenance or forced outages.

The availability factor is the actual hours available in a year divided by the total number of hours in a year i.e. 8,760 hours. The target availability factor is assumed as 90.0%.

Power Plant Capacity Factor
The anticipated capacity factor of the Project is 85% of the total number of hours in the year.

Power Plant Heat Rates
Assumed heat rates at base load at metering point is 12'000 kJ/kWh (LHV) [η_{th}=30%]

4.2.3 Revenue Assumptions

The assumptions for the calculation of the revenue are summarised below:

Parameter	Units
Capacity Rate Financial (Year 1 – 21)	RM 10.00 per kW per month
Tariff Rate	RM 0.167 per kWh

Escalation
An escalation per annum is assumed as follows:

Capacity O & M Revenues → 1%
Energy O & M Revenues → 2%

4.2.4 Expenses Assumptions

Annual Operating Costs
The table below summarises the assumed annual operating costs for the Project.

Operating Expense Items	Annual Costs (mio RM) 1st Year	Annual Costs (mio RM) 21st Year
Fuel Costs	0.734	0.802
Fixed Operating Cost	2.374	2.422
Variable Operating Cost	0.711	1.021
Total Operating Expense	**3.811**	**4.245**

Escalation
An escalation rate of 2% per annum compounded is assumed on all operating costs, excluding financing charges, license fees, insurance, cess fund contributions and human resource fund contributions.

Biomass Fuel Costs
Biomass Fuel cost is assumed to be RM 10 per ton (0.94 RM/GJ) based on average lower heating value of 10'690 kJ/kg.

4.2.5 Financing Assumptions

Debt repayment period: 10 years from COD
Interest rate : 6.5 %
Other fees: 0.5%
Facility fees: 1.4% (from total amount)

4.2.6 Taxation Assumptions

Taxation assumptions are referenced to the Malaysian Tax Code. The following assumptions were made:

Corporate income tax
Assumed to be constant over the PPA period at 28.0%.

Investment Tax Allowances
The Model assumes the Project enjoys Investment Tax Allowance on 70% of the main assets.

4.2.7 Economics Assumptions

Foreign Exchange
The USD/RM exchange rate is assumed to be 3.8000/1.00 and the Euro/RM exchange rate is 3.336/1.00.

Inflation
The inflation rate is assumed to be 4% per annum throughout the PPA period.

4.3 Tariff Calculation

Tariff calculations for the entire life of the PPA (21 years) have been given in tables and diagrams attached to Appendix 7.10.

The major assumptions underlying these calculations are given in section 4.2 above.

4.4 Expected Tariff

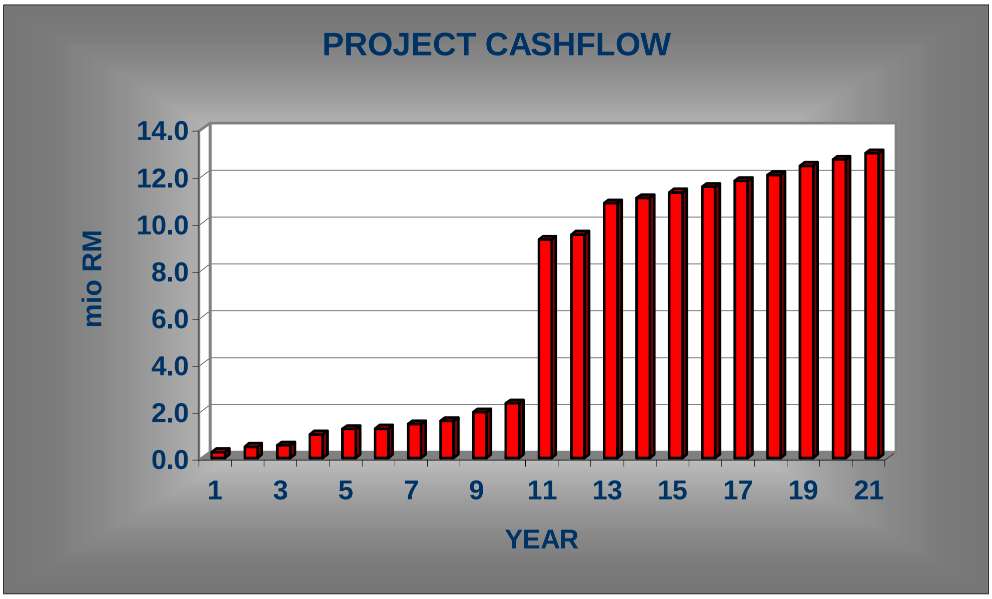
Based on other two similar projects expected tariff for power generation unit from oil palm biomass power plant shall vary between 0.16 – 0.17 RM/kWh.

4.5 Project Cashflow

The following assumptions have been made for project cashflow calculation (please refer also to Appendix 7.10):

- Total investment costs → 63.5 mio RM
- Net capacity → 8.68 MW
- Capacity factor → 85%
- PPA period → 21 years
- PPA Tariff → 0.167 RM/kWh
- Debt repayment period → 10 years
- Developer equity → 25%
- Interest rate → 7%
- Tax & duties → 0

The result, shown in the following diagram, shows a positive cashflow over the entire PPA lifetime of 21 year.



Also after consideration of all possible taxes and duties, which can be imposed to the project later, it is expected that the project will be profitable for the investor.

However, the possible project risk as described in the following section shall be analyzed.

5. Project Risk Aspects

This section provides an overview of certain factors, which may present risks that may adversely affect the cash flow and commercial performance of the Project.

The following does not purport to be a complete or exhaustive review of all risks facing the project Investor.

The table below is a summary of relevant risks and mitigating factors associated with the Project.

RISK MATRIX			
Risk	Risk Factor 5=Max 0=Min	Bearer of Risk	Mitigating Factors
Construction Period Risks			
Completion Risk	1	Contractor-Investor	Turnkey contract – liquidated damages
Construction Price Risk	2	Contractor-Investor	Turnkey Contract – Fixed price
Permitting and Approvals	0	Contractor-Investor	To obtain the majority of permits and approvals.

RISK MATRIX			
Risk	Risk Factor 5=Max 0=Min	Bearer of Risk	Mitigating Factors
Operating Risks			
Project Performance	2	Operator – Investor	Contract warrantees-Liquidated damages
Technology	2	Contractor - Investor	Relatively new technology in Malaysia
Market Demand and Price	2	Investor – TNB	Long term PPA required
Energy Despatch	2	Investor – TNB	Long term PPA with capacity payments preferable
Operating and Maintenance Costs	2	Operator – Investor	Support from major equipment supplier required
Biomass Supply	2	Investor	Long term delivery agreement with palm oil producers (POP) required
Biomass Price	3	Investor	Present price 10 RM / Ton; Long term price agreement with POP required
Equipment Breakdown or Failure	1	Operator - Investor	Critical spare parts must be available on site + proper insurance coverage
Regulatory and Environmental Risks			
Environmental	0	Investor	Environmental Impact Assessment that ensures compliance with all required environmental regulations must be performed. Operator shall regularly monitor the Project's environmental parameters to ensure compliance.
Emissions	0	Contractor - Investor	The Contract shall provide for guaranteed emission levels.
Waste Disposal	0	Operator – Investor	Shall be considered in project design
Economic and Financial Risk			
Inflation	1	Investor - TNB	PPA
Interest & Exchange Rate	2	Investor	Conservative assumptions & hedging
Force Majeure	3	Investor – TNB - POP	Subject to terms of PPA and biomass supply agreement

5.1.1 Completion Risk

There is a risk that delays in construction will result in delays in operations and thus increased construction costs and a delay in revenue receipts.

The Contractor shall be liable for liquidated damages.

5.1.2 Construction Price Risk

There is a risk that the construction cost will exceed the projections.

Contract with a fixed price (lump sum turnkey contract) is required.

5.1.3 Permitting and Approvals

There is a risk that the issuance of certain permits and approvals may be delayed or that certain permits and approvals will not be obtained.

The contractor shall be liable to obtain a majority of the permits and approvals required for the construction of the power plant.

5.1.3 Project Performance

There is a risk that the completed power plant will not perform as guaranteed by the contractor.

In the event the contractor does not meet the Guaranteed Net Output and the Guaranteed Net Heat Rate, the contractor shall be liable for liquidated damages.

5.1.4 Technology

In any power plant there is a risk that the technology employed will fail causing additional replacement costs and loss of revenue.

All of the components used in the power plant shall be proven technology supplied by recognised equipment manufacturers with extensive manufacturing experience.

5.1.5 Market Demand and Price

Increased competition as a result of restructuring in the Malaysian power industry may lead to reduced demand and/or prices for power produced by the Project.

In the event of a restructuring of the Malaysian electricity industry, the Investor and TNB shall negotiate in good faith amendments to the PPA to enable full participation by the Investor in the restructured market.

The power plant utilises local biomass fuel and supplies local network. Thus there is a very high probability that it will be demanded in a pool market system.

5.1.6 Energy Despatch

The Project may be despatched at a low level thereby reducing revenues available.

The PPA shall be structured with a capacity (to cover all fixed and capital costs) payment and an energy (to cover the biomass fuel and variable operating costs) payment.

5.1.7 Operating and Maintenance Costs

There is a risk that operating and maintenance costs will exceed projections.

The Operator shall be subject to liquidated damages in the event of non-performance for availability, capacity, heat rate and emissions under the O&M Contract.

5.1.8 Biomass Fuel Supply

There is a risk that biomass fuel supply could be impaired, thereby decreasing the output of the Project.

In addition, issues such as the logistic of biomass supply (estimated average 250 – 500 tons/day), the storage, treatment processes to convert it into usable fuel must be taken into consideration.

5.1.9 Biomass Fuel Price

There is a risk that increases in the price of oil palm biomass could increase thereby decreasing the cashflow of the Project.

Major concern is that the biomass waste now has an affordable value but there is no telling how the price tag will look like in a few years. Palm oil biomass waste is now sold at RM10 per tone compared with RM25 paid to generate the same amount of heat from coal.

5.1.10 Equipment Breakdown or Failure

There is a risk that a failure of certain equipment may cause forced outages under the PPA, thereby reducing the cashflow of the Project.

All of the components used in the power plant shall be proven technology supplied by recognised equipment manufacturers with extensive manufacturing experience.

The Investor (operator) shall purchase and maintain a stock of all critical spare parts for the power plant. In the event of a breakdown, the operator shall use the spare parts onsite to expedite the repairs.

The Investor shall maintain certain insurance including industrial all risk and industrial all risk – advance loss of profits policies.

5.1.11 Regulatory and Environmental Risks

The Project is required to comply with environmental regulations governing operation of the power plant, including meeting air, water and noise emission standards. Non-compliance could result in the suspension or cancellation of the License and/or the imposition of fines. The adoption of new laws or regulations, or changes in the interpretation or application of existing laws or regulations could require the Investor to make additional material expenditures on environmental compliance, and Investor's ability to operate the Power Plant in a cost effective manner could be materially adversely affected.

The Investor and the operator shall undertake an EIA monitoring program designed to ensure compliance with all material environmental regulations. Pursuant to the O&M contract, the operator shall be required to meet certain guaranteed levels with respect to emissions. In the event the operator does not meet these emission levels, the operator shall be liable for liquidated damages.

5.1.12 Inflation

The Project's revenues may not be sufficiently adjusted to compensate for inflation in operating costs.

The PPA shall provide for escalation of the fixed and variable operating components of the tariff.

5.1.13 Interest Rate

There is a risk that increases in interest rates may adversely affect the cashflows of the Project.

Conservative estimates and assumptions for interest rates should be used in forecasting debt service payments.

5.1.14 Exchange Rates

Certain Project capital and operating costs will be in foreign currencies, whereas the financing and revenues for the Project are in Ringgit Malaysia.

RM portion to be maximized and other currencies hedged.

5.1.15 Force Majeure

In the event of a force majeure, the Investor may be subject to certain additional costs, which will negatively impact the Project and its cashflows.

Many scenarios are possible, however this shall be covered properly in PPA and Project other agreements and contracts.

6. Summary & Conclusions

6.1 Summary

The renewable, biomass fuel based energy market is growing rapidly worldwide.

There are hundreds of biomass-fired steam and electricity generating plants currently operating in the USA. Also their economic feasibility can pose challenge, their technical feasibility is well proven.

However, the further development and future direction of oil palm biomass for power generation will very much depend on the requirements of the economy in terms of reliability and security of energy supply.

In line with the objective of diversifying the sources of energy, the Government of Malaysia has already identified biomass and other renewable energies as an alternative source of energy, which should be promoted.

However, there are a number of challenges that inhibit the development of renewable energy.

Following some aspects related to utilization of biomass for power generation and global environment protection are summarized:

Biomass includes all kind of wet and dry agricultural by-products, forestry wood waste products and also including residues, and energy crops.

Biomass has the potential to sustainably provide a major proportion of the primary global energy supply and is therefore an exciting opportunity for the next millennium. It will satisfy many of the roles played by fossil fuels as conversion technologies mature.

The most common form in which biomass is available in Malaysia is oil palm residues.

Studies show that sustainably harvested biomass residues currently supply about 7% of the world's 1990 primary energy demand.

An exciting alternative economic model promises a better life everywhere without destroying the earth's natural support systems. The new economy will be powered not by fossil fuels, but by various sources of wind energy, solar energy (where also biomass energy belongs to) and hydrogen.

Wind power already supplies 8% of Denmark's electricity and 15% of the electricity for Schleswig-Holstein in Germany.

Utilizing Malaysia's biomass, about 750MW or 5% of total power generation from this new energy sources could be produced by the year 2005 and another 5% by the end of this decade.

As such, the choice to use oil palm biomass for power generation is not difficult but requires lot of organization and logistic skill. Nevertheless, the driving force to use oil palm biomass for power generation is the market, which will clearly have a very important influence on economic viability for sustainable country development in the future.

In order to promote the development of green, biomass, electricity, the following is expected from both, Government of Malaysia and TNB:

Grant full support for new biomass based power generation projects;

A forward-looking and committed TNB management;

Ensure guaranteed access for electricity generated in biomass fueled power plant to the national grid;

To streamline and simplify administrative procedures for the installation of biomass fueled power plants;

Ensure that the calculation of tariffs for connecting biomass fueled power plants to the national grid are fair and non-discriminatory;

Introduce a bonus system for surplus production;

Provide clear and concise information to the general public and producers about the environmental and economic costs and benefits of new biomass based power generation technology.

Advanced biomass-based systems have the potential to contribute significantly to the Malaysia energy supply in the future. The central goal for development is to create an economically and environmentally sustainable system, based on a fuel-supply infrastructure that will enable investment in modern high-efficiency power-production cycles.

6.2 CONCLUSIONS

Under the following assumptions:

- Total investment costs → 63.5 mio RM
- Net capacity → 8.68 MW
- Capacity factor → 85%
- PPA period → 21 years
- PPA Tariff → 0.167 RM/kWh
- Debt repayment period → 10 years
- Developer equity → 25%
- Interest rate → 7%

The project is generating over the life time period of 21 years positive cash flow, beginning with +0.3 mio RM (0.5% from total cost) and ending with 13 mio RM (20.5% from total costs).

The average debt service ratio is 1.32 and the average time interest earned ratio is 6.75.

I&C AG Recommendation

Based on the above figures, this Preliminary Project Feasibility Information as well as on the Government's promotional campaign for utilization of biomass for power generation, it is recommendable to follow the project whose assignment is construction of a 10 MWe Power Plant, based on oil palm waste biofuels.