

ENVIRONMENTAL PUMPING SYSTEMS

# Offshore wind installation







A wide-angle photograph of an offshore wind farm in the North Sea. Several wind turbines are visible in the distance, stretching across the horizon. The water is a deep blue with whitecaps. In the foreground, the deck of a ship is visible, showing various pieces of equipment and machinery. A red vertical line is on the left side of the page.

# The future of offshore wind installation

Green energy is the future of the blue economy. The potential of our oceans to sustainably support increasing energy demands is fuelling rapid growth in the offshore wind sector. In fact, experts predict that energy produced in North Sea waters alone could meet European electricity consumption four times over.

Achieving that potential, however, is going to take innovation. As the need to build new wind farms intensifies, with bigger turbines further out in deeper waters, we will have to find new ways of thinking and new ways of doing things.

Working in collaboration with the Norwegian Geotechnical Institute (NGI), Framo has pioneered the development of suction bucket anchor installation for offshore wind foundations. Compared to traditional monopile foundations, this unique method enables faster, more cost-effective and less noisy installation that ensures a sturdy structure for turbines of any size.

Installation of the suction anchor relies on an innovative design combined with Framo's well-proven pumping technology, used in the maritime industry for more than half a century. Decades of experience with similar installations in offshore oil and gas has given us extensive knowledge for ensuring dependable foundations even in the roughest of waters. It's how Framo enables offshore wind energy on safe ground – in all weather conditions.





## INTRODUCTION

# Suction bucket jackets: a proven, reliable alternative to monopiles

Based on pump technology used in all types of applications in the marine industry for more than fifty years, Framo has developed suction anchor technology for installing foundations that can support large wind turbines. This proven innovation offers a wide range of advantages over monopile foundations that have long been the traditional design used for offshore wind installations.

Extensive testing has shown that the suction bucket design is suitable for any soil conditions except gravel and boulders. The technology has previously been used for installations at depths close to 2000 metres.

### **Fast, cost-effective and sustainable**

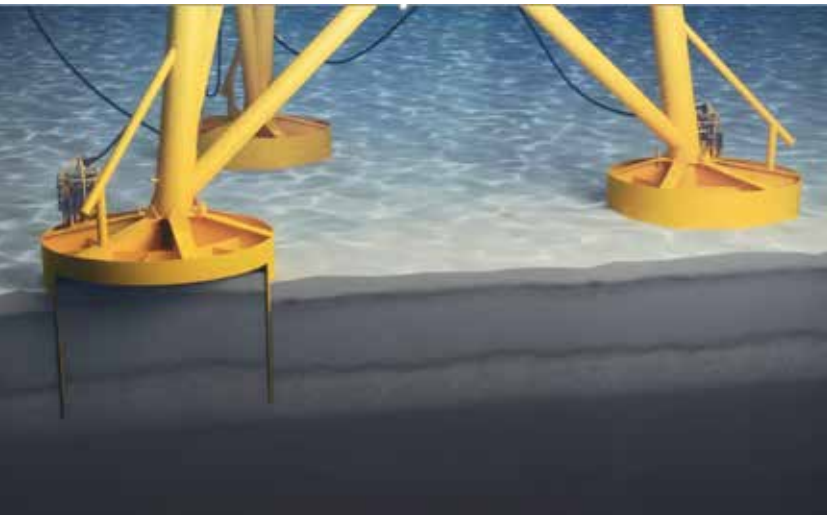
In addition to a higher degree of stiffness that better supports today's higher capacity turbines, suction bucket jackets can also be installed more quickly than older monopile designs. The result is higher turnover, for greater cost-efficiencies for the entire project scope.

This design further offers environmental benefits, as the suction bucket jacket requires less steel in the manufacturing process than monopiles.

By eliminating the need for a hammer in installation, the process is also essentially noise free and poses no harm to the surrounding marine environment. That means an expanded window for installation in areas where noise restrictions typically limit available work time.

### **Smart trunk design for ROV-free installation**

Framo's suction bucket technology features a smart trunk design that ensures air and water quickly and efficiently evacuate through the buckets as they are lowered to the seabed. This unique method eliminates any problems concerning the heeling of the structure due to air pockets in the buckets during installation.



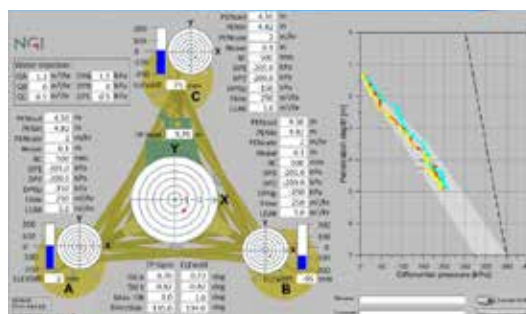
Traditionally, a remotely operated underwater vehicle (ROV) would be needed to close the ventilation hatch before pumping and to close and seal the bucket interface after installation. In addition to their high cost, ROVs suffer from poor visibility, especially in muddier waters, which extends installation time. They also run the risk of high downtime.

With the Framo trunk, however, the Framo pump skid enables remote opening and closing of the lid, meaning no ROV is required. This ensures a quicker turnaround for each foundation installation, reducing time and overall costs for the whole project.

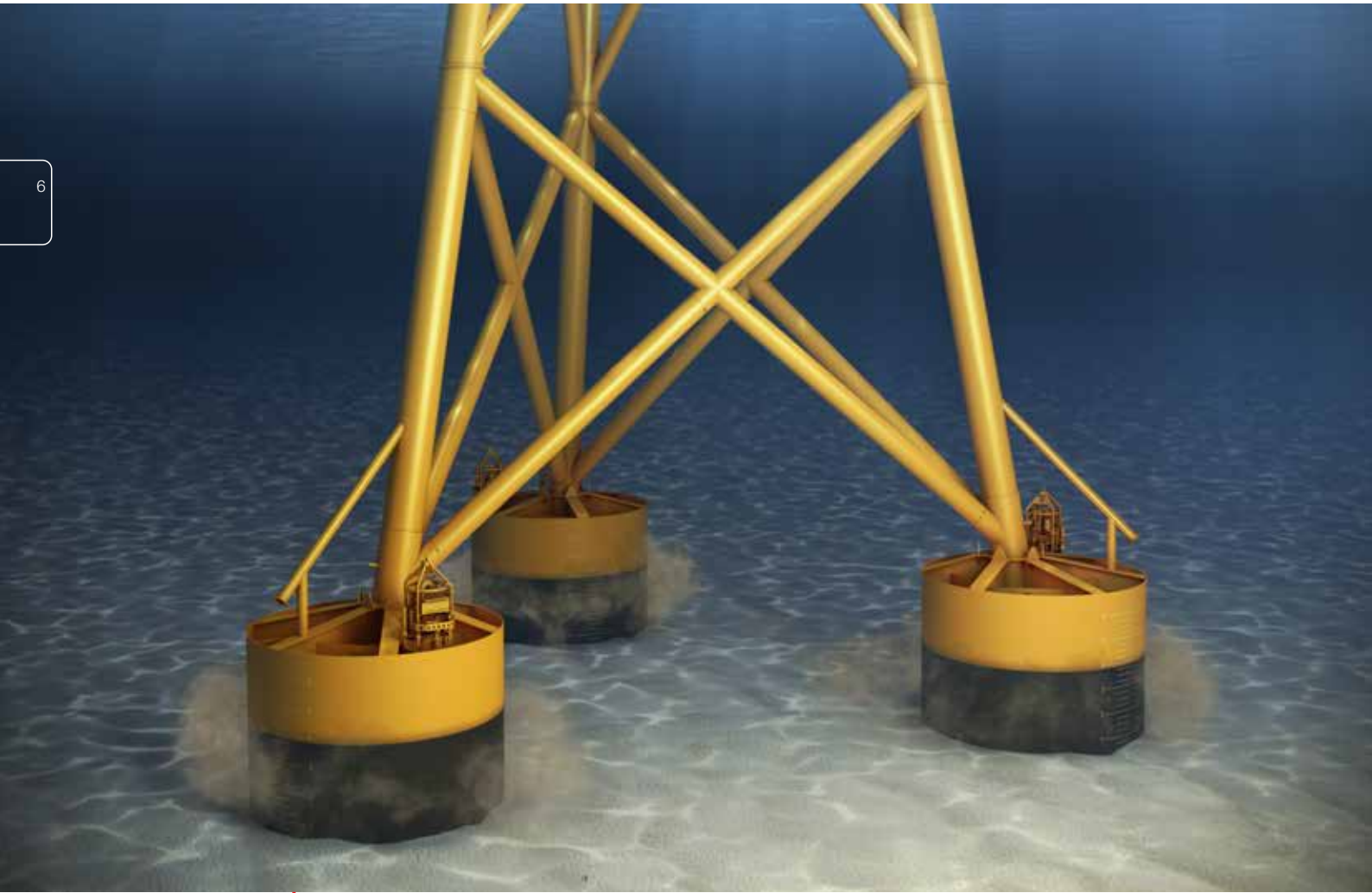
#### A partnership with a flawless track record

For over 30 years, Framo has partnered with NGI, an industry-leading source of expertise on geotechnical survey and monitoring. To date, this collaboration has resulted in more than 300 suction anchors successfully installed in various soil conditions. All of that experience has gone in to continuously improving the design of the suction bucket technology used for anchoring offshore wind turbines.

NGI has been working in offshore geotechnical engineering since the 1970s. Today, they have become a prominent supplier to the global offshore wind energy industry, sought after by major developers in Europe, North America, Asia and beyond. Their unique knowledge of offshore geotechnics and monitoring, in combination with their geo-services offering, helps Framo customers optimize turbine foundation design, installation and performance.







## DESIGN

# Designed for tomorrow's offshore wind needs

### How it works

Framo and NGL begin each project with a cone penetration test that provides important information about the layering properties of the seabed. With more than 60 years of geotechnical experience, NGL can use this test to optimize the planning, design and supervision of bucket installations in the varying and often difficult soil conditions present in offshore locations. NGL then provides geotechnical design and sizing of the buckets in order to achieve the required holding capacity and match the actual soil conditions.

The Framo-developed Launch and Recovery System (LARS) supports all equipment during the installation of the suction buckets.

Framo's unique trunk design ensures efficient evacuation of air and water from the buckets as they descend underwater. Once the buckets partially penetrate the seabed, the lids are closed remotely, sealing the top of the buckets. Framo pumping technology then pumps the water out,

creating under-pressure that causes the buckets to silently penetrate the seabed. NGL proprietary software secures precise control for each bucket, with full verification for the verticality of the installation.

### Framo suction anchors for floating offshore wind installations

Harnessing the power of the ocean's wind to meet our growing energy needs is going to take more wind farms, further out at sea, in deeper waters than ever before. In addition to new, innovative fixed installation technologies, this is also driving the development of full-scale floating wind farms.

Framo's marine pumping technology offers an ideal solution for ballasting and de-ballasting during the construction of floating wind farms. They were used in this way, for example, at Hywind Scotland, the world's very first fully floating commercial wind installation. Framo pumps can even be used for ballasting to compensate for variable wind velocity when floating wind turbines are in operation.

# Supply scope for Framo suction anchors in fixed offshore installations

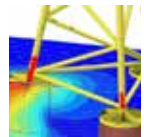
## A . Analysis of ground conditions

- Field testing
- Analysis and evaluation of data



## B . Design of suction anchor buckets

- Geotechnical and detailed design



## C . Delivery of hardware

- Delivery of Trunk to fabrication contractor



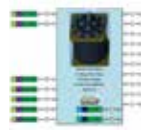
## D . Provision of suction anchor pump system

- LARS
- Pump skid
- PDC
- Instrumentation for operation surveillance



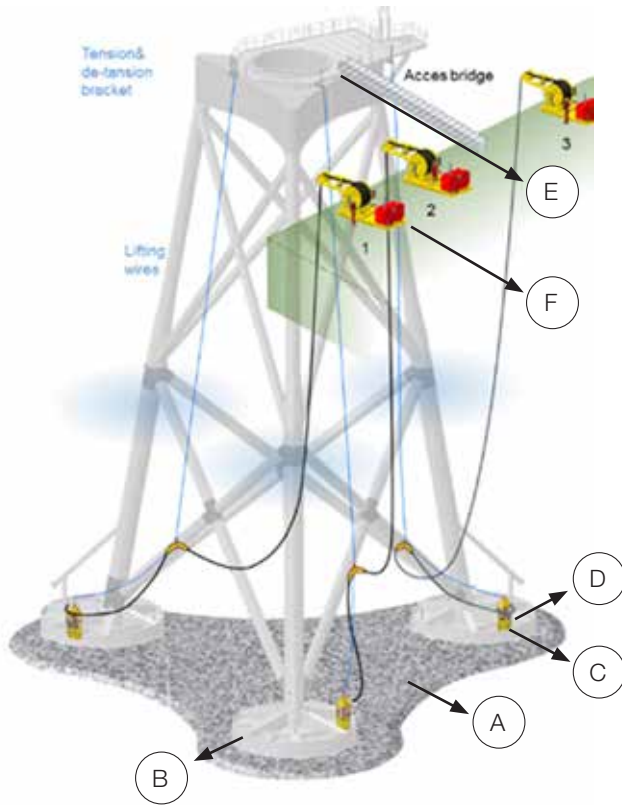
## E . Provision of instrumentation

- Instrumentation – project specific



## F . Suction operation

- Supporting offshore personell



### Why choose suction anchor foundation

- Foundation stability
- Better suited for larger turbines
- Less steel than monopiles
- Shorter installation time and in one go
- Environmentally friendly
- Simpler removal
- Geographical site conditions exclude monopiles



Dudgeon, Hornsea and Dogger Bank fieldse  
Test bucket used during Dudgeon penetration  
trials (Statoil)

## REFERENCES

# Framo in the offshore wind industry

To date, Framo equipment – including our suction bucket anchor technology – has been used to support the development and growth of offshore wind farms around the world. Here are just a few examples:

### 2018

Framo and NGL supports Ørsted in the design, and installation of 20 Framo suction bucket jacket foundations for Borkum Riffgrund 2, a 450 MW wind farm in German waters.

### 2016

Framo marine pumps are employed for critical ballasting and deballasting operations during the

construction of the Hywind Scotland wind farm, the first of its type to rely fully on floating wind turbine installations.

### 2014

Framo suction bucket jacket foundations were used for penetration trials performed at what will become the Hornsea and Dogger Bank wind farms.

### 2013

Framo supplies and operates of pumping and monitoring equipment for penetration trails performed in varying and challenging soil condition at the Dudgeon wind farm field. 22 different locations are successfully tested with methods for decreasing penetration resistance.





## REFERENCES

# Framo suction bucket technical information

### Product scope

The Framo suction bucket jacket foundation is delivered as a fully integrated system that includes all necessary components, including:

- Framo Launch and Recovery System (LARS)
- Trunk (32")
- Power distribution
- Pump skid with fully integrated instrumentation package for measuring critical parameters

The instrumentation package comes with software for monitoring, and it includes a range of display options and real-time plotting facilities that can be user-defined. A range of derived parameters can be calculated in real time by the bucket monitoring. Parameters include:

- Inside and outside penetration depth
- Soil heave and bottom clearance
- Pumped water flow and leakage monitoring
- Tilt
- Total and differential pressure in bucket

### Specifications and functionality details:

- Flow capacity: 600-1000 m<sup>3</sup>/h
- Pressure capacity: up to 8 bar
- Ventilation capacity: High; 40" non-restricted ventilation
- Full electrical redundancy on pump skid
- Pump cavitation pressure: proven as low as 0.1 bar absolute pressure – especially critical in shallow waters
- Reversed pump flow function for cycling
- Manpower requirements: Low; Framo Launch and Recovery System (LARS) enables control of pump skid by just one operator
- Framo interface enables easy offshore installation as well as total closure/isolation of a single suction anchor bucket



## Support for offshore wind farms: HVAC platform cooling

As one of the industry's leading pumping system suppliers, Framo has decades of experience delivering seawater lift pumps to a wide range of offshore installations.

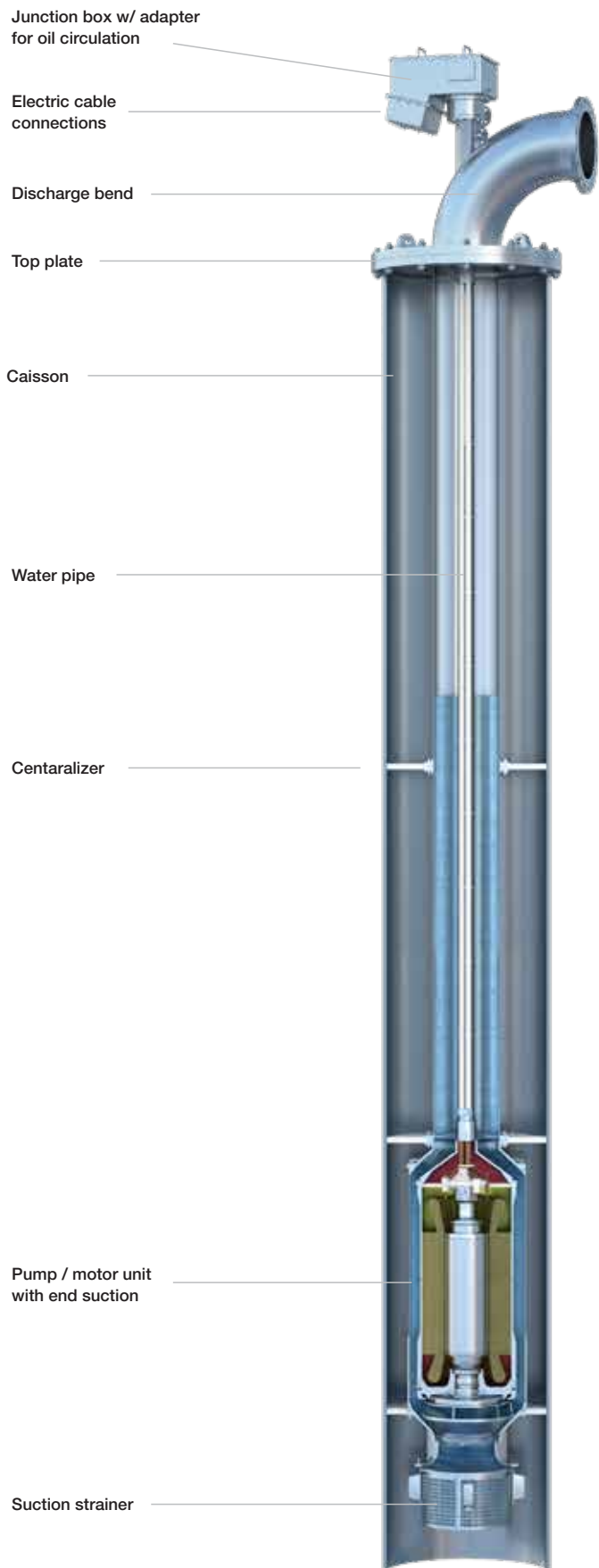
In Framo's cable-free concept, the electric submersible pump is suspended from a riser pipe containing a built-in transmission system for the electrical power. The pump itself is an end-suction centrifugal pump, driven by an integrated oil-filled induction motor designed for direct on-line start (DOL) or variable-speed drive (VSD) operation.



The power transmission system integrated in the pipestack is a unique feature for the Framo submersible electric pumps. The electric conductors are located inside a protective oil pipe, which is mounted concentric in the water pipe forming a complete section of the pipestack. When the riser pipe sections are stacked, spring-loaded sliding connectors on the conductors create a safe and reliable electrical connection. The pump system is insulated, cooled and lubricated by a small external oil circulation unit, which creates an internal overpressure that prevents any ingress. The external oil circulation unit also continuously monitors the condition of the submerged pump/motor, providing information about temperature, pressure, cleanliness and seal integrity to the control system.

**Main advantages with Framo cable-free submersible pumps:**

- Certified for hazardous areas
- End suction to ensure maximum NPSH (net positive suction head) availability
- No submerged penetrations or cable handling
- Built-in power transmission
- Stiff shaft operating below first critical speed, ensuring low vibration levels
- Ingress protection through overpressure
- Compact, low-weight design
- Simple and easy installation
- Condition monitoring





## Proven marine technologies

For decades, ships and offshore platforms around the world have trusted Framo pumping technology to meet their extreme demands for performance, reliability and safety. Framo has now brought this same dependable technology to the offshore wind industry.

At the core of many of Framo's products is our hydraulically driven, submerged pumping technology. These pumps revolutionized marine liquid cargo handling when we first introduced them in the 1960s, and they are still widely used across the

industry today. Throughout the years, Framo has also developed, installed, operated and maintained pumping systems on thousands of tankers as well as oil and gas installations.

In addition to our technologies, our world-class service organization provides dependable support from knowledgeable and experienced technicians who can be there to assist you as soon as you need them. We also offer training for your crew to ensure optimal use of the system at all times.





## Innovation to create new possibilities at sea

Framo has a long history of developing new types of pumping systems that can be used for a wide range of marine industry applications. Examples include water circulation, feed water, sludge treatment and much more.

At our headquarters outside of Bergen, Norway, we established the Innovation division to discover

new areas and markets where our pump technology and knowledge can be used. Here we have gathered a mix of pump technology experts and talented professionals from other disciplines who bring new thoughts and ideas.





## OUR COMPANY

# A partner to rely on

Framo has proud roots that stretch back to 1938. Customers have put their trust in our unique pumping technology since we introduced it in the early 1960s. But even more important is the trust they place in us.

### **Driven by a simple idea**

Framo has a belief that pumps should never be isolated from the task they perform. It's a belief that revolutionized marine cargo handling, where a submerged pump in each tank is now the standard for faster, safer, more cost-effective business. And it offers similar benefits in our offshore wind solutions.

It's also a belief backed up by experience. Framo has existed for nearly 80 years, and for the last 50+ years our sole business has been pumps and pumping systems.

### **Full control over production**

We don't just design Framo solutions. We see our designs through at our own facilities in Norway. No Framo product is delivered from anywhere else.

Our manufacturing is built on decades of experience, plus the most advanced machinery and techniques in the industry. Each of our skilled employees there takes pride in delivering the best – and is integral to the finished result.

Furthermore, all of our products undergo full-scale testing. This means you can be confident that your installation will deliver reliable performance from day one.

### **From Norway to the world**

Framo is a recognized leader in pumping systems. Customers around the globe turn to us, both for pumps and for expertise in meeting their challenges. Today Framo is also part of Alfa Laval, a world leader in heat transfer, centrifugal separation and fluid handling. As a result, our pumping technology contributes to still more comprehensive solutions.





**Head office FRAMO AS**

P.O. Box 23, NO-5329 Florvåg, Norway  
Phone: +47 55 99 90 00  
E-mail: [marine@framo.no](mailto:marine@framo.no)

[framo.com](http://framo.com)

**FRAMO Nederland**

Edisonweg 18  
P.O. Box 305  
NL-3200 AH Spijkenisse  
The Netherlands  
Phone: +31 181 619311  
[nederland@framo.no](mailto:nederland@framo.no)

**FRAMO Houston**

3002 East 13th Street  
La Porte, Texas 77571, USA  
Phone: +1 281 884 4800  
[houston@framo.no](mailto:houston@framo.no)

**FRAMO Singapore**

17 Tuas View Circuit  
Singapore 637575  
Republic of Singapore  
Phone: +65 6210 2400  
[singapore@framo.no](mailto:singapore@framo.no)

**FRAMO Nippon**

Kotsu Building 5F, 15-5  
Shinbashi, 5-chome  
Minato-ku  
Tokyo 105-0004, Japan  
Phone: +81 3 5776 2405  
[tokyo@framo.no](mailto:tokyo@framo.no)

**FRAMO Korea**

Rm 608, Centum Sh Valley  
35, Centum Dong – Ro  
Haeundae – Gu, Busan  
Korea, 612-020  
Phone: +82 51 743 6942/3  
[busan@framo.no](mailto:busan@framo.no)

**FRAMO Shanghai**

Building No.5, 123  
Lane 1165, Jin Du Road  
Min Hang District, Shanghai  
China 201108  
Phone: +86 21 6115 5000  
[shanghai@framo.no](mailto:shanghai@framo.no)

**FRAMO do Brasil**

Av. Presidente Vargas, 463  
/19º andar, Rio de Janeiro  
CEP 20071-003, Brazil  
Phone: +55 21 2507 7898  
[brasil@framo.no](mailto:brasil@framo.no)

**FRAMO Middle East**

Al Quoz Industrial Area  
P.O. Box 21467  
Dubai, United Arab Emirates  
Phone: +971 4 346 9143  
[dubai@framo.no](mailto:dubai@framo.no)

**FRAMO Service**

P.O. Box 44  
NO-5329 Florvåg, Norway  
Phone: +47 55 99 92 00  
[service@framo.no](mailto:service@framo.no)

**FRAMO Fusa**

Venjanaset  
NO-5641 Fusa, Norway  
Phone: +47 55 99 96 00  
[marine@framo.no](mailto:marine@framo.no)

**FRAMO Holsnøy**

Rosslandsvegen 933  
NO-5918 Frekhaug, Norway  
Phone: +47 55 99 75 00  
[piping.marine@framo.no](mailto:piping.marine@framo.no)

**FRAMO Flatøy**

Flatøyvegen 24  
NO-5918 Frekhaug, Norway  
Phone: +47 55 99 94 00  
[oil&gas@framo.no](mailto:oil&gas@framo.no)



Visit us online at  
[www.framo.com](http://www.framo.com)



View a demonstration  
of our offshore wind solutions