

## **MLNG DUA DEBOTTLENECKING PROJECT**

Yahya Ibrahim  
Senior General Manager  
Malaysia LNG, Malaysia  
yahyai@petronas.com.my

Tariq Shukri  
LNG Consultant  
Foster Wheeler Energy Limited, Reading, U.K.  
Tariq\_shukri@fwuk.fwc.com

### **ABSTRACT**

Malaysia's Petronas LNG Complex in Bintulu, Sarawak, is an integrated facility with upstream activities directly connected to downstream LNG plants and export terminal. The facility produces up to 23 million tones of LNG annually, from three LNG plants, with a total of eight modules (trains). The three plants are owned by Malaysia LNG Sdn Bhd, Malaysia LNG Dua Sdn Bhd and Malaysia Tiga Sdn Bhd, which are all subsidiaries of the national petroleum corporation, Petronas.

The MLNG Dua plant comprises three identical LNG process modules, utilizing the propane precooled liquefaction process. Utilities are provided by adjacent facilities. The liquefaction unit produces subcooled LNG at approximately -161 °C which is rundown directly to storage.

MLNG Dua Sdn Bhd is implementing a debottlenecking project to increase its production capacity by approximately 20%, by the novel addition of a new extended end flash unit, and uprating some of the existing equipment including the propane and mixed refrigerant refrigeration systems and associated gas turbine drivers.

Project execution for each module includes installation of new equipment, modification of existing equipment and installation of tie-ins during scheduled shutdowns. Installation work outside shutdowns is carried out as much as possible to minimize the shutdown period.

This paper presents the technical background to the project, including details of the novel extended end flash unit, and the project development phases.

## INTRODUCTION

### Petronas LNG Complex

The Petronas LNG complex at Bintulu, Sarawak, occupies an area of over 276 hectares and produces up to 23 MTPA of LNG. It is comprised of 8 LNG modules (trains) constructed in three different projects (Table 1):

**Table 1. Petronas LNG Complex**

PETRONAS LNG	Module	Original LNG Design Production Capacity (MTPA)
MLNG	3 nos (module 1,2 & 3)	8.4
MLNG Dua	3 nos (module 4,5 & 6)	7.8
MLNG Tiga	2 nos (module 7 & 8)	6.8

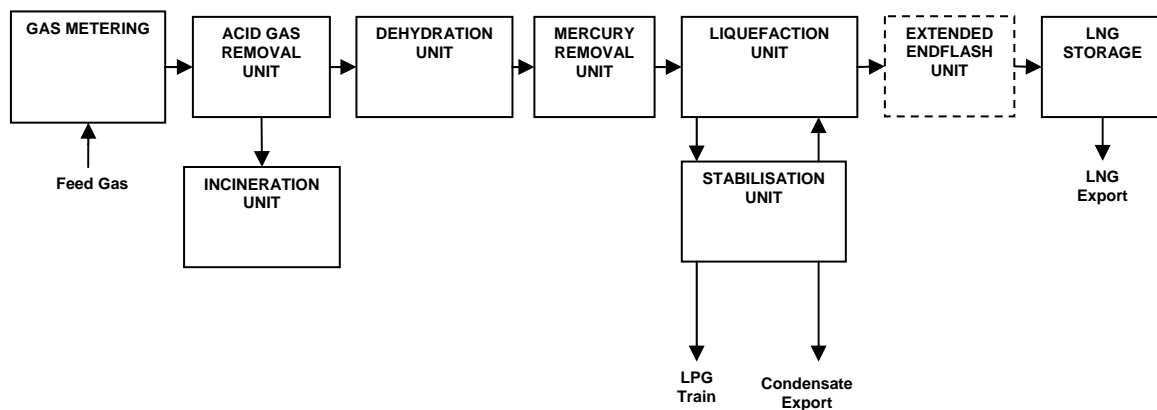
All modules are based on the propane precooled mixed refrigerant process utilising the Air Products & Chemicals Inc. (APCI) main cryogenic heat exchanger (MCHE). MLNG, completed in 1980, uses steam turbine drivers for the main refrigerant compressors, and sea water cooling. MLNG Dua, completed in 1995, uses gas turbine drivers for the main refrigerant compressors, and hybrid sea water and air cooling. MLNG Tiga, completed in 2004, uses gas turbine drivers for the main refrigerant compressors, and air cooling. The facilities share common LNG rundown, storage tank and export facilities.

The Petronas LNG complex, including power generation and utilities systems, is run by MLNG as an integrated facility.

### MLNG Dua

MLNG Dua was built to take full advantage of spare utility systems availability from the MLNG facility, e.g. sea cooling water and expansion of some of these systems.

The overall process scheme is shown in Figure 1.



**Figure 1. MLNG Dua Overall Process Scheme**

The liquefaction units in MLNG Dua produce subcooled LNG from the MCHE at about  $-161\text{ }^{\circ}\text{C}$  which is rundown directly to storage. There are no end flash units as in MLNG and MLNG Tiga (in MLNG and MLNG Tiga, warmer LNG is produced from the MCHE which is then cooled to storage temperature by flashing in endflash units (generating fuel gas) before being pumped to storage).

The propane refrigerant system compressor is a three-stage single casing compressor with side streams, for three levels of cooling. The compressor is driven by a GENP Frame 6 gas turbine with a steam turbine starter/helper drive. The mixed component refrigerant (MCR) compression system is made up of a low pressure axial compressor and a two stage single casing high pressure centrifugal compressor. The MCR compressors are driven by a single GENP Frame 7 gas turbine with a steam turbine helper/starter drive. The steam turbines are supplied by a high pressure steam from MLNG boilers and the returned low pressure steam is sent for process heating and utility use. The excess is condensed via a steam turbine power generator.

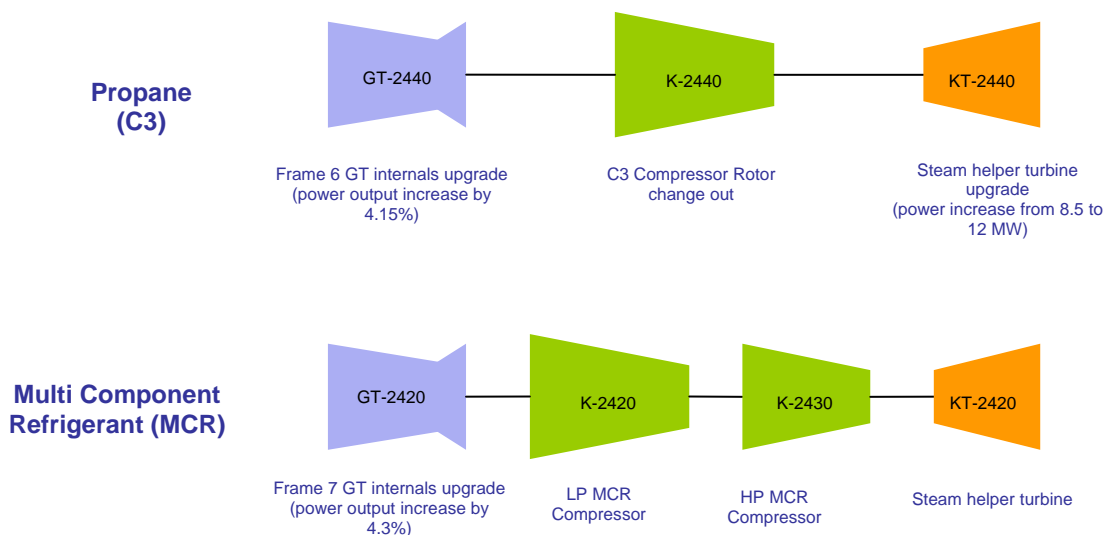
MLNG Dua has several features which were considered novel for LNG plants at the time of construction. These include:

- Use of frame 6 and frame 7 gas turbine mechanical drives
- Steam helper turbines
- Hydraulic expanders for pressure let-down in LNG and heavy MCR
- Axial compressor for low pressure MCR
- Heat recovery from gas turbine exhaust, and hybrid air and water cooling.

## DEBOTTLENECKING

MLNG Dua is being debottlenecked to meet a higher export demand of LNG. Increased production is achieved by the uprating of power available to the main refrigeration C3 and MCR systems (Figure 2) and the addition of a new (extended) end flash unit. Existing process and utilities systems are checked for new operation and modified as required, including equipment, valves, relief valves, piping, etc. Where possible, replacement of existing equipment is avoided and changes are limited to simple modifications. Additional equipment is added to existing units only where absolutely necessary.

The main technical changes to increase MLNG Dua LNG production are summarised in Table 2.



**Figure 2. Main Refrigerant Compressors and Drivers Upgrade**

**Table 2. Project Technical Scope**

<b>Debottlenecking Description</b>	<b>Unit or Systems Involved</b>	<b>Equipment Added or Modified</b>
Addition of new equipment or units per module	Extended end flash process	<ul style="list-style-type: none"> <li>- End flash &amp; booster compressors</li> <li>- Printed circuit heat exchanger (PCHE)</li> <li>- End flash &amp; KO drum</li> <li>- LNG rundown pumps</li> </ul>
Upgrading main refrigerant compressors and drivers per module	Main gas turbines  C3 compressor  C3 steam starter/helper turbine	<ul style="list-style-type: none"> <li>- Upgrade F6 &amp; F7 Power output</li> <li>- New internals (shaft &amp; impellers)</li> <li>- New rotor</li> </ul>
Debottlenecking existing systems and equipment to support increased production per module	C3/MCR cooling systems  Relief system  Hydraulics (natural gas, C3 & MCR )Fuel gas system  Tie-ins	<ul style="list-style-type: none"> <li>- New MCR/sea water cooler</li> <li>- Enhanced C3 kettles</li> <li>- New RVs and headers</li> <li>- Valves/control valves</li> <li>- Headers and heaters</li> <li>- Piping</li> </ul>
Additional common power generation to support increased production	Power generation	<ul style="list-style-type: none"> <li>- Two frame 5 sets</li> <li>- Fuel gas KO drums</li> <li>- Heaters</li> </ul>

**Philosophy**

The current plant production is ultimately limited by the power available to the main refrigeration compressors (C3 and MCR) and potentially by the heat transfer area in the MCHE.

The C3 refrigeration upstream MCHE is upgraded by increasing the power output of the gas turbines and by modifying the compressor to allow a higher propane circulation rate. This will allow higher natural gas flowrate but the inlet temperature to the MCHE is

limited to the lowest temperature achieved by the low level propane system to avoid sub-atmospheric suction pressure in the first stage C3 compressor.

Modifications to MCHE itself are limited to operational changes to increase the MCR refrigeration e.g. by increasing flowrate and discharge pressure.

To increase production significantly from the existing plant, refrigeration capability could be added downstream of the MCHE. One way of achieving this is by the addition of an end flash unit or nitrogen expansion cycle.

### **Options Considered**

During the feasibility study phase the following options were considered for refrigeration downstream of MCHE, in addition to gas turbine power uprating:

- Simple end flash unit
- Extended end flash unit
- Nitrogen cycle (as in AP-X™ process by APCI)

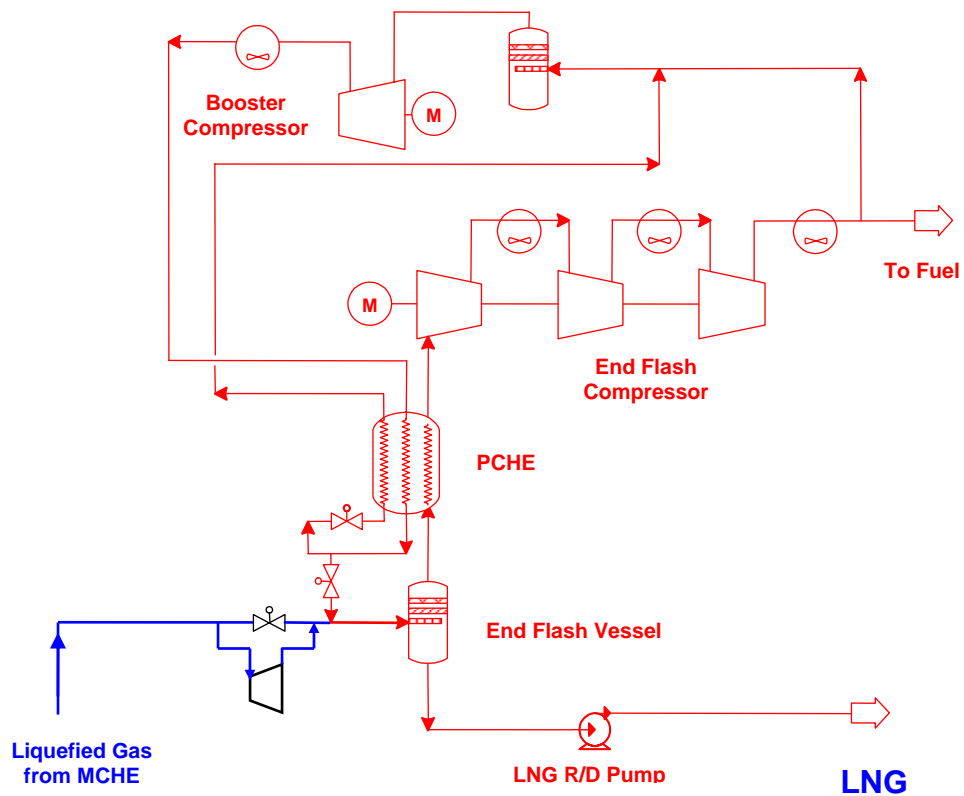
The end flash unit reduces overall LNG specific power (power required per ton of LNG produced) enabling higher production from the available power. Nitrogen cycles provide the highest increased capacity but also the highest CAPEX.

An end flash unit option was selected for development. The selection is project-specific and was based on capacity, CAPEX, OPEX, environmental impact, operation and project execution. The project execution plan required minimum production losses by implementing existing equipment modification and tie-ins installation during scheduled overhauls, allowing later commissioning of new units.

### **Extended End Flash**

A schematic of the extended end flash unit is shown in Figure 3. Process gas liquefied in the MCHE leaves at a higher temperature than existing operation. Currently the liquefied stream is cooled to approximately -161 °C and, after pressure let down via a hydraulic expander or JT valve to 6 bara, flows directly as LNG product to storage tanks. With the new unit the stream exits at approx. -154 °C thus allowing more throughput through the cryogenic exchanger for the same heat duty. After pressure let down to 1.15 bara (as LNG storage pressure) it flows to a flash vessel to separate the flashed gas. The liquid from the vessel is then pumped by new LNG pumps to storage tanks.

Cold is recovered from the flashed gas in the PCHE and the gas is compressed by a 3 stage flash gas compressor to the fuel gas system at approximately 25 bara.



**Figure 3. Extended End Flash Unit**

The scheme so far resembles a conventional end flash unit where cold recovery is typically achieved against light MCR or other process stream. In the extended end flash scheme above, part of the compressed flash gas is recycled via a one stage booster compressor. The recycled gas is compressed to about 70 bara, cooled by an air cooler and liquefied in the PCHE by heat exchange with the flash gas. The pressure is then let down and the stream is mixed with the feed to the flash vessel. To extend the operating range and allow more recycle gas to be liquefied, part of the liquefied stream is used as an auto-cooling stream by pressure let down and routing back via PCHE to booster suction. This provides more refrigeration in the PCHE

MLNG Dua does not provide all its energy requirements as it imports utilities such as steam and electric power from common facilities. A conventional end flash scheme would have generated flash gas in excess of the fuel gas demand for the same LNG production capacity.

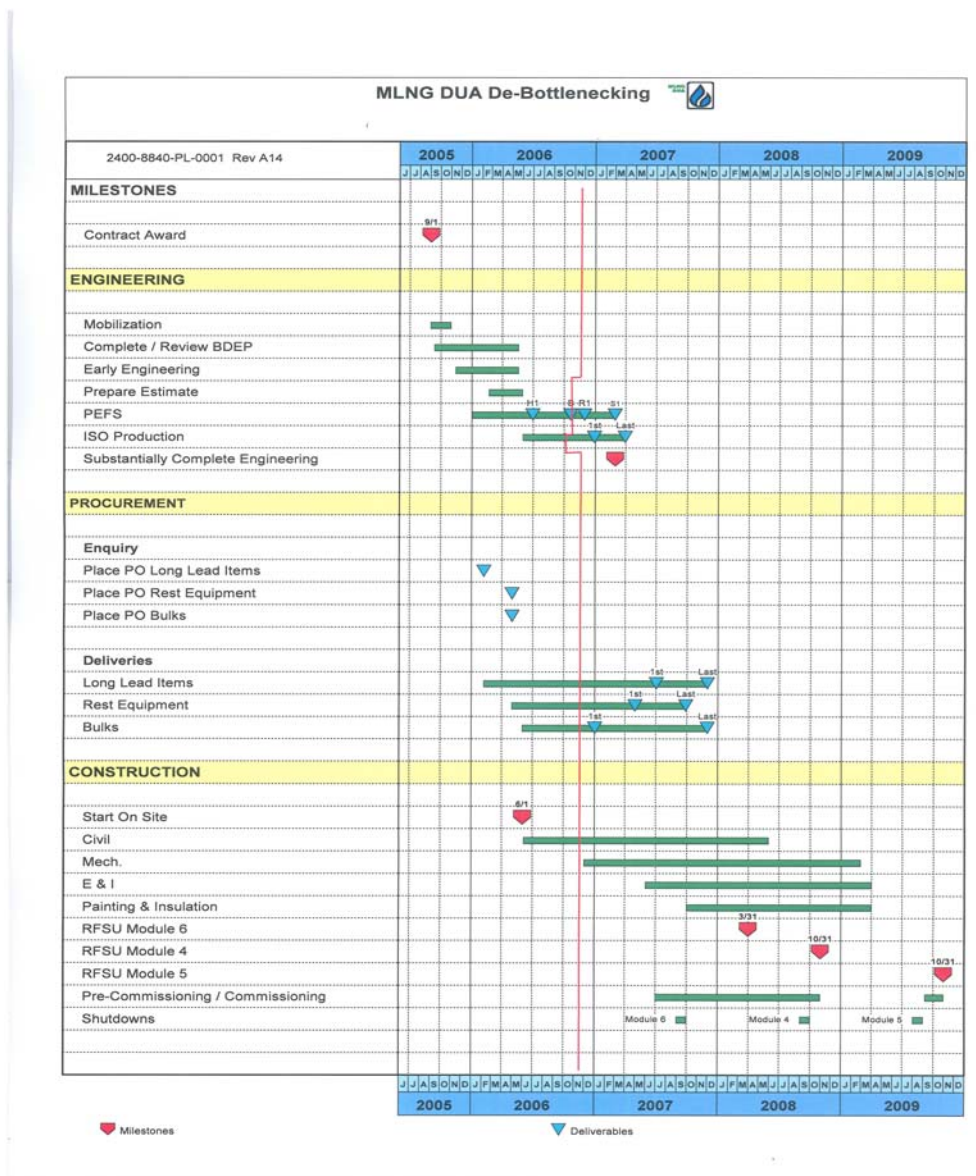
## PROJECT METRICS

A summary of project features is given in Table 3.

**Table 3. Project Indicators**

Item	Unit	Existing	Debottlenecked
Capacity	% of original design	104*	121
Module LNG Rundown (original design 8,000 TPD)	TPD	8,300	9,700
Specific power	kW/TPD	13.5	13.2
Specific power for increment production	kW/TPD		11.4
Contribution to increased production (of 17%):			
Power upgrade			8%
Extended end flash			8%
Equipment upgrade			1%

\* Based on design case (future) operating composition



**Figure 4. Overall Project Schedule**

## PROJECT DEVELOPMENT

The project follows PETRONAS project implementation phases. An overall project schedule is shown in Figure 4.

### Screening Study/Basis of Design (BOD)/Basic Design Package (BDP)

These early phases of the project were carried out by MLNG/Shell Global Solutions International (Shell GS). In these phases current plant status was reviewed, debottlenecking capacity and options identified and technology selection made based on

agreed criteria. These were then developed into the BDP and invitation to bid (ITB) to enable engineering, procurement and construction Management (EPC contractors to bid for the front-end engineering design (FEED) and the engineering, procurement and construction management (EPCm) contract. This included a preliminary project cost estimate.

To maintain the schedule some early engineering activities were undertaken and procurement orders placed prior to FEED award. The main items being the gas compressor and gas and steam turbine drivers upgrade.

### **Basic Design Engineering Package (BDEP) or FEED**

The FEED phase of the project was carried out by Foster Wheeler and its local partner, OGP (a subsidiary of PETRONAS), supported by an Owner/MLNG Project Management Team (PMT)

It was executed on a fast-track basis to enable critical orders, especially those for the work to be done during the shutdown, to be issued. An early issue which required addressing was the availability of as-built documentation for existing facilities especially that for the older MLNG facilities.

During this phase the feasibility of some of the work items was reassessed and some options were deleted and others added to meet project requirements. In particular the MR steam helper upgrade was deleted and so were some associated steam boiler modifications. A second gas turbine power generator was added to address overall power balance sparing philosophy.

Also, as a result of above and some early compressor vendor information heat and material balances had to be revised. Early detail engineering activities were also commenced during this time.

In spite of that this phase was completed earlier than planned and major orders placed. The contractor also carried out a  $\pm 15\%$  cost estimate for the project to enable the final investment decision (FID) to be made.

### **EPCM phase**

The work 'rolled' straight into the EPCm phase pending FID, to meet the schedule.

For this phase MLNG formed an Integrated Owner Project Management Team (IOPMT) to execute the work, made up of MLNG and EPCm contractor personnel supported by Shell GS. Detailed design documentation was progressed in time for vendor awards and clarifications.

Construction personnel were relocated to site at Bintulu and some site construction activities have already taken place, specifically the steam modification, where a new

header had to be installed, and cooling water work. Some tie-ins for this work were installed during a planned shutdown for the relevant steam turbo-generator.

The phase also included dynamic studies for the main compressors, fuel gas system, end flash system and LNG rundown. Also studies were made to confirm equipment capabilities, including thermal rating work, and studies by APCI to confirm the operation and integrity of MCHE.

### **Current Status and Future Work**

As of January 2006, detail engineering activities are over 70% complete, and following substantial completion, the team will relocate to site to complete construction and commissioning work

Immediate targets are to complete engineering to support procurement activities and finalise the construction schedule for the 40-day shutdown planned for September 2007 for the first module to be modified, to install tie-ins and the modifications required for immediate operation after completion of shutdown, in particular the propane compressor and gas and steam turbine upgrading.

Following completion of the shutdown there will be an interim period of operation with uprated drivers and compressors but without the extended end flash system which will not be ready. LNG production will increase due to increased power. This mode of operation has also been studied to ensure safety and performance.

The end flash unit is expected to be completed in the first quarter of 2008 and is planned to be brought on line with minimum interruption to production.

Work completion for the other two modules is planned for 2008 and 2009 respectively.

### **Summary**

This is the first application of a novel process which is expected to deliver an economically and technically feasible approach to delivering increased LNG output from Petronas' MLNG Dua facility to meet the growing demand for LNG.