ESTEYCO

ELISA

GRAVITY BASED FOUNDATIONS

Installed without heavy-lift vessels

ELISA technology

Main advantages

- ✓ Depending on conditions, ELISA can deliver significant **cost reduction** as compared to other bottom fixed solutions
- ✓ Manufacturing cost for a GBS unit of 18MW WTG (OWF 450MW), 40m water depth 4,3M€ (**240€/kW**).
- ✓ **Scalability** in terms of **WTG size** (+15MW), **water depth** (up to 70m), **construction infrastructure** and **installation means**.
- ✓ **Full in-shore assembly** of the overall WTG on harbor - lower risk
- ✓ Suited for **industrialized** construction and intensive in **local content** of workforce, raw materials and installation means.
- ✓ Complete **independence of heavy-lift vessels**: logistics based on economic and readily available means.
- ✓ ELISA promotes competition and **overcomes bottlenecks in the supply chain**.
- ✓ Robust, durable, fatigue tolerant and maintenance-free concrete substructure: **reduced OPEX costs.**
- ✓ Compatible with **ATOMS technology** for on-site **Major Component Replacement**
- ✓ **Suitable for most soil conditions**, including relatively soft or rocky seabed.
- ✓ Minimize the dependence on steel, with a higher price volatility, providing a higher **price certainty**.
- ✓ More **environmentally friendly**: noiseless installation, full decommissioning & significant reduction of Carbon Footprint

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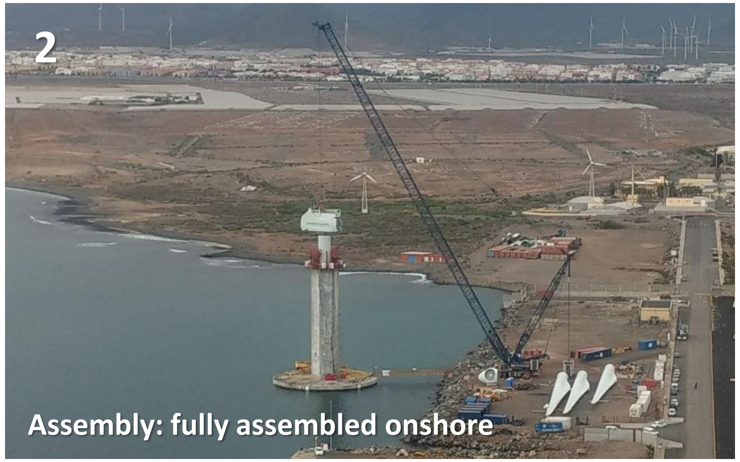
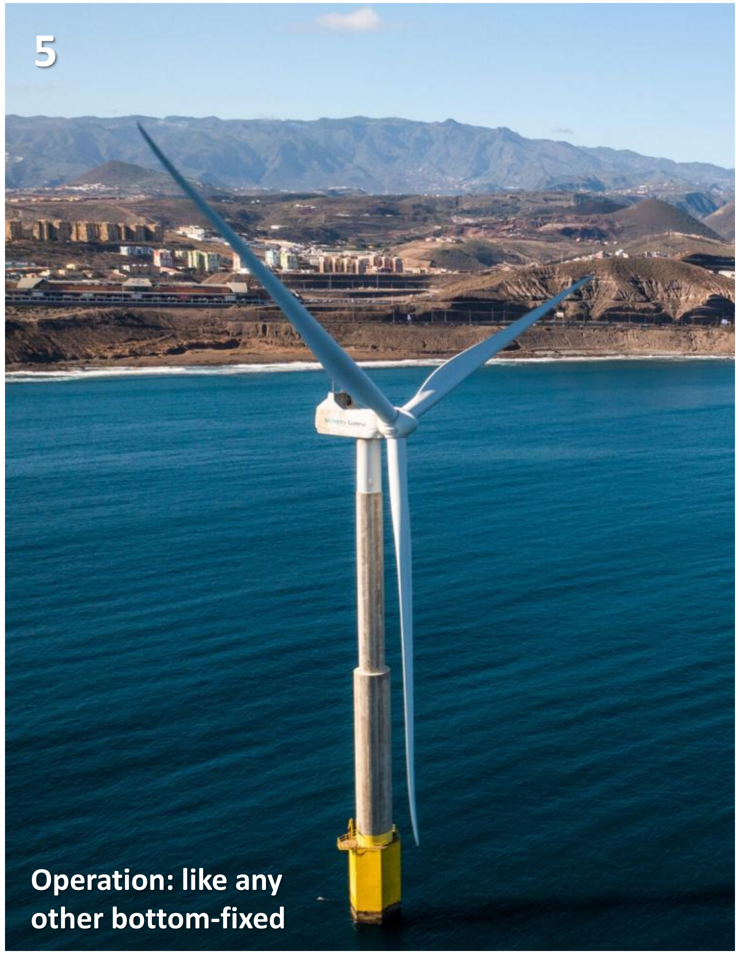
ELISA technology

Self-installing offshore bottom-fixed substructure

- ✓ **ELISA** uses a **Gravity-Based foundation (GBS)** configured to act as a **buoyant platform** to allow for the joint **installation of the substructure and the WTG**.
- ✓ Each complete GBS&WTG unit is **fully assembled onshore**, **conventionally towed** to the site and **installed with low-cost means** (tugboats)
- ✓ The **TIM Platform** is the key low-cost and re-usable mean used to ensure high levels of **stability** during the complete **towing and ballasting processes.**





ELISA technology

Manufacturing: Conventional concrete structure for simpler and low-cost construction

The ELISA technology is well suited for execution strategies with **high local content and reduced requirements on harbour infrastructure.**

Thanks to its simple geometry (horizontal slabs and vertical walls) and reduced draft, ELISA can be directly **manufactured on floating barges**, which qualitatively reduces the quay area needed. This emulates the large successful experience with very cost-effective serial manufacturing of concrete caissons.

High fabrication rates of ca. **4 units/month** can be achieved for the ELISA technology despite of the small harbour area used.

The GBS units are manufactured in two stages:

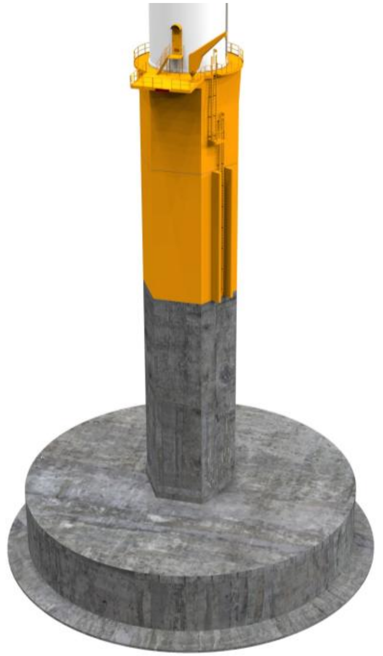
- in 1st stage the base is manufactured onto a floating barge emulating concrete caisson construction techniques.
- In 2nd stage, after the base is floated-off, the concrete shaft or tower is built working from the quay.

To fabricate the GBS's base, single modular barges can be used. Two barges will be required to deliver 4 unit/month production rates.

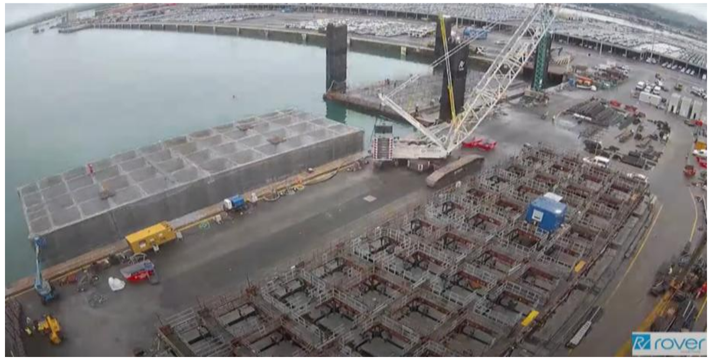
The concrete shaft of tower may be built afloat or with the base grounded onto a gravel layer. We would recommend the use of gravel beds when possible, to facilitate the towers erection. Three tower construction positions shall be required to deliver 4 unit/month production rates

Only **conventional construction machinery and auxiliary means** (sliding or climbing formwork) with high availability in the market are required. No heavy-lift equipment is necessary.

Bearing capacity requirements of the yard are low (only conventional cranes and non-heavy transports needed in execution), so **port upgrade is not required**.



Base and first section of the tower (T0)



Concrete caissons construction in semisub barges

Example of construction lay-out in ports like LeHavre or Langosteira

ELISA technology

Modular submersible barges for base construction (Airbarge solution)

Direct construction of the bases emulating concrete caisson construction is very cost effective and qualitatively reduces harbor infrastructure requirements as previously described. However, it naturally requires adequate barges prepared for float-off operations and with the required dimensions and loading capacity. For production ratios of 4 units/week as envisioned for Baltyk I, two such barges shall be required.

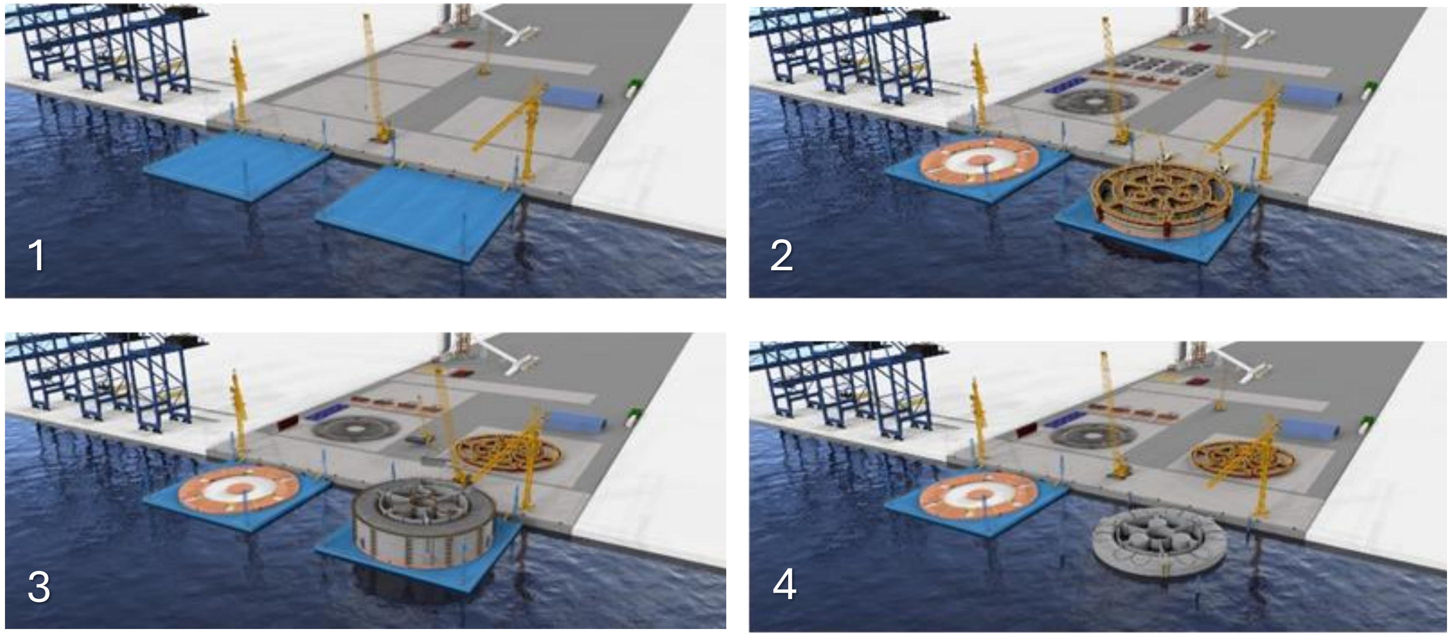
In direct collaboration with SARENS, Esteyco is offering a solution based on existing and proven modular barges which provide reliable, economic and available means very well suited for base construction and float-off. Its modularity and linked size flexibility makes it possible to emulate concrete caisson techniques with floaters of virtually any size.

This solution is based on conventional and commercial existing modular pontoons which incorporate a simple and economic retrofit for controlled ballasting of the modules. Water ballasting of many compartments is managed by simply regulating air flow & pressure in a limited number of control points along the barge perimeter, with no need for any piping, valves, or water pumps.

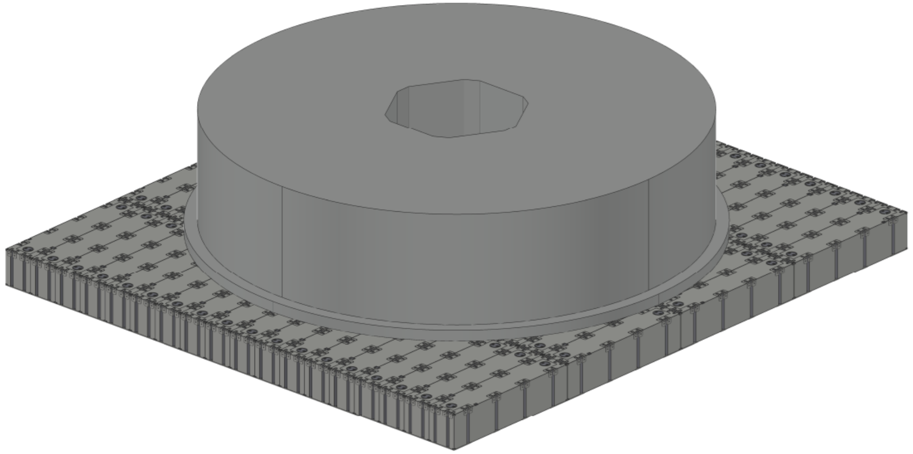
The depth of the modular barge is only 3m, which reduces the water depth needed for the float-off operation. Combined with a reduced float-off draft of the bases (circa 5m), this solution can be applicable in any quay with ca.9m water depth which can be found in virtually any major harbor infrastructure.

Full details on the Airbarge solution based on SMB (Sarens Modular Barges) can be provided to Equinor upon request

Contributor: sarens



Example of construction sequence based on Airbarge technology for the concrete tanks of the WHEEL floater



Aibarge modular solution sized for construction of the Baltyk I bases

ELISA technology

Rotor and Nacelle assembly onshore (WTG Integration)

As offshore wind turbines approach 20MW size the **availability of capable offshore cranes** to handle their installation may become a bottleneck.

The use a jack-up vessels can also be a limited by soil conditions or water depth.

To avoid these issues, with ELISA each complete GBS&WTG unit can be **fully assembled onshore**, conventionally towed to the site and installed with low-cost means (tugboats), as in floating wind.

The ELISA technology makes it possible to install the steel tower and WTG in controlled harbour conditions, reducing both cost and risk an enhancing possibilities for industrialization.

The WTG can also be **pre-commissioned onshore**, further reducing the required offshore works and lowering the consequences of any issue identified during the commissioning process.

Commercially available ringer cranes can perform the installation of 20MW+ WTGs **with conventional (non-telescopic) steel towers**. Mobilizing such cranes implies a significant cost, but its relevance is reduced in large-scale projects with a large number of units.

These cranes can serve from one position two WTG assembly stations, allowing for faster installation rates.

Usual rates: 2 days per unit in terms of crane usage (full steel and turbine assembly) and 3-3.5 days for pre-commissioning (w/o crane usage)

In the case onshore cranes are not available, ELISA can be also designed to incorporate ESTEYCO's **proven telescopic tower technology**, reducing the installation height which greatly reduces the crane requirements and improves the cost and availability of capable enough onshore cranes.

RNA in ELICAN project

ELISA technology

The TIM platform: Transport and Installation Module

The TIM is a **low-cost and reusable** auxiliary mean for installation.

It can be temporarily coupled with the GBS to allow for a **solidary behavior** while afloat.

It ensures **high levels of stability** during the complete towing and ballasting process.

It provides **stabilizing forces to the tower**, while **allowing for vertical sliding** during the ballasting process.

Thanks to the TIM, **foundation size and material usage can be optimized,** and be essentially driven by the installed condition, not by temporary installation stages.

The self-installing GBS can adopt a very **simple geometry:**

- allowing for simpler low-cost construction
- using a slender shaft for convenient **transparency to wave loading.**

All systems in the TIM are **fully redundant,** being therefore designed to comply with all applicable **damaged stability** requirements

The use of the TIM is **unmanned**. Its operation and performance is controlled and monitored remotely. Safe accessibility is in any case provided in case of contingency.

The **Coupling Ring System (CRS) active guides** allow control and regulation of the forces acting at the TIM-tower interface.

TIM configuration and functioning is fully analogous for ELI and ELISA, but TIM size for ELI is lower.

TIM approaching the ELISA GBS substructure

TIM platform coupled to the ELISA GBS substructure prior to tow-out

ELISA technology

Marine operations

TRANSPORT

TIM is coupled to GBS before setting sail.

Each transport requires 1 main DP tugboat.

Usual reference Towing Speed: 3 knots (increasable if convenient).

Reference weather limits: Hs=2m and wind speed=18 m/s at hub height.

Base is submerged in inshore waters, to reduce the duration of offshore installation window and improve seakeeping performance.

Very high natural periods ensure very slow motions. Tilt and accelerations in the turbine are comfortably far from the thresholds defined by OEM.

BALLASTING

Connection of 2 extra tugboat for positioning.

Control of operation and ballasting means from Support Control Vessel.

Redundant real-time monitoring of all critical parameters (inclination, accelerations, water levels, forces at the TIM-tower interface, GBS draft, distance to seabed, GPS positioning, etc.)

Reference weather limits: Hs=2m and wind speed=18 m/s at hub height.

Unmanned structure at any moment (safe accessibility is ensured but used only in case of contingency).

Remotely controlled hydraulic TIM guides to regulate the lowering process, inclinations and tower forces / reactions.

Underwater surveillance with ROV.

Towed Transport of the ELISA Pilot unit (1 tugboat)

Configuration for ballasting onto the seabed (3 tugboats +1 control vessel)

ELISA technology

Adaptability of the ELISA technology to different conditions or needs

ELISA with telescopic tower

ELISA with conventional steel tower

ELI GBS

	ELISA with telescopic tower	ELISA with steel tower	ELI
WTG assembly on harbour	YES	YES	NO
Standard Steel Tower	NO	YES	YES
Jack-up for WTG assembly	NO	NO	YES

ELISA WITH TELESCOPIC TOWER can become the option of choice when the WTG weight and installation height exceed the capacity of available onshore cranes.

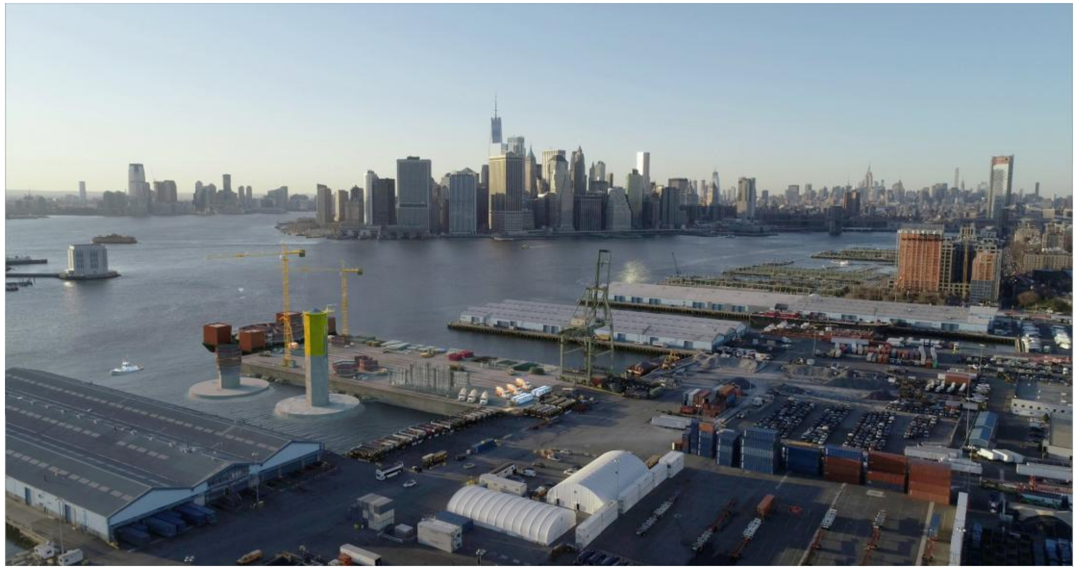
ELISA WITH CONVENTIONAL STEEL TOWER is usually the preferred and most competitive option when a capable enough onshore crane can be mobilized for the project.

If a suitable Jack-up vessel for WTG installation is available and cost-competitive ELI IS ALSO A COMPETITIVE OPTION, for instance in projects in which part of the units are using monopiles. A sensitivity analysis of ELI has been included in this study.

ELISA technology

Capacity to evolve and adapt depending on project conditions

Alternatives for yard construction: Serial vs parallel production – precast vs in situ



Caissons techniques for fabrication: floating docks and semi-submersible barges

Local vs decentralised manufacturing: :management of bottlenecks in supply chain

ELI GBS evolution with conventional independent installation of WTG with jack-ups

video: https://www.youtube.com/watch?v=y1HaokUSulw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