# Assistance on Liquefied Natural Gas Import Options for Myanmar Phase 1:

## Presentation of Draft Final Report

## January 2017

MJMEnergy Ltd

www.mjmenergy.com



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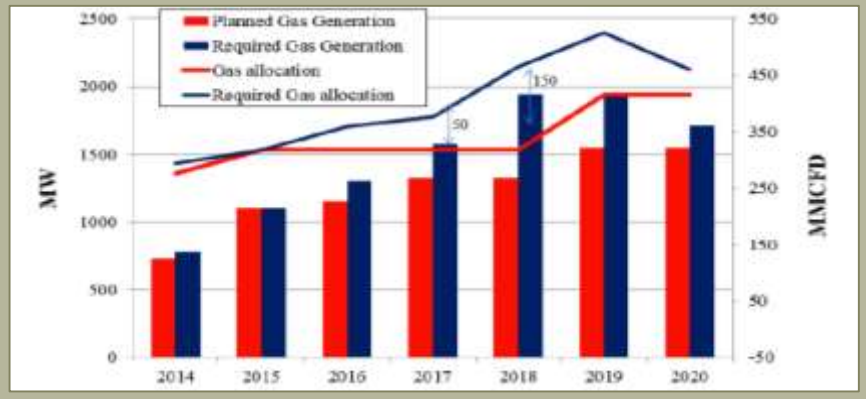
# Section 1: Introduction

# Background

- Overview of the Myanmar gas market
  - Energy consumption is among the lowest in the world, 70% of the population have no access to electricity.
  - Consumption per capita is around 160 kWh per annum, 20 times less than the world average.
  - Only 16% of rural areas have power grid access
- Gas fired power generation demand is growing
  - Indigenous gas production is constrained due to years of under investment. Resulting in a potential supply/demand deficit.




## Possible gas supply options for Myanmar

With this supply/demand deficit, there are 3 options.

***Option 1*** - importing LNG to supplement domestic gas while new gas exploration gets underway.

***Option 2*** - Myanmar's swapping LNG with local gas.

***Option 3*** – Supply options can include cooperation with neighboring countries on bilateral / regional gas trade, to jointly benefit from existing and future natural gas supply/import infrastructure.

# Objectives of this project

- Providing support to the Government of Myanmar (GoM) in developing a gas sector development plan by focusing on the near-to-medium term options to meet the gas demand in Myanmar.
- Focusing on gas import options related to LNG, which could initially be used as a bridging fuel while new gas exploration gets underway in Myanmar.
- In particular, the focus is on the possibilities for LNG receiving facilities in Myanmar, which given the proposed timescales suggest prospects for development of floating regasification LNG terminals.
- In particular, this project will be focused on three key tasks, Tasks 1(a), 1(b) and 1(c) which are summarised in the right hand panel.

## Key deliverables for this project

**Task 1(a)** – Siting analysis to assess potential locations of LNG import facilities in Myanmar.

**Task 1(b)** – Development of a prioritisation framework and accompanying analytical tool for LNG import options and locations.

**Task 1(c)** – Prepare an overview of the LNG markets that Myanmar may access with a view of procuring LNG to be physically swapped with gas export partners

# The MJMEnergy Team

- MJMEnergy have developed a bespoke Project Team as follows:
- ***MJMEnergy*** is a UK-based firm providing technical and commercial consultancy throughout the world with a clear focus on natural gas and LNG related projects.
- ***Penguin Energy Consultancy*** (PEC) is a UK-based, independent energy industry techno-commercial consultancy and training provider. PEC has been involved in 46 LNG projects in 28 countries over 20 years, In addition PEC will be assisted by CA Metocean consultants
- ***Economic Consulting Associates Limited (ECA)*** was formed in 1997 to provide economic and regulatory consulting services to industry and government. ECA specialises in advising on economics, policy and regulatory issues in the utilities industries, with particular expertise in the gas sector.
- ***Drennan Marine Consultancy Ltd*** - is a LNG marine specialist with experience working in over 20 countries worldwide and is well used to ranking multiple locations in a structured and consistent way against relevant marine criteria including natural shelter, navigational risk and the capability of local services.

## Members of the consortium

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ECA

Drennan
MARINE CONSULTANCY

# Section 2: Key Issues

# Key Issues – Schedule and duration

- The economy has been growing and demands more electricity.
- Current hydroelectric capacity is limited.
- Gas fired power generation demand is growing.
- Significant quantities of Myanmar's gas is sold to Thailand and China.
- There is an impending gas shortage in Myanmar.
- MOGE is under considerable pressure to provide additional gas.
- Myanmar's upstream sector is exploring for new supplies but schedule is mid term to long.
- LNG is needed to provide a bridging solution.
- The need is urgent.
- The contract duration is uncertain depending on the success of offshore drilling.

## Key Points

There is considerable pressure on the MOGE to resolve its gas shortage quickly.

Whilst additional supplies of gas from Myanmar's upstream resources should be available this may take longer than expected.

LNG is needed as bridging solution but the duration of the supply is uncertain.

# Key Issues - Metocean environment

- Successful commercial operation requires the LNG facility to operate for a very high percentage of the year (typically >97%). This requires the LNG facility to
  - Remain connected to the gas export pipework Be able to offload LNG from LNG carriers on schedule.

- Metocean conditions (wind and wave) are the main external factor in determining availability and operability.
  - Coastal waves were simulated using numerical modelling at each location.
  - 20 years long time series of wave height, wave direction, wave period, wind speed and wind direction were derived to assess the level of exposure.

## Key points

Met-ocean analysis is key to the site selection

# Key Issues - Social, cultural and environmental issues

- Also key in deciding the suitability of each site will be the inclusion of the following factors:
  - Impact on sensitive environmental areas such as national parks, marine reserves, coral and mangrove forests, etc.
  - Impact on community issues such as fishing grounds and tourist areas (revenue generation).
  - Impact on culturally sensitive sites such as temple complexes, sports stadia etc.
- Maps, internet resources and guide books have been consulted to establish headline impacts, if any.
- External project financing will be contingent on good environmental performance.

## Key Points

The Social, cultural and environment assessment is at a very high level and only uses publically available data.

Good environmental performance is key to project financing.

# Key Issues – Weather and geology

- Weather
  - Weather systems primarily come to the coast of Myanmar from the south west.
  - The south west monsoon can produce high winds and flooding.
  - Cyclones are a regular feature of Myanmar's weather.

- Geology
  - Myanmar sits on the borders of 3 tectonic plates.
  - Earthquakes caused by plate movement and active faults are common.
  - Some volcanic activity is also present.

## Key Points

Severe weather can be expected during the lifetime of the LNG facility.

A significant earthquake is possible during the lifetime of the LNG facility.

# Key Issues - Local infrastructure

- A LNG facility needs local infrastructure to be able to be constructed, maintained & operated:
  - Tugs able to move and position the LNG carrier at the LNG facility.
  - Roads or marine transport able to deliver construction equipment and material, operating consumables and provide access for staff and vendor representatives.
  - Availability of ports able to provide services such as pilotage, importation of equipment etc. and have appropriate rules and experience of hydrocarbon operations.
  - Access to skilled people to operate or support the LNG facility or the ability for expatriates to access the facility.

## Key Points

Myanmar has limited local infrastructure and much of the required capabilities are remote from the proposed site.

# Key Issues – Cost and ownership

- A LNG facility and the associated importation contract is likely to be the largest investment Myanmar has made.
- Some technology options may be leased rather than purchased to reduce impact.
  - Leasing reduces control.
  - BOT/BOOT options may be available.
- Capital investment in owned facilities may be large compared to the potential duration of the LNG import contract.
- Capital and operating (including leasing) costs need to be analysed on the same basis.

## Key Points

Capital and operating costs need to be analysed on the same basis.

# Key Issues – Storage capacity and vaporisation rates

- LNG delivery may be delayed by bad weather or gas vaporisation may exceed norms leading to a shortage of LNG.
- Some storage margin within the LNG facility to keep gas export/power generation running is important.
- Storage is expensive.
- Security of supply/Storage margins are a political issue and should be set by MOEE.
- Vaporisation capacity is relatively inexpensive and therefore not considered a key issue.

## Key Points

Security of supply needs to be set by MOEE.

LNG storage is expensive.

Vaporisation capacity is inexpensive and not a key issue.

# Key issues – Pipelines

- RLNG needs to be transported to the power plants by gas transmission pipelines.
- Myanmar's pipeline network is old and is claimed to be in poor condition.
- Key assumptions
  - All projects have been costed on the basis of building new 30 inch pipelines.
  - Based on a flow of 500mmscfd a 30 inch pipeline would not require compression.
  - The existing pipeline network may need to be expanded or reinforced to cope with the additional demand – these costs are not included.

Overview of gas pipeline infrastructure in Myanmar

# Section 3: Site Selection

# Methodology

A three level selection methodology has been used

- Stage 1 (Concept selection) - Technology concept selection is based on overriding system performance requirement. (Schedule and ownership, etc.)
- Stage 2 (Qualitative selection) – A qualitative tool based on traffic lights provides preliminary scoping of a range of sites.
- Stage 3 (Discounted expenditure selection) –A simple discounted expenditure tool which allows both capital costs and operating costs to be compared simultaneously is used to provide the 3rd stage of selection.

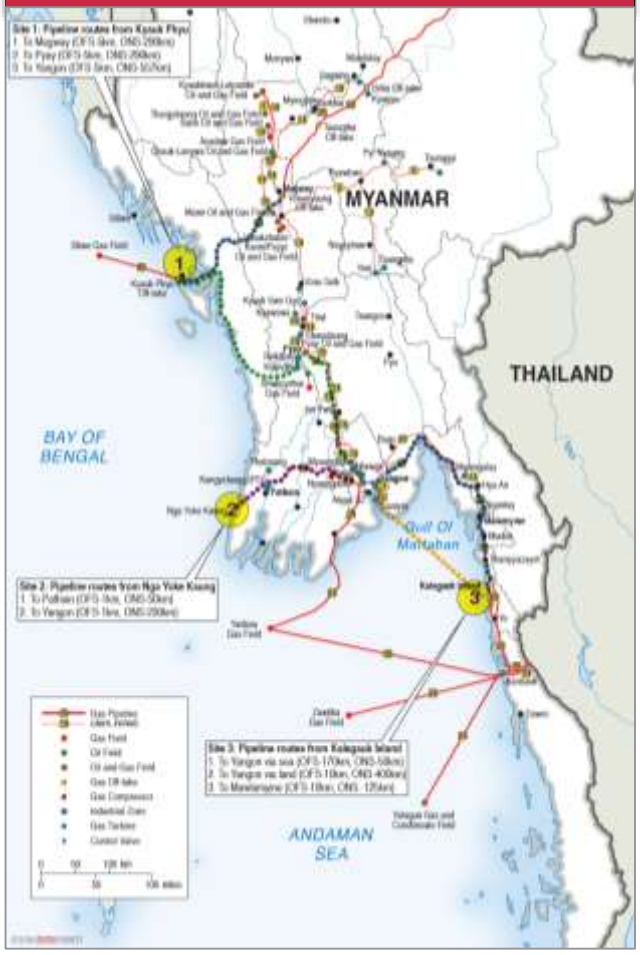
## Key Points

3 level selection process which improves in granularity as it progresses.

# Site overview

- MOGE requested that 3 general areas were examined for suitable LNG import sites as shown below
- Kyuak Phyu in Rakhine state
  - 2 sites reviewed on the Madegyan River.
- Nga Yoke Kuang in Ayeyarwady state
  - 2 site onshore in Ngayok Bay.
  - 2 sites offshore in mid depth and deep water.
- Kalegauk Island in Mon state
  - 1 site onshore on the east of the island.
  - 1 site offshore in mid water to the northwest of the Island.

## Site Options

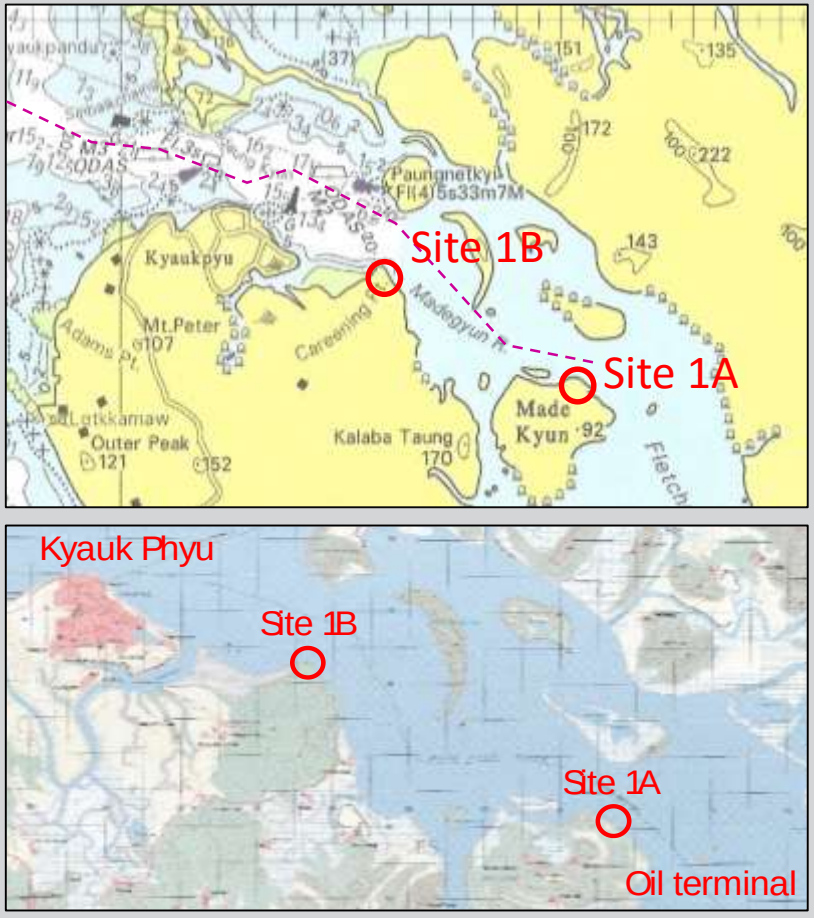


# Section 4: Site 1 Kyuak Phyu

# Site 1: Kyauk Phyu overview

- Two sites considered on the Madegyan River to the south east of Kyauk Phyu
  - Site 1A on Made Island close to or adjacent to the Shwe Oil Terminal.
  - Site 1B on Ramree Island close to the Naval Base at Careening Point.

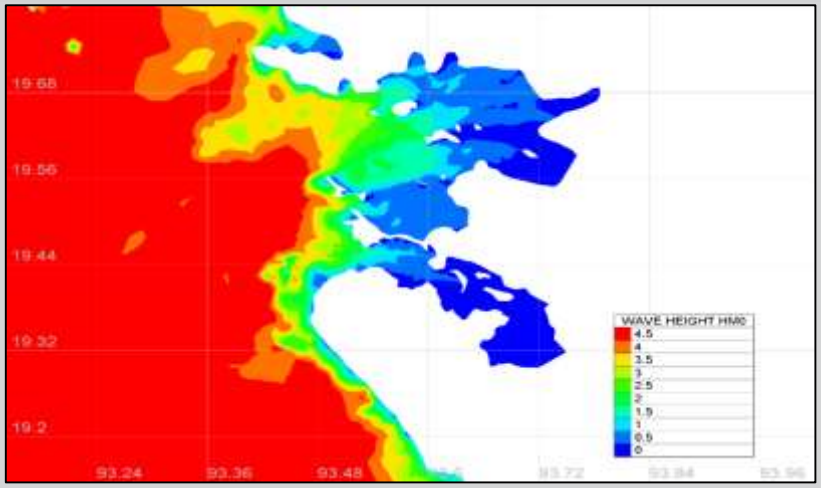
## Site 1: Kyauk Phyu overview



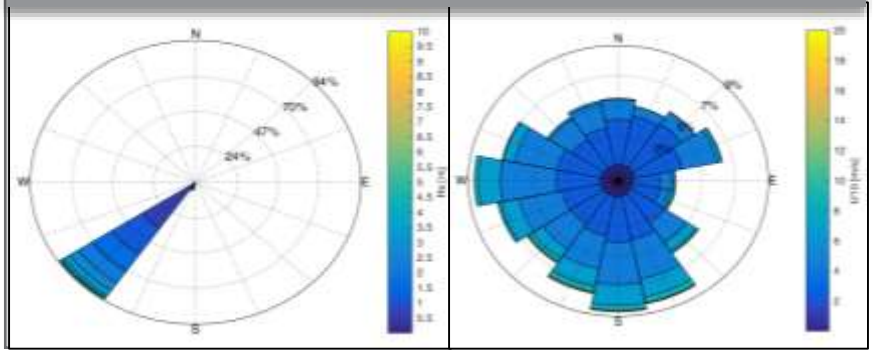
# Site 1: Metocean analysis

- Both sites are well sheltered by Ramree Island from the prevailing SW wind and monsoon.
- Non cyclonic storms will not affect the LNG facility.
- Winds are insufficient to challenge LNG carrier mooring guidelines.
- A very good marine site

## Non Cyclonic Storm

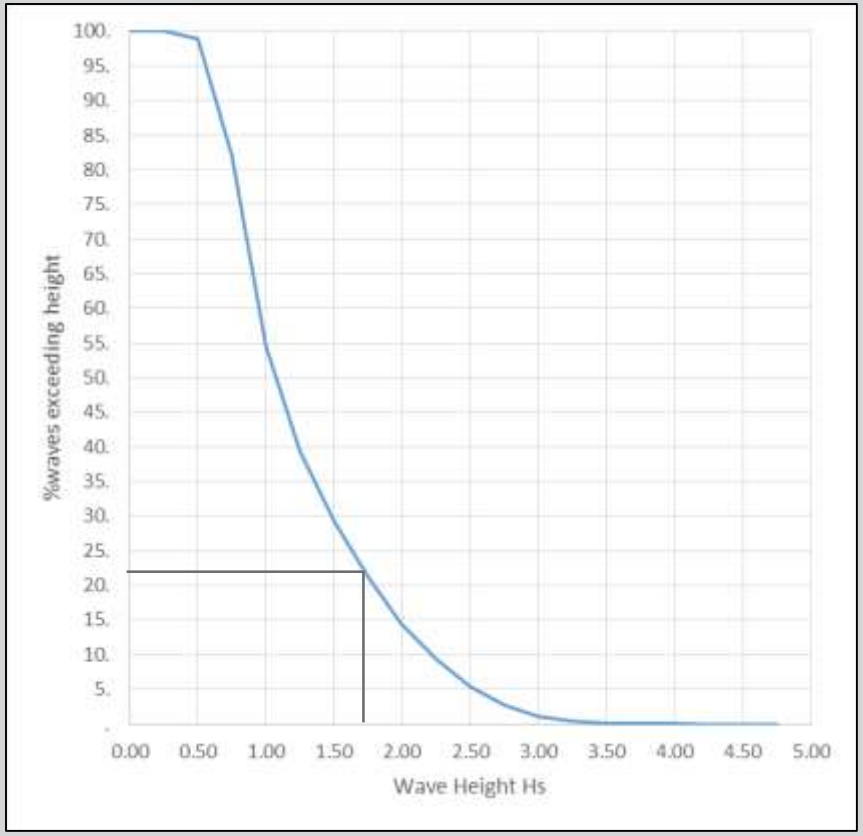



## Wave & wind rosettes

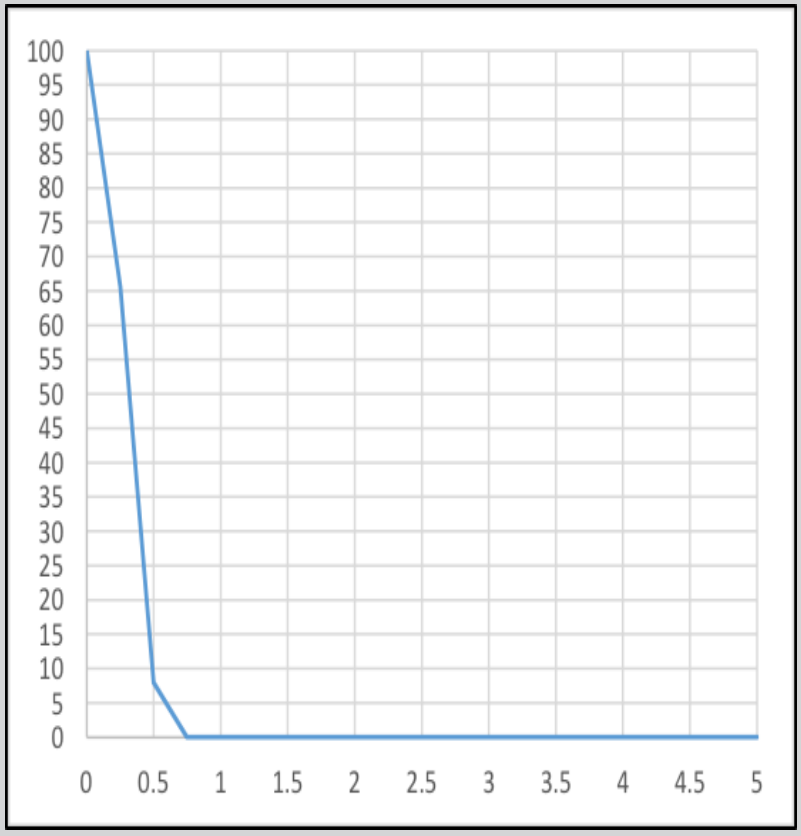


# Site 1: Metocean analysis

## % Wave exceedance At the pilot station




## % Wave exceedance At the berth

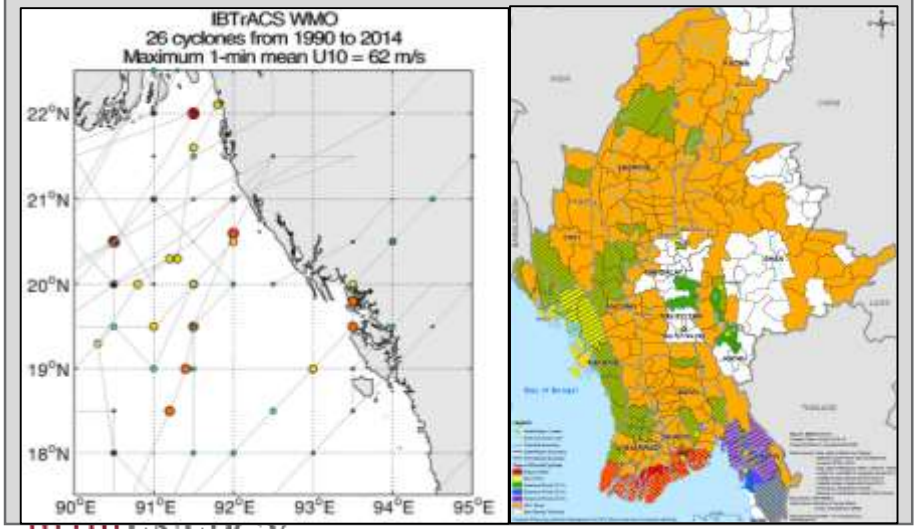


# Site 1: Weather & Geology

## Weather

- Cyclones are prevalent in Northern Myanmar and should be expected.
- Flooding has occurred twice since 2010.

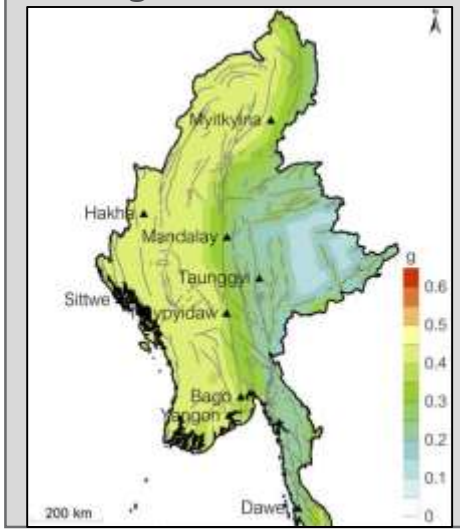
*Cyclone tracks & flooding events*




## Geology

- Magnitude 4 and 5 earthquakes have occurred nearby.
- High peak ground accelerations are anticipated (0.4 – 0.45g).
- Sai Krone mud volcano near Site1B.

*Peak ground accelerations*

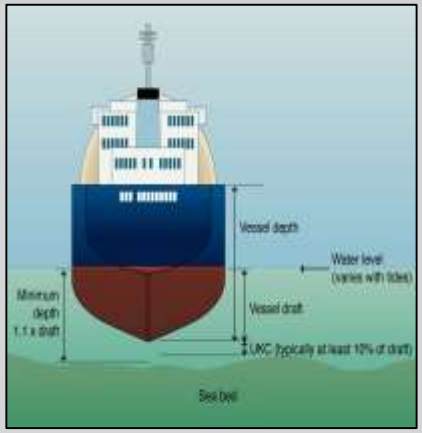


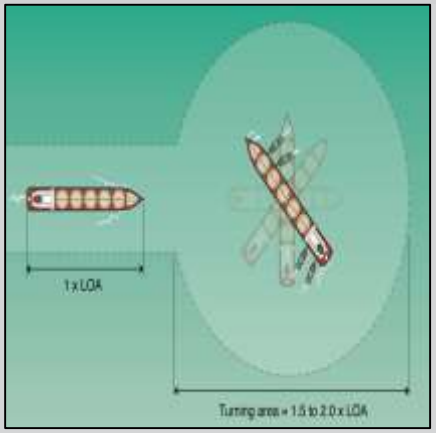

*Sai Krone*

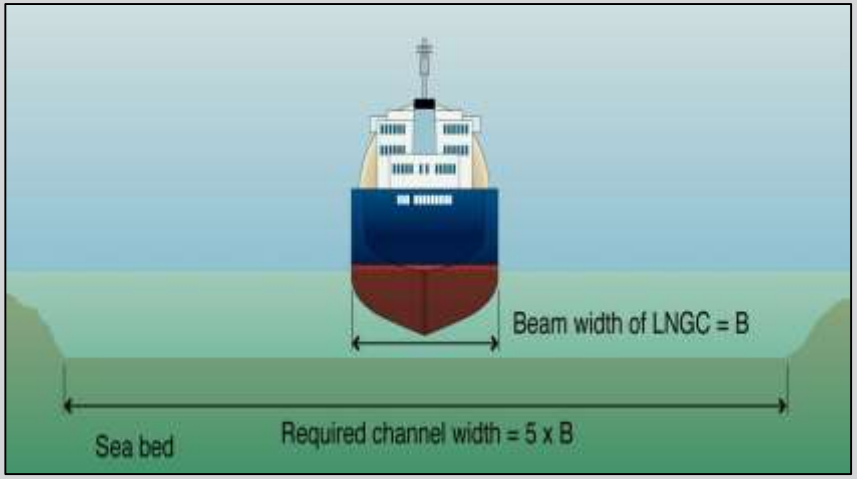
# Site 1: Navigation analysis

- A deep water channel to the oil terminal already exists and is large enough for LNG carriers.
- Jetty is relatively short but should be optimised with the minor dredging required to make a berth pocket out of the main channel.
- No wave protection required.
- A good marine site.

## Navigation requirements



# Site 1: Environmental, Social & Cultural Impact

- Mangrove is definitely present in Combermere Bay. Coral and seagrass may be present.
- Oil terminal has upset local residents who have made environmental and economic claims
- Protests against development should be expected.
- Anecdotal comments about issues around the oil and gas pipelines.

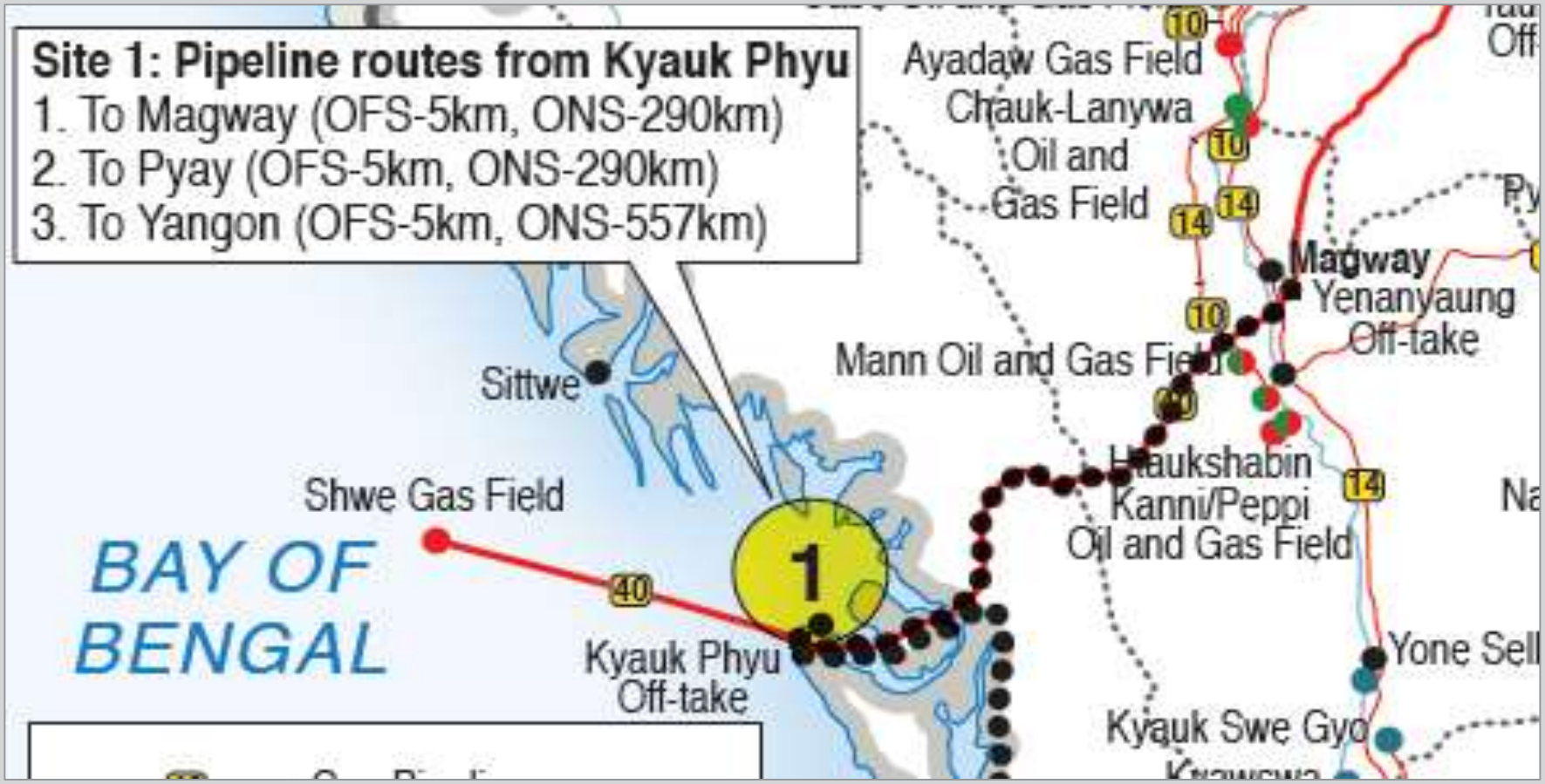
## Environmental impacts

*Mangrove areas around Kyauk Phyu*

*Pipeline & terminal protests*

# Site 1: Pipelines – re-use

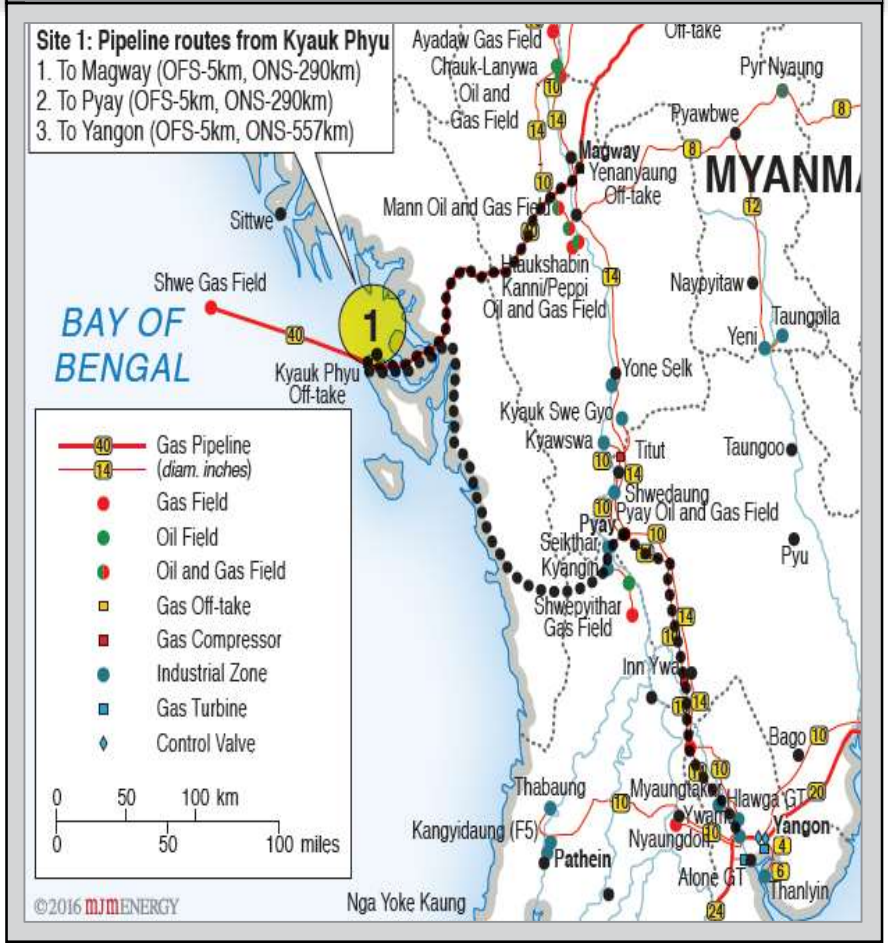
## Negotiate access to the existing Shwe pipeline to Magway



# Site 1: Pipelines - new

- Option 1 – New 290km pipeline to Magway in the ROW of the Shwe pipeline
- Option 2 – A new 290 km pipe to Pyay following the route of the current road.
- Option 3 – A new ROW in the road to Pyay and then follows the 14" pipeline to Yangon, total distance estimated at around 557km.
- All pipelines are 30 inch to avoid need for compressor stations.

## Pipeline routes



# Site 1: Local Infrastructure

- Suitable tugs available at oil terminal – availability uncertain.
- Unable to provide essential business services for foreign investors.
- Little industry and low skilled workforce.
- Health care underfunded and poorly equipped.
- No significant port infrastructure.
- Poor road connections.

## Tug Infrastructure

*5 tugs at oil terminal*

# Site 1: Technology selection

- Any near shore solution based on a jetty.
- Mid water depth option is possible but significant additional dredging required so no advantage.
- Jetty moored FSRU is most flexible option with a short delivery timescale.
- Onshore terminal should be considered if LNG supply is for longer than 10 years or high levels of security of supply are required.

## Jetty moored FSRU

*FSRU Independence in Lithuania*

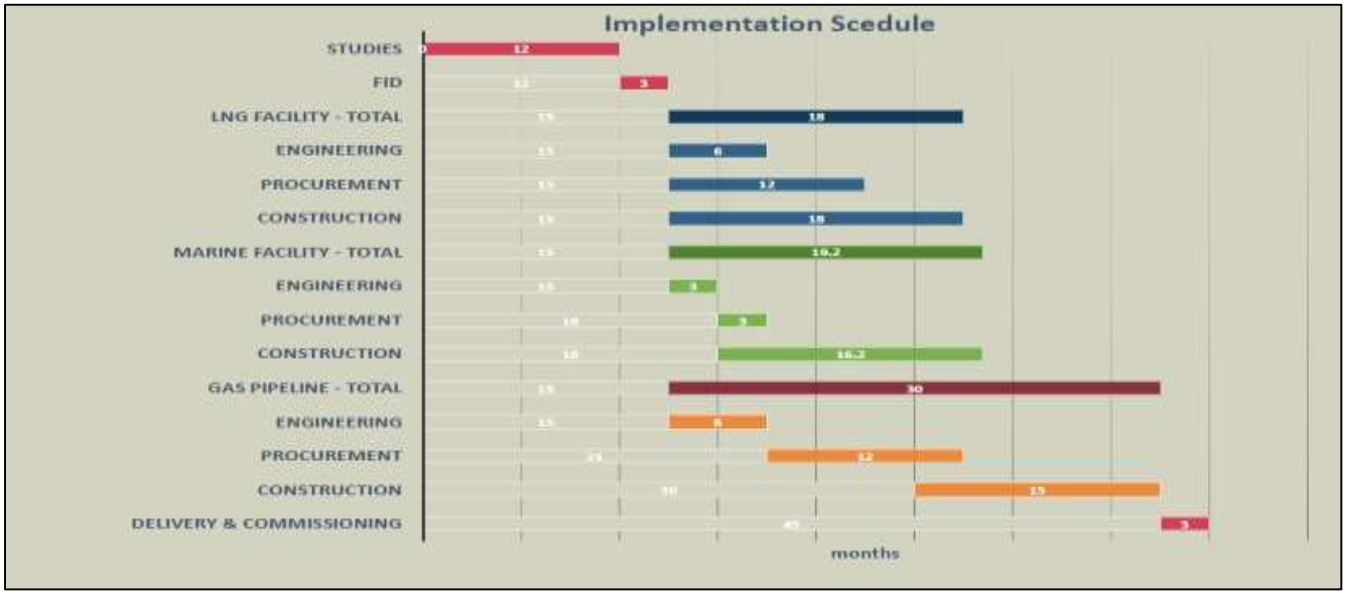
# Site 1: Results – Site 1: Kyauk Phyu Traffic light scoring

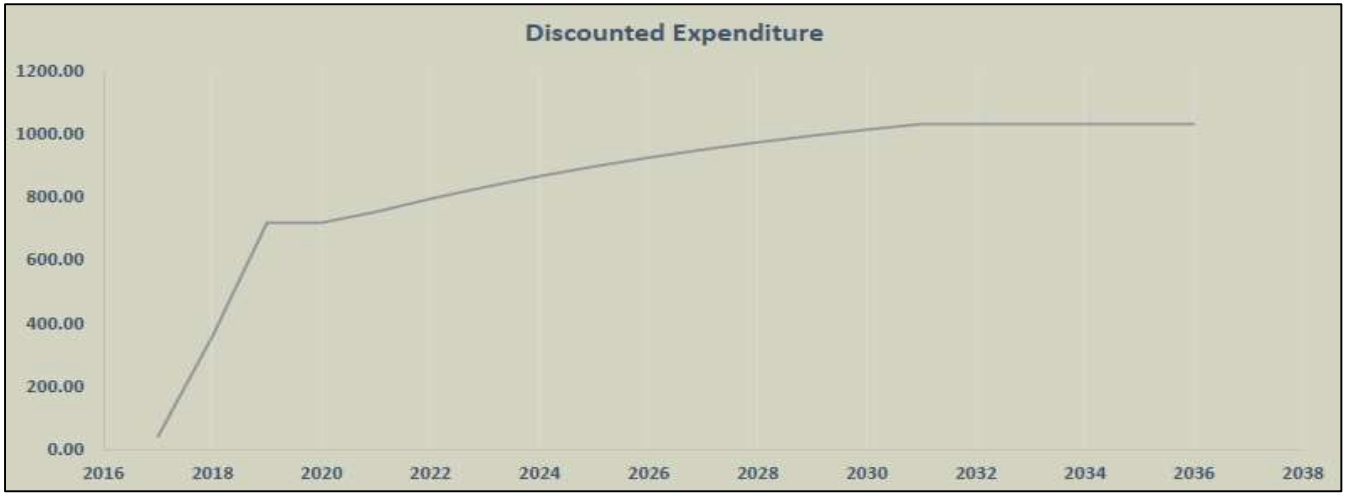
| | | Site 1: Kyauk Phyu | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Site 1A: Madav Island | | | | | | | Site 1B: Kyauk Phyu | | | | | | |
| | | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | NGRV in deepwater | GBS | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | NGRV in deepwater | GBS |
| **GETTING LNG TO THE TERMINAL** | | | | | | | | | | | | | | | |
| 1 | How much dredging is required to create a channel to the terminal? | | | | | | | | | | | | | | |
| 2 | What Jetty length is required to be able to moor a near shore FSRU/LNG Carrier? | | | | | | | | | | | | | | |
| OR | What Subsea pipeline length is required to connect a midwater or deepwater FSRU or LNGRV? | | | | | | | | | | | | | | |
| 3 | How much marine traffic is currently being experienced? | | | | | | | | | | | | | | |
| 4 | Are there local visibility limitations? | | | | | | | | | | | | | | |
| 5 | Are there any other factors that limit the site? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **STORING LNG** | | | | | | | | | | | | | | | |
| 1 | What is the wave environment like? | | | | | | | | | | | | | | |
| 2 | How variable is the wind/wave environment? | | | | | | | | | | | | | | |
| 3 | Might the LNG facility be impacted by extreme weather? | | | | | | | | | | | | | | |
| 4 | Will the site cause any destruction or exclusion to environmentally sensitive areas? | | | | | | | | | | | | | | |
| 5 | Will the site cause any destruction or exclusion to culturally and historically sensitive areas? | | | | | | | | | | | | | | |
| 6 | Will the site development and operation impact the local community in any detrimental way? | | | | | | | | | | | | | | |
| 7 | Will the site development and operation increase the risk of harm/fatality to the local community? | | | | | | | | | | | | | | |
| 8 | Are there risks to the LNG facility from geological events? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **GETTING GAS TO MARKET** | | | | | | | | | | | | | | | |
| 1 | Can LNG be vaporised in sufficient volume and in an environmentally acceptable way? | | | | | | | | | | | | | | |
| 2 | What is the onshore pipeline length? | | | | | | | | | | | | | | |
| 3 | What is the difficulty in laying the onshore pipeline? | | | | | | | | | | | | | | |
| 4 | What is the offshore pipeline length? | | | | | | | | | | | | | | |
| 5 | What is the difficulty in laying the offshore pipeline? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **LOCAL INFRASTRUCTURE** | | | | | | | | | | | | | | | |
| 1 | Is there sufficient towage available to berth the LNG carrier? | | | | | | | | | | | | | | |
| 2 | Is there currently any port rules and infrastructure appropriate to hydrocarbon importation at the proposed LNG | | | | | | | | | | | | | | |
| 3 | Is there sufficient infrastructure to accommodate workers and their families, expatriates and vendor personnel? | | | | | | | | | | | | | | |
| 4 | Is there emergency response and Health care capability? | | | | | | | | | | | | | | |
| 5 | Education and Skills? | | | | | | | | | | | | | | |
| 6 | Is there access to a major port with connecting roads? | | | | | | | | | | | | | | |
| 7 | Is there access to an international airport with road/rail links? | | | | | | | | | | | | | | |
| 8 | How adequate is the marine infrastructure? | | | | | | | | | | | | | | |

# Site 1: Results – Summary data inputs for the analysis for Site 1A2

| PHYSICAL PARAMETRS: | | Data |
|---|---|---|
| LNG facility size | | 170,000 $m^3$ stored with 500 mmscfd vaporiser capacity |
| LNG facility type | | FSRU |
| Location | | Nearshore |
| Ownership | | Lease |
| geology | | <0.4 g acceleration |
| Jetty length | | 200 m |
| Breakwater | | Not required |
| Dredging | | 2,000,000 $m^3$ |
| Gas pipeline | | 5 km of 30 inch offshore + 557 km of 30 inch onshore |
| Design LNG ship | | 163,000 $m^3$ |
| **FINANCIAL AND ECONOMIC PARAMETERS:** | | **Data** |
| Project start year | | 2017 |
| LNG import term | | 10 years |
| Discount rate | | 10% |
| Lease rate | | 140,000 US$/day |
| Fuel oil cost | | 470 US$/ton 380 cst Singapore |
| Electricity cost | | 0.05 US$/kWh (70 kyats/kWh) |
| Tug cost | | US$ 15,000/day each (no mobilisation costs) |
| **CAPITAL COSTS: Description of key areas** | | **Value** |
| FSRU | | [illegible] 0 US$ million (lease) |
| Jetty | | 138 US$ million |
| Dredging | | 10 US$ million |
| Gas pipeline | | 677.6 US$ million |
| Local infrastructure | | [illegible] 0 US$ million |
| TOTAL | | 826.03 US$ million |
| Note 1: No BOT/BOOT purchase payment was assumed at the end of the contract life. | | |
| **OPERATING COSTS: Description of key areas** | | **Operating costs** |
| FSRU lease | | 51 US$ million pa |
| Fixed costs | Labour | [illegible] 3 US$ million pa |
| | Insurance | [illegible] 2 US$ million pa |
| | Inspection and maintenance | [illegible] 2 US$ million pa |
| | Supporting infrastructure | [illegible] 0 US$ million pa |
| Variable costs | Fuel oil | [illegible] 6.48 US$ million pa |
| | Electricity | [illegible] 0 US$ million pa |
| | Towage | [illegible] 1.6 US$ million pa |
| TOTAL | | 66.20 US$ million pa |
| **Notes** | | |
| 1. The above calculation is based on a 557 km connecting pipeline to Yangon. If Site 1A2 was to opt for the shorter 290 km onshore connection to either Pyay or Magway the CAPEX costs would be reduced by $320.4 million, with an equivalent reduction in the DCF figure. | | |

# Site 1: Results – Implementation schedule and cash flow

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# Site 1: Results Summary

## Site 1A2

- Schedule to market: 48 months
- Capital Cost: 826 US$ million
- Operating cost: 66 US$ million/year
- Discounted Expenditure: 1032 US$ million

- Calculation based on 557 km pipeline to Yangon

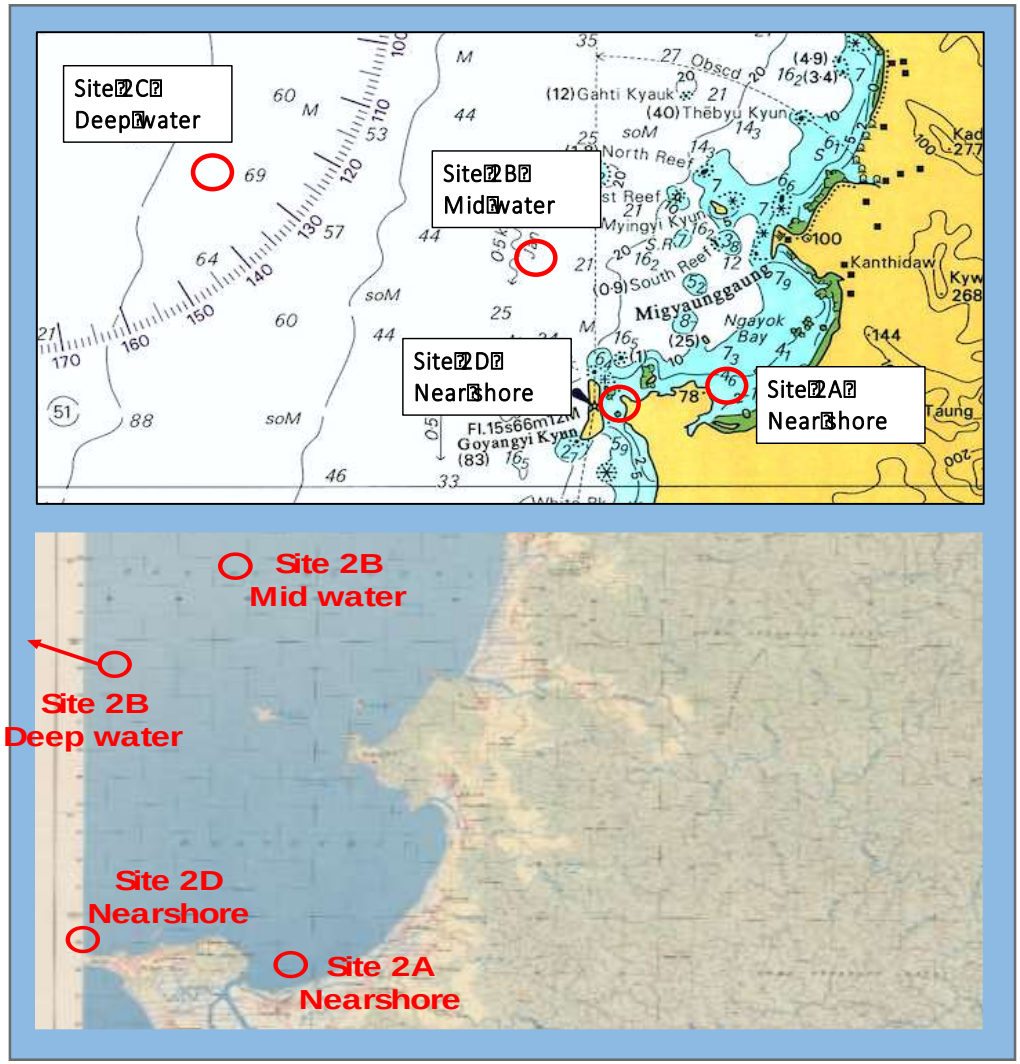
# Section 5: Site 2 Nga Yoke Kaung

# Site 2: Overview

## Site Locations

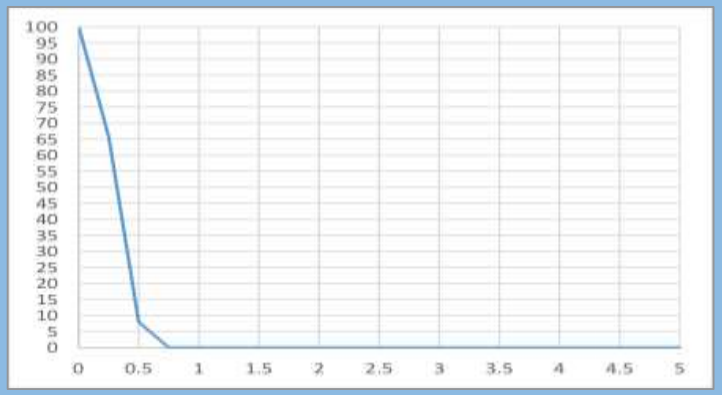
Three sites considered as follows:

- Site 2A near the shore sheltered behind the headland to the south of Ngayok Bay.
- Site 2B in 20 m of water beyond the islands to the north end of Ngayok Bay about 10 – 15 km offshore.
- Site 2C in 80 m of water 30-40 km offshore of Ngayok Bay.
- Site 2D near the shore at the southern headland about 1.0km off shore

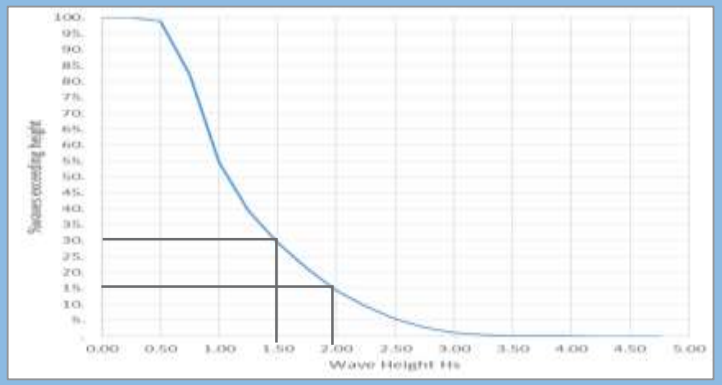


# Site 2: Metocean analysis

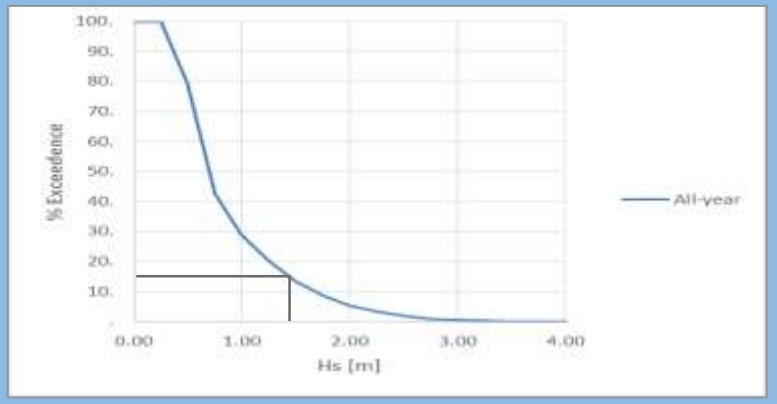
## Wave height exceedance curves (Pilot station) Site 2A



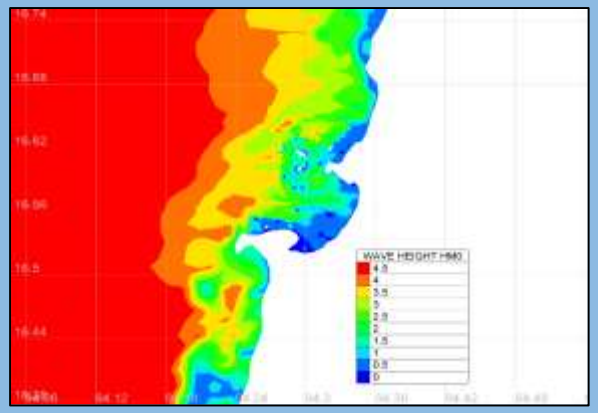

## Wave height exceedance curves (Pilot station) Sites 2B and 2C




## Wave height exceedance curves (Pilot station) Sites 2D



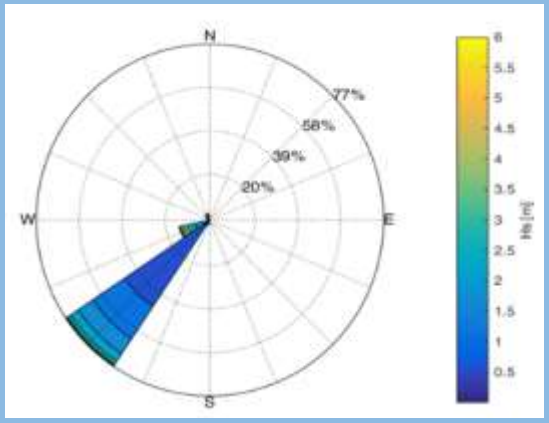

## Non Cyclonic Storm



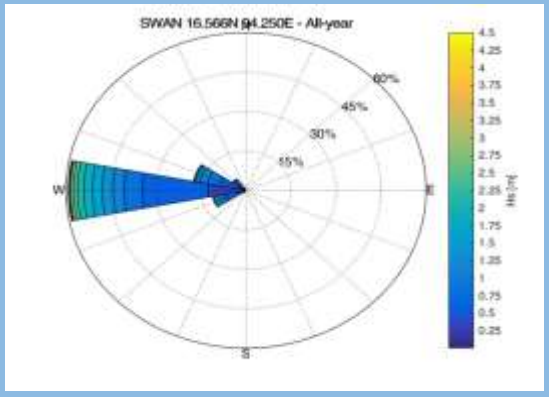
# Site 2: Metocean analysis

- All four sites are exposed to SW winds and monsoon
- Sites 2A and 2D have some shelter behind the headland
- Non cyclonic storms will impact operations at Sites 2B and 2C
- Winds are insufficient to challenge LNG carrier mooring guidelines

## Wave & wind rosettes 2A,B,C




## Wave & wind rosettes 2D

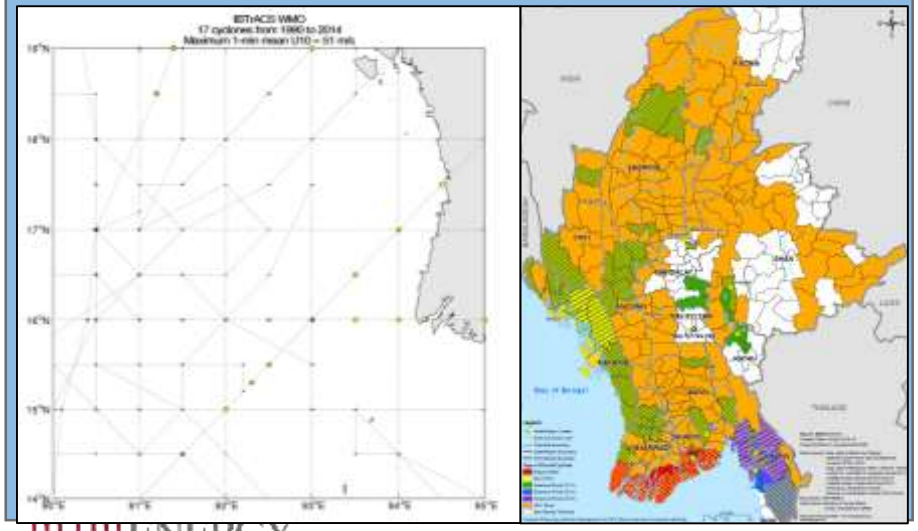


# Site 2: Weather & Geology

## Weather

- Cyclones are prevalent in Northern Myanmar and should be expected.
- Flooding has occurred twice since 2010.

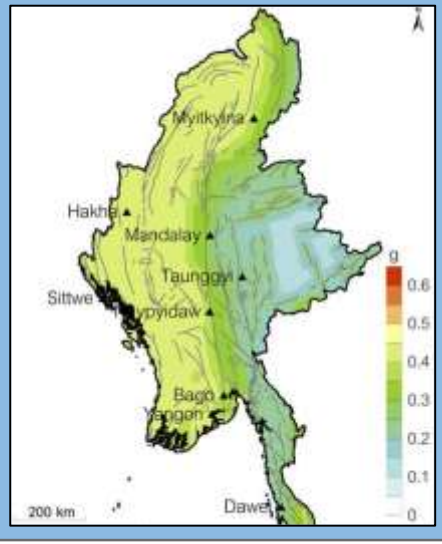
*Cyclone tracks & flooding events*



## Geology

- Magnitude 3 and 4 earthquakes have occurred nearby.
- High peak ground accelerations are anticipated (0.4 – 0.45g).

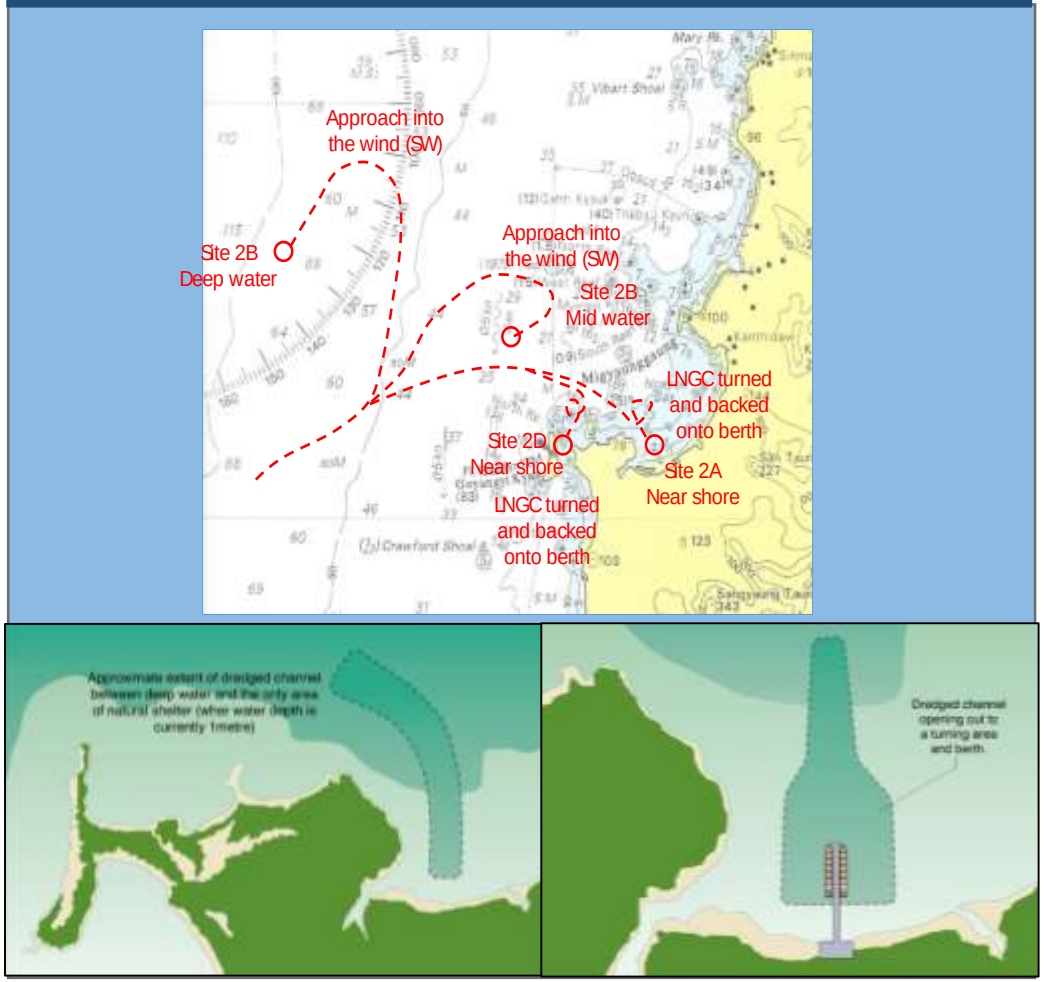
*Peak ground accelerations*



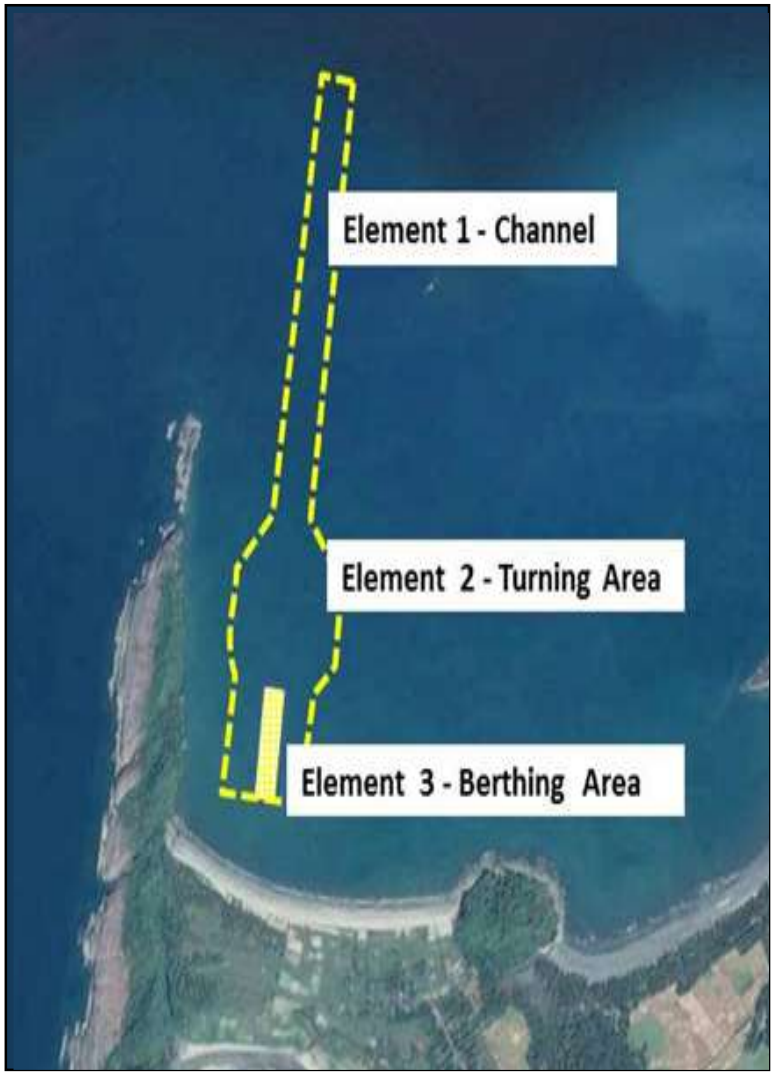
# Site 2: Navigational assessment

- Site 2A is in very shallow water (2m) and needs extensive dredging to 14 m for a LNG carrier to berth on a short jetty.
- Reducing the dredging by extending the jetty reduces and then eliminates the wave protection provided by the headland
- Offshore sites 2B and 2C are in deep water and present no navigational issues

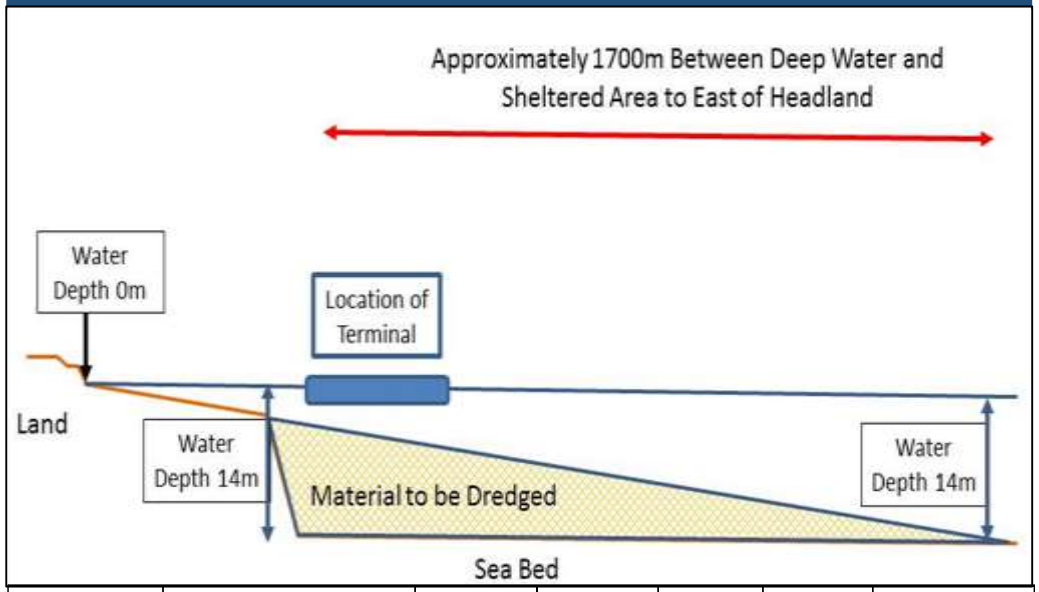
## Navigating to Site 2



# Site 2: Navigational assessment




## Navigating to Site 2D




| Element | Area To Be Dredged (Description) | Area To Be Dredged (Area in m2) | Current Estimated Mean Water Depth (m) | Required Water Depth (m) | Depth to be Dredged (m) | Volume of Dredged Material (m3) |
|---|---|---|---|---|---|---|
| 1 - Channel | 1500m channel x 217m wide | 325,500 | 9.0 | 14.0 | 5.0 | 1,627,500 |
| 2 - Turning Circle | 285m diameter circle | 255,278 | 3.0 | 14.0 | 11.0 | 2,808,058 |
| 3 - Berthing Area | (4 x Beam) x (1.5 x LOA) | 74,214 | 3.0 | 14.0 | 11.0 | 816,354 |
| | | | | | TOTAL ESTIMATE OF DREDGED MATERIAL in CUBIC METRES | 5,251,912 |

# Site 2: Environmental, Social & Cultural Impacts

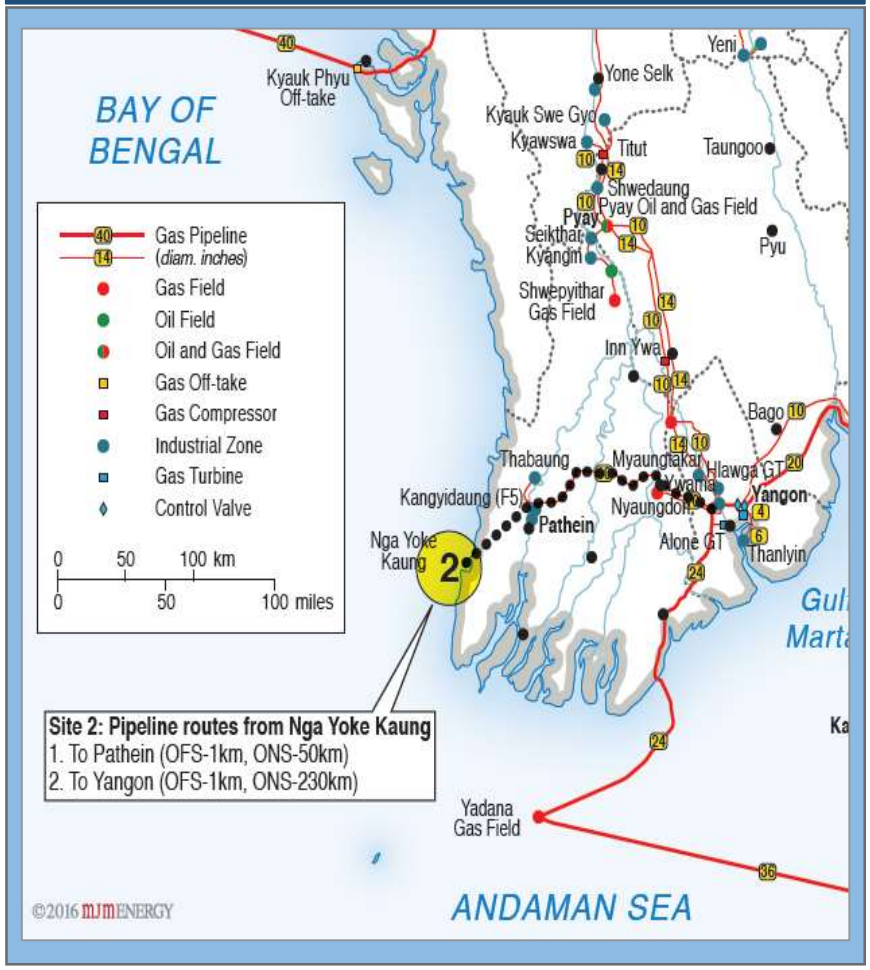
- Coral and mangrove are definitely present. Seagrass and turtles may be present.
- Local tourist industry advertises snorkelling and diving.
- Beach resorts in the general area.
- Coal fired power plant in the bay rejected after local protests.
- Dredging would damage coral as would cold water/biocide return from vaporisation.
- Four local villages potentially impact by near shore terminal.

## Environmental impact


# Site 2: Pipelines

- Background - Existing 10 inch pipeline to Yangon via Pathein to Thabaung is too small and low pressure for new flows.
- Option 1 - Lay new 30 inch 50km pipeline in a new ROW to Pathein.
- Option 2 - Lay a new 30 inch 230km pipeline via Pathein to Yangon
- No reinforcement costs required unless gas is required for proposed power plant at Shwedaung.

## Pipeline route



# Site 2: Local infrastructure

- No tugs, nearest tugs at Shwe oil terminal.
- No coastal port or port authority.
- Pathein is only able to provide the most basic business services.
- Little industry and relatively low skill workforce.
- Technical and IT universities in Pathein should be able to provide some skills .
- Health care present.
- Large port at Pathein for river traffic but with no significant port infrastructure.
- Poor road connections.

## Pathein

# Site 2: Technology selection

- Near shore site 2A too difficult environmentally
- Mid (Site 2B) or deep water (Site 2C) options possible but challenging
- Little difference in wave environment so deep water, buoy moored, FSRU preferred as more robust in extreme weather
- Near shore site 2D is environmentally difficult
- Site has all the issues as site 2A but at smaller scale
- Challenging but possible

## Technology selection

Callenging!

Site 2C Deep water

Site 2D Protected by headland

# Site 2: Results –Nga Yoke Kuang traffic light scoring for 2A, B and C

| | | Nearshore Site 2A | | | | | | | Offshore Sites 2B & 2C | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | LNGRV in Deepwater | GBS | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | LNGRV in Deepwater | GBS |
| **GETTING LNG TO THE TERMINAL** | | | | | | | | | | | | | | | |
| 1 | How much dredging is required to create a channel to the terminal? | | | | | | | | | | | | | | |
| 2 | What Jetty length is required to be able to moor a near shore FSRU/LNG Carrier? | | | | | | | | | | | | | | |
| OR | What Subsea pipeline length is required to connect a midwater or deepwater FSRU or LNGRV? | | | Not Possible | | | Not Possible | | | | | | | | |
| 3 | How much marine traffic is currently being experienced? | | | | | | | | | | | | | | |
| 4 | Are there local visibility limitations? | | | | | | | | | | | | | | |
| 5 | Are there any other factors that limit the site? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **STORING LNG** | | | | | | | | | | | | | | | |
| 1 | What is the wave environment like? | | | | | | | | | | | | | | |
| 2 | How variable is the wind/wave environment? | | | | | | | | | | | | | | |
| 3 | Might the LNG facility be impacted by extreme weather? | | | Not Possible | | | Not Possible | | | | | | | | |
| 4 | Will the site cause any destruction or exclusion to environmentally sensitive areas? | | | | | | | | | | | | | | |
| 5 | Will the site cause any destruction or exclusion to culturally and historically sensitive areas? | | | | | | | | | | | | | | |
| 6 | Will the site development and operation impact the local community in any detrimental way? | | | | | | | | | | | | | | |
| 7 | Will the site development and operation increase the risk of harm/fatality to the local community? | | | | | | | | | | | | | | |
| 8 | Are there risks to the LNG facility from geological events? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **GETTING GAS TO MARKET** | | | | | | | | | | | | | | | |
| 1 | Can LNG be vaporised in sufficient volume and in an environmentally acceptable way? | | | | | | | | | | | | | | |
| 2 | What is the onshore pipeline length? | | | Not Possible | | | Not Possible | | | | | | | | |
| 3 | What is the difficulty in laying the onshore pipeline? | | | | | | | | | | | | | | |
| 4 | What is the offshore pipeline length? | | | | | | | | | | | | | | |
| 5 | What is the difficulty in laying the offshore pipeline? | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| **LOCAL INFRASTRUCTURE** | | | | | | | | | | | | | | | |
| 1 | Is there sufficient towage available to berth the LNG carrier? | | | | | | | | | | | | | | |
| 2 | Is there currently any port rules and infrastructure appropriate to hydrocarbon importation at the proposed LNG site? | | | | | | | | | | | | | | |
| 3 | Is there sufficient infrastructure to accommodate workers and their families, expatriates and vendor personnel? | | | | | | | | | | | | | | |
| 4 | Is there emergency response and Health care capability? | | | Not Possible | | | Not Possible | | | | | | | | |
| 5 | Education and Skills? | | | | | | | | | | | | | | |
| 6 | Is there access to a major port with connecting roads? | | | | | | | | | | | | | | |
| 7 | Is there access to an international airport with road/rail links? | | | | | | | | | | | | | | |
| 8 | How adequate is the marine infrastructure? | | | | | | | | | | | | | | |

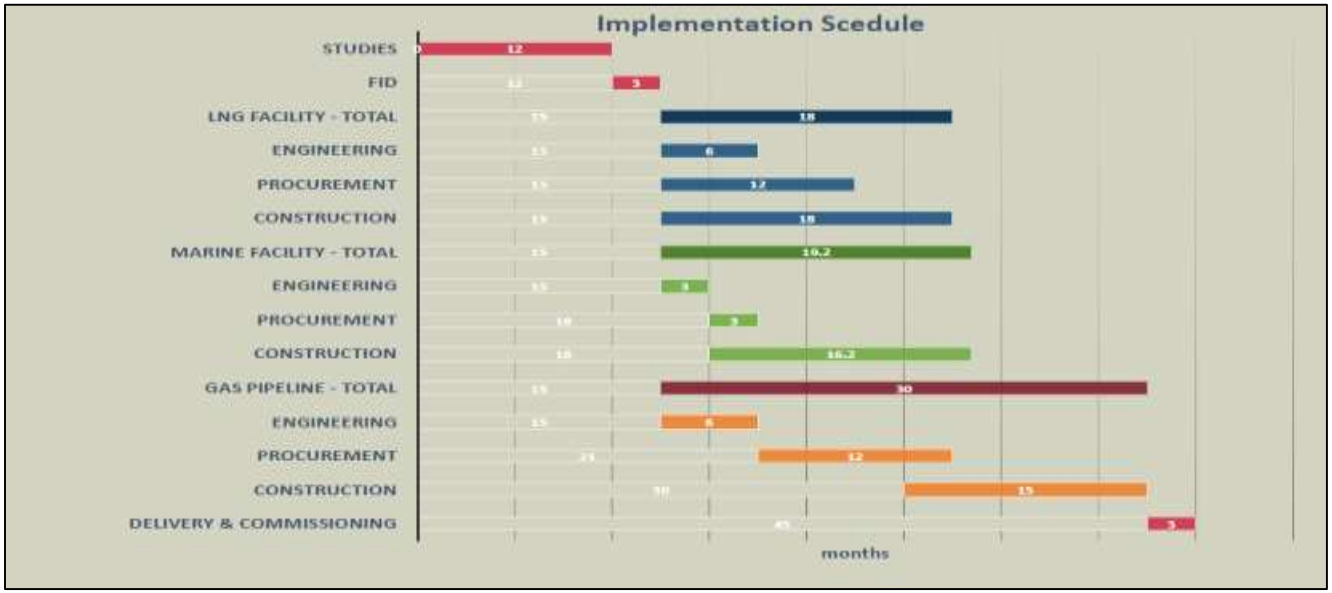
# Site 2: Results –Nga Yoke Kuang traffic light scoring for 2D

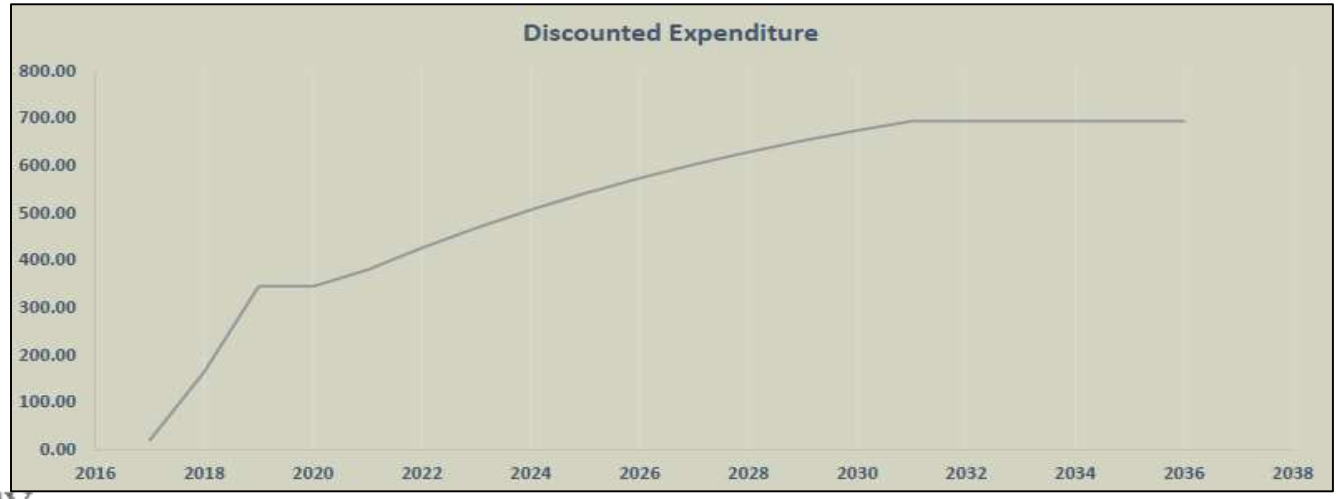
| | | Nearshore Site 2 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | LNGV in Deepwater | GBS |
| **GETTING LNG TO THE TERMINAL** | | | | | | | | |
| 1 | How much dredging is required to create a channel to the terminal? | | | | | | | |
| 2 | What Jetty length is required to be able to moor a near shore FSRU/LNG Carrier? | | | | | | | |
| OR | What Subsea pipeline length is required to connect a midwater or deepwater FSRU or LNGRV? | | | Not possible | | | Not possible | |
| 3 | How much marine traffic is currently being experienced? | | | | | | | |
| 4 | Are there local visibility limitations? | | | | | | | |
| 5 | Are there any other factors that limit the site? | | | | | | | |
| | | | | | | | | |
| **STORING LNG** | | | | | | | | |
| 1 | What is the wave environment like? | | | | | | | |
| 2 | How variable is the wind/wave environment? | | | | | | | |
| 3 | Might the LNG facility be impacted by extreme weather? | | | Not possible | | | Not possible | |
| 4 | Will the site cause any destruction or exclusion to environmentally sensitive areas? | | | | | | | |
| 5 | Will the site cause any destruction or exclusion to culturally and historically sensitive areas? | | | | | | | |
| 6 | Will the site development and operation impact the local community in any detrimental way? | | | | | | | |
| 7 | Will the site development and operation increase the risk of harm/fatality to the local community? | | | | | | | |
| 8 | Are there risks to the LNG facility from geological events? | | | | | | | |
| | | | | | | | | |
| **GETTING GAS TO MARKET** | | Onshore pipeline | | | | | | |
| 1 | Can LNG be vaporised in sufficient volume and in an environmentally acceptable way? | | | | | | | |
| 2 | What is the onshore pipeline length? | | | | | | | |
| 3 | What is the difficulty in laying the onshore pipeline? | | | | | | | |
| 4 | What is the offshore pipeline length? | | | | | | | |
| 5 | What is the difficulty in laying the offshore pipeline? | | | | | | | |
| | | | | | | | | |
| **LOCAL INFRASTRUCTURE** | | | | | | | | |
| 1 | Is there sufficient towage available to berth the LNG carrier? | | | | | | | |
| 2 | Is there currently any port rules and infrastructure appropriate to hydrocarbon importation at the proposed LNG site? | | | | | | | |
| 3 | Is there sufficient infrastructure to accommodate workers and their families, expatriates and vendor personnel? | | | | | | | |
| 4 | Is there emergency response and Health care capability? | | | Not possible | | | Not possible | |
| 5 | Education and Skills? | | | | | | | |
| 6 | Is there access to a major port with connecting roads? | | | | | | | |
| 7 | Is there access to an international airport with road/rail links? | | | | | | | |
| 8 | How adequate is the marine infrastructure? | | | | | | | |

# Site 2: Results –Summary data inputs for the analysis for Site 2D

| PHYSICAL PARAMETRS: | | Data |
|---|---|---|
| LNG facility size | | 170,000 $m^3$ stored with 500 mmscfd vaporiser capacity |
| LNG facility type | | FSRU |
| Location | | Nearshore |
| Ownership | | Lease |
| geology | | <0.4 g acceleration |
| Jetty length | | 0 m |
| Breakwater | | Not required |
| Dredging | | 5,200,000 $m^3$ |
| Gas pipeline | | 1 km of 30 inch offshore + 230 km of 30 inch onshore |
| Design LNG ship | | 163,000 $m^3$ |
| **FINANCIAL AND ECONOMIC PARAMETERS:** | | **Data** |
| Project start year | | 2017 |
| LNG import term | | 10 years |
| Discount rate | | 10% |
| Lease rate | | 140,000 US$/day |
| Fuel oil cost | | 470 US$/ton 380 cst Singapore |
| Electricity cost | | 0.05 US$/kWh (70 kyats/kWh) |
| Tug cost | | US$ 15,000/day each (24 days mobilisation)) |
| **CAPITAL COSTS: Description of key areas** | | **Value** |
| FSRU | | 0 US$ million (lease) |
| Jetty | | 46 US$ million |
| Dredging | | 26 US$ million |
| Gas pipeline | | 278 US$ million |
| Local infrastructure | | 0 US$ million |
| TOTAL | | 350 US$ million |
| Note 1: No BOT/BOOT purchase payment was assumed at the end of the contract life. | | |
| **OPERATING COSTS: Description of key areas** | | **Operating costs** |
| FSRU lease | | 51 US$ million pa |
| Fixed costs | Labour | 8 US$ million pa |
| | Insurance | 2 US$ million pa |
| | Inspection and maintenance | 2 US$ million pa |
| | Supporting infrastructure | 2.2 US$ million pa |
| Variable costs | Fuel oil | 6.48 US$ million pa |
| | Electricity | 0 US$ million pa |
| | Towage | 14.6 US$ million pa |
| TOTAL | | 81.4 US$ million pa |
| **Notes** | | |
| 1. The above calculation is based on a 230km connecting pipeline to Yangon. If Site 2D was to opt for the shorter 50km onshore connection to Pathein the CAPEX costs would be reduced by $204 million, with an equivalent reduction in the DCF figure. | | |

# Site 2: Results – Implementation schedule and cash flow



# Site 2: Results Summary

## Site 2D

- Schedule to market: 48 months
- Capital Cost: 350 US$ million
- Operating cost: 80 US$ million/year
- Discounted Expenditure: 682 US$ million

- 230 km pipeline to Yangon, a shorter pipeline to Pathein may be possible

## Site 2C

- Not developed – considered too challenging

# Section 6: Site 3 Kalegauk Island

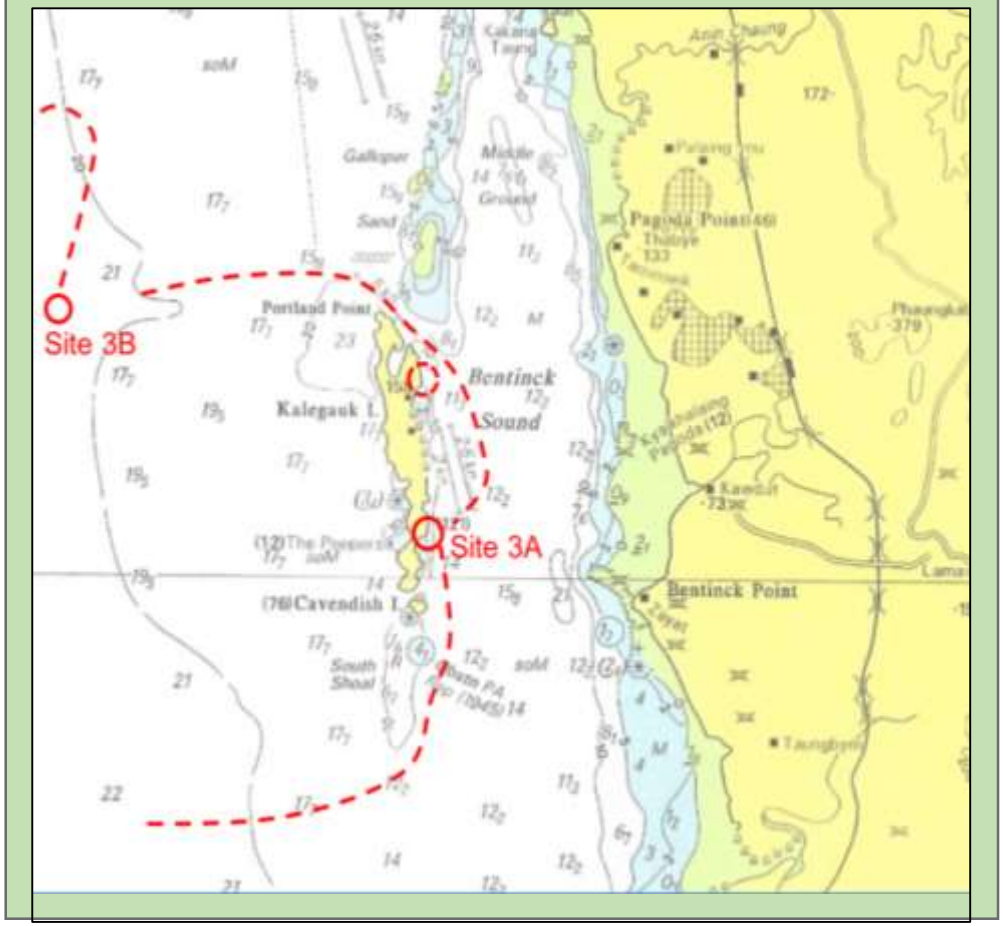
# Site 3: Overview

Two sites considered

- Site 3A in Bentinck Sound to the east of Kalegauk Island. (NB: Two sites are possible but proximity to local populations favours the southern site – the northern site is not considered further.)

- Site 3B is located offshore in 20 m of water in the Andaman Sea to the northwest of Kalegauk Island.

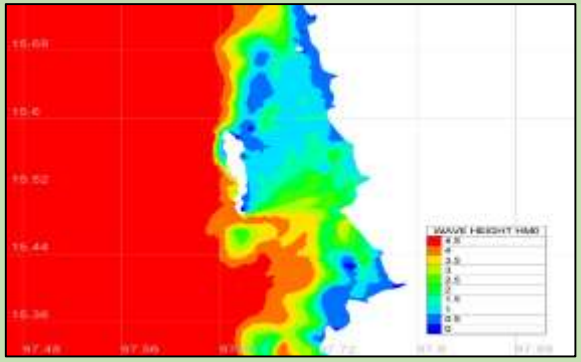

## Site Locations



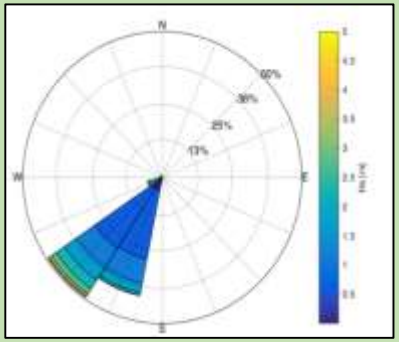
# Site 3: Metocean Analysis

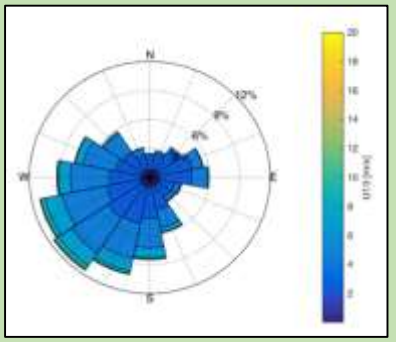
- Both sites are relatively sheltered from SW winds and monsoon by the Andaman Islands.
- Site 3A has additional protection from Kalegauk Island.
- Non cyclonic storms will impact operations at Sites 3B but are infrequent.
- Winds are insufficient to challenge LNG carrier mooring guidelines.

## Non cyclonic storm



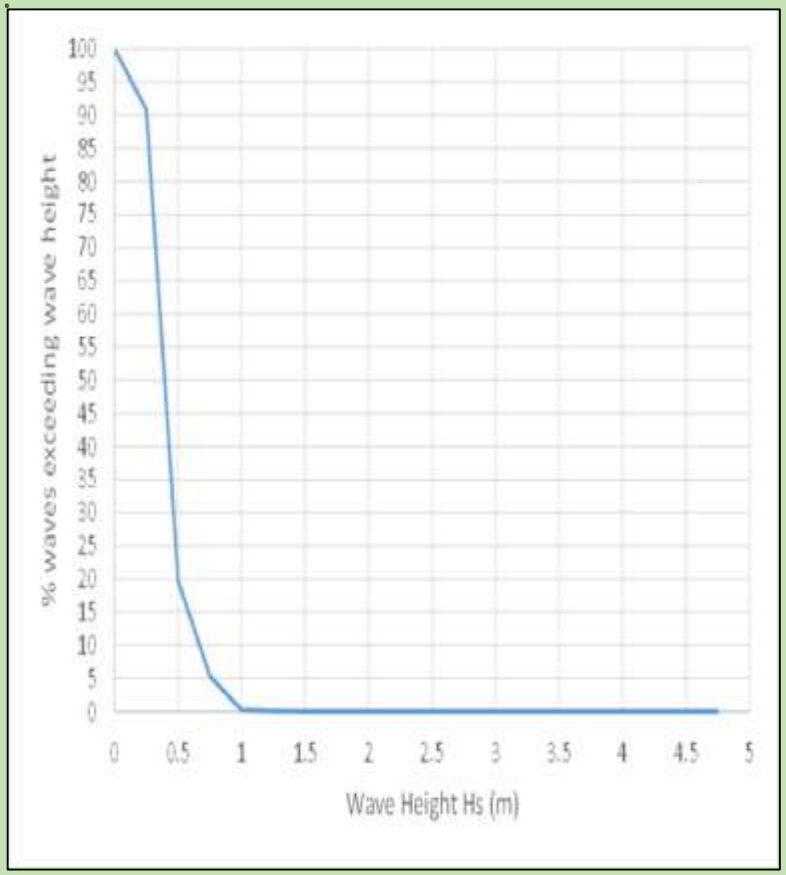
## wind & wave rosettes



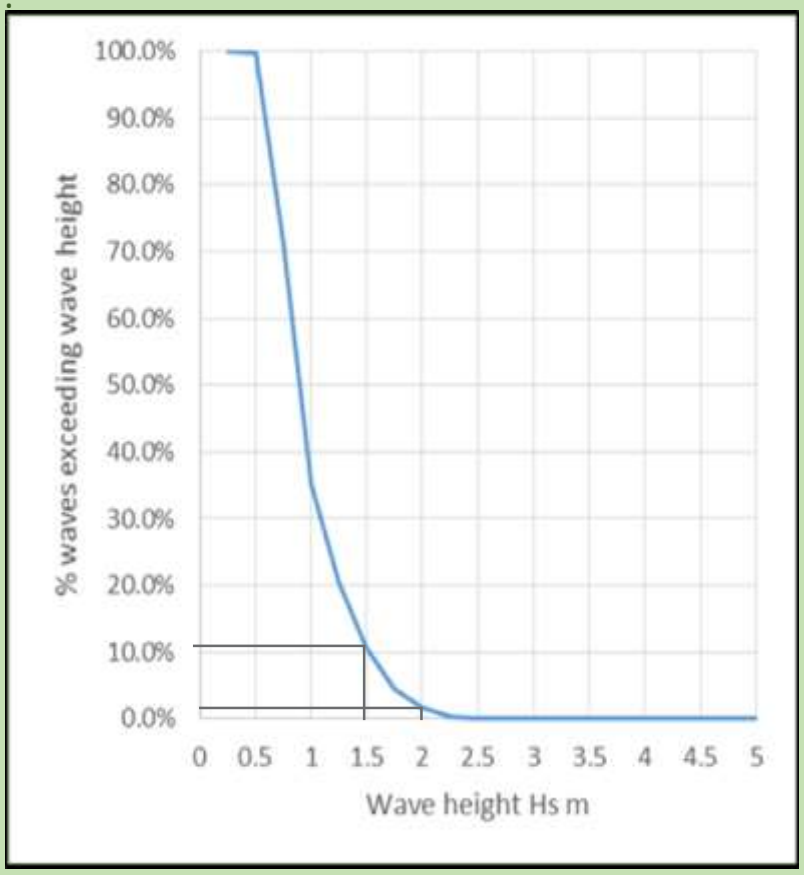


# Site 3: Metocean Analysis

## Wave height exceedance curve at berth Site 3A




## Wave height exceedance curve at pilot station Site 3B

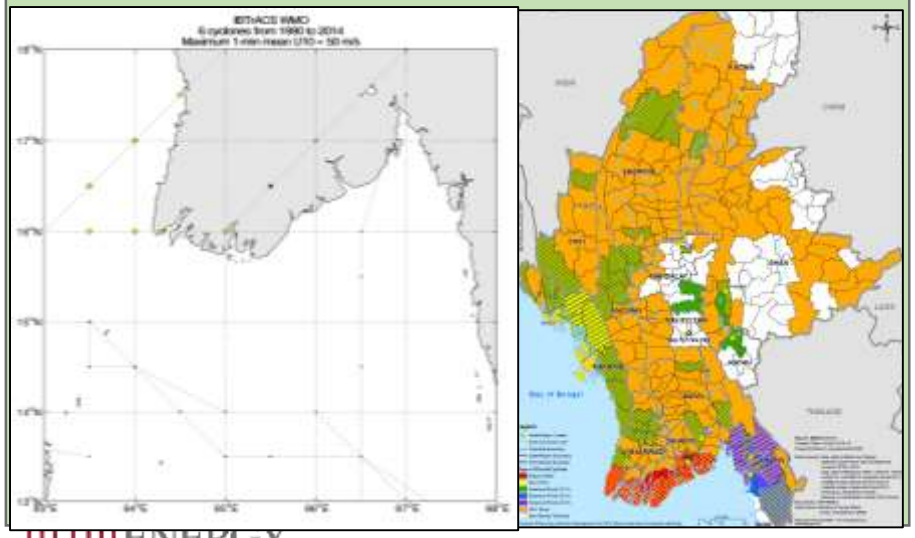


# Site 3: Weather & Geology

## Weather

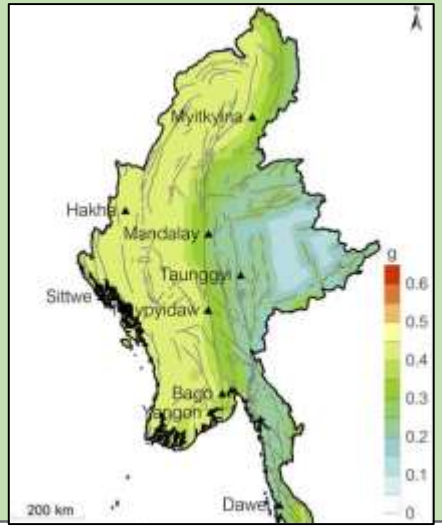
- Cyclones are infrequent in this part of Myanmar, cyclones are deflected by the Andaman Islands.
- Flooding occurs on a seasonal basis.

*Cyclone tracks & flooding events*



## Geology

- There have been no recorded earthquakes in the vicinity of Kalegauk Island. There have been several Magnitude 4 – 5 earthquakes in the Andaman Sea to the west.
- Moderate peak ground accelerations are anticipated (<0.2g).




*Peak ground accelerations*

# Site 3: Navigational assessment

- Site 3A is in 12 m of water + tides.
- No dredging is required if LNG transit times are controlled to high slack water.
- A dredged berthing pocket to 14 m sufficient for a LNG carrier to escape an incident will be required.
- Offshore site 3B is in a water depth of 20 m and presents no navigational issues.

## Key Points


| Heights In Metres Above Chart Datum | | | | |
|---|---|---|---|---|
| Tidal Condition | Mean High Water Spring Tides | Mean High Water Neap Tides | Mean Low Water Neap Tides | Mean Low Water Spring Tides |
| Tidal Height, m | 5.5 | 3.9 | 2.5 | 0.9 |

# Site 3: Environmental, Social & Cultural Impacts

- Kalegauk Island has 2 villages and 2 smaller settlements. Avoiding hazards and impacts is possible but restricts the space available.
- Fishing is important to Mon state but the muddy seabed here is probably of lower value than further south.

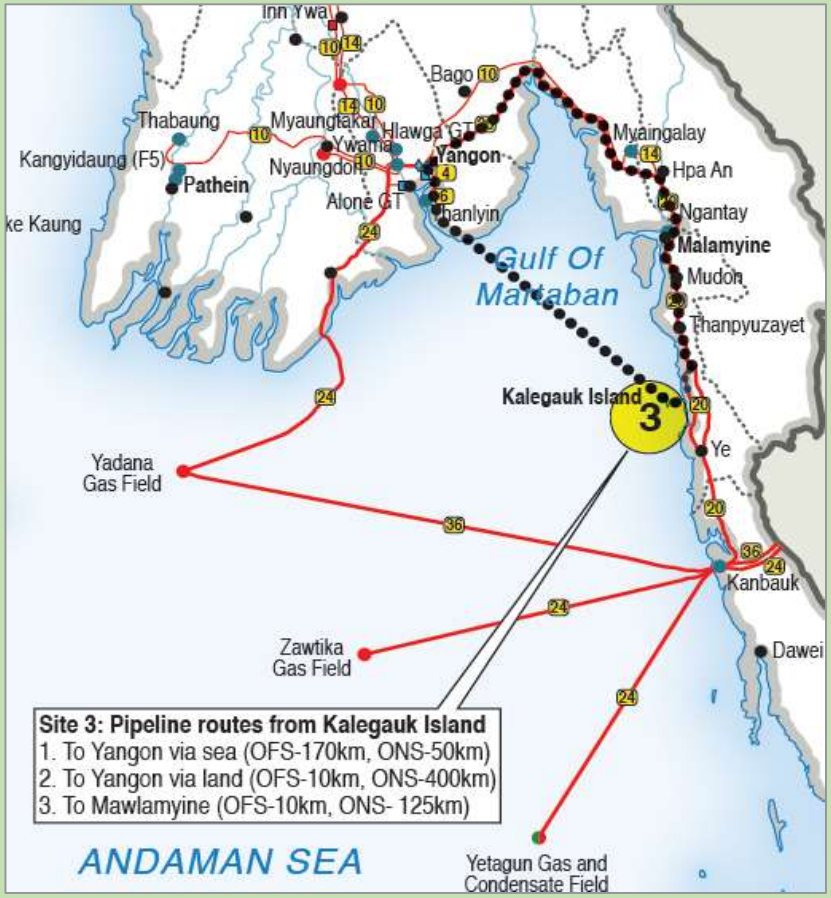
## Key Points

”Pristine” coast but development starting
Foreigners had no access until recently
Some deforestation by rubber plantations

# Site 3: Pipelines

- Current pipeline: Kaunbauk – Yangon via power stations at Mawlamyine.
- Reinforcement is underway but slow.
- Option 1 – 170 km of 30 inch subsea pipeline to Yangon + 50km onshore.
- Option 2 – 400 km of 30 inch pipeline in ROW to Yangon + 10km offshore.
- Option 3 – 125 km of 30 inch pipeline to Mawlamyine + 10 km offshore.
- Key assumptions are no compression or reinforcement.

## Key Points



# Site 3: Local infrastructure

- No tugs, nearest tugs at Shwe oil terminal.
- No port or port authority.
- Ye is the nearest town but is unable to provide the most basic business services.
- Little industry and relatively low skill workforce.
- Mawlamyine has higher education establishments.
- Health care at Ye is seen as poor
- Port at Mawlamyine for river traffic but with no significant port infrastructure.
- Good road & rail connections but these may be in poor condition.

## Key Points

Ye – very limited infrastructure

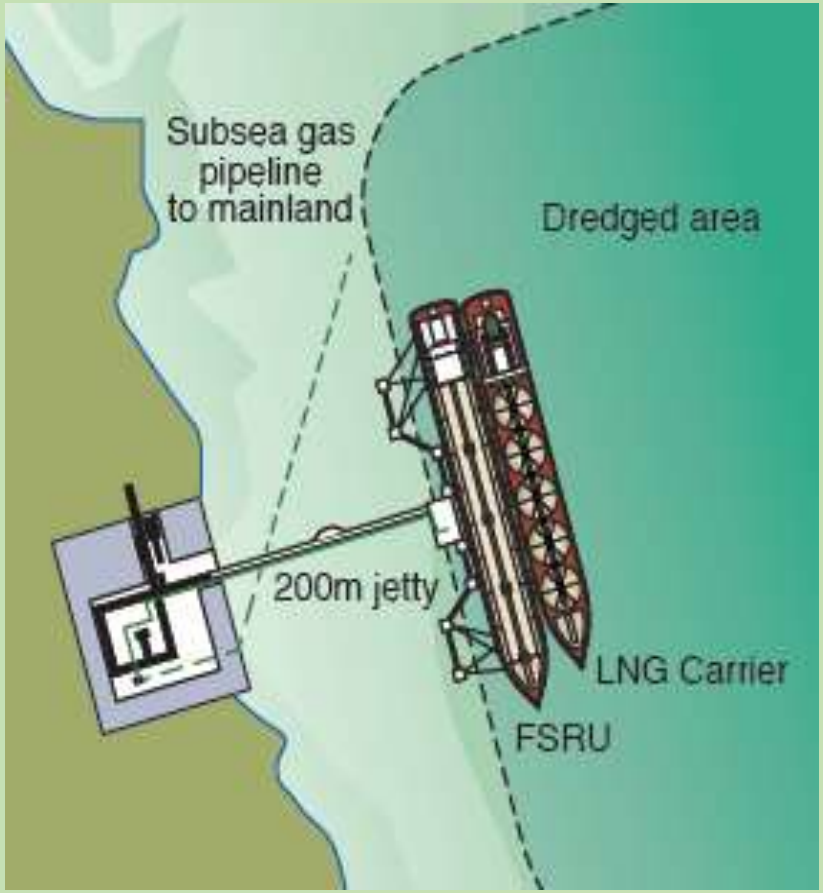
# Site 3: Results – Kalegauk Island traffic light scoring

| | | Nearshore Site 3A | | | | | | | Offshore Site 3B | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | LNGRV in Deepwater | GBS | Onshore terminal | FSRU on Jetty | Midwater FSRU | Deepwater FSRU | FSU on Jetty | LNGRV in Deepwater | GBS |
| **GETTING LNG TO THE TERMINAL** | | | | | | | | | | | | | | | |
| 1 | How much dredging is required to create a channel to the terminal? | | | | | | | | | | | | | | |
| 2 | What Jetty length is required to be able to moor a near shore FSRU/LNG Carrier? | | | | | | | | | | | | | | |
| OR | What Subsea pipeline length is required to connect a midwater or deepwa FSRU or LNGRV | | | | | | | | | | | | | | |
| 3 | How much marine traffic is currently being experienced? | | | | | | | | | | | | | | |
| 4 | Are there local visibility limitations? | | | | | | | | | | | | | | |
| 5 | Are there any other factors that limit the site? | | | | | | | | | | | | | | |
| **STORING LNG** | | | | | | | | | | | | | | | |
| 1 | What is the wave environment like? | | | | | | | | | | | | | | |
| 2 | How variable is the wind/wave environment? | | | | | | | | | | | | | | |
| 3 | Might the LNG facility be impacted by extreme weather? | | | | | | | | | | | | | | |
| 4 | Will the site cause any destruction or exclusion to environmentally sensi areas? | | | | | | | | | | | | | | |
| 5 | Will the site cause any destruction or exclusion to culturally and historica sensitive areas? | | | | | | | | | | | | | | |
| 6 | Will the site development and operation impact the local community in a detrimental way? | | | | | | | | | | | | | | |
| 7 | Will the site development and operation increase the risk of harm/fatality the local community? | | | | | | | | | | | | | | |
| 8 | Are there risks to the LNG facility from geological events? | | | | | | | | | | | | | | |
| **GETTING GAS TO MARKET** | | Onshore pipeline | | | | | | | Subsea pipeline | | | | | | |
| 1 | Can LNG be vaporised in sufficient volume and in an environmentally acceptable way? | | | | | | | | | | | | | | |
| 2 | What is the onshore pipeline length? | | | | | | | | | | | | | | |
| 3 | What is the difficulty in laying the onshore pipeline? | | | | | | | | | | | | | | |
| 4 | What is the offshore pipeline length? | | | | | | | | | | | | | | |
| 5 | What is the difficulty in laying the offshore pipeline? | | | | | | | | | | | | | | |
| **LOCAL INFRASTRUCTURE** | | | | | | | | | | | | | | | |
| 1 | Is there sufficient towage available to berth the LNG carrier? | | | | | | | | | | | | | | |
| 2 | Is there currently any port rules and infrastructure appropriate to hydrocarbon importation at the proposed LNG site? | | | | | | | | | | | | | | |
| 3 | Is there sufficient infrastructure to accommodate workers and their famil expatriates and vendor personnel? | | | | | | | | | | | | | | |
| 4 | Is there emergency response and Health care capability? | | | | | | | | | | | | | | |
| 5 | Education and Skills? | | | | | | | | | | | | | | |
| 6 | Is there access to a major port with connecting roads? | | | | | | | | | | | | | | |
| 7 | Is there access to an international airport with road/rail links? | | | | | | | | | | | | | | |
| 8 | How adequate is the marine infrastructure? | | | | | | | | | | | | | | |

# Site 3A: Technology Selection

- Any near shore solution based on a jetty.
- Mid water depth option is possible but significant additional dredging required so no advantage.
- Limited space on the island away from people which will make an onshore terminal challenging but its potential cannot be ruled out at this stage.
- Jetty moored FSRU is most flexible option with a short delivery timescale.

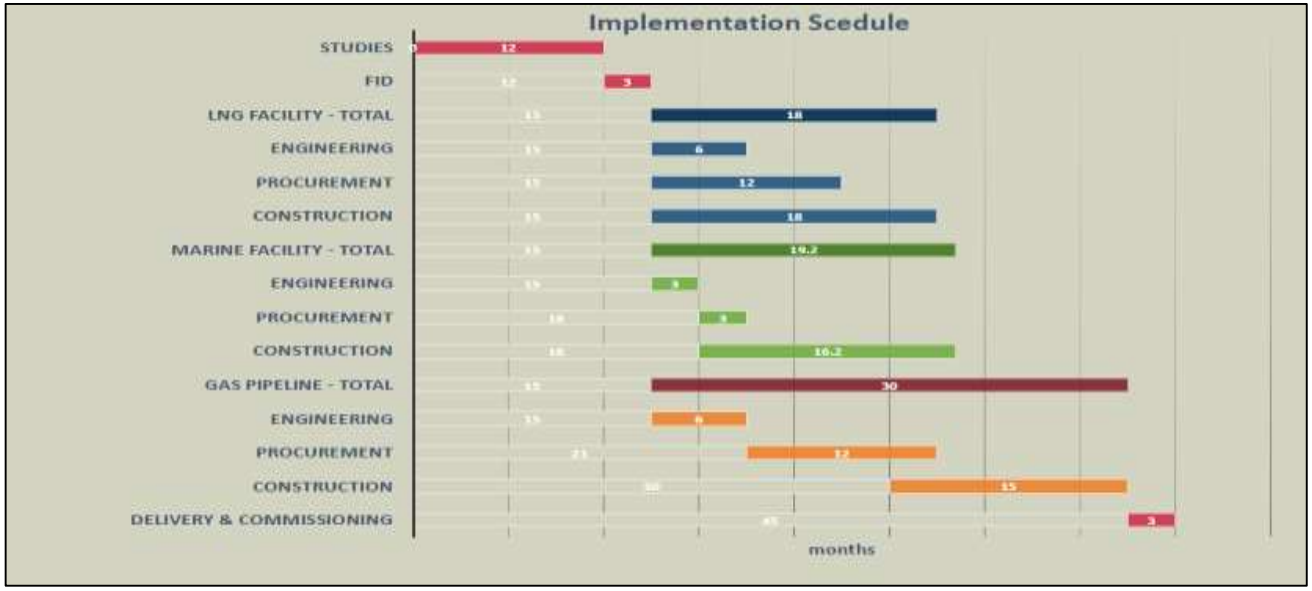
## Technology selection

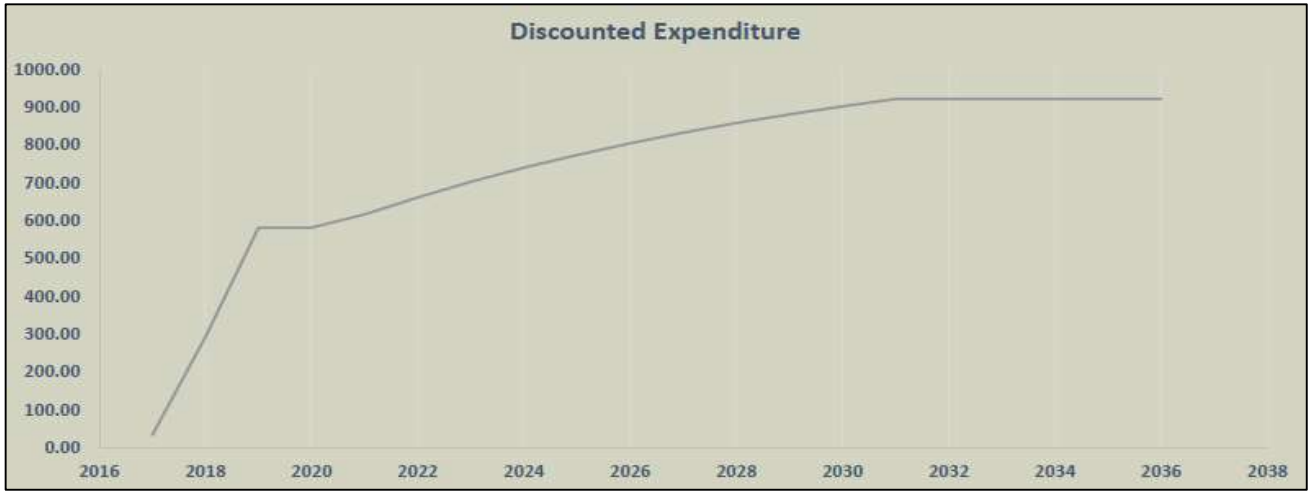


# Site 3: Results – Summary data inputs for the analysis for Site 3A2

| PHYSICAL PARAMETRS: | | Data |
|---|---|---|
| LNG facility size | | 170,000 $m^3$ stored with 500 mmscfd vaporiser. |
| LNG facility type | | FSRU |
| Location | | Nearshore |
| Ownership | | Lease |
| geology | | <0.2 g acceleration |
| Jetty length | | 300 m |
| Breakwater | | Not required |
| Dredging | | 450,000 $m^3$ |
| Gas pipeline | | 10 km 30 inch subsea pipeline + 400 km onshore |
| Design LNG ship | | 163,000 $m^3$ |
| **FINANCIAL AND ECONOMIC PARAMETERS:** | | **Data** |
| Project start year | | 2017 |
| LNG import term | | 10 years |
| Discount rate | | 10% |
| Lease rate | | 140,000 US$/day |
| Fuel oil cost | | 470 US$/ton 380 cst Singapore |
| Electricity cost | | 0.05 US$/kWh (70 kyats/kWh) |
| Tug cost | | US$ 15,000/day each plus 4 days mobilisation |
| **CAPITAL COSTS: Description of key areas** | | **Value** |
| FSRU | | 0 US$ million (lease) |
| Mooring | | 167 US$ million |
| Dredging | | 2.5 US$ million |
| Gas pipeline | | 498 US$ million |
| Local infrastructure | | 0 US$ million |
| TOTAL | | 668 US$ million |
| Note 1: No BOT/BOOT purchase payment was assumed at the end of the contract life. | | |
| **OPERATING COSTS: Description of key areas** | | **Operating costs** |
| FSRU lease | | 51 US$ million pa |
| Fixed costs | Labour | 3 US$ million pa |
| | Insurance | 2 US$ million pa |
| | Inspection and maintenance | 2 US$ million pa |
| | Supporting infrastructure | 0 US$ million pa |
| Variable costs | Fuel oil | 6.5 US$ million pa |
| | Electricity | 0 US$ million pa |
| | Towage | 14.6 US$ million pa |
| TOTAL | | 80.2 US$ million pa |
| **Notes** | | |
| 1. The above calculation is based on a gas pipeline to Yangon. If an intermediate solution was developed with the onshore pipeline stopping at Mawlamyine only 125km from where RLNG is landed from the FSRU a saving of around $330 million would be possible. | | |

# Site 3: Results – Implementation schedule and cash flow 3A2

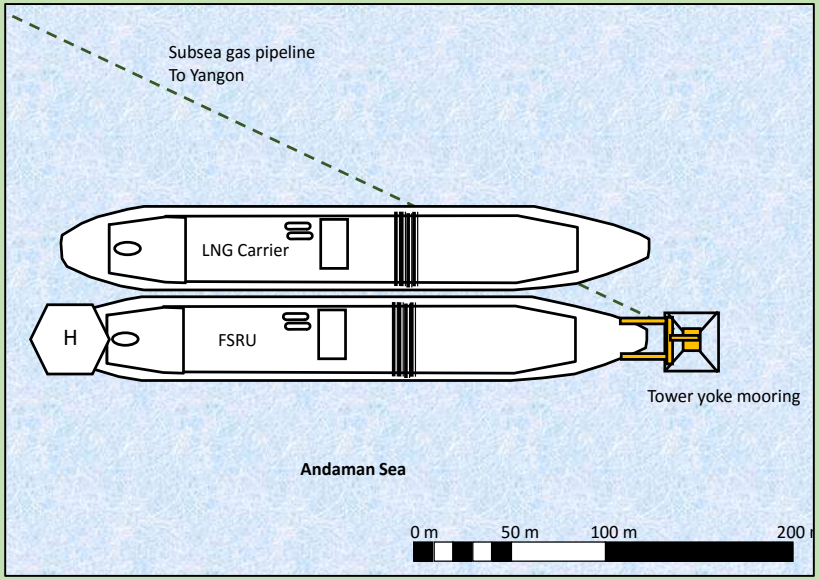


# Site 3B: Technology Selection

## Technology selection

- The variability in wave direction is small so an island jetty may be possible although wave heights will marginally limit availability.




## Technology selection

- Water depth is about 20 m and relatively exposed so a tower yoke mooring is preferred.

# Site 3: Results – Summary data inputs for the analysis for Site 3B2

| PHYSICAL PARAMETRS: | | Data |
|---|---|---|
| LNG facility size | | 170,000 m3 stored with 500 mmscfd vaporiser |
| LNG facility type | | FSRU |
| Location | | Mid water |
| Ownership | | Lease |
| geology | | <0.2 g acceleration |
| Jetty length | | Not required |
| Breakwater | | Not required |
| Dredging | | Not required |
| Gas pipeline | | 170km 30 inch subsea pipeline + 50 km onshore |
| Design LNG ship | | 163,000 $m^3$ |
| **FINANCIAL AND ECONOMIC PARAMETERS:** | | **Data** |
| Project start year | | 2017 |
| LNG import term | | 10 years |
| Discount rate | | 10% |
| Lease rate | | 140,000 US$/day |
| Fuel oil cost | | 470 US$/ton 380 cst Singapore |
| Electricity cost | | 0.05 US$/kWh (70 kyats/kWh) |
| Tug cost | | US$ 15,000/day each plus 2 days mobilisation |
| **CAPITAL COSTS: Description of key areas** | | **Value** |
| FSRU | | 270 US$ million (leased) |
| Mooring | | 31 US$ million |
| Dredging | | 0 US$ million |
| Gas pipeline | | 66 US$ million |
| Local infrastructure | | 0 US$ million |
| TOTAL | | 397 US$ million |
| Note 1: No BOT/BOOT purchase payment was assumed at the end of the contract life. | | |
| **OPERATING COSTS: Description of key areas** | | **Operating costs** |
| FSRU lease | | 51 US$ million pa |
| Fixed costs | Labour | 3 US$ million pa |
| | Insurance | 2 US$ million pa |
| | Inspection and maintenance | 2 US$ million pa |
| | Supporting infrastructure | 2.2 US$ million pa |
| Variable costs | Fuel oil | 6.48 US$ million pa |
| | Electricity | 0 US$ million pa |
| | Towage | 14.5 US$ million pa |
| TOTAL | | 81.4 US$ million pa |

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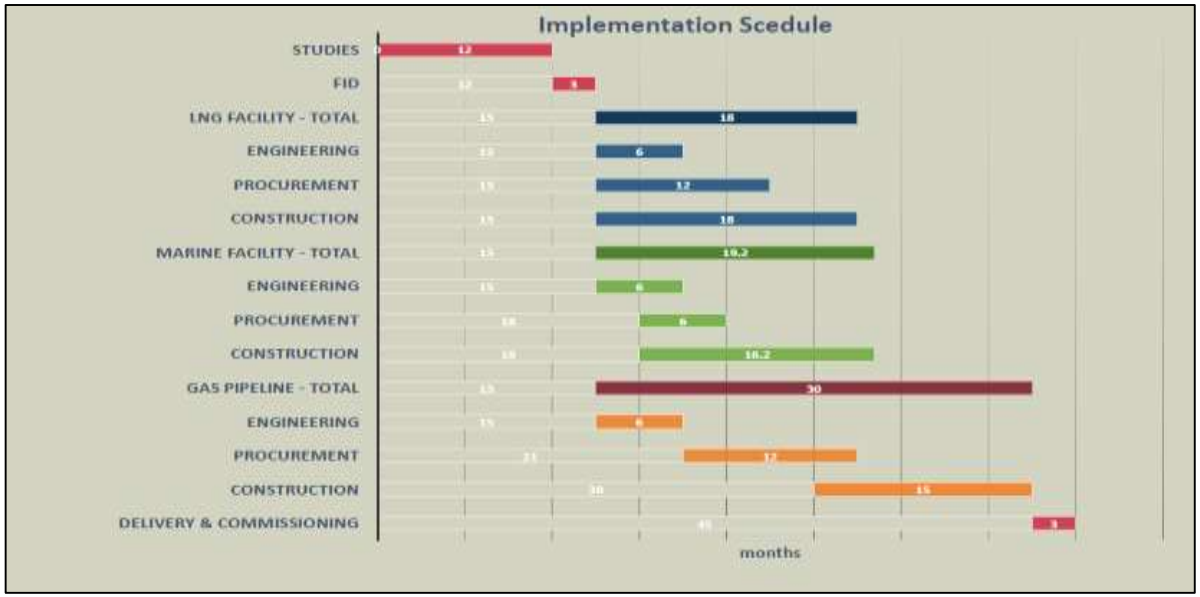
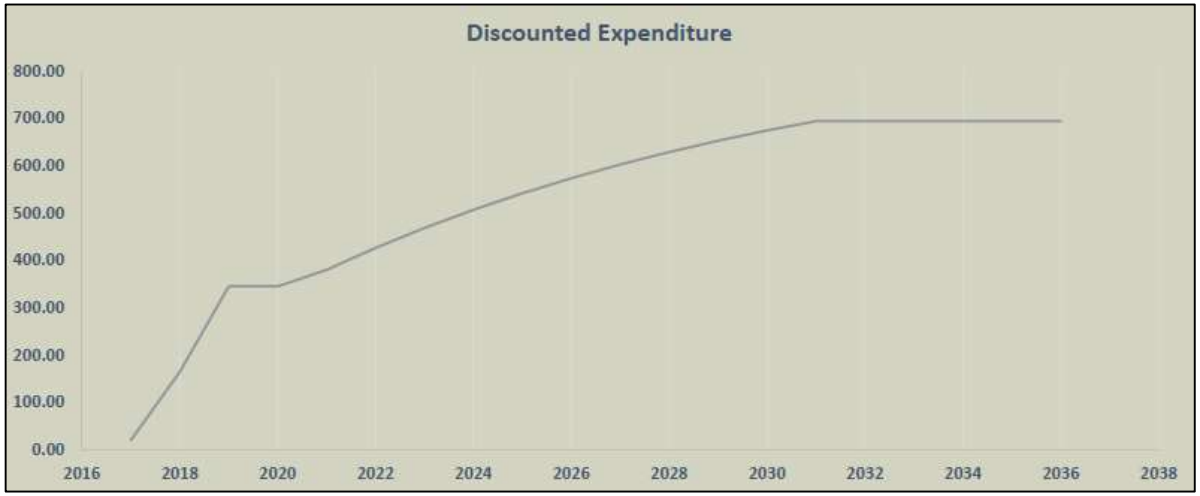
# Site 3: Results – Implementation schedule and cash flow 3B2



# Site 3: Results Summary

## Site 3A2

- Schedule to market: 48 months
- Capital Cost: 668 US$ million
- Operating cost: 80 US$ million/year
- Discounted Expenditure: 948 US$ million

- 400 km onshore pipeline to Yangon, a shorter pipeline to Mawlamyine may be possible

## Site 3B2

- Schedule to market: 48 months
- Capital Cost: 397 US$ million
- Operating cost: 81 US$ million/year
- Discounted Expenditure: 720 US$ million

- 170 km subsea pipeline connecting to 50 km onshore pipeline

# Section 7: Conclusions and Recommendations

# Conclusions - Schedule

All sites similar in terms of schedule

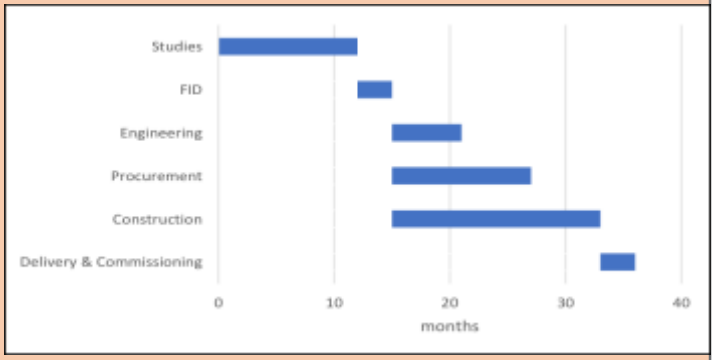
- LNG supply possible in 3-4 years includes
  - 1 year of studies, permitting and financing.
  - 2-3 years of engineering, procurement and construction.

- Engineering, procurement & construction
  - FSRU 18 - 24 months
  - Marine jetty/dredging 18 – 24 months
  - Gas pipeline 24 - 30 months

- Schedule should coincide with newbuild FSRU current under consideration coming to market

## Schedule

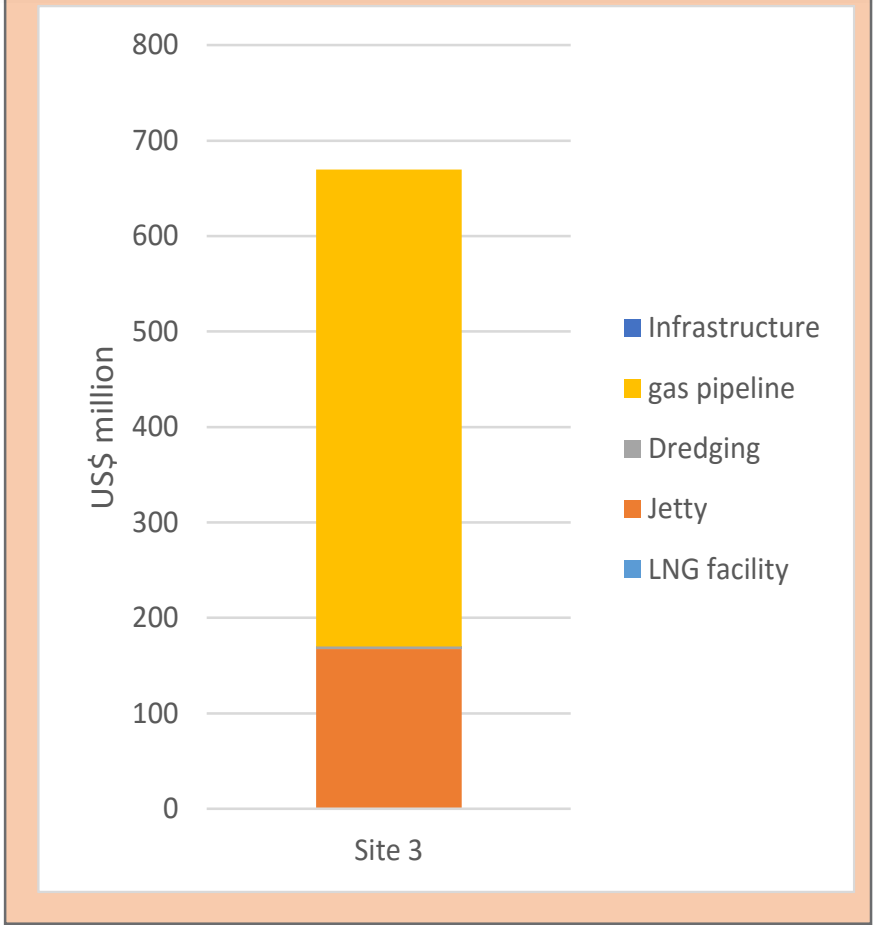
FSRU/LNG is not the rate determining step



# Conclusions – Capital Investment

- The FSRU is presumed to be on a leased basis
- Capital investment required for
  - Marine facilities
    (May include in FSRU package)
  - Gas pipelines
- Operating costs are anticipated to be US$ 60 - 80 million pa including the FSRU lease
- US$ 140,000 per day assumed for lease (US$ 51 million pa)

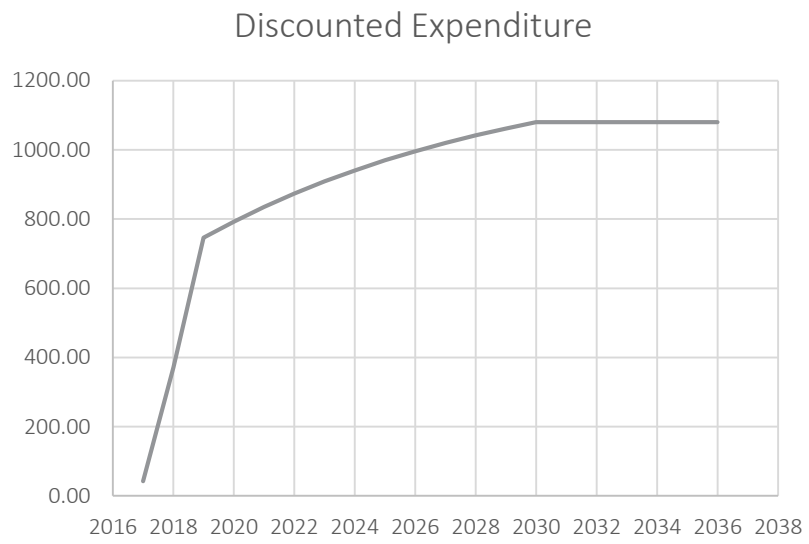
## Capex breakdown



# Conclusions – DCF numbers

- To compare capital costs with operating costs over the lifetime of the LNG lease/import contract a NPV model has been used
- As no LNG price/sales income estimates are part of the scope of work a view can only be taken of discounted expenditure

## Cash flow model



# Conclusions – Site comparison

| Site | Schedule | Capital Investment | Operating Expense | Discounted Expenditure |
|---|---|---|---|---|
| Site 1A2 | 48 months | 826 US$ million | 66 US$ million pa | 1,032 US$ million |
| The above calculation is based on a 557km connecting pipeline to Yangon. If Site 1A2 was to opt for the shorter 290km onshore connection to either Pyay or Magway the CAPEX costs would be reduced by $320.4 million, with an equivalent reduction in the DCF figure. | | | | |
| Site 2D | 48 months | 350 US$ million | 80.3 US$ million pa | 682 US$ million |
| The above calculation is based on a 230km connecting pipeline to Yangon. If Site 2D was to opt for the shorter 50km onshore connection to Pathein the CAPEX costs would be reduced by $204 million, with an equivalent reduction in the DCF figure. | | | | |
| Site 3A2 | 48 months | 668 US$ million | 80.2 US$ million pa | 948 US$ million |
| The above calculation is based on a gas pipeline to Yangon. If an intermediate solution was developed with the onshore pipeline stopping at Mawlamyine only 125km from where RLNG is landed from the FSRU a saving of around $330 million would be possible. | | | | |
| Site 3B2 | 48 months | 397 US$ million | 81.4 US$ million pa | 720 US$ million |
| No comments. | | | | |

Schedules and costs (+/-50%) for each site examined are shown in the table

*Notes:* *Site 1A new pipeline from Magway to Yangon (via Shwe) or direct to Yangon*
*Site 2C has a relatively low metocean availability of 85%*
*Site 2D needs to find a solution to getting a subsea pipeline past coral*
*Site 3A could use a subsea pipeline direct to Yangon which improves economics*

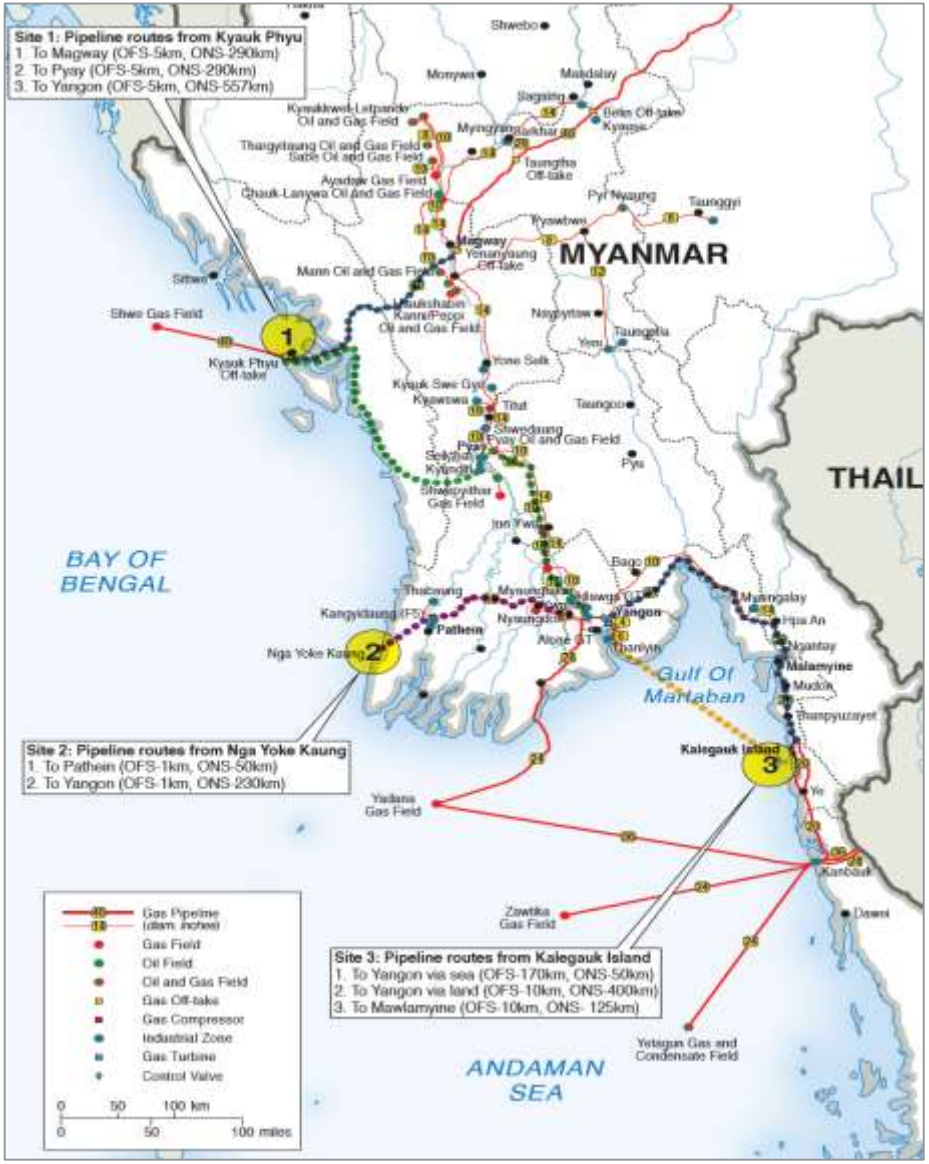
# Conclusions – Site selection

Four sites were shortlisted and examined in more detail.

- Site 1A looks a good site but pipeline is long.
- Site 2D – In the cheapest route to Yangon but there may be environmental concerns and delays.
- Site 3A looks the best marine site but an onshore pipeline route to Yangon is long.
- Site 3B is a compromise with the subsea pipeline option across the Gulf of Martaban looking promising.

## Site options

# Site selection conclusions



# Schedule Conclusions

- LNG infrastructure is not on the critical path for most options
  - There are no unchartered FSRUs available until 2019-20
- Gas pipelines can be on the critical path but are always close to the critical schedule
  - Marine facilities and gas pipelines can be accelerated by working on multiple fronts but this may have a cost impact
  - Procurement of material/equipment is a key issue and although schedules are improving still represents a bottleneck

## Key Points

Permitting and financing will take longer than engineering pre FID

# Cost Conclusions

- All options use a FSRU
  - This is assumed to leased for a period (10 years)
  - There is no capital expenditure associated with the FSRU
- All capital expenditure is for onshore/shoreline facilities
  - Pipeline expenditure dominates capital investment
- Operating costs are dominated by fuel/electricity
- Towage costs will be high if tugs need to travel some distance to the LNG facility

## Lease rates

Lease rates become significant over the charter lifetime.

A rate of US$ 140,000/day has been used.

This is the upper end of the current range but FSRUs are in short supply so rates may rise further

# Future work

More detailed work will be required in the following areas.

- The site location including;
  - Bathymetric and topological surveys.
  - Calibrated metocean assessments preferably using measured wave data.
  - Environmental and social studies.
- LNG supply strategy
  - MOGE need to have a clear understanding of how much LNG volume is to be imported at what rate and over what period.
- FSRU design and availability
  - A detailed design feasibility study for the FSRU.
- Onshore gas transportation
  - A detailed design feasibility for the offshore and onshore pipelines taking into account road and river crossing, difficulty of terrain and local system reinforcment costs.

## The limits of this study

Ideally the Consultants would have preferred to have met with the marine authorities and visited the proposed sites.

The pipeline costs are based on broad $million /km no allowance has been made for difficult terrain or road and river crossings.

# Future work

- This study is based on piping gas to Yangon for power
- Alternative option would be to produce electricity more locally and transmit by wires

- Site 1 could use the Shwe pipeline to Mingian for a northern power hub
- Site 2 would continue to pipe gas to Yangon for power generation
- Site 3 could be piped to Mawlamyine for a southern power hub

- Economics of Sites 1 and 3 would be improved

## A future study should consist of the following

Compare energy transmission by wire compared to energy delivery by pipe

# Thank you

# Any questions?

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