EPC Project Execution for LNG Plant

October, 2016
Chiyoda Corporation
CHIYODA at a Glance

- Founded on January 20, 1948
- Integrated Engineering & Construction Service Provider
- Employees: Over 8,200 (Global Basis)
- Capital: USD 384 Million (FY 2015)
- Revenue: USD 5.4 Billion (FY 2015)
- New Orders: USD 3.6 Billion (FY 2015)
- Global Headquarters @ Yokohama, Japan

March 2016
Exchange rate: JPY113/$
LNG Project Experiences

34 FEED/PS projects
26 EPC projects**

** 43 trains, 172 million tons of LNG
Chiyoda’s Involvement in LNG Production

Chiyoda’s Involvement in Liquefaction throughout the world (by capacity), as No.1 LNG Contractor

Worldwide LNG Plant Capacity awarded since 2005
Chiyoda’s Experience in Simultaneous Mega EPC Projects Execution

Chiyoda constructed 8 mega LNG trains and 2 gas processing plants simultaneously.
All Ranges of LNG Investment

(Unit: mtpa per train)

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LNG Supply Chain

Gas Production

Gas Treating & Liquefaction

Gas to Pipeline

LNG Shipping

LNG Regasification

Impurity removal
Refrigeration / liquefaction

Liquefaction reduces the volume of natural gas by approximately 600 times.
Chiyoda’s LNG Technologies

- Standardization of LNG Plant Design based on a New Concept (CHIYODA LNG-X)
- Chiyoda Mini LNG (m-LNG)
- Chiyoda’ FLNG
- Chiyoda Mid-Sized LNG
Example for LNG Process / C3-MR

Source: Oil & Natural gas review
There are 3 types of LNG plant construction method as stated below.

**Stick-Built (Conventional Method)**
- All component of plant including equipment structure, piperack and building are constructed at construction site.

**Module**
- Plant consisting of equipment structures, piperacks and buildings are divided into a number of modules considering various aspect of the plant design and construction.
Construction Method (Stick Built・Module・FLNG)

- As construction schedule for Module is much longer than Stick built and cost is higher than Stick-built if labor wage is almost same at module yard and at construction site, adoption of Module is limited only for cases such as;
  - Extremely high labor wages and Import of Labor is difficult from strong labor union
  - Extremely harsh weather condition i.e., Arctic, No sun light during winter
  - Construction difficulty due to political situation etc.

- Comparison of construction labor cost for Stick Built and Module for Process Area (1 Train)
  1) Stick Built (Construction site : Australia)
     Labor MH at Site : 12 million MH / Unit Rate : 350 US$/MH
     Cost : 4.2 billion US$
  2) Module (Construction site : Australia, Module yard : China)
     Labor MH at Module Yard : 17 million MH / Unit Rate : 25 US$/MH
     Labor MH at Site : 2.5 million MH / Unit Rate : 350 US$/MH
     Cost : 1.3 billion US$

**Delta Cost : approx. 3 billion US$**
Construction Method (Stick Built・Module・FLNG)

- Comparison of EPC schedule

![Graph showing comparison of EPC schedule for different construction methods. The graph plots project completion time against LNG plant capacity (MTPA). Key points include Stick Built Plant, Module Plant, 2nd or 3rd Trains, Weather (Cold) Restriction, Construction Boom (2005-2008), and 2nd Train.]
**Construction Method (Stick Built・Module・FLNG)**

### Floating LNG (FLNG)

- FLNG is adopted only limited case where there is an advantage of overall cost including upstream subsea pipeline since FLNG capex is higher than onshore construction. And there is a challenge since there is no commercial operational plant yet.

- FLNGs under construction

<table>
<thead>
<tr>
<th>Prelude FLNG</th>
<th>Petronas 1&amp;2</th>
<th>Caribbean FLNG</th>
<th>Golar FLNG (Hili)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>Petronas</td>
<td>Exmar</td>
<td>Golar</td>
</tr>
<tr>
<td>5 mtpa(all liquid)</td>
<td>1.2 – 1.6 mtpa</td>
<td>0.5 mtpa</td>
<td>2.2 mtpa</td>
</tr>
<tr>
<td>New build</td>
<td>New build</td>
<td>New build (barge)</td>
<td>Conversion</td>
</tr>
<tr>
<td>Shell DMR</td>
<td>N2 expander</td>
<td>B&amp;V SMR</td>
<td>B&amp;V SMR</td>
</tr>
<tr>
<td>7 years+ (*1)</td>
<td>5 years (*2)</td>
<td>3+ years(*3)</td>
<td>3+ years</td>
</tr>
</tbody>
</table>

Note 1) 1st LNG in 2018 expected  
Note 2) PFLNG 2 is suspended  
Note 3) cancelled
Stick Built LNG Project (1/4)

Reference is an LNG Project in a remote area in Papua New Guinea

- **Client**: ExxonMobil PNG Ltd.
- **Location**: 25km Northwest to Port Moresby, Papua New Guinea
- **Plant**:
  - LNG 3.45 MMTPA x 2 trains
  - Marine Offloading Terminal
  - Common and Support facilities
- **Market**: Japan, Taiwan, China
- **Scope of Work**: FEED/EPC
- **Process**: C3-MR

Courtesy of ExxonMobil PNG Ltd.
Plant Overview

Courtesy of ExxonMobil PNG Ltd.
Project History (2008~2014)

2008

2011

2012

2014

Courtesy of ExxonMobil PNG Ltd.
PNG utilize the aero-derivative gas turbines (GTs) for the refrigeration compressors

Advantages for Selection of Aero-derivative GT

- Higher efficiency (Less consumption of feed gas as fuel)
- Lower CO2 Emission
- Shorter Down Time
- Easier start-up (Small start-up torque)
- Easier installation due to enhanced package system
- Lighter weight body (Small Loading Data)
- Compact system (Effective to Plot Plan Design)

Source of fig.: http://www.ecomagination.com/portfolio/pgt25-dle-g4-dle
Parallel operation of Refrigerant compressors

Two (2) parallel C3 compressors and three (3) parallel MR compressors are selected in accordance with the size (duty) of aero-derivative GT.

Disadvantage

◆ Complication of compressors operation

In case of the number of compressors increases, system operation will become difficult. To avoid influence to the LNG production due to tie-in / tie-out (connection / disconnection) of each compressor, more sensitive control and operating procedure are required.

The refined dynamic simulation technique was fully used for and incorporated into system.

Successfully stared up quickly and achieved target LNG production rate!!
Air-cooling system

Advantage

- Reduce concerns to marine environment
- Reduce infrastructure installed cost

AFC can transfer the heat from the process fluid into ambient air with limited environmental concerns, and eliminate extensive water intake facility as well as water piping system including outfall system.

Disadvantage

Reduction of cooling performance due to Hot Air Recirculation

The LNG production will be influenced by the performance of the main cooling system. In case of larger AFC system, the plant performance due to Hot Air Recirculation will be a concern, and appropriate measures need to be required.
Air-cooling system

HAR impact to LNG production were checked by process simulation from the result of Hot Air Recirculation study by CFD. The results were incorporated into Plot Plan and equipment & structure design at each engineering phase. **HAR impact was controlled within the very limited level.**

**Challenge Outcome / Accomplishment:**
- Reduced & minimized environmental impact to sea ecosystem,
- Minimized infrastructure installed cost, and
- Eliminated construction delay possibility of buried piping from cooling water intake due to rainy season.
Construction Site of Tangguh Project and PNG Project
Comparison of Ambient Condition

Average ambient temperature and precipitation for construction site of Tangguh LNG Project and PNG LNG project are as shown below.

- The ambient temperature at the both plants are almost same due to close location as shown in the previous page.
- The precipitation of each month at Tangguh LNG plant site is higher than those at PNG LNG plant site.

![Graphs showing average monthly mean temperature and precipitation for PNG and Tangguh LNG plants.](image)
Stick Built LNG Project (2/4)

Reference is an LNG Project Constructed under Harsh Conditions in Russia

- Sakhalin Island
- Client: Sakhalin Energy Investment Company Ltd.
- Annual Production Capacity: 4.8 MMTPA x 2 trains
- Process: Shell DMR
- Russian 1st LNG Plant
- Challenge of Sub-Arctic Conditions

Courtesy of Sakhalin Energy Investment Company Ltd.
Stick Built LNG Project (3/4)

Reference is an LNG Project in a remote area in Oman

- Client: Oman LNG L.L.C.
- Location: Qalhat, Oman
- Plant: LNG 3.3 MMTPA x 2
  LNG & LPG Terminal
- Scope of Work: EPC
- Process: C3-MR

- Client: Qalhat LNG S.A.O.C
- Location: Qalhat, Oman
- Plant: LNG 3.3 MMTPA x 1
  LNG & LPG Terminal
- Scope of Work: FEED & EPC
- Process: C3-MR

Courtesy of Qalhat LNG
National Content Contribution

Specialty of Qalhat LNG

Concentric Circular Recruiting

1st Priority on Local Region

2nd priority
Sharqiya region like Ibra and Jalan.

3rd priority
other area in Oman like Muscat and Nizwa.

Training

Two Big Projects executed in parallel in Sur Area.

<table>
<thead>
<tr>
<th>Project</th>
<th>Peak Worker</th>
<th>Omani and Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fertilizer (Start 2002)</td>
<td>8,000</td>
<td>1,600 (20%)</td>
</tr>
<tr>
<td>Q-LNG (Start 2003)</td>
<td>3,500</td>
<td>1,300 (35%)</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>11,500</strong></td>
<td><strong>2,900</strong></td>
</tr>
</tbody>
</table>

Ref. Previous Project:
Peak No. of Omani: 1,000
Omanisation Ratio: 15%
No of trained Omani: 350

Since this scale of skilled Omani workforce is not available in this region. Extensive Training becomes required.
National Content Contribution

Accomplishment of Omanisation

<table>
<thead>
<tr>
<th>Omani (Manhead)</th>
<th>Omani + Expatriate (Manhead)</th>
<th>%*</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>659</td>
<td>1,560</td>
<td>42.2%</td>
<td>As of 13th November ’05</td>
</tr>
<tr>
<td>1,353</td>
<td>3,669</td>
<td>36.9%</td>
<td>Peak</td>
</tr>
</tbody>
</table>

*: This figure is one month only.

Omani Off-the-Job Training Program

<table>
<thead>
<tr>
<th>Name of Subcontractor</th>
<th>Training Institute</th>
<th>No. of Trainees Graduated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carillion Alawi</td>
<td>NTI</td>
<td>76</td>
</tr>
<tr>
<td>BEC (O&amp;M)</td>
<td>TATI</td>
<td>3</td>
</tr>
<tr>
<td>BEC (MEI)</td>
<td>TATI</td>
<td>348</td>
</tr>
<tr>
<td>WACASCO</td>
<td>NHI</td>
<td>11</td>
</tr>
<tr>
<td>Interbeton</td>
<td>NTI</td>
<td>8</td>
</tr>
<tr>
<td>Al Jaber</td>
<td>Al Jaber Training Centre (Abu Dhabi)</td>
<td>6</td>
</tr>
<tr>
<td>CAPE EAST</td>
<td>CAPE EAST Training Centre</td>
<td>445</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>897</strong></td>
</tr>
</tbody>
</table>
National Content Contribution

Civil Subcontractor Training Achievement

- 324 interviewed (MoM)
- 168 trainees
- 74 trainees joined
- 94 drop out of trainees
- 54 working force

32% conversion

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Leaflets of Qalhat LNG (QLNG) Project were handed to Oman Chamber of Commerce & Industry, Sur Municipality, Office of Walli and directory to Shops & Subcontractors in Sur. Shops & Subcontractors, who interest in the project, contact to us. Local Content Database is prepared to share information at Omanisation Club.
National Content Contribution

Procurement and Subcontract from Neighboring Village

- A total of 2.7 Million Omani Riyal. (Equiv. 7.0 Million USD) in goods and services have been procured from a neighboring village.
National Content Contribution

Key Performance Indicator (KPI)

<table>
<thead>
<tr>
<th>KPI</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KPI 1</td>
<td>Accomplishment of 35% Omanisation</td>
</tr>
<tr>
<td>KPI 2</td>
<td>Employing Omani people from neighboring village, Sur and Sharqiya region</td>
</tr>
<tr>
<td>KPI 3</td>
<td>Off-the-Job training for Omani people</td>
</tr>
<tr>
<td>KPI 4</td>
<td>Employing Omani graduated from Off-the-Job training</td>
</tr>
<tr>
<td>KPI 5</td>
<td>Local procurement and/or local subcontract from neighboring village, Sur and Sharqiya region</td>
</tr>
</tbody>
</table>
National Content Contribution

Key Performance Indicator (KPI)

OVERALL PERFORMANCE SCORE IS 95.67 AGAINST TARGET OF 80
OMANISATION LEVEL 37.5% AGAINST TARGET 35% HIGHEST IN OMAN

KPI 1 - Accomplishment of 35% Omanisation (87.6)
KPI 2 - Sur/Sharqiya Omanis (100.0)
KPI 3 - Off the Job Trainees (100.0)
KPI 4 - Graduated Employee (100.0)
KPI 5 - Local Procurement (100.0)

Scores Chart:
- (91 - 100)
- (81 - 90)
- 80
- (0 - 79)
- As of November 2005
National Content Contribution

Omanisation Award

We received an honour for its remarkable effort toward Omanisation
National Content Contribution

Chiyoda is always ready to support clients’ requirements by reflecting lesson learned from various past projects.

- Maximize use of local services
- Maximize number of local employees
- Contribution to local society
- Technology transfer
- Training of local people

Signing ceremony of training course in Japan for Qatari engineers witnessed by Qatari Emir and Japanese Prime Minister.

Chiyoda concluded a training “Memorandum of Understanding” with Empresa Nacional de Hidrocarbonetos (ENH) in Mozambique, and a training MOU with Ministry of Energy & Minerals (MEM) in Tanzania.

Training Center built by Qalhat Project in Oman.
No Loss Time Incident during entire Project duration

Omani HSE Training

<table>
<thead>
<tr>
<th></th>
<th>Total Projected</th>
<th>Total attended</th>
<th>Attendance%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>690</td>
<td>469</td>
<td>69.61%</td>
</tr>
<tr>
<td>2nd</td>
<td>595</td>
<td>470</td>
<td>79.00%</td>
</tr>
<tr>
<td>3rd</td>
<td>789</td>
<td>738</td>
<td>93.54%</td>
</tr>
<tr>
<td>4th</td>
<td>809</td>
<td>737</td>
<td>91.10%</td>
</tr>
<tr>
<td>5th</td>
<td>743</td>
<td>692</td>
<td>93.14%</td>
</tr>
</tbody>
</table>

Omani refreshed course is continuous held in addition ordinary course. 3,106 Omanis attended.

Texts of HSE Training for Omani
No Loss Time Incident during entire Project duration
No Loss Time Incident during entire Project duration

Qalhat LNG

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Worked Manhour</td>
<td>20,200,000*</td>
</tr>
<tr>
<td>No. of Fatality</td>
<td>0</td>
</tr>
<tr>
<td>Lost Workday Cases</td>
<td>0</td>
</tr>
<tr>
<td>Restricted Work Cases</td>
<td>8</td>
</tr>
<tr>
<td>Medical Treatment Cases</td>
<td>24</td>
</tr>
<tr>
<td>Total Recordable Cases</td>
<td>32</td>
</tr>
<tr>
<td>Total Recordable Injury Rate</td>
<td>0.32</td>
</tr>
<tr>
<td>Lost Time Injury Rate</td>
<td>0</td>
</tr>
</tbody>
</table>

No Loss Time Incident during entire project duration with 37% Omanisation
Reference is a Super Large Capacity LNG Project in Qatar

- Chiyoda constructed more than 90% of LNG production capacity in Qatar.
- Substantial contribution to Qatar’s annual production capacity of 77 million tonnes of LNG.

Qatargas II
Annual Production Capacity:
7.8MMTPA x 2 trains
Process: AP-X

Rasgas (3)
Annual Production Capacity:
7.8MMTPA x 2 trains
Process: AP-X

7.8 MMTPA is the world’s largest production capacity train.
Key Quantities (3LLNG Total)

- Concrete used: 730,000 m³
- Structural Steel used: 145,000 tons
- Gross weight of Machinery: 260,000 tons
- Gross weight of Pipe: 240,000 tons
- Total length of Cable: over 20,000 km
- Highest Structure: Flare Stack 200 m
- Capacity of LNG Storage Tank: 140,000 m³
- Area of Painting work: 3,200,000 m²
- Volume of Marine Transport: 2,800,000 FT
- Number of Crane used: over 650
- Number of Commuting Buses: 600
Number of Workers Recruited and Nationalities

- 20,000 Workers (39 Countries) in 2006,6
- 57,000 Workers (70 Countries) in 2007,6
- 75,000 Workers (86 Countries) in 2008,6
- 53,000 Workers (63 Countries) in 2009,6
The proportion of workers from India, Philippines and Nepal is big.
Module Project (1/2)

Reference is an Module Project under Extremely Harsh Weather in Russia

- **Client**: Yamal LNG
- **Location**: Port of Sabetta, Yamal Peninsula, Russia
- **Plant**: 16.5 MMTPA (5.5 MMTPA x 3 Trains)
- **Scope of Work**: EPC
- **Process**: APCI C3-MR
Harsh Weather Condition

Module construction method is adopted due to harsh weather condition at construction site.

- Day Light less than 3 hours : 4 months
- Temperature less than 0 deg. C : 8 months
<table>
<thead>
<tr>
<th>Yard</th>
<th>Module Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMENS</td>
<td>40,200 MT</td>
</tr>
<tr>
<td>COOEC</td>
<td>159,800 MT</td>
</tr>
<tr>
<td>PJOE</td>
<td>105,900 MT</td>
</tr>
<tr>
<td>BOMESC</td>
<td>48,600 MT</td>
</tr>
<tr>
<td>CPOE</td>
<td>14,700 MT</td>
</tr>
<tr>
<td>McDermott (China)</td>
<td>12,400 MT</td>
</tr>
<tr>
<td>McDermott (Batam)</td>
<td>18,700 MT</td>
</tr>
<tr>
<td>SMOE</td>
<td>8,100 MT</td>
</tr>
<tr>
<td><strong>Total Module Weight</strong></td>
<td><strong>408,400 MT</strong></td>
</tr>
</tbody>
</table>
Construction Site View


Module Project (2/2)

Reference is an Module Project under High Salary Level in Australia

- **Client**: INPEX Operations Australia Pty Ltd.
- **Location**: Darwin, Northern Territory
- **Plant**: 8.4 MMTPA (4.2 MMTPA x 2 Trains)
- **Scope of Work**: EPC
- **Process**: APCI C3-MR
High Salary Level at Construction Site

Module construction method is adopted due to high salary level at construction site.

- High Salary Level in Australia: Average Weekly Earning
  Lowest (Accommodation and food services industry): AU$1,122
  Highest (Mining industry): AU$2,780
  Construction: AU$1,710

- High Quality Accommodation Camp

http://image.search.yahoo.co.jp/search?r=2&ei=UTF-8&p=INPEX+ICHTHYS+Village
# Module Yard Fabrication

<table>
<thead>
<tr>
<th>Yard</th>
<th>Module Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>STP&amp;I</td>
<td>82,700 MT</td>
</tr>
<tr>
<td>COOEC</td>
<td>44,200 MT</td>
</tr>
<tr>
<td>CUEL</td>
<td>38,700 MT</td>
</tr>
<tr>
<td>AG&amp;P</td>
<td>16,500 MT</td>
</tr>
</tbody>
</table>

**Total Module Weight** 182,100 MT
FLNG

New Concept

Seeking for an innovative solution to monetize stranded offshore gas reserves without H2S has led to the invention of the FLNG

- avoiding significant cost for subsea pipe line to shore and associated gas compression facility

FLNG solution has then been proposed as alternative of various gas utilization applications, i.e. onshore / nearshore reserves, pipeline gas aiming;

- avoiding complicated/lengthy permitting, regulatory approvals associated with onshore
- reducing costs with onshore construction, e.g. site prep, high labor cost
- reducing the work at isolated area where workforces are limited

FLNG capacity and technologies vary depending on the Client needs and most optimum application
## Recent Chiyoda’s major FPSO/FLNG experiences (all new build hull & storage)

<table>
<thead>
<tr>
<th>Project</th>
<th>Client</th>
<th>Location</th>
<th>Scope</th>
<th>Capacity</th>
<th>Process</th>
<th>Award</th>
<th>Delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scarborough FLNG</td>
<td>Esso Australia Resources Pty. Ltd.</td>
<td>Australia</td>
<td>Conceptual Study</td>
<td>3.5 MTPA</td>
<td>Patent</td>
<td>2016</td>
<td>c.a. 5 yrs</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>Australia</td>
<td>Pre-FEED</td>
<td>2.3 MTPA</td>
<td>mixed ref. w/CWHE</td>
<td>2015/2016</td>
<td>5 – 6 yrs</td>
</tr>
<tr>
<td>Coral FLNG</td>
<td>Eni East Africa S.p.A.</td>
<td>Mozambique</td>
<td>FEED</td>
<td>3.2 MTPA</td>
<td>mixed ref. w/CWHE</td>
<td>2014</td>
<td>5 – 6 yrs</td>
</tr>
<tr>
<td>Jangkrik Floating Production Unit</td>
<td>Eni Muara Bakau B.V.</td>
<td>Indonesia</td>
<td>FEED EPCI</td>
<td>N/A</td>
<td>N/A</td>
<td>2012</td>
<td>c.a. 3 yrs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>Scarborough FLNG</td>
<td>Esso Australia Resources Pty. Ltd.</td>
<td>Australia</td>
<td>Pre-FEED Optimisation Study</td>
<td>6.8 MTPA</td>
<td>mixed ref. w/CWHE</td>
<td>2012</td>
<td>5 – 6 yrs</td>
</tr>
<tr>
<td>Abadi FLNG</td>
<td>INPEX Masela, Ltd.</td>
<td>Indonesia</td>
<td>FEED</td>
<td>2.5 MTPA</td>
<td>mixed ref. w/CWHE</td>
<td>2013</td>
<td>5 – 6 yrs</td>
</tr>
<tr>
<td>Petrobras FLNG</td>
<td>Petrobras Netherlands B.V.</td>
<td>Brazil</td>
<td>FEED Pre-EPC</td>
<td>2.7 MTPA</td>
<td>mixed ref. w/CWHE</td>
<td>2009</td>
<td>5 – 6 yrs</td>
</tr>
</tbody>
</table>

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FLNG

**Hull & Storage Type**

**New build vessel**
- Flexible in production capacity
- Flexible in site condition
- High initial CAPEX
- Long delivery

**LNG carrier conversion**
- Limitation in capacity
- Relatively benign sea
- Lower initial CAPEX (*1)
- Shorter delivery (*1)

**Barge**
- Flexible in production capacity
- Nearshore application
- Lower initial CAPEX (*1), (*2)
- Shorter delivery (*1), (*2)

Note 1) LNGC can be used as LNG storage.
2) In case of new LNG storage built inside barge, longer delivery and higher CAPEX.
FLNG for large gas reserves aiming high efficiency with large capacity, hence the mixed refrigerant with CWHE be selected.

Small reserve, early monetization of onshore/nearshore gas tends to select simpler and lower initial CAPEX investment technology, i.e. single phase refrigerant or SMR with cold box.
FLNG

Chiyoda’s Minimum CAPEX FLNG

While many FLNG projects are proposed, very few of them are sanctioned due to high CAPEX.

CHIYODA proposes a **CAPEX minimum** Concept with

"$600 – $800 per LNG ton"*

* Note ; under benign and shallow water condition. CHIYODA has countless cost reduction ideas, i.e.:

- LNGC conversion to FLNG:
- Hybrid (direct mounted and module) construction:
- Single phase refrigerant technologies:
- Shorter delivery:
New LNG Business Opportunity in Indonesia

Chiyoda provides **Full Supports** to client from FS, FEED, EPC, O&M for the entire LNG business value chain.

FS: Feasibility Study  
FEED: Front End Engineering Design  
O&M: Operation and Maintenance
Mini LNG

Mini LNG Plant is beneficial for its plant operator due to the followings.

- Lower investment cost and smaller risks
- Easier to secure product offtakers
- Shorter schedule and faster monetization (Standard “Mini LNG” project duration up to Commissioning & Start up is around 34 months for 0.3 MTPA case, which is approx. 20 months shorter than those for conventional approach.)
- Energy supply in remote areas where gas pipeline is not available

Suitable liquefaction process for Mini LNG (up to 1mtpa of LNG production) are **N2 expander Process and SMR process**. Chiyoda’s advanced N2 Expander Process(*) is superior to the other N2 expander process. While, SMR process, licensed by 3rd party, provides higher liquefaction efficiency and better flexibility in operation. **Chiyoda can offer both N2 and SMR process.**

* Patent pending

**Advantages of Chiyoda mini LNG**

- **Fast Production**
  - Standardized Design
  - Modularized Design

- **Lower Investment Cost**
  - Simplicity
  - Low CAPEX
  - Low OPEX
1. Configurations of Power Ship

- Floating Regasification and Power Generation Unit
  (Min. ~ 50 MW: Gas Engine, 50 MW ~ 170 MW (*1): Gas Turbine Combined Cycle)
  (*1) Max Power can be expanded upon Customer’s Request
  Dual Fuel Type (Diesel Oil & Natural Gas) can be available.
- LNGC (LNG Carrier) Conversion to Multiple Power Ships
- Hybrid Type available (Power Generation and Gas Transmission)(*2)
  (*2) Utilizing LNG Cryopower available (Patented Technology by Chiyoda)
- Utilization of LNG Storage Tank in LNGC for Lower CAPEX and Shorter Power Ship Delivery

2. Applications of Power Ship

- Electrical Power Supply for Countries with Remote and Small Islands.
- At Nearshore Small or Medium Size Offshore Gas Fields, Power Ship can produce Electricity on the Ship and send Electrical Power to Onshore.
- Peak Shaving for Power Supply in Seasonal Variation Demand Area.
- Rescue Operation for Suffered Natural Disaster’s Areas.
3. Chiyoda’s Advantages for Power Ship

Chiyoda has Many Advantages for Power Ship Design

◆ No.1 Shares in LNG Receiving Terminals in Japan

◆ Many Experiences and Know How in;
  - Process Design for LNG Receiving Systems
  - Regasification and Gas Send-out
  - Cool Down & Commissioning Work

◆ Chiyoda’s Project Experiences of Gas FPSO and FLNG can be utilized for Power Ship Project Execution.
EPC Execution

Information Technology i-Plant 21

- Integrate Engineering, Procurement and Construction in seamless and maximum reliability of EPC.
- Allocate the most advanced and reliable IT systems.
EPC Execution

Home Office / Engineering MH

Total Home Office MH of LNG project are in the order of magnitude shown below.

<table>
<thead>
<tr>
<th>Project Scale</th>
<th>Total HO MH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Scale Plant</td>
<td>4,500,000 – 5,500,000</td>
</tr>
<tr>
<td>Middle Scale Plant</td>
<td>2,500,000 – 3,500,000</td>
</tr>
<tr>
<td>Full Copy Plant</td>
<td>35 - 45 % of Original Plant</td>
</tr>
</tbody>
</table>

* The above figures vary depending on project requirement.

Chiyoda uses HVEC (High Value Engineering Center) for detail engineering in order to keep its competitiveness in LNG plant construction industry.

CPh OFFICE
MANDALUYONG

Number of Employees: 901 (As of August 31, 2016)

L&TC MAIN ENG. OFFICE
VADODARA

Number of Employees: 617 (As of August 31, 2016)
Sourced equipment and material in QUALITY from all over the world (over 15 countries)
Sourced equipment and material in QUALITY from all over the world (over 15 countries)
Total of 400,000 freight-tons were recorded for transportation.
<table>
<thead>
<tr>
<th>Project</th>
<th>Designated Port &amp; Country</th>
<th>Year</th>
<th>Total Freight Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oman LNG</td>
<td>Qalhat, Oman</td>
<td>2003</td>
<td>80,000</td>
</tr>
<tr>
<td>Sakhalin LNG</td>
<td>Prigorodonoye, Russia</td>
<td>2003-2004</td>
<td>400,000</td>
</tr>
<tr>
<td>Qatargas I &amp; II</td>
<td>Ras Laffan, Qatar</td>
<td>2005-2009</td>
<td>800,000</td>
</tr>
<tr>
<td>RasGas LNG</td>
<td>Ras Laffan, Qatar</td>
<td>2005-2009</td>
<td>780,000</td>
</tr>
<tr>
<td>Qatargas 3 &amp; 4</td>
<td>Ras Laffan, Qatar</td>
<td>2005-2009</td>
<td>840,000</td>
</tr>
<tr>
<td>PNG LNG</td>
<td>Motukea, Papua New Guinea</td>
<td>2009-2012</td>
<td>390,000</td>
</tr>
<tr>
<td>Tangguh LNG</td>
<td>Tangguh, Indonesia</td>
<td>2016-on going</td>
<td>2,500,000</td>
</tr>
</tbody>
</table>
Two ways of inland transportation to Site
Normal & Container cargoes from Port Moresby Harbor to Site (~25km)
Heavy & Large Bulk Cargoes from Fairfax Harbor New Wharf to Site (~18km)

Year 2009
Used Private New Wharf Instead of Temporary MOF

Year 2014
New Wharf Under Construction

New Wharf in Service

PNG LNG Site
Fairfax Harbor
Port Moresby Harbor

Courtesy of ExxonMobil PNG Ltd.
Overcoming technical difficulties and minimizing disturbance to the local community while hauling heavy cargos to site using public roads.

Total number of cargo: 348 items (106,000Ft)

Heaviest item: 541 tons

Longest item: 53 meters

Courtesy of ExxonMobil PNG Ltd.
EPC Execution

Logistic

Transportation distance from port to site: 18km (public road)

Total: 165 bays of AFC

Courtesy of ExxonMobil PNG Ltd.
EPC Execution

Construction

Increase in Capacity of LNG Production and Capacity of Acid Gas Absorber

<table>
<thead>
<tr>
<th>Completion Year</th>
<th>2000</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site</td>
<td>Oman</td>
<td>Russia</td>
<td>Qatar</td>
</tr>
<tr>
<td>LNG Capacity (mtpa/Train)</td>
<td>3,300</td>
<td>4,800</td>
<td>7,800</td>
</tr>
<tr>
<td>Absorber Capacity (Tonnage)</td>
<td>416</td>
<td>590</td>
<td>1,340-1,380</td>
</tr>
</tbody>
</table>

A large-size crane (2,000ton, Demag CC4800) for installation of large machinery (Absorber 1,450Ton)

Courtesy of Qatargas Operating Company Limited
EPC Execution

Construction

The peak period of Qatargas I&II
Cranes : 250
Cranes over 100Ton : 45

Courtesy of Qatargas Operating Company Limited
EPC Execution

Construction

Build on time the 10,000-bed camp for all Company, Contractor, and Subcontractor personnel. (PNG Project)

Courtesy of ExxonMobil PNG Ltd.
The 10,000-bed camp includes power supply, water supply, effluent treatment facility, and living and recreational facilities. (PNG Project)
EPC Execution

Construction

Qatargas I&II project
Camp to accommodate 22,000 workers

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EPC Execution

Construction

Qatargas I&II project
Contractor Camp

Courtesy of Qatargas Operating Company Limited
EPC Execution

Specialty for LNG Plant Construction

- Slag Catcher Metering Facility
- Acid Gas Removal
- Dehydration
- Mercury Removal
- Heavy Hydrocarbon Removal
- Liquefaction
- Boil Off Gas
- Refrigerant Storage
- Condensate
- Refrigerant Compressor
- Gas Turbine
- Fuel Gas System
- Gas Turbine Power Generation
- Boiler
- Seawater Intake
- Fuel Gas System
- Degreasing
- Pneumatic Piping Pressure Test
- Large Bore Piping Internal Cleaning
- Refrigerant Compressor Mechanical Running Test

Source: Oil & Natural gas review
EPC Execution

Chiyoda’s Reliability Program

• **Reliability Program - Objective**
  The Reliability Program focuses on eliminating overlooked inherent weaknesses through each phase of the project, in order to **deliver a Highly Reliable Plant** to its clients.

• **Lessons Learnt**
  Maintain a Database of Lessons Learnt obtained from failures/successes through its own project execution experience, and feeding back to current works.

• **Cold Eye Review**
  Review of Project execution by an independent body based on objective views, identifying potential deficiencies and Project risk areas.

• **Intensive Design Review**
  Review the identified critical engineering & design themes in order to point out critical engineering problem areas, and verify solutions.

• **Un-Interrupted Start-Up (UISU) Program**
  Hands-on experience with the Un-Interrupted Start-Up Program together with lessons learnt from past projects will be utilized on new project commencing with FEED and through all subsequent phases of the Project.

*All LNG plants constructed by Chiyoda operate continuously above its rated capacity*
EPC Execution

Chiyoda’s Reliability Program

1. Qalhat LNG Project in Oman:
   First drop of LNG in **9.1 days** from Ready for Start-Up (RFSU).
   First Cargo in 30 days from RFSU.

2. Qatargas 3 & 4 (Train 7):
   First drop of LNG in **11 days** from feed gas injection.
EPC Execution

LNG Data Base

Chiyoda’s experience in LNG plants is stored in an LNG data base that comprises 7 major categories for ease of reference and retrieval.
EPC Execution

Chiyoda’s Earlier Involvement for Maximizing NPV

Superior Project Definition with EPC Expertise

- High quality project definition in early project stage based on the vast experience.
- Continuous execution from FEED to EPC

- Maximizing CAPEX reduction, hence, maximizing NPV
Thank you