DP CleanTech
Creating value from waste

Specialist Complex Fuels Waste to Clean Energy Power Plant

Mahachai Samut Sakhon Province, Thailand

2019 Thailand Energy Awards (Thailand Ministry of Energy) :
Winner of "On-grid Renewable Project" Category

2014-2018 Frost & Sullivan :
Winner of "Thailand Biomass Power Competitive Strategy Innovation & Leadership Award"

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Introduction

The Mahachai Green Power power plant in Thailand is one of the first plants in the world designed to utilise all the waste from coconut palms and convert it to clean energy. It was developed for Mahachai Green Power Co., Ltd, a Thai-German joint venture. The major shareholders are TPC Power Holding PCL and CarbonBW Thailand Co. Ltd.

The unique 9.9MWe high pressure, high temperature plant was specifically designed to handle all coconut waste, including the husk, shell, frond, leaves and stems. The plant was delivered on a full EPC turnkey basis and included the supply and installation of all components: Boiler, Steam Turbine, Water Cooling Tower, Water Treatment Plant, Fuel and Ash Handling, Electromechanical and Control systems, 22kV Transformer station and Switchgears. The plant began operations in April 2016 using coconut waste. After 12 months, the composition of the feedstock began to vary month to month, to reflect economic considerations and fuel availability.

Plant Design

- Designed 'from chute to stack', ensuring optimal integration of different components, maximum efficiency and performance.
- Designed for primary coconut feedstock of 45% moisture content, but also permits simultaneous combustion of different fuel types, sizes and moisture content.
- Advanced design and use of corrosion resistant materials to enable operation at full capacity (more than 8,300 hr/pa) with minimal maintenance downtime.

Fuel	Coconut residues (husk, shell, bunch, frond, leaves, trunk)
Fuel consumption	Design fuel mix: 323t/d (45% moisture) or 167t/d (dry)
Calorific value	8.35 MJ/KG
Power output	9.9MWe (gross)
Steam flow	40t/h
Steam pressure	92 bar
Steam temperature	537 °C
Boiler efficiency	90%
Gross plant efficiency	31%
Net Heat Rate	13,250kJ/kWh
Availability	**>8,300 hours/year**

Plant Performance 2016-2020

During the first year after commissioning, and using mainly coconut waste, the plant operated at 94.2% availability and exported 71,724,240 kWh of green power to the local grid.

However, when fuel quality or fuel availability is variable, the composition of the fuel can be adjusted to take advantage of abundant or cheaper feedstock, without affecting performance or output. In recent years, the plant has been running successfully on different proportions of coconut waste, wood chips, rice husks and EFB. All these fuels are notoriously difficult for efficient combustion.

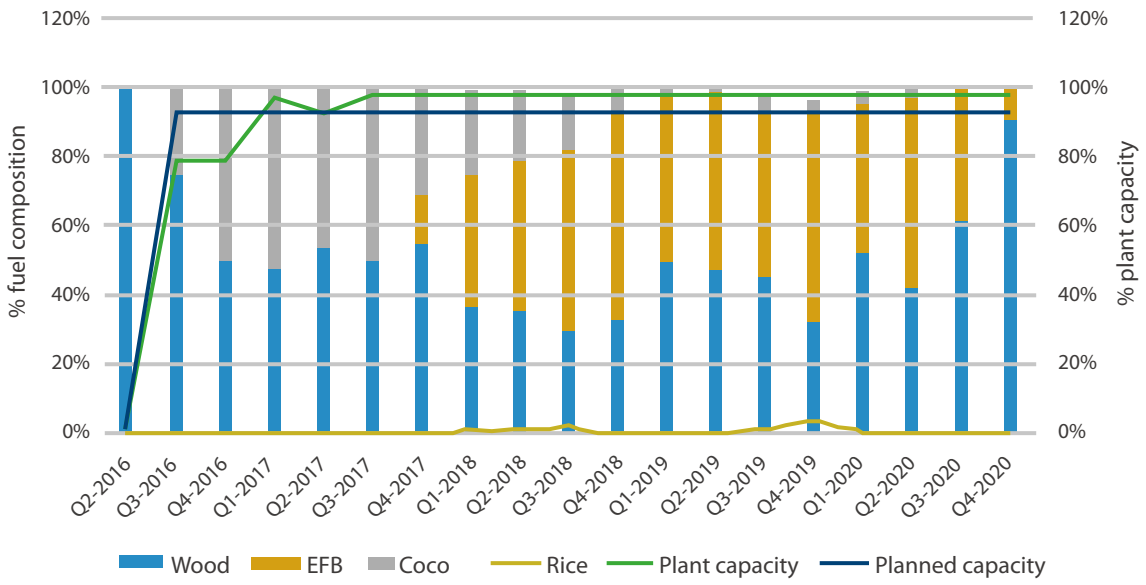

Coconut Waste


Wood Chips


EFB


Rice Husk

Fuel variation and Mahachai plant performance 2016-2020



Performance Commentary

- The range in fuel inputs and moisture levels has varied considerably from the design fuel, but performance has remained high and stable.
- For many plants, this variability would cause significant problems in the boiler and grate, and even plant failure. In particular, the use of EFB (Empty Fruit Bunch) is a frequent cause of power plant failure. Unlike most plants, DP's solution can successfully process and combust highly corrosive and complex EFB and similar fuel types.
- Fuel quality and availability are ongoing challenges faced by the power plant. In particular, during the rainy season the humidity/moisture levels at times exceed 60-65% full load. However, this has not caused any problems. The continued high and stable performance demonstrates the advanced fuel flexibility of DP technology, reflecting superior design knowhow.

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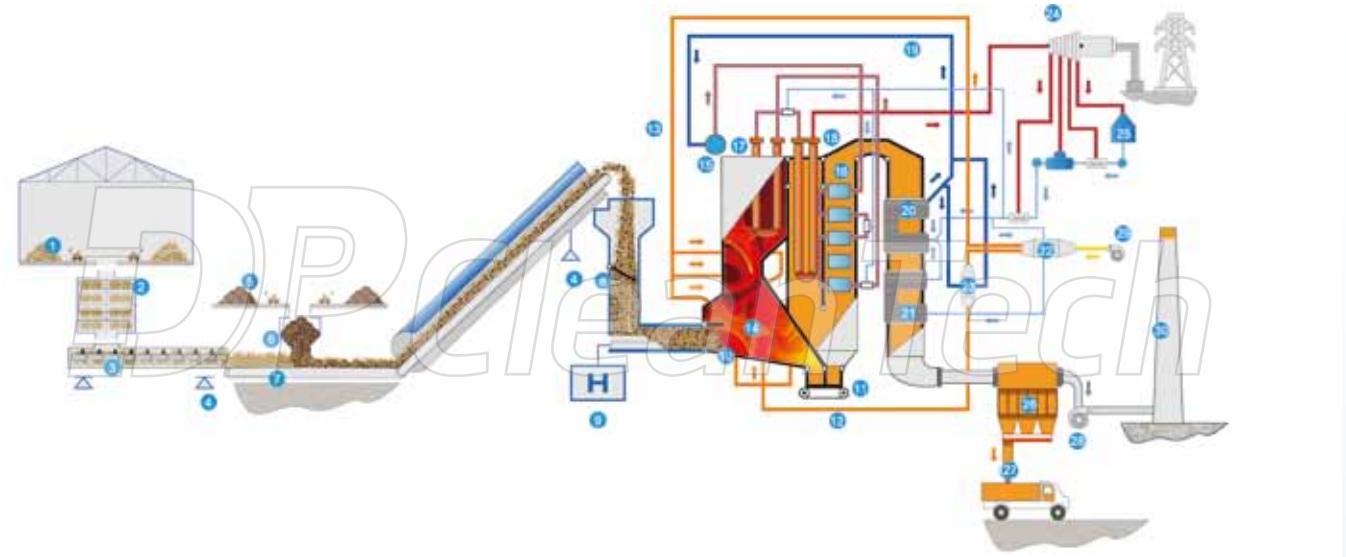

1 Shredded fuel	7 Belt conveyor	13 Secondary air	19 Boiler feed water	25 Water-cooled condenser
2 Walking floor	8 Pusher feeder	14 Combustion chamber	20 Economizer	26 ESP filter
3 Screw conveyor	9 Hydraulic station	15 Steam drum	21 Flue gas cooler	27 Ash handling
4 Weight cell	10 Vibrating grate	16 Superheater 1	22 Air preheater 1	28 ID fan
5 Non-shredded fuel	11 Slag conveyor	17 Superheater 2	23 Air preheater 2	29 FD fan
6 Feeding hopper	12 Primary air	18 Superheater 3	24 Steam turbine generator	30 Stack

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Fuel Handling

Fuel storage is both outdoors and indoors, and transported to the pusher feeder via 2 automatic moving floors, screw and belt conveyors. The screw conveyor system is equipped with weight cells to ensure proper fuel consumption data management. Belt conveyors transport the fuel to the inlet hopper of the pusher feeder. There is also an alternative fuel inlet via a ground hopper directly on to the belt conveyors. The pusher feeder is a unique solution which will allow the combustion of pre-processed feedstock, feeding the fuel into the boiler combustion chamber.

Combustion Process

DP's proprietary Water-Cooled Vibrating Grate regulates combustion, using an alternating vibration cycle of between 1.5–3 minutes for a period of 3–5 seconds at a time. Combustion air is fed to the furnace both from beneath and above the grate. The grate is divided into 3 primary air zones. The first zone is subjected to high turbulence to aid the release of volatile matter and moisture. The second stage is the pyrolysis, the third stage is for burning out. The fuel ash and slag are transported along the grate by the vibrating movement into the slag fall, then into a submerged slag conveyor, finally discharging into a slag pit.

The grate was designed specifically for biomass combustion and will reliably and effectively accommodate mixtures of woody and herbaceous fuel. The vibration inhibits the formation of large slag particles, common in biomass combustion. This makes the grate suitable for burning fuels with high slagging and sintering propensities. With fewer moving parts than a standard moving grate, less maintenance is needed.

High Pressure, High Temperature (HPHT) Boiler

DP's unique and well proven steam boiler is a water tube boiler with hanging superheaters producing 40 tons of steam per hour at 92 bar and 537°C. The steam is used in a conventional steam cycle turbine. The specially selected materials and advanced temperature control counteract the fouling and corrosive effects of the fuel. The flue gas, having been cooled in the boiler, is cleaned in an electric filter before being discharged through the stack.

Flue Gas Cleaning

DP's advanced combustion and emissions handling techniques ensure that all gaseous plant emissions are well below regulatory standards. An electrostatic precipitator filter removes particulate matters. Fly ash is collected in a storage silo via a dense phase pneumatic transport system and can be discharged from the silo into trucks for redistribution as fertilizer. The plant is equipped with a CEMS (Continuous Emission Monitoring System) for online monitoring of emissions.

Steam Turbine Generator

The steam turbine generator set in this plant was manufactured and delivered under DP supervision. The generator and gearbox are German manufactured and designed to produce electricity up to 9.9MW gross.

Substation: Transformer and Transmission System

A transformer station with medium voltage switchgears is the connection point to the 22kV grid of the Provincial Electricity Authority. The plant can supply approximately 72,000MWh of electricity to the provincial grid annually.

Plant and Boiler Automation

DP developed and programmed the entire advanced boiler control system to enable 100% automatic operation in continuous run-time; and the plant can operate at full capacity for more than 8,300 hours per year with minimal operator assistance. The automation system monitors the combustion process and fuel feeding system using proprietary software and data supplied from field instrumentation, enabling adjustments to be made automatically for different feedstock combinations. The process is regulated automatically but can also be manually controlled if necessary.

Powerful data trend and automatic reporting functions enable fast diagnosis and troubleshooting, minimizing downtime. All boiler protection and plant safety interlock functions are also controlled by the DPAAC solution for maximum safety and reliability.

Client Testimonial

CarbonBW

"The plant entered first operation in early 2016, using mainly coconut husk waste. The operation of the plant met our expectations and beyond. The degree of automation is high and the performance and efficiency levels are excellent, setting a new standard for the use of coconut waste in power plants. Since 2017, we have used a variety of different fuel types such as wood chips, EFB and rice husks, in various proportions and often simultaneously. The result has been exceptional and exceeded our expectations, giving us the chance to optimize our fuel purchase. We are more than happy to have the flexibility in using different fuel types even with varying humidity levels; and it gives us a unique competitive advantage. The after-sales support that we have received is excellent and the teamwork has been fantastic. I can thoroughly recommend DP's plant solution as a first-class product in all respects".

Roland Vogel (Managing Director of CarbonBW Thailand Co., Ltd.) December 2020.