# MARINE MODELLING FOR AN ONSHORE LIQUEFIED NATURAL GAS TERMINAL IN GUJARAT, INDIA

## Providing input to the preparation of Front End Engineering Design

HPCL Shapoorji Energy Limited (HSEL) – a joint venture between state-owned Hindustan Petroleum Corporation Limited and SP Ports Private Limited – intends to construct an onshore liquefied natural gas (LNG) import and regasification terminal in Chhara, a village in Gujarat, India. HSEL has appointed Engineers India Limited (EIL) as consultant to prepare Front End Engineering Design (FEED) packages, which are used as the basis for bidding the Execution Phase Contracts (Engineering Procurement Construction) and as the design basis. To support EIL in their preparation of FEED, HSEL engaged DHI to carry out a marine modelling study for the proposed terminal.

### MARINE MODELLING STUDIES FOR AN LNG TERMINAL

Chhara port is being developed as an all-weather port with water depth available to -20m chart datum. The wave tranquillity within the port will be achieved by an offshore breakwater on the natural shoal bank approximately 2.5 km away from the shore line. DHI conducted a marine modelling study to help establish if the construction of the terminal was viable. Our scope of work spanned different areas, including:

- Oceanographic site data analysis
- Metocean modelling accounting for near-actual site conditions
- Littoral drift assessment and sediment rate assessment
- Downtime analysis to establish the threshold performance criteria for the operation of LNG terminal

*Site location in Chhara, a village in the Gujarat state, India. © DHI*

### CLIENT

HPCL Shapoorji Energy Ltd

### CHALLENGE

- Determining water level to ascertain the deck elevations of offshore and onshore facilities
- Establishing the threshold performance criteria to operate the LNG marine terminal
- Assessing the conditions of littoral drift and sediment rate
- Conducting mooring analysis for the proposed LNG carrier for starboard and port side berthing
- Carrying out 2D and 3D ship navigation simulation studies

### SOLUTION

Using a full package of modelling solutions, we:

- established acceptable wave conditions inside the new port, providing accurate design wave conditions
- modelled the change in hydrodynamics of the port waters and resulting moored vessel interactions
- determined probable future impact on the coastlines

### VALUE

The marine modelling studies we carried out provided the required input for the preparation of Front End Engineering Design (FEED) by Engineers India Limited (EIL).

### LOCATION / COUNTRY

Gujarat, India

### SOFTWARE USED

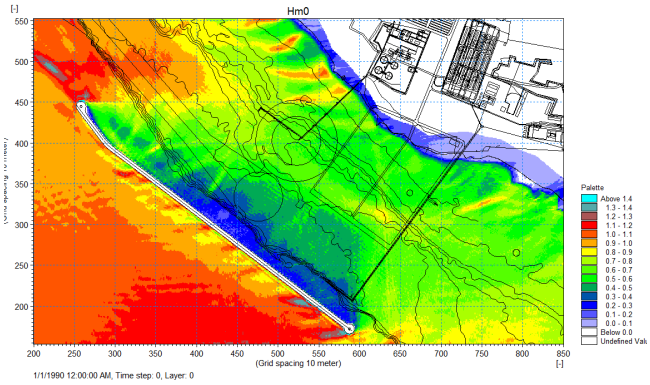
MIKE 21

- Study of site specific hazards including effects of tsunamis for the project area
- Navigation simulation studies for a range of LNG carrier designs
- Dynamic mooring analysis
- Carrying out coastal impact assessment studies

## USING MIKE 21 TO MODEL PORT CONDITIONS

We used MIKE Powered by DHI's two-dimensional (2D) coastal modelling software MIKE 21 to model the current conditions at the port. We studied wave transformation under fair weather and cyclone conditions, currents, sediment transport and morphological evolution.

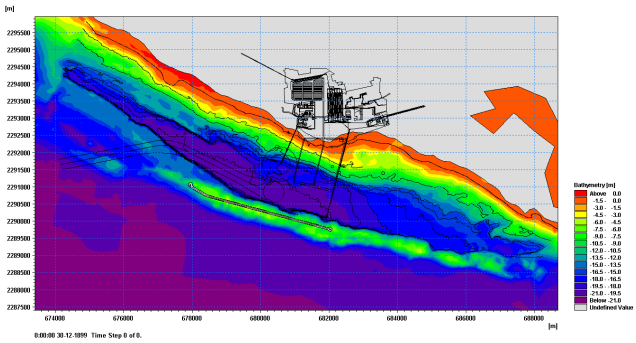
MIKE 21 allowed us to provide sufficient coverage of the overall port surroundings and maintain the required level of detail at key locations, while achieving reasonable model simulation times. For the wave transformation modelling, we applied our third generation spectral wind-wave model – MIKE 21 SW. We then analysed the modelled long-term wave conditions. This provided the design wave as well as the normal wave conditions governing port operations. A nearshore wave model was applied to describe the wave conditions inside the port area.




*Snapshot of significant wave height inside the port. © DHI*

The hydrodynamic (HD) modelling was done using our 2D HD flow model, MIKE 21 FM. MIKE 21 FM was used to model free-surface flows, based on a finite volume solution to the non-linear shallow water equations. The model simulated water level variations and flows in response to a variety of forcing functions, including tides, winds and waves. The HD model encompassed the Gulf of Khambhat area. It included a detailed representation of the HD flow field and water levels from the general port area and adopted a flexible mesh discretisation of the model domain.

The set-up included a detailed high-resolution description of the proposed LNG terminal berths. The calibrated model was used to simulate the HD flow fields used in the moored vessel analyses.



*Bathymetry near the port (HD model). © DHI*

## STORM SURGE MODELLING

The processes of selecting design water level and waves are site specific. Storm surge and cyclonic waves are hind casted from cyclonic track records. The cyclone track of the November 1982 cyclone – which resulted in 341 casualties and heavy flooding –made an appearance very close to the proposed terminal. We carried out storm surge simulations using MIKE 21 HD to assess the surge levels at the LNG terminal for eight such extreme events passing near the site. The 2D wind fields are generated with the cyclone wind generation tool in MIKE 21.

## MOORING STUDY

The main aim of the mooring study was to review the proposed mooring layout for the berth for three types of LNG carrier vessels, all of different sizes. The results were used to compare against safe operating conditions and minimum breaking load (MBL) guidelines.

The outcomes of the mooring analysis were checked against the criteria published by the Oil Companies International Marine Forum (OCIMF, 2008) using the industry-standard mooring software OPTIMOOR.

## PROJECT VALUE

DHI simulated design parameters such as wind, wave, current and water levels at the proposed LNG site. These same values are recommended for input to the FEED prepared by EIL. We analysed major mooring issues which had to be resolved before proceeding into the construction phase and carried out mooring analysis to assess potential downtime based on safe working conditions in the vessels.

## CLIENT TESTIMONIAL

> *The marine modelling studies conducted by DHI are of the highest standards and we are pleased with the outcome.*
>
> *Dushyant Chaturvedi—HPCL Shapoorji Energy Ltd*

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