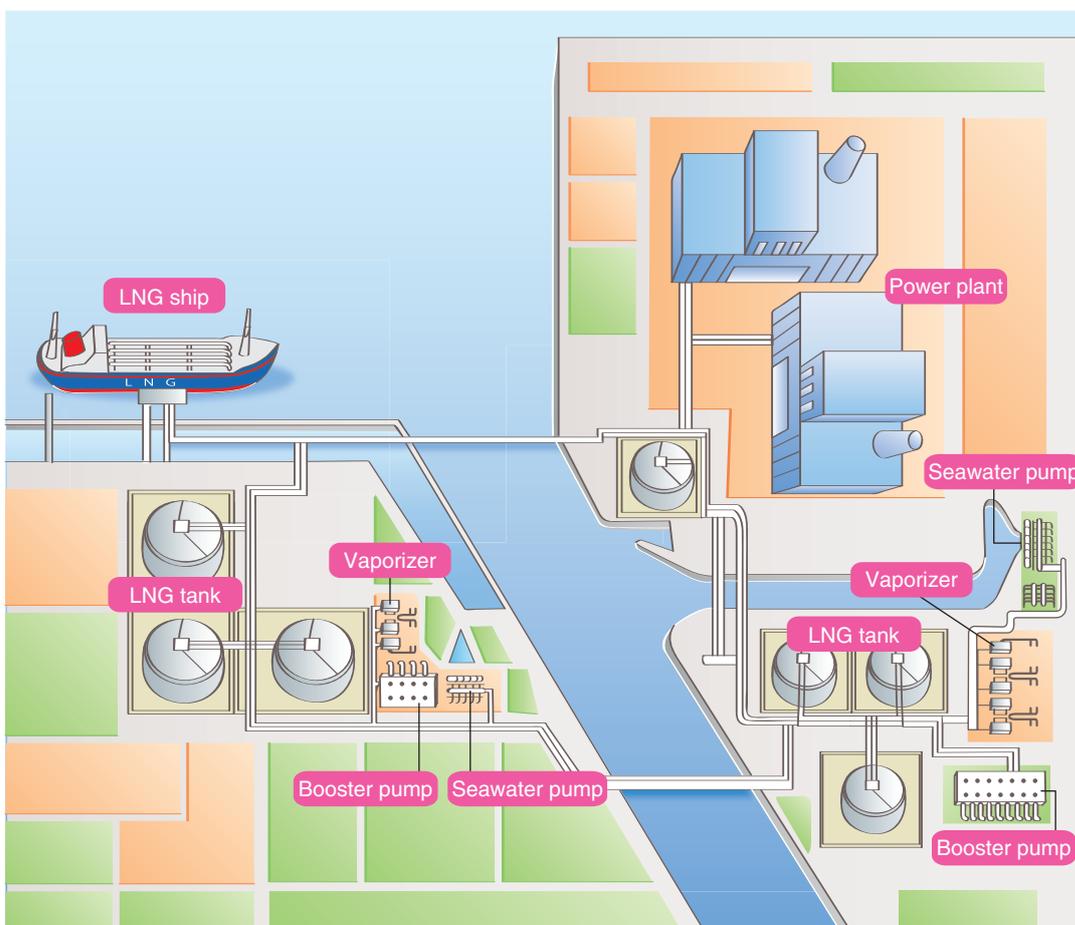


# A Simulator that Replicates an Authentic Training Environment

## An LNG terminal operational training simulator enabling training linked to power plant

Society's need for Liquefied Natural Gas (LNG) is rising, and stable LNG terminal operation is becoming increasingly important. A simulator that faithfully replicates a real plant has been developed as a tool for operational training to maintain, improve and pass on plant operating skills, as well as for pretesting and verification when expanding or renewing facilities. In addition, a brand new form of training linked to a power plant simulator has been achieved.



Overview of LNG terminal

## The rising importance of LNG terminals

Currently, all nuclear power plants in Japan are offline, and power is increasingly supplied from thermal power plants using LNG as fuel. According to the Energy White Paper 2014 by the Agency for Natural Resources and Energy, the energy balance shifted from 30.8% nuclear and 27.2% LNG in 2010 to 1.0% nuclear and 43.2% LNG in 2013, with LNG power compensating for the decrease in nuclear power. For this reason, LNG terminals are becoming more important, and a more stable supply is in demand.

## Expectations for simulators

With the increasing dependence on LNG power, the stable operation of LNG terminals and the training to ensure such operation also become more important. Simulators are being utilized as a leading means for carrying out operational training effectively.

Simulators are commonly used in everyday life through automobile driving instruction and in video games, but simulators are also widely used for operational training related to ships, airplanes and other types of transport, as well as machinery and plant equipment.

IHI has utilized its wealth of technology and knowledge to deliver an operational training simulator for LNG terminals for use with plant facilities. A simulator that replicates actual plant facilities is being recognized as an effective tool for ensuring stable operation of plant facilities, and appropriate operation during times of malfunction or emergency.

## The IHI LNG terminal operational training simulator

The IHI operational training simulator emphasizes authenticity all the way down to the operator's console, and the control logic. Operating screens use the same software as the real plant controller, thereby enabling an immersive and authentic operational training experience. In addition, the simulator is also showing promise as a tool for pretesting and verification when making software modifications of the plant controller.

Additionally, a process model, based on a physics model is implemented for the plant simulation, enabling a high-precision simulation in which the response characteristics for crucial processes differ by just a few percentage points between the simulator and the actual equipment. This enables pretesting that can be conducted before commissioning, and allows control adjustments for commissioning the actual equipment to be completed in a short period. Furthermore, it allows commissioning to be completed safely by reducing risks such as bugs and other potential causes of failure in advance.

The simulator provides an operational environment that enables team-based training operations for abnormal situations using the same number of teams that are based at an LNG terminal. For larger team operations, IHI has achieved a system capable of linked training that encompasses accurate

simulation of both the LNG terminal as well as facilities on the power plant side. In this article, the operational training simulator will be introduced.

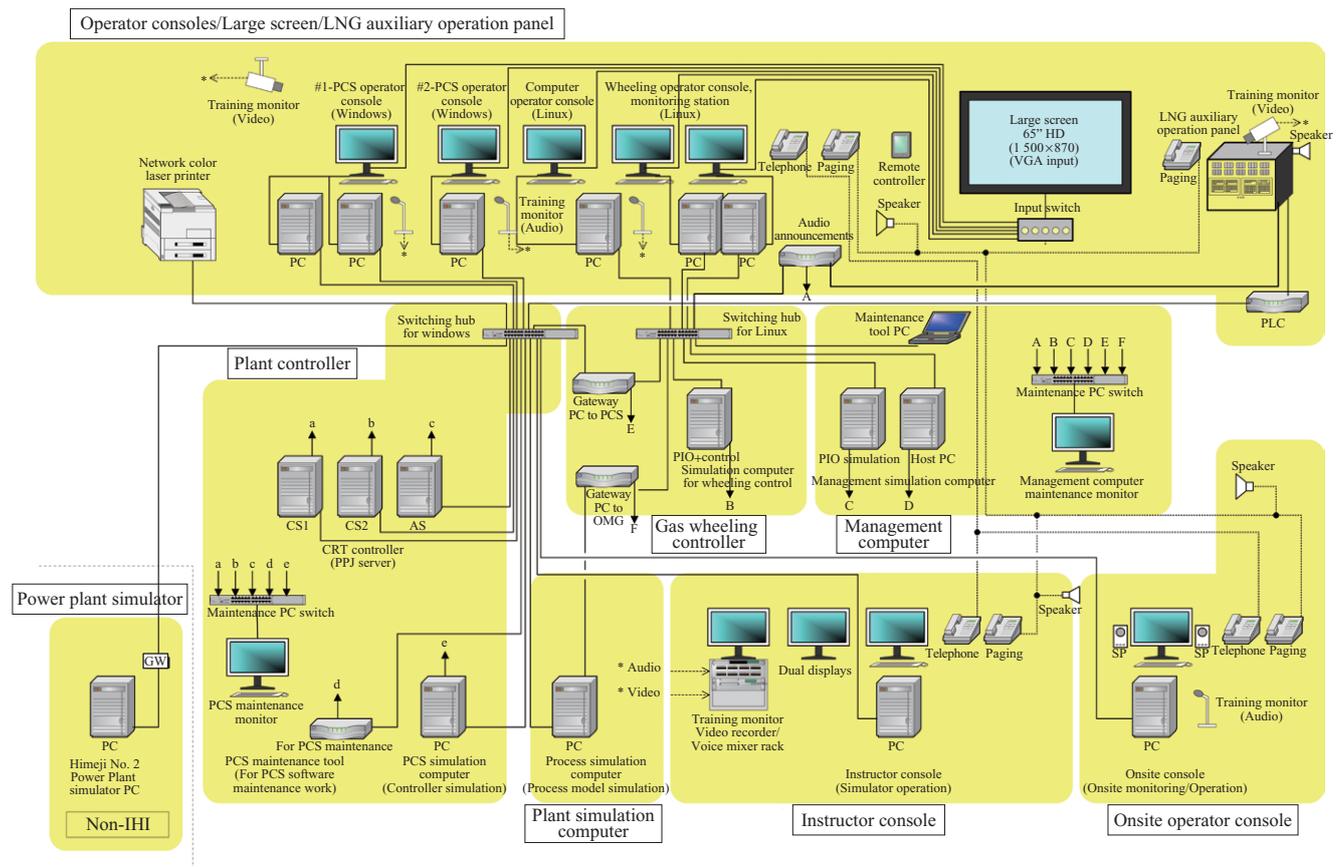
## Progress of the LNG terminal operational training simulator

The operational training simulator introduced in this article was delivered to the Kansai Electric Power Company (KEPCO). Before describing the simulator itself, an overview of an LNG terminal and its role in power generation will be discussed. The above diagram illustrates the relationship between an LNG terminal and a power plant. LNG transported by an LNG ship is stored in LNG tanks via an unloading facility. After the LNG is pressurized and converted to natural gas, the natural gas is supplied to the power plant. In other words, the LNG terminal is a facility that includes functions for the unloading, storing and gasification (pressurization/vaporization) of LNG, and is an important facility for the stable supply of power.

Even today, operational training for LNG terminals intended for thermal power plants is generally composed of classroom lecture. Since the training environment is significantly different from the actual plant, immersive training for real-world operation cannot be achieved. Furthermore, training on the actual plant is practically impossible, because the facilities cannot be taken offline. As a result, in many LNG terminals, the operators must face the difficulties of gaining operational training by relying on past experience and intuition.

The LNG terminal at KEPCO's Himeji No. 2 Power Plant supplies fuel to KEPCO's highest-capacity thermal power plant, as well as to the No. 1 Power Plant. The Himeji LNG Terminal is composed of various facilities, and is also equipped with facilities for supplying town gas and offloading LNG to tankers. Stable running of these facilities requires not only operational control during normal operation, but also operational training for emergencies that could conceivably occur in the event of an accident.

In addition, to achieve higher efficiency the power generation facilities at the Himeji No. 2 Power Plant are currently under renewal from a conventional generation system to a combined generation system. As part of this effort, IHI is responsible for the fuel gas supply facility of the LNG terminal, and has carried out work to raise the pressure of existing low-pressure supply gas facilities as well as work to consolidate the central control room of the power generation facility and the LNG terminal. This difficult task of renewing the facilities must be completed without taking the power generation facility or the LNG terminal offline and made commissioning a challenge for IHI. Meanwhile, IHI delivered a simulator as part of a facility enhancement project at the Himeji LNG Terminal approximately 20 years ago, and the simulator has been used effectively to maintain and improve operational aptitude as well as for pretesting of facility repairs and upgrades.



System configuration of LNG terminal operational training simulator

Accordingly, in order to meet the current challenges, IHI developed, updated, and applied a large-scale simulator that retains the same functions of existing facilities, while also adding new features and expanding the range of simulation to cover all LNG terminal subsystems.

## The pursuit of authenticity

The renewal of the preexisting simulator was organized around the following four concepts.

- (1) To reconstruct a system implementing the latest technology while also retaining legacy functions.
- (2) To improve functionality for more user-friendly control.
- (3) To achieve a new function of linked training with a power plant simulator developed by another company.
- (4) To incorporate control equipment with the same specifications as its real-facility counterpart, and enable authentic operational training.

Introducing a simulator based on these concepts yielded the following four merits.

- (1) Even young and inexperienced operators are able to learn consistent control operations.
- (2) Particularly, to prepare for accidents and other issues during real-world operation, it is possible to virtually train for various emergency situations that cannot be experienced during normal operation, and foster the

learning of flexible operational techniques.

- (3) By pretesting control logic modifications, facility repairs and upgrades can be carried out at lower risk and with higher reliability.
- (4) Through advance training of the controls used when commissioning the renewal of facilities, the staff on duty are able to carry out commissioning smoothly, enabling a safe and orderly transition to service.

## A new generation simulator

The system configuration of the new simulator consolidates multiple subsystems provided by the control system manufacturers, which are unified on a single network to create a large-scale system as illustrated above. The main functions and features of the new simulator are given below.

- (1) Simulation method

The LNG terminal simulation model adopts a dynamic simulator, enabling the precise simulation of processes based on a physics model of each piece of equipment and the pipe topology. The controller works by using an emulator, enabling the software that runs on the actual controller to run on PCs used in the simulator.

- (2) Simulator instructor function

The simulator is equipped with basic operating functions such as starting and stopping the simulator (Run/Freeze),

and editing a simulation scenario and the initial state (operational starting state). In addition, the new and expanded functions include the ability to change the simulation speed (0.5x, 2x, 4x), as well as snapshot (saving the state at a point in time) and backtrack (reverting back to a snapshot from a later state) functions. The malfunction configuration settings are also improved to be more user-friendly.

(3) Linked training with power plant simulator

Although individual simulation according to a full model of the LNG terminal and a simple model of the power plant is still possible, the new simulator is capable of cooperating with non-IHI power plant simulators installed alongside it in a simulator room, enabling a joint, linked training equivalent to the real facilities. This setup, which enables linked training on separately constructed large-scale simulators that cooperate with each other is a first within Japan.

As a result, if a process varies on the LNG terminal side, various process values are communicated to the power plant side via a model of the gas pipeline. Control signals are also exchanged between controllers, and depending on the degree of process variation, it is possible to simulate the conditions of a power plant trip (shutdown of an individual generator unit), just like in real plant.

(4) Other improvements over the legacy simulator

The simulator room has been streamlined to occupy approximately 1/3 the floor space of the old installation, and since the major hardware is all composed of low-cost PCs, a reduction in facility costs is also possible.

### Additional benefits for commissioning front-loading

By utilizing the simulator from the commissioning stage of the renewal project, the time spent for repeating adjustment work on the actual equipment could be shortened, thereby contributing to trouble-free completion of the renewal project without accidents such as equipment damage and power

plant trips due to mistakes in control adjustments. These advantages of introducing the simulator exceeded initial expectations, and not only the customer but also the plant manufacturer in charge of the renewal project gained a new appreciation of the significant merits of introducing the simulator.

As part of the linked training with the power plant simulator, a malfunction was created in which a vaporizer at the LNG terminal failed and shut down. This enabled the customer and IHI to check how much operation can be sustained under a fuel gas pressure drop until the power plant trips, and collect foundational data for examining operation plans.

This large-scale simulator, which offers many advantages even during plant commissioning and is also capable of linking up with a simulator of another facility, was only possible thanks to IHI's extensive track record of delivering a variety of plant facilities and wealth of technology accumulated over the years.

### An ever-evolving simulator

Since new construction and renewal projects for LNG terminals are expected to continue increasing in the light of future energy demands, we urge many customers to adopt operational training simulators in combination with actual plant.

In the future, we plan to develop a series of products ranging from large-scale simulators like the one introduced in this article, to mid- and small-scale simulators. With this lineup, we will continue to propose and materialize new undertakings in concert with customer needs.



LNG terminal operational training simulator

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