

## World's Largest FLNG-Prelude

(Reference: Shell Global)

Shell is constructing the world's first floating liquefied natural gas (FLNG) project. This will help to unlock new energy resources offshore and has the potential to revolutionize the way natural gas resources are developed. Discover the project and the people involved.



### Key facts

**Location:** Browse Basin, Australia

**Depth:** ~250 metres

**Category:** Floating liquefied natural gas

**Interest:** Shell 67.5%, INPEX 17.5%, CPC 5%, KOGAS 10%

**Fields:** Prelude and potentially other Shell natural gas assets in the region

**FLNG facility production capacity:** At least 5.3 million tonnes per annum (mtpa) of liquids: 3.6 mtpa of LNG, 1.3 mtpa of condensate and 0.4 mtpa of liquefied petroleum gas

**Key contractors:** Technip Samsung Consortium

### Prelude FLNG in Numbers

>600 engineers worked on the facility's design options



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**>200km (125 miles)** is the distance from the Prelude field to the nearest land

**4 soccer fields**, laid end to end, would be shorter than the facility's deck

**175 Olympic-sized swimming pools** could hold the same amount of liquid as the facility's storage tanks

**6,700 horsepower** thrusters will be used to position the facility

**50 million liters** of cold water will be drawn from the ocean every hour to help cool the natural gas

**6 of the largest aircraft carriers** would displace the same amount of water as the facility

**93 meters (305 feet)** is the height of the turret that runs through the facility, secured to the seabed by mooring lines

**-162° Celsius (-260° Fahrenheit)** is the temperature at which natural gas turns into LNG

**1/600** is the factor by which a volume of natural gas shrinks when it is turned into LNG

**117% of Hong Kong's annual natural gas demand** could be met by the facility's annual LNG production

**20-25 years** is the time the Prelude FLNG facility will stay at the location to develop gas fields





## Current developments

Shell took the final investment decision (FID) on the Prelude FLNG project on May 20, 2011.

We started building a floating liquefied natural gas (FLNG) facility to produce and export LNG off the coast of Australia.

Engineers worked more than 1.6 million hours during the engineering and design phase of the Prelude FLNG project.

Since FID, Shell has welcomed three joint venture partners to the project – INPEX (17.5%), KOGAS (10%) and CPC Corporation (5%).

The construction phase of the Prelude FLNG project is well under way. Our aim is to deliver Prelude FLNG safely and to do it right. This means developing a facility that is safe, robust, reliable and with high availability to enable continuous, stable LNG production.

Safety and quality are the priority for Shell at all Prelude project locations. Together with our contractors, we are constantly working to ensure that safety comes first and that everyone goes home safely every day. We have a team of 250 inspectors deployed at project locations to check that all equipment and material is delivered in accordance with our specifications.

Prelude is a global project, with fabrication of components taking place all over the globe. A key location is Geoje, South Korea, where the Prelude FLNG hull and topsides are under construction at the Samsung Heavy Industries (SHI) shipyard – which has one of the few dry docks in the world big enough to construct a facility of this size.

In November 2013, Shell celebrated the launch of the Prelude FLNG hull. For a whole year, steel was welded together by thousands of workers at the SHI yard to create the biggest hull ever built. Once structurally complete, and weighing approximately 200,000 tons, the hull was floated in the dry dock



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before it was towed by nine tug boats through the Geoje harbour to its new position on the quay, where it is secured by 32 heavy mooring ropes.

At Geoje, the topside modules, many of which weigh as much as a single typical offshore platform, are now being installed on the hull and integrated. Early commissioning has begun.

As many as 5,000 people work on the Prelude FLNG facility on any given day at Geoje. In the Middle East, in Dubai, the construction of the Prelude FLNG turret mooring system is progressing well. Once assembled, it will be the largest turret in the world, almost 100 meters high. The first turret module was completed in September 2013 and transported to Geoje, where it was installed into the hull before it was floated. Since August 2014, four more turret modules have been shipped to Geoje and integrated into the hull.

The Noble Clyde Boudreaux drilling rig was towed to the Prelude FLNG location off the coast of Western Australia in August 2013, and drilling of the production wells is under way. The first well was completed in late December 2014.

Malaysia has been the main location for the project's subsea system design and the construction of subsea Christmas trees, manifolds and control equipment, with two Christmas trees already installed subsea at the Prelude location in late 2014.

The Prelude loading arms are under construction at the FMC manufacturing facility in Sens, France, and in February 2014, the first Prelude loading arm was tested. Ocean conditions and the extreme cold of the LNG were simulated and the tests were deemed a success.

In Darwin, Australia, the main onshore supply base for Prelude is complete. The site is already receiving spare parts and equipment for the Prelude FLNG facility.

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Shell has founded a dedicated search and rescue helicopter service in Broome, Australia, to support drilling activity and later the Prelude FLNG facility. It is supported by a dedicated team of highly trained pilots, paramedics, engineers and crew. The service is on standby 24-hours a day and is able to respond within 15 minutes during daylight hours and 30 minutes at night.

Shell started recruiting Australian production and maintenance technicians in 2012. Since then, more than 1,200 people have been employed and moved to Geoje, South Korea to work on operations readiness for Prelude.

Once operational, the Prelude FLNG facility will produce at least 5.3 million tons (mtpa) per annum of liquids: 3.6 mtpa of LNG, 1.3 mtpa of condensate (equivalent to 35,000 bbl/d) and 0.4 mtpa of liquefied petroleum gas (LPG).

Prelude FLNG is the first of what we expect to be many FLNG projects, which will build on our existing capability and LNG leadership.



### Technology

The floating facility will chill natural gas produced at the field to  $-162^{\circ}\text{C}$  ( $-260^{\circ}\text{F}$ ), shrinking its volume by 600 times so it can be shipped to customers in other parts of the world.



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The Prelude FLNG facility will be 488m (1,600 feet) long, 74m (240 feet) wide and along with its contents, will weigh around 600,000 tons. It will be the largest floating offshore facility in the world.

Once constructed, the facility will be towed to its location, some 475 kilometers (around 300 miles) north-east of Broome, Western Australia.

There the facility will be moored and connected to the undersea infrastructure and the whole production system commissioned.

The Prelude FLNG facility has been designed to withstand the most powerful tropical cyclones.

It will remain permanently moored at the location for around 20-25 years before needing to dock for inspection and overhaul.

The LNG, LPG and condensate produced will be stored in tanks in the hull of the facility.

LNG and LPG carriers will moor alongside to offload the products.

Many of the technologies used on the FLNG facility are ones we have used successfully onshore, but some have been adapted or modified in order for the processes, such as liquefaction and offloading, to run at sea.

Important attributes of Shell's FLNG design are:

- it can provide high production rates of up to 6 million tons per annum (mtpa) of liquids (including LNG, LPG and condensate);
- it can process a wide range of gas compositions and can export LPG and condensate;
- it uses an efficient double mixed refrigerant liquefaction cycle;
- it can stay on station and does not have to be moved during severe weather conditions such as cyclones, which will increase the availability of the plant.

New technology that has been developed for FLNG includes LNG tanks that can handle sloshing, close coupling between the producing wells and the



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processing facility, LNG offloading arms, cooling water intake risers, turret and mooring systems, and the marinization of processing equipment such as absorption columns and the main cryogenic heat exchangers. All of these technologies have been extensively modeled and tested to ensure they can operate safely and efficiently under marine conditions.

### Markets

The Prelude FLNG project is well placed to help meet the growing natural gas demand of Asia.

### Environment and society

The project will create around 350 direct and 650 indirect jobs.

Shell started recruiting Australian process and maintenance technicians in 2013. Since then, more than 120 people have been employed and many have been deployed to Geoje, South Korea to work on operations readiness for Prelude.

The technicians recruited are highly skilled, with extensive experience in either LNG or relevant industries. Training them in Geoje gives them hands-on experience of the FLNG facility, which will be crucial during the commissioning, start-up and operation and maintenance of Prelude.

Most of the service technicians will be recruited in 2015. They will manage the support services for Prelude (rigging, scaffolding crane operations, materials handling and emergency response).

Shell has teamed up with the Australian work experience program, Work Inspiration, to offer high school students the opportunity to learn more about a career in energy. Shell ran a pilot of the program in Perth in 2014, and is now rolling it out with schools in Broome, Western Australia. Students learn about careers from Shell employees and contractors, and get real-life experience to see if a career in energy is for them.



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Prelude will also provide taxes and revenue to Australia and create opportunities for local businesses. Shell is awarding about 200 contracts to support the Prelude FLNG facility during operations and maintenance. There will be significant contracting activity throughout 2015, with the award of the facilities management services, maintenance, supply vessels and underwater services contracts taking place this year.

In Western Australia, to build local capacity and expertise to support the Prelude FLNG project, Shell is investing millions of dollars in Australian universities and education providers.

Shell has partnered with the Challenger Institute of Technology in Western Australia to develop a bespoke FLNG training program for Prelude technicians. Challenger is currently delivering the foundation training programme for Prelude FLNG technicians before they begin work at Geoje, South Korea. Training takes place at Challenger's Australian Centre for Energy and Process Training (ACEPT). It is the first training of its kind anywhere in the world.

This investment in the Challenger Institute and ACEPT is key to supporting the growth and capability development of the ACEPT center, so it can continue to train future talent which is in high demand in the Australian LNG industry.

Shell has committed to sponsoring a Certificate II Process Plant Technology scholarship class at ACEPT. This will allow selected participants to undergo training with the full support of Shell so they can pursue a career in the industry.

Through a multi-million dollar partnership with the University of Western Australia (UWA) and its Energy and Minerals Institute, Shell is funding geotechnical engineer Winthrop Professor David White, as the Shell EMI



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Professorial Chair in Offshore Engineering, to improve offshore capabilities in Western Australia.

The Shell EMI team teach 100 undergraduates in offshore engineering and deliver courses to the industry in Perth and internationally. The EMI Chair is seen as a valuable industry resource for companies like Chevron and Woodside, who also work closely with the Chair on research.

Through the partnership with EMI, Shell partly funds former chief Shell engineer, Mike Efthymiou – who played a significant role in the development of Shell's FLNG design, and developed patented FLNG technology – in a part-time professorial role. Through the partnership, UWA is able to benefit from Mike's extensive industry experience offshore in research projects, and from his teaching of undergraduates.

The Australian Government gave the Prelude FLNG project environmental approval on November 12, 2010.

The Prelude project will use significantly less materials, land and seabed than developing the same gas via a similar onshore facility.

Developing the gas at the location of the gas field will reduce impact on sensitive coastal habitats, as FLNG avoids the need for shoreline pipe crossings, dredging and jetty works. Product carriers will be far from coastal reefs and whale migration routes.