

Where energies make tomorrow ●

Modularization

Managing construction risk through
reduction of site manhours

T.EN

**TECHNIP
ENERGIES**

Global leader in modular solutions

Pioneering in plant modularization

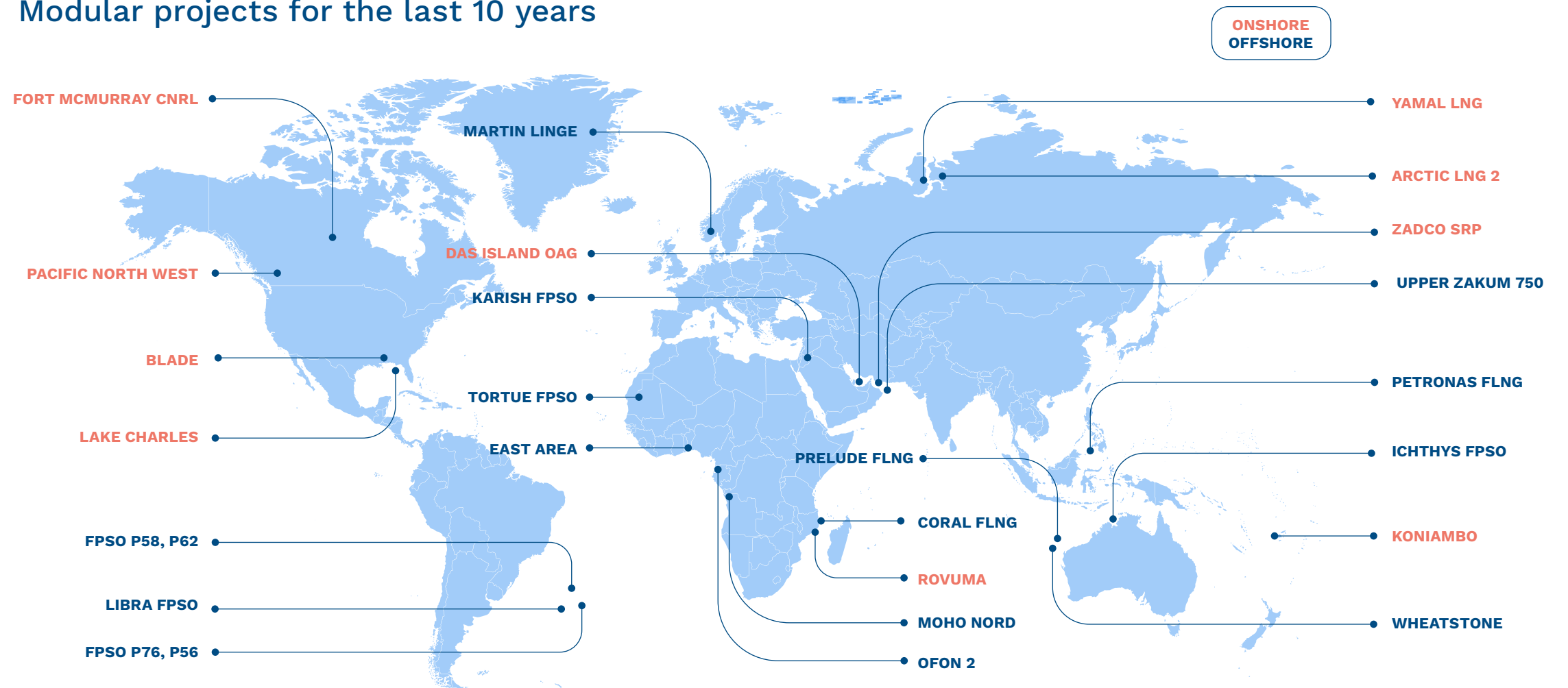
Technip Energies's expertise and know-how cover all aspects of modularization from design to onsite integration. We assist our clients in defining the strategy that best fits their project

needs, offering extensive experience in working with yards, particularly in Asia and optimized designs to reduce or mitigate construction risks. We have developed numerical

methods for plantwide modularization planning. We have now referenced more than 2,000 fabrication partners who are classified and regularly assessed.



Modular projects for the last 10 years



Leading design and fabrication of all types of modules

As an EPC contractor and modularization specialist, Technip Energies takes turnkey responsibility for delivery of process plants using a wide range of modules from small to mega. Each project is unique and no matter its size, a tailor-made cost effective modular solution is available to our clients.

The types of modules range from skids to packages, buildings, process and utilities.

Onshore projects	Offshore projects
OAG Das Island 710 t max/module 9,800 t total	Energear Karish FPSO 1,260 t max/unit 13,200 t topsides + 1 LQ
Koniambo-Nickel 3,640 t max/module 37,000 t total	Shell Prelude FLNG 5,800 t max/unit 76,000 t topsides
Yamal LNG 8,200 t max/module 480,000 t total	Martin Linge 10,500 t max/unit 25,000 t 3UPF + 1 LQ
Arctic LNG 2 13,900 t max/module 518,000 t total	Wheatstone CPP 35,000 t topsides

MODULARIZATION MITIGATES RISK IN HARSH ENVIRONMENTS

Recent project achievements have shown that modularized construction provides schedule certainty in seemingly impossible places.

- **Inside the arctic circle**
Extreme cold and polar nights like on the Yamal LNG project in Siberia
- **Remote South Pacific islands**
Sparse population such as for the Koniambo Nickel Smelter project in New Caledonia
- **Artificial islands in the Arabian gulf**
Heat stress as for the Upper Zakum 750 project in the Arabian gulf



Why modularize?

Modularization is a strategy for industrial plant construction that relies on the portioning of a facility into prefabricated sub-units assembled in well-equipped and well-located fabrication yards to be then transported to often remote construction sites where modules are interconnected.

Technip Energies has successfully executed projects using many types of modules from small truckable skids to complete process units in mega modules.

When to consider modularization ?

Modularization can avoid cost and schedule overruns on the most challenging sites.

INADEQUATE OR HIGH COST WORKFORCE

- High direct manpower cost
- Unavailable local workforce
- Shortage of skilled manpower

PRODUCTIVITY BARRIERS

- Harsh climate
- Political and social instability
- Lack of construction equipment

DIFFICULT SITE ACCESS

- Complex or elongated logistics

What can be modularized?



Process units



Buildings



Piperacks



Skids



Utilities

To ensure the full benefit from modularization, planning in the project must be done at the earliest. Refer to “Prefabrication, Preassembly, Modularization, and Offsite Fabrication in Industrial Construction: A Framework for Decision-Making”.



The many advantages of modularization

DERISKED CONSTRUCTION

- Overcome low availability of skilled manpower on site
- Mitigate harsh climatic conditions
- Simplified coactivities (SIMOPS)
- Controlled fabrication environment
- Limit interfaces (schedule derisking)
- Reduce site congestion
- Manage political and economical instabilities
- Simplify customs procedures

REDUCED SITE COSTS

- Construction manhours
- Flatten peak manpower
- Work on construction equipment
- Site supervision
- Decreased camp size
- Simplified logistics (material and personnel)

KINDER ON THE ENVIRONMENT AND LOCAL COMMUNITIES

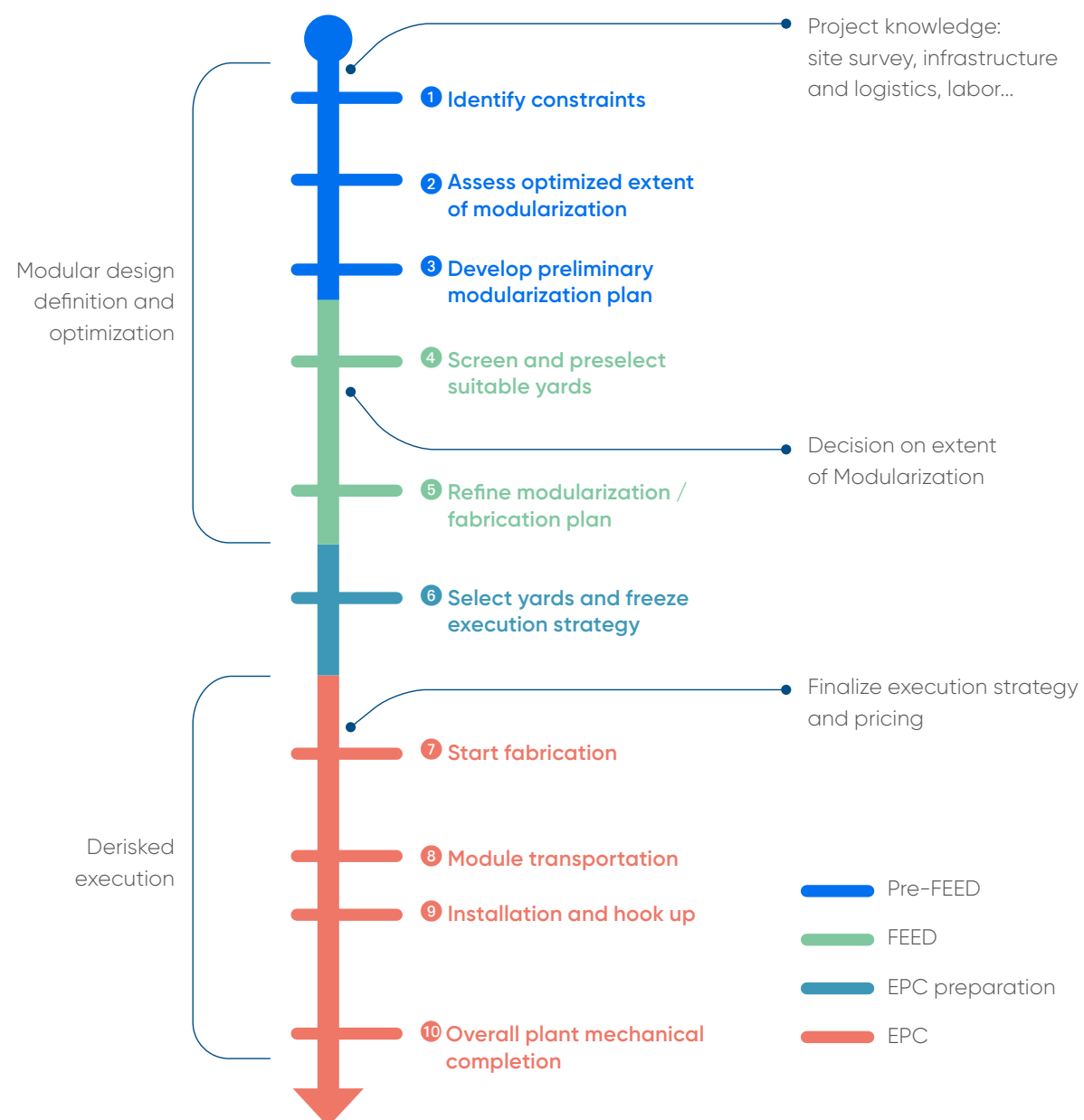
- Little or no dependence on local resources
- Decrease impact to local infrastructure
- Reduce temporary construction and storage areas
- Overcome site constraints

IMPROVED QUALITY

- Reliable QHSE management
- Lower costs
- Higher and better controlled productivity
- Availability of skilled manpower
- Easier monitoring of progress and work fronts
- Integrated fabrication facilities
- Quick access to sea
- Module precommissioning
- Real estate availability

From concept to delivery

Technip Energies modularization expertise is available from the earliest project phases.



Organization of a modularized project

A modularized project organization differs from a pure stick-built approach. Technip Energies's experience shows that these differences fall into four main areas.



PROCESS, SAFETY AND ENGINEERING

- Process development to consider module arrangement and subsequent layout
- Safety studies to be conducted at the earliest stage
- Instrumentation and electrical design focusing on minimizing inter-modules cabling and local cabinet outside of the modules
- Steel structures defined for marine and land transportation
- Adapted civil designs (underground and foundations)

- MOF / site Infrastructure
- SPMT simulation for offloading / transportation / installation
- Preservation and maintenance up to handover

FABRICATION YARD

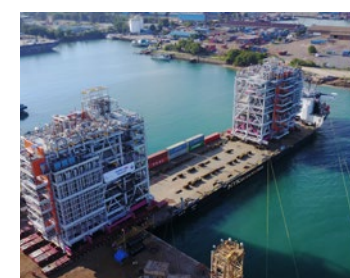
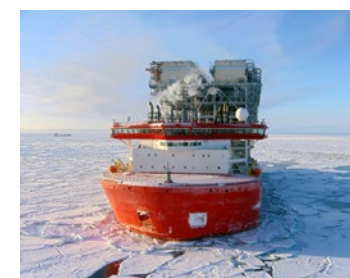
- Early identification and selection based on yard capabilities and experience
- Access and offloading strategy
- Precommissioning and commissioning capabilities (utilities)
- Validate QHSE plan

CONSTRUCTION SITE

- Civil (roads, platforms, sewage, networks)
- Hookup
- Pressure testing including closure welds
- Cable pulling
- Heavy lifts for equipment outside modules
- Final precommissioning and commissioning

SCHEDULE AND LOGISTICS

- Earlier procurement to suit module fabrication sequence and duration
- Optimized overall construction schedule considering site activities, module fabrication duration at multiple yards and erection sequence
- Optimization of the module shipping plan including eventual transshipment
- Heavy transportation vessel screening and selection



Stick-built vs. modular

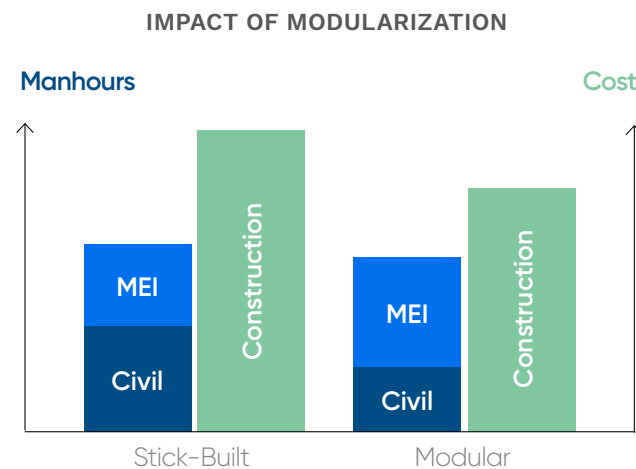
Supporting the decision-making process with NIMO

Technip Energies has developed NIMO, a proprietary numerical simulation tool based on Monte Carlo algorithms, to assess the best construction strategy for a given project.

MAIN OBJECTIVES:

Identify the optimum extent of modularization (corresponding to minimum CAPEX) in terms of:

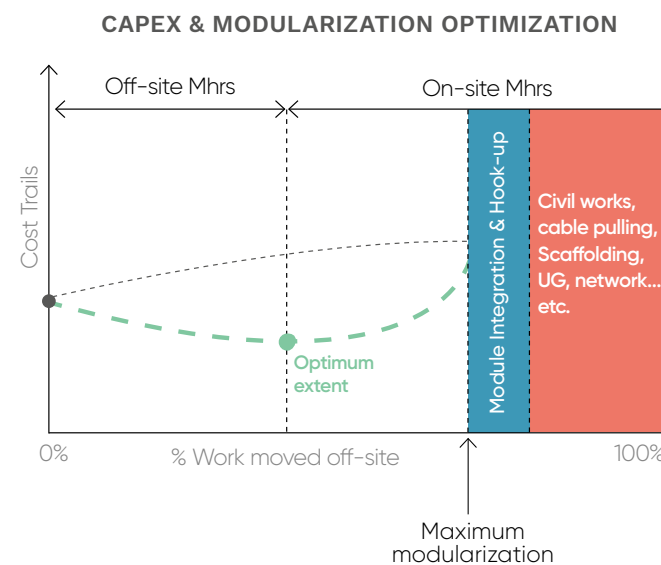
- module size/weight
- offsite manhours transferred from site to yard
- Outline the associated execution strategy
- This assessment needs only a few inputs, mainly an equipment list, and can therefore be deployed very early in the project.



A construction-oriented approach

- Extensive assessment of logistics to determine the maximum size and weight of modules
- Full screening of modular configurations from stick-built to maximum modularization to select the best configuration

“NIMO, our simulation tool, captures all aspects of modularization to support the decision-making process.”



Floatover / Unideck

Over four decades, Technip Energies has built up a worldwide track record, designing and installing very large offshore platform topsides by floatover and offering industry leading expertise in Transport & Installation (T&I) engineering design and T&I operation management.

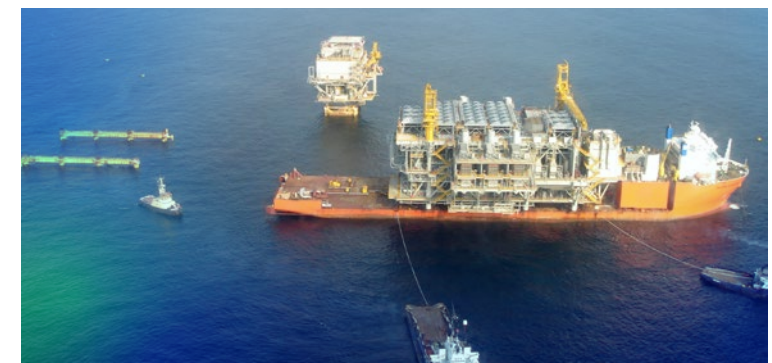
Our optimized solutions for modularization are based on demonstrated successful applications in EPCI projects:

- Module weighing with load cells or hydraulic jacks
- Module load out by skidding or with SPMT
- Transportation by barges or heavy transportation vessels
- Module load in and setting on foundation supports.



Our capabilities include in particular:

- Definition of SPMT arrangement and optimization of module geometry for transportation
- Vessel screening and selection thanks to fleet & market knowledge
- Marine spread subcontract management
- Method Statements for load out / load in
- Module engineering for load out / transportation / load in
- Grillage /substructure design
- Internal & external sea fastening design
- Specification of equipment for load out / load in & procurement
- Quay design verification & preparation
- Mooring system design
- Module preservation and energization when required
- Interface management
- System integration and tests
- HAZID studies of module displacement operations
- Coordination with Marine Warranty Surveyor for approval of marine operations
- Coordination & supervision during operations
- Shipping plan
- Vessel fleet monitoring during navigation
- Motion & acceleration monitoring of modules
- Weather routing services



Mega modularization

Technip Energies has pushed the plug and play module concept to the limit with mega modularization. Complete process units in modules weighing up to 25 kt or more, drastically reduce integration at the onshore or offshore construction site. It also facilitates commissioning activities at the fabrication yards.

The Mega Modularization technology consists of merging several conventional mid-size modules into a single mega module containing complete systems with minimum interfaces.

Main benefits

DESIGN

- Decrease the tonnage of structural steel
- Reduce piping quantities
- Offer dedicated local, electrical and instrumental rooms per module allowing full cable pulling at yard
- Extensive dimensions provide for more flexibility to develop an optimal layout taking into account: Process requirements, center of gravity, safety distances, operation and maintenance considerations (access, evacuation...)
- No need of conventional central pipe rack, freeing unused space
- Reduce overall plant footprint

SCHEDULE AND COST

- Save cost and integration time
- Decrease the number of shipments
- Maximize precommissioning / commissioning activities at yard and enable the tests of full / integrated systems
- Minimize integration work between modules
- Shorten planning, limit integration
- Offer integrated construction completion and precommissioning and commissioning activities, to reduce the risk of carryover work
- Simplify precommissioning and commissioning sequences for site works

FABRICATION

- Feasible for many yards
- Reduce required construction area at yards
- Decrease the number of loadouts
- Reduce fabrication manhours

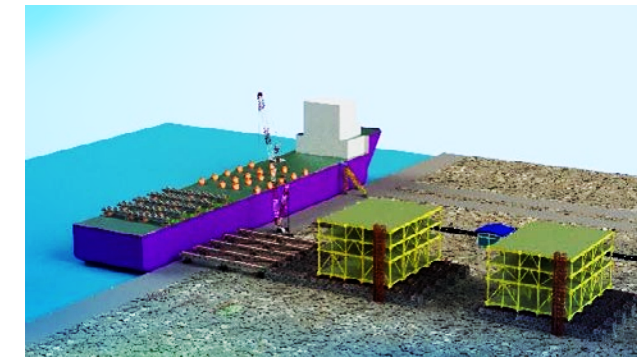


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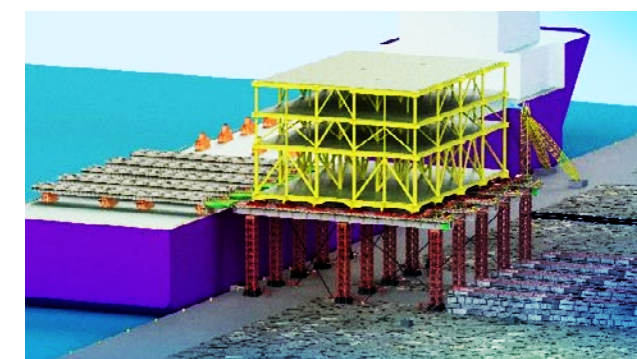
A maxi modularization concept to derisk project execution while saving CAPEX and reducing schedule.

Jack and skid deck module transfer to hull

We offer this cost effective solution to handle FLNG and other deck mounted mega modules.



The mega module is moved from the assembly area to the quayside using SPMTs

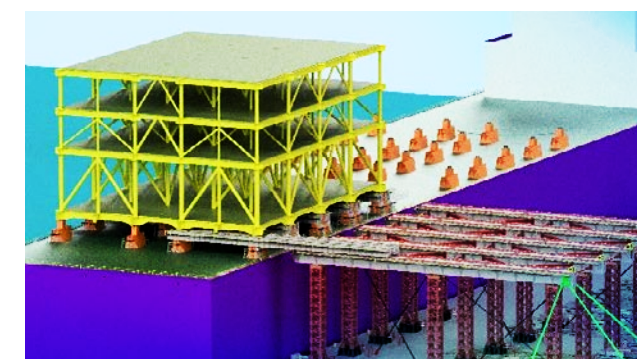


The skid deck elements are installed on the hull deck stools and the mega module is lifted to the hull deck level using a proven elevating system such as climbing jacks or gantries equipped with strand jacks



The mega module is transferred onto the hull using hydraulic skidding and jacked down onto the stools.

Full control of the hull level is ensured by water ballasting



After completion of skidding and jacking down operations, the skid deck elements are retrieved onshore

Selecting and working with fabrication yards

Assessing the yards' technical and commercial offering

During front-end engineering, several yards are prequalified. We use an open bidder list to ensure the best yard is selected for a specific scope of work.

MAIN EVALUATION CRITERIA: AUDITS

- HSE performance
- Quality and inspection
- Fabrication capability
- Project management
- Engineering capability
- Procurement and subcontracting plan
- Resource mobilization
- Price

Technip Energies audits yards of potential interest. Work packages can be adjusted to the yards' capacity and competition may be increased. The preselected yards are audited a second time using the FMECA* methodology. Main processes are audited and design office disciplines are reviewed.

An action plan is issued to each yard. All actions are closed out before the effective date of the contract.

EARLY WORK

For selected yards, an agreement is signed prior to final subcontract award to secure the best conditions and resources, set the effective date, define early activities, close the audit actions plan and ensure the immediate efficiency of the yard after contract signature. Preselected yards are involved in constructability reviews and workshops to mitigate risks and adapt the design as necessary.

HSE performance improvement in execution

During execution, we continue to work with our fabrication yards to encourage quality performance of which HSE is a central feature.

TRAINING PROGRAM

- Increasing workforce HSE awareness for a safe project execution.

comply with HSE rules and maintain a proactive approach to safety and environmental protection.

PROJECT INCENTIVE SCHEMES

- Enhancing HSE performance by motivating the work-force. Our project incentive scheme and balance of consequences programs motivate personnel to

HSE CAMPAIGNS

- Increasing workforce proactivity in managing risks onsite.
- Environmental awareness improving environmental performance in the yard.

To promote environmental performance, we record and analyze all yards' key environmental performance indicators on a monthly basis:

- Emissions
- Energy consumption
- Water consumption
- Waste generation



Our key references

Yamal LNG

THE LARGEST MODULARIZATION PROJECT EVER

- Clients: Novatek, Total, CNPC and Silk Road Fund
- Location: Russia

Yamal LNG is a large-scale LNG project in northern Siberia operated by the Novatek-TOTAL-CNPC-SRF joint-venture. The scope of work included the design, supply and startup of three LNG trains in an area where major gas reserves had never been fully developed due to the harsh arctic environment. The project, completed by a joint venture led by Technip Energies with JGC and Chiyoda, was completed ahead of schedule and within budget despite extreme conditions and logistics challenges through the Bering Strait.

MODULE FABRICATION IN CHINA AND INDONESIA

Excellent yard performance based on:

- Early interaction and extensive front-end work
- Recurrent gap analysis and audits
- Incentives for good QHSE performance
- Close integration of client during selection

LOGISTICS

- Module design: Accelerations and fatigue induced by severe navigation conditions
- Module sizing limited by Suez canal, Zeebrugge lock, land transportation clearances
- Largest fleet of heavy transportation vessels ever assembled 20 flat deck ships including semi-submersibles

ACHIEVEMENTS

Safety

- TRCR 0.05 (target < 0.2); LTIR 0.011 (target < 0.07)
- >50 M MHs LTI-free achieved across all yards

Quality

- Average module carryover < 0.9% (0.16% for Tr3)
- Client satisfaction > 8/10

Schedule

- First modules delivered 18 m after FID
- All three train modules set on foundations within 45 m



KEY FIGURES

- 142 modules, some weighing more than 6,500 tons
- 360 site preassembled piperacks (SPPs)
- 75,000 people involved
- 10 fabrication yards in China and Indonesia
- 20 heavy transportation vessels
- 1,600 supervisors in yards at peak

Coral South FLNG

- Client: Coral FLNG SA
- Location: Mozambique

Coral South floating liquefied natural gas (FLNG) is the third FLNG unit in the world and the largest floating structure in Africa, making one of Technip Energies's most important projects.

It will be the world's first ultra-deep-water FLNG facility to operate at a water depth of 2,000m and is expected to produce 3.4 million tonnes (Mt) of LNG a year. The Technip Energies-led TJS Consortium involving JGC Corporation and Samsung Heavy Industries (SHI) was awarded the engineering, procurement, construction, installation, commissioning (EPCIC) and subsea scopes in a single contract, in June 2017. The project is led by Eni alongside with the other Area 4 partners, namely ExxonMobil, CNPC, ENH, Kogas and Galp Energia.

KEY FIGURES

- LNG Capacity: 3,4 MTPA
- Water depth: 2,150 m



Koniambo

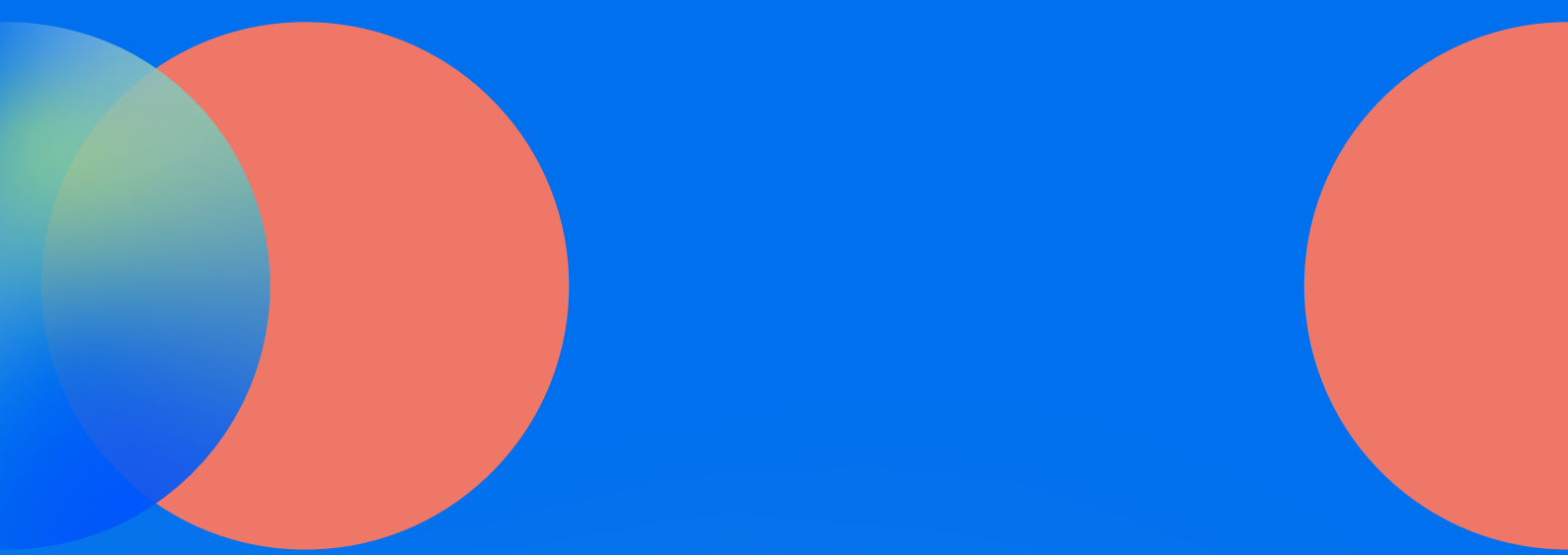
- Client: Xstrata
- Location: New Caledonia

Koniambo is a major mining and metal development. It comprises an open-cut nickel mine and a pyrometallurgical plant. Koniambo Nickel Project is one of the world's biggest and highest-grade nickel laterite deposits.

KEY FIGURES

- 15 modules - 37,000 tons
- Nickel plant: 60,000 t/yr
- Ferronickel production: 176,000 t/yr
- Open pit mines, wet material: 10MM t/yr
- Ore to Mmtallurgical plant: 2.5M t/yr (dry)





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