NGL RECOVERY PROJECT AT BADAK LNG PLANT

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ABSTRACT

The Indonesian East Kalimantan Production Sharing Contractors (PSC’s) are producing gas for the PT Badak LNG Plant (eight LNG Train Plant with a production capacity of 22.5Mt/a of LNG) located in Bontang and for the “Domestic” Plants (Fertilizer, Ammonia and Methanol Plants) located also in Bontang. From the gas gathering center located 57km upstream of the LNG Plant, there is a pipeline network consisting of four pipelines (2x42” and 2x36”) supplying feed gas to the LNG Plant and the “Domestic” Plants. The total amount of feed gas supplied to the “Domestic” Plants is 450MMSCFD consisting of 150MMSCFD of lean gas (heavy ends already extracted by one of the PSC’s) and 300MMSCFD of feed gas taken from the pipeline network. The problem with the feed gas taken from the pipeline network is that heavy ends containing propane, butane and condensates are condensing. These condensed heavy ends are currently collected upstream of the “Domestic” Plants and flared. This is a loss of valuable products. In addition, the feed gas is still containing heavier components which are more valuable than the methane, the primary component required by Domestic Plants. If extracted, these heavier components can be sold as end products at a better price than the feed gas.

PT Badak has developed 1) in a first step a new mode of operation of one of the LNG Train to be able to recover some of the heavy ends currently flared by the “Domestic” Plants and 2) in a second step a new project to maximize the recovery of the heavy ends from all the feed taken from the pipelines network and sent the methane to the “Domestic” Plants.

1- **New mode of operation of the LNG Plant**: the fifth LNG Train (called Train “E”) has been designed with the facility to send lean gas from the overhead of the Scrub-column (column adjusting the composition of the feed gas of the Main Cryogenic Heat Exchanger) to the “Domestic” Plants. Therefore allowing PT Badak to produce additional quantities of propane, butane and condensates when the LNG Plant is not at its maximum sustainable LNG production. This facility was commissioned in 2005 as the LNG Plant was not at its maximum sustainable capacity. However the amount of lean gas that could be sent to the “Domestic” Plants was limited to 50MMSCFD as during this mode of operation, the amount of LNG produced by Train “E” is reduced. The key driver is the PT Badak LNG commitments.

2- **NGL extraction Project**: to further increase the propane, butane, condensates and even ethane recovery from the 300MMSCFD of feed gas taken from the pipelines network and sent to the “Domestic” Plants without affecting the LNG production from the LNG Plant, PT Badak has developed a Project called “Ethane Plus Extraction Project” (EPEP). This Project, currently under FEED stage, will recover 99.26% of the ethane and 100% of the other heavier components (propane, butane and condensates) of the feed gas. The propane, butane and condensates will be fractionated and sold as sales products while the extracted ethane will be injected in the LNG to increase its ethane value. In addition – and this is an improvement for the “Domestic” Plants – the “Domestic” Plants will receive a gas with a lower carbon dioxide content and with a higher methane content compared to the current mode of operation.

This paper will present in details the current new mode of operation of the PT Badak LNG Plant and the future EPEP.
TABLE OF CONTENT

Abstract

1. Background
   1.1. East Kalimantan Feed Gas Distribution
   1.2. Domestic Plants
   1.3. LNG Plant Facility

2. NGL Recovery Project

3. EPEP Project Scope

4. EPEP Plant Sizing

5. Material Balance

6. Potential Production Loss from LNG Plant

7. Utility Supplies
   7.1. Electricity and Gas Turbine Generators (GTG)
   7.2. Hot Oil
   7.3. Aerial Coolers
   7.4. Nitrogen
   7.5. Air Supply
   7.6. Fuel Gas
   7.7. Water
   7.8. Wastewater Treatment

8. Project Staging

9. Summary

10. List of Table

11. List of Figures
1. BACKGROUND

Ethane Plus Extraction Project (EPEP) is intended to extract natural gas liquids (NGL) from the raw gas supplied to Domestic Plants. Currently, there is about 450 MMSCFD feed gas supplied to the Domestic Plants consisting of 150 MMSCFD lean gas from Chevron LEX Plant and another 300 MMSCFD raw gas from pipeline transmission system. The gas supplied from the LEX Plant is a lean gas after its heavier ends content are extracted. This gas is sent separately from the raw gas pipeline system to Domestic Plant. On the other hand, the raw gas supplied from the pipeline transmission system still contains heavier hydrocarbon components which are economically more valuable compared to Methane, the only component required by Domestic Plants. Therefore, a project called EPEP was established to extract NGL from the raw gas.

1.1. East Kalimantan Feed Gas Distribution

East Kalimantan feed gas is produced by Total Indonesie, VICO, and Unocal. The gas reservoir is scattered in the delta of Mahakam River, the longest river in Indonesia located in East Kalimantan (Borneo Island). Total Indonesie is the major gas producer with a production capability of 2639 MMSCFD, followed by VICO and Chevron with the production rates of 575 MMSCFD and 191 MMSCFD, respectively. The last two gas producers are having a declining gas production lately that will affect all the assumption in feasibility study of this project.

The gas is gathered in Muara Badak, 57-km southern of Bontang City. From Muara Badak, the gas is delivered using two 36-inch and two 42-inch pipelines to Bontang. The main portion of the gas is consumed by PT Badak NGL, a Natural Gas Liquefaction Plant, and the rest is supplied to Domestic Plants.

In addition to the raw gas supplied from the pipeline, Domestic plants are also fed with the lean gas from Chevron LEX Plant that combines in the SKG Station. SKG is the metering and control station of the gas delivered to Domestic Plants (attachment 1). There are 4 parallel pipelines from SKG to Domestic Plant: two 16-in line, one 18-inch line and one 20-inch line called “New Sistima Line”. The gas to SKG station is supplied by four pipelines from kilometer 53 (KM-53) of pipeline transmission system. The high heating value (HHV) of the raw gas from pipeline is varying in the range of 1080~1105 BTU/SCF while the HHV of Chevron lean gas is at 1017 BTU/SCF. The pressure is adjusted to 35.5 (+/- 1 kg/cm$^2$g) for ammonia and methanol plants. The gas to fertilizer plant is further boosted to 48 kg/cm$^2$g by three compressors.

1.2. Domestic Plants

Domestic Plants consist of Kaltim Fertilizer Plant (KFP), Kaltim Methanol Industri (KMI), Kaltim Pasific Amoniak (KPA), and Kaltim Parna Industri (KPI). The last two plants are producing ammonia. The Fertilizer Plant itself comprises four fertilizer manufacturing units. In their processes, these plants require basically only methane, while the other hydrocarbon components do not necessarily increase the production yield except for the methanol plant.

The current Domestic plant design consumptions are as follows, but the actual demand is below the design and varies from time to time depending on the supply and demand.

1. (KFP) Kaltim Fertilizer Plant: 280 MMSCFD
2. (KMI) Kaltim Methanol Industri: 66 MMSCFD
3. (KPA) Kaltim Pasific Amoniak: 65 MMSCFD
4. (KPI) Kaltim Parna Industri: 50 MMSCFD

1.3. LNG Plant Facility

Badak LNG Plant is the main consumer of the East Kalimantan gas. The plant is capable of producing LNG at 22.4 mtpa, LPG both Propane and Butane at 1 mtpa, and condensate at 1.6 million m$^3$/year. The
A facility for exporting lean gas from Train E was constructed in the early of 1990s. It takes the lean gas outlet of the Scrub Column (Demethanizer) splitting the flow of the gas fed to the cryogenic heat exchanger to the lean gas export line. Designed to deliver up to 50 MMSCFD lean gas, this facility was hardly utilized because of the competition between LNG production target on one side and lean gas export to Domestic Plants on the other side. This facility was once continuously operated since May 2005 during the low LNG production demand but three months later it was stopped due to high LNG production mode.

2. NGL RECOVERY PROJECT

The problem with the feed gas delivered to the Domestic Plants taken from the pipeline network is that heavy ends containing propane, butane and condensates are condensing. These condensed heavy ends are currently collected upstream of the “Domestic” Plants and flared. This is a loss of valuable products. Recovery of the heavier component by utilizing the extra refrigeration load in LNG Plant is not as simple as it was thought as mentioned earlier. Since the required hydrocarbon component by the Domestic Plants is primarily methane, a project called Ethane Plus Extraction Project (EPEP) was initiated. This project is intended to extract the NGLs from the raw gas supplied to Domestic Plant in a separate facility from the LNG Plant, hence its operation will not affect the operating stability of the existing LNG plant.

2.1. Technology Selection

Several technologies have been evaluated as the main process to separate methane from the NGL, such as, lean oil absorption, refrigeration, and turbo expander technologies.

- **Absorption Plants or Lean Oil Plant**
  The most efficient lean oil absorption plants recover only about 40 percent of the ethane, 90 percent of the propane, and 100 percent of the butane and heavier hydrocarbons from the gas. Additional heat is required to separate the products from the lean oil, and additional cooling is required in order to re-liquefy the raw products before fractionation. Lean oil absorption plants usually have higher operating costs than refrigeration plants or turbo expander plants. Therefore, this old type process was dropped from selection.

- **Refrigeration Plants**
  If the major purpose of a plant is to condition rich gas to meet certain pipeline specifications, the mechanical refrigeration plant may be the proper selection. Refrigeration is used to condition produced gas to meet pipeline hydrocarbon dew point specification, Btu specification, limited liquid recovery of heavier hydrocarbons such as C5+ or a combination of these objectives. The straight refrigeration plant is limited to chilling the gas stream to the range of -34°C to -40°C. This limits product recovery to about 60 percent of the propane and much less ethane at typical plant operating pressure. As the intention of the project is to recover heavier components starting from Ethane, this technology was skipped.

- **Cryogenic Turbo Expander Plants**
  Cryogenic turbo expander plants is capable to recover from 60 to 90 percent of the ethane, 90-98 percent of the propane, and 100 percent of the butane and heavier hydrocarbon components from the rich gas. A turbo expander plant is compact and relatively simple to install and operate. The inlet gas to a turbo expander plant must have essentially all of the water and CO₂ removed to prevent hydrate formation to the level of respectively 1 ppm and 100 ppm depending on the cryogenic temperature achieved. Turbo expander plants have less process equipment (towers and external heating) than
lean oil absorption plants, but they have more mechanical equipment (gas heat exchangers and recompressors).

If ethane recovery is the objective, the expander process is the most economical means for recovering a high percentage of ethane and heavier hydrocarbons from a gas stream. A turbo expander plant is the first design considered because it is comparable in cost to a refrigeration plant, but it is more efficient and achieves greater liquid recovery. Turbo expander plants can be designed to operate with an inlet gas pressure ranging from a minimum of 33.4 kg/cm$^2$ (475 psig) up to 101.2 kg/cm$^2$ (1440 psig). The selection of turbo expander technology for EPEP Plant was based on this consideration. Three license processes were evaluated at the final stage before selecting one of the best in terms of price and cooperative degree.

3. EPEP PROJECT SCOPE

The EPEP plant is designed to recover 99.2% of ethane and 100% of propane, butane and other heavier hydrocarbon components from the raw gas using turbo-expander technology. This Plant will be located in the area at of Kilometer 55 (KM-55) of the pipeline transmission system or 2 kilometers upstream of the LNG Plant. The reason that EPEP Plant is located close to the LNG is due to utility supply back up, product storage facility, and land use permission.

The raw gas will be supplied from the existing tie-ins to Domestic plants at KM-53.5, by diverting it to EPEP Plant and returning the methane-rich gas product, called residue gas, back to this line downstream of the isolation valve. Later, this isolation valve will act as an automatic back up valve for the EPEP Plant in supplying the gas to Domestic Plant in case EPEP Plant trips or is shut down (see Figure 1).

The recovered ethane vapor from the EPEP Plant will be recompressed and recombined with the raw gas delivered to the LNG plant through the pipeline transmission system. This ethane will increase the feed gas heating value, which in turn, will increase the LPG yield from the LNG plant by replacing the LPG content in LNG product with higher ethane composition. This is because some of the LPG content is maintained in the LNG product to keep its heating value within the target range.

This EPEP plant is designed to have a feed gas knock out drum (KOD) as the inlet facility to separate liquid hydrocarbon and water from the gas stream. The gas from KOD will then be treated in the CO$_2$ removal unit to remove its CO$_2$ content down to 0.3 mole% using amine absorption process. This water-saturated gas will be separated from its moisture and mercury contents consecutively in dehydration unit and mercury removal bed. These treatments are intended to avoid clogging of the cryogenic unit by frozen CO$_2$ and water due to extremely low temperature operating condition. Mercury is notorious to attack equipment made from aluminum-based alloy commonly used in cryogenic system by forming amalgam.

The treated gas is sent to turboexpander unit for NGL extraction (see Figure 2). Firstly, the pressure of the treated gas is increased by a booster compressor driven by a turboexpander. Then, this gas is isentropically expanded through the turboexpander after being chilled by cool streams of residue gas and ethane streams in cold box heat exchangers. The expanded stream is separated in a demethanizer column to produce methane-rich gas called residue gas from the column overhead and NGL at the bottom. The residue gas is then recompressed to achieve its required pressure of 39 kg/cm$^2$ minimum at receiving point in Domestic Plant. The bottom product, the NGL, will be fed to De-ethanizer, to separate ethane from the heavier components. The overhead product of the De-ethanizer column, ethane-rich gas, will be recompressed and recombined with the raw gas delivered through the pipeline transmission system.

The bottom product of the De-ethanizer Column, is separated in the next distillation columns to produce separately LPG C3, LPG C4, and condensate. The LPG C3 and C4 will be cooled down to their storage temperatures in a multi-component refrigeration unit before being stored at atmospheric pressure in the existing storage tanks located about 4-5 kilometers away from the EPEP Plant. To avoid heat-in leak in a
long insulated product piping, the LPG product refrigeration unit will be located close to the existing LPG storage in the LNG Plant.

Figure 1. Schematic Diagram of Piping Configuration of EPEP Project

EPEP Plant is designed to have aerial coolers for cooling system in the whole plant. The use of sea water as the cooling media is avoided to prevent higher sea water temperature at the outlet point from the existing LNG Plant. Different from the existing LNG Plant, EPEP Plant will have gas turbine drivers for residue gas compressor and power generation. For small compressors, electric motor will be used as the driver. Hot oil system will be used as the heating media for reboilers and heaters. Furnaces will be provided to heat up the circulated hot oil.

To optimize the energy consumption of EPEP Plant, the flue gas from the gas turbines will be utilized as the heating media for drier reactivation gas and hot oil preheater. By these arrangements, the fuel gas consumption for the EPEP Plant is only 4 percents from its feed gas.
4. EPEP PLANT SIZING

Even though the EPEP Plant is designed with the capacity calculated from the volumetric flow rate of residue gas to be delivered, but this calculation is actually derived from the energy delivery basis. The feed gas contract requires that the gas producer to deliver a total of 166,825,000 MMBTU/year or equivalent with a daily delivery of 475,055 MMBTU. By subtracting 150 MMSCFD lean gas delivered from Chevron LEX Plant at a HHV of 1017 BTU/SCF, the required supply gas from the pipeline transmission system becomes 304,500 MMBTU/day. The shrinkage sales gas due to the NGL extraction as well as fuel gas consumption will be made up through additional flow of the raw gas.

EPEP Plant is designed to have the capability of processing the feed gas 15% above the required delivered gas by Domestic Plants. This requirement increases the plant capacity to 350,180 MMBTU/day of delivered gas. In addition, in producing this amount of delivered gas, EPEP Plant is estimated to require fuel gas a total of 16 tons/h or equivalent with 19.72 MMSCFD. This will add up to the feed gas requirement from the pipeline transmission system of equivalent with 440 MMSCFD.
5. MATERIAL BALANCE

In evaluating the material balance of EPEP Project, there are two purposes of the material balance and the way it is calculated. Firstly, the material balance is calculated with the EPEP Plant alone as the envelope. This material balance calculates the component recovery in relative to the feed to EPEP Plant.

Secondly, the material balance is calculated with a larger envelope to include LNG Plant which will be affected by the change of its feed composition due EPEP Plant process. As the feed gas supply from gas producer is currently limited, and the energy delivery to Domestic Plants is to be maintained, the recovery of NGL in EPEP Plant will cause energy shrinkage in the lean gas delivered to Domestic Plants. To make up this energy shrinkage as well as for fuel requirement in EPEP Plant, more feed gas will be processed in EPEP Plant until its lean gas production reaches the same energy delivery as before the EPEP Plant exists. A total of 110 MMSCFD additional feed gas is required for this purposes and to be taken from the feed gas delivered to LNG Plant because it shares the feed gas with the Domestic plants. For the cost-benefit analysis, the component recovery from EPEP Plant as the products will be compensated by the product increase or decrease in the LNG Plant.

The following is the production capacity of the EPEP Plant.

1. **Ethane**: 99.2% or equivalent with 261,285 tons/year ethane will be recovered from the feed to EPEP Plant as vapor product and to be recompressed back into the pipeline system feeding the LNG plant. Ethane will be used for the following purposes:
   a). To replace the LPG content in LNG product as the heating value booster; therefore, ethane replacement will, in turn, increase the LPG production from the LNG plant.
   b). When the ethane production is more than the LPG content in LNG (energy to energy), its value will be converted into LNG price equivalent, as no more potential LPG product replacement left in LNG.

2. **Propane**: 100% or equivalent with 257,900 tons/year propane will be recovered as LPG Propane product.

3. **Butane**: 100% or equivalent with 150,444 tons/year butane will be recovered as LPG Butane product.

4. **Pentane+**: 100% or 115,123 tons/year pentane and heavier ends will be recovered as condensate product. This is equivalent with 1,043,068 barrels/year.

6. POTENTIAL PRODUCTION LOSS FROM LNG PLANT

In a wider envelope covering the LNG and Domestic Plants, the above recovery will potentially cause production losses from the LNG Plant due to lighter feed gas composition and energy shrinkage makeup to domestic plants, with the assumption that the total amount of feed gas delivered from gas producer remains constant, or in other words there is no additional feed gas supplied from the gas producers. The following are the potential production losses from the LNG plant.

1. LNG production loss : 654,990 tons/year.
2. LPG C3 production loss : 73,990 tons/year.
3. LPG C4 production loss : 43,160 tons/year.
4. Condensate production loss: 33,030 tons/year or equivalent with 299,400 barrels/year.

In this sense, a net production gain will be used for a wider envelop of material balance analysis. As a result, the life-cycle cost-benefit analysis will also be affected depending upon the feed gas availability scenarios. The schematic drawing showing the gain and loss of EPEP project can be found in Figure 3. Detail economical analysis can be found later in this paper.
Figure 3. Material Balance Comparison Before and After EPEP Plant

**BEFORE EPEP PROJECT**

LEX PLANT LEAN GAS
HHV 150 MMSCFD 1,017.0 BTU/SCF

FEED GAS DISTRIBUTION
FROM FIELD 3,595 MMSCFD HHV 1,109.2 BTU/SCF

DELIVERY CONTRACT 457,055 MMBTU/D

DOMESTIC PLANTS

BADAK LNG PLANT

PRODUCTS:
- LNG
- LPG C3
- LPG C4
- CONDENSATE

**AFTER EPEP PROJECT (Limited Feed Gas Case)**

LEX PLANT LEAN GAS
HHV 150 MMSCFD 1,017.0 BTU/SCF

RESIDUE 304 MMSCFD HHV 1,000.3 BTU/SCF

EPEP PLANT

TO EPEP 385 MMSCFD (Addition 110 MMSCFD)

NGL RECOVERIES:
- C2 261,285 tons/year
- C3 257,901 tons/year
- C4 150,444 tons/year
- i-C5+ 1,043,683 bbl/year

BADAK LNG PLANT

PRODUCTS:
- Gain/Loss
  - LNG -7.27 std cargoes
  - LPG C3 183,916 tons/year
  - LPG C4 107,285 tons/year
  - CONDENSATE 744,279 bbl/year

FROM FIELD 3,595 MMSCFD HHV 1,109.2 BTU/SCF (Reduction 110 MMSCFD)
7. UTILITY SUPPLIES

EPEP Plant is conceptually built as an independent plant. Therefore, this plant should be able to self-suffice all the utility required to support the production process. In order to minimize capital cost, life-cycle cost analyses are made in deciding the utility units to be used in the plant.

7.1. Electricity and Gas Turbine Generators (GTG)

The electricity for the plant will be supplied from 3 times 50% of gas turbine driven generators. In the existing LNG Plant, the power generations as well as the refrigeration compressors are mainly driven by steam turbine except two power generators driven by gas turbine. The electric power required by the whole EPEP Plant is 18 MW. The flue gas of the GTG is utilized to preheat the hot oil. It is estimated that the flue gas heater can save up to 30 percent of the total fuel gas required for heating the hot oil. The GTG will supply electric power for lighting, instrumentation system, motors of pumps and small size compressors. An interconnecting the existing LNG Plant will be provided as the back up only. However, the EPEP Plant is designed to be able to start up by itself from black out without assistance from the existing LNG Plant.

7.2. Hot Oil

Hot oil is selected as the heating medium for the reboilers in amine unit, distillation columns of fractionation unit and defrost heater. This is because EPEP Plant will not produce steam to minimize capital cost for boiler installation. The hot oil will operate at a low temperature of 148°C and a high temperature of 177°C. Waste heat recovery unit (WHRU) of the GTG will be utilized as the preheater. The utilization of WHRU can save LP fuel gas consumption by 30 percent. Further heating of the hot oil will be done in a furnace. The fuel gas for the furnace will be taken from residue gas inlet of the residue gas compressor. Total energy consumption for the hot oil is estimated 30 MW.

7.3. Aerial Coolers

Air is the selected medium for cooling process in the coolers and condensers. Aerial coolers are selected to avoid further increase of cooling water temperature at the outlet point of the existing cooling water outfall system.

7.4. Nitrogen

Nitrogen will be produced from two nitrogen generation units. One unit will be producing Gas Nitrogen (GAN) only from a Pressure Swing Absorption (PSA) unit and the other will have the capability of producing both GAN and LIN (liquid nitrogen) from a cryogenic unit. A storage tank and vaporizer will be provided for shutdown purpose when the requirement for nitrogen for plant purging is high. This equipment will also serve as the back up for nitrogen supply in case the GAN producing unit trips. Each nitrogen generator unit will produce GAN at a rate of 800 Nm³/h, while the cryogenic unit will be capable of producing LIN at a rate of 100 liters/hour in addition to its GAN production. The feed air to the nitrogen unit at a rate of 2400 Nm³/h will be supplied from air compressor in the Plant Air and Instrument Air Unit.

7.5. Air Supply

Plant air and instrument air system will be supplied from air compressors driven by electric motors. The will be 3 compressors rated at 3,000 Nm³/h. In the instrument air system, a receiver tank is provided with the capability to back up the instrument air system for 20 minutes.

7.6. Fuel Gas

The fuel gas system is designed with three pressure levels. The high pressure (HP) fuel gas is supplied from the discharge of the residue gas compressor at a pressure of 30 kg/cm²g (426 psig). The consumers
of the HP fuel gas are gas turbines for GTG and Residue Gas Compressor. The medium pressure (MP) fuel gas is provided only to supply for smokeless flare system. The EPEP Plant will use fuel-assisted smokeless flare system. Therefore, this MP fuel gas will not be in a continuous operation. The low pressure (LP) fuel gas is designed at a pressure of 3.5 kg/cm² (50 psig). The main source of LP fuel is from residue gas at the suction of the residue gas compressor. A small part of the LP fuel is also supplied from Amine Flash Drum in continuous basis and from the fractionation unit in intermittent basis. The consumer of the LP fuel gas is hot oil furnace.

A back up for the fuel gas system is provided directly from the feed gas outlet of the KOD at inlet facility. A heater is also provided for the HP fuel supply to maintain the temperature of this untreated feed gas 10°C above its dew point.

7.7. Water

The water is fully dependent on the supply from the existing LNG Plant facility. The water supply includes utility/fire water, potable water and demineralized water for amine system make up. Storage tanks will be provided in EPEP Plant to ensure the reliability of supply for a certain period of time in case the supply from LNG Plant is disturbed.

7.8. Wastewater treatment

Dedicated wastewater treatment will be provided for EPEP Plant. This treatment includes oil separator, oxidation or aeration pond, etc.

8. ECONOMICAL ANALYSIS

The objective of the EPEP project is to extract as much NGL from rich gas as possible and convert it into specialty products that have higher value than the bulk traditional product as raw gas.

In evaluating the economical aspect of the project, a life-cycle cost and benefit analysis is used as the tool. Due to limited feed gas supply from the gas producer as experienced recently, several scenarios were developed in order to get a more realistic analysis in evaluating the situation as follow:

1. **Base Case**: The base case is where the gas supplied is shortage (like today). The energy shrinkage due to extraction of heavier components as well as energy consumption by EPEP Plant will be compensated by taking a part of the raw gas delivered to LNG Plant. Therefore, there will be a consequence of loss of LNG production opportunity. The LNG, LPG and condensate prices are respectively USD 6.4/mmbtu, USD 410/ton, and USD 60/bbl, respectively. These prices are the current market prices. The benefit is calculated based on the different price of “Extracted Liquid Product Benefit” with “the price difference between LNG and the additional raw gas to Domestic Plant to make up the shrinkage.” The LPG and condensate prices are USD300/ton and USD18/bbl.

2. **Case-1**: This case is similar with Base Case, except that the prices of LNG, LPG and condensate are respectively USD 3.85/mmbtu, USD 300/ton, and USD 18/bbl. These are the assumed prices for the project feasibility study. This case is made to compare the project pay out time with the current product prices in Base Case.

3. **Case-2**: This case is different from the other two cases. It is assumed that the gas supply is unlimited. Therefore the shrinkage gas make up was taken directly from the stranded gas in the wells. Hence, the make up gas to Domestic Plant will not affect gas delivery to LNG Plant.

The operating cost of EPEP Plant is estimated based on the SGS benchmark result where the average operating cost of LNG plant is 3.0 USD ton of product. However, PT Badak’s operating cost is 63% of the
average LNG plant operating cost. Therefore, the operating cost of the EPEP Plant is USD1.9/ton of feed gas processes.

8.1. Pay Out Time Period

Table 1 below shows the calculation summary of the pay out time period. This calculation is derived from the above scenarios.

Table 1. Project Pay Out Time Calculation

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<td>15.06</td>
<td>26.91</td>
<td>1.30</td>
</tr>
<tr>
<td>Remarks: Gas Supply</td>
<td>Limited</td>
<td>Limited</td>
<td>Unlimited</td>
</tr>
<tr>
<td>LNG Production</td>
<td>Loss</td>
<td>Loss</td>
<td>Gain</td>
</tr>
<tr>
<td>LPG Production</td>
<td>Gain</td>
<td>Gain</td>
<td>Gain</td>
</tr>
</tbody>
</table>

Note:
1 Std LNG cargo = 125,000 m3
2,940,603 mmbtu

From the above calculation, the pay back period for this project is between 1.3 and 27 years depending on the gas supply availability and product prices. The higher the LNG prices, which is linked to the oil price, the more economically feasible of this project.

However, considering the shortage of feed gas supply to Bontang lately, this project will potentially reduce the feed gas supply to LNG Plant to make up the energy shrinkage of feed gas to Domestic Plant after EPEP as well as for power consumption of EPEP Plant. The limited feed gas supply causes the project pay back period becomes longer than originally predicted as shown in Base Case in the above table.
9. PROJECT STAGING

At the early stage of the project, several scenarios were analyzed to proceed with the project in order to accommodate the pressure to accelerate the project execution. An option to have a turn key project was evaluated because this project management style would execute the project in the shortest time. Options to have one licenser with several Engineering, Procurement, and Construction) EPC Contractors were also considered; however, due to uncertain of the selected licenser at this stage, this option was dropped. Another concern is that, with this kind of project style there was a possibility of change order due to unclear project definition at the early stage. A potential increase of project cost is possible.

Later, the project was decided to proceed with a Front End Engineering Design (FEED) stage first, and then followed by an EPC stage. This project style will give the flexibility to the owner in selecting an EPC contractor because the project scope is more clearly defined.

The FEED is scheduled to be completed by mid of February 2006 for 5.5 months period. The EPC is estimated to require three years for completion. The continuation of this project to EPC stage is still waiting for the management and government decision.

10. SUMMARY

- EPEP project was made to recover more valuable hydrocarbon components from rich gas delivered to domestic plants but these components do not necessarily increase their production yield. In addition, this project will also save the flared hydrocarbon liquid condensed during its travel through the pipeline system.
- NGL recovery from the feed gas by utilizing extra refrigeration capacity during low LNG demand in competition with the LNG production requirement.
- Turboexpander technology was selected as the main process for the EPEP Plant because of its high energy efficiency and high NGL recovery level. By this technology, EPEP Plant will recover 99.2% of ethane, and 100% of propane, butane, and heavier hydrocarbon component.
- EPEP Plant will require only 4 percent for its fuel consumption from the feed gas.
- The pay out time of EPEP Project is ranging from 1.3 to 27 years depending upon the feed gas supply availability and product prices.
- The continuation of this project to EPC stage is still waiting for management and government decision.

11. LIST OF TABLE

Table 1. Project Pay Out Time Calculation

12. LIST OF FIGURES

Figure 1. Schematic Diagram of Piping Configuration of EPEP Project
Figure 2. Schematic Diagram of Turboexpander Unit
Figure 3. Material Balance Comparison Before and After EPEP Plant